

Economic valuation of ecosystem services of three reservoirs and their importance for lake governance in Malaysia

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Abstract

Economic valuation of ecosystem services is an important research area to support integrated lake basin management and governance. As such, the economic valuation of ecosystem services was carried out in three reservoirs in the country, namely Sembrong Lake in Johor, Bukit Merah, and Chenderoh Lakes in Perak. The contingent valuation method (CVM) was undertaken to estimate the conservation value of all three reservoirs based on the assessment of the willingness to pay (WTP) for such conservation effort while the travel cost method (TCM) was to estimate the tourism value potential of the reservoirs. Additionally, direct values of water, fish, and flood mitigations were carried out for Sembrong Lake. The WTP per person per year for all three lakes was estimated at RM15.19 for Sembrong, RM17.20 for Bukit Merah, and RM15.76 for Chenderoh, respectively. The total economic values for conservation were RM381.6 million, RM130.7 million, and RM131 million for Sembrong, Bukit Merah, and Chenderoh lake respectively. The TCM analysis indicated that the mean recreation benefits per visitor per year were highest in Bukit Merah (RM294) followed by Chen-

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deroh, (RM197) and Sembrong (RM36). The direct values for Sembrong Lake were RM384.3 million with flood mitigation contributing 62% of the values. Based on this study, the economic values of ecosystem services of the three lakes are substantial and provide a significant welfare contribution to the society. Lake managers and decision-makers should give high priority to the management and conservation of lakes in order to enhance lake ecology that ensures long-term benefits to society.

Keywords: Contingent valuation, ecosystem services, man-made lakes, travel cost method

1. Introduction

Lakes provide invaluable services for mankind and living beings. The ecosystem services can be categorised into four categories namely resource provisioning, regulation and maintenances, cultural and supporting. These services are increasingly being evaluated to support decision making and develop management strategies or policies related to the benefits of different service by nature and their trade-offs [1]. Economic valuation of ecosystem services has been identified as important research in the National Blueprint for Lakes and Reservoir Research and Development in Malaysia since 2015 [2]. Such valuation not only enables greater understanding of the ecosystem services but can also enhance the financing pillars of Integrated Lake Basin Management. Valuation of lake ecosystem services is limited in Malaysia; only Tasek Bera was evaluated before year 2000 [3] followed by Putrajaya Lake [4] [5] and Paya Indah Wetland that was evaluated in 2015 [6].

Evaluation of ecosystem services has been widely undertaken worldwide ranging from forest and woodlands, wetland, freshwater system, and marine and coastal systems [7] [8] [9]. Among the categories of services, cultural services were the most widely valued [8] [9]. In Malaysia, valuation of lake ecosystem services are gaining acceptance and have been extended to evaluate the impact of climate change on lakes [10] as well as assessing the different lake attributes such as in Chini Biosphere reservoir [11]. However,

valuation of ecosystem services towards conservation and recreational potential was limited. This study was performed to support the development of integrated lake basin management plans for the three selected reservoirs. The aim was to identify the values of lake's main ecosystem services in monetary terms to enable stakeholder prioritised management and conservation efforts.

2. Materials and methodology

2.1 Study area

This study was carried out in three large but relatively shallow reservoirs in Malaysia. The surface area of the reservoir in decreasing order: 33 km² (Bukit Merah), 25 km² (Chenderoh) and 8.5 km² (Sembrong). Chenderoh reservoir is the oldest hydropower reservoir, built in 1930 with a mean depth of 4.5 m. The reservoir also functions as flood mitigation, recreation and aquaculture. Bukit Merah reservoir is the oldest irrigation reservoir in the country, built in 1906 with a mean depth of 2.5 m. The lake has multi-function which includes flood mitigation, domestic water supply, arowana sanctuary and industry and tourism. The sembrong reservoir is the newest among the three reservoirs, built in 1984 and having a mean depth of 3.2 m. The main functions of the reservoir are flood mitigation, and water supply.

2.2 Methodology

This study uses three economic valuation methods comprising indirect economic valuation namely Contingent Valuation Method (CVM), Travel Cost Method (TCM) and direct valuation method.

CVM was undertaken to estimate the conservation value of all the reservoirs based on the assessment of the willingness to pay (WTP) for such conservation efforts. The mean WTP of the double bounded dichotomous choice (DB-DC) contingent valuation method is estimated as the area under

the probability function of accepting the price bid posted to the respondent [12], which is as shown in Equation (1):

$$E(WTP) = \int_L^U (1 + e^{\alpha + \beta WTP})^{-1} dbid \quad (1)$$

where $(1 + e^{\alpha + \beta WTP})^{-1}$ represents the probability of saying YES, and upper (U) and lower (L) limits of the integration. The mean is calculated as follows:

$$E(WTP | \underline{x}, \beta) = \underline{x}' \left[-\frac{\hat{\alpha}}{\hat{\delta}} \right] \quad (2)$$

Table 1 illustrates the description of variables used in the valuation of WTP.

TCM was undertaken to estimate the tourism value potential of the reservoirs; where the 'price' of the site is determined by the time and travel costs incurred by people visiting the site. TCM is estimated based on the Equation 3

$$\widehat{CS} = \frac{1}{-\hat{\beta}_{TC_i}} \quad (3)$$

$\widehat{CS}$ represents the total consumer surplus for the site, and $\hat{\beta}_{TC_i}$ is the coefficient for the travel cost. The total CS of the lake is calculated using Equation 4:

$$TCS = \widehat{CS} * annual\ visitors \quad (4)$$

CVM and TCM were carried out at all lakes where data collection was completed through survey questionnaires and interviews with visitors at the lakes. All data analyses were carried out in STATA Statistical software.

The Direct Value Method (DVM) was only applied for Sembrong Lake due to available data. The direct economic values estimated were water rent, fish rent and flood damages as the following:

- i. Yearly harvested fish value from Sembrong Lake based on annual fish catch and price rate that is issued by the Department of Fisheries;

- ii. The water value for domestic supply (using the water volume extracted for consumption in Kluang population and water treatment cost); and
- iii. The possible flood damage salvaged by the Sembrong Dam (cost for road repair and hydraulic structure based on past flood damages)

Table 1. *Description of variables for CVM.*

Variable	Definition
wtp1	First response on willingness to pay (Yes=1, No=0)
wtp2	Second response on willingness to pay (Yes=1, No=0)
bid1	First bid price
bid2	First bid price
jantina	Gender (Male=1, Female=0)
umur	Age (years)
kahwin	Marital status (Single=1, Married=0)
hh	Household size
income	Monthly income (RM/month)
eduyr	Number of years in schooling (years)
yakin1	Level of confidence in paying to thrust fund (Very confidence=1, Not confidence=0)
jobgov	Type of job (Government and private sector=1, others=0)

3. Results and discussion

The total number of respondents obtained in this study were 105 respondents (Sembrong Lake), 300 respondents (Bukit Merah Lake) and 300 respondents (Chenderoh Lake) respectively.

Figures 1 and 2 shows the education level and age of respondents. Most respondents in Chenderoh and Bukit Merah survey were college or university graduates while those in Sembrong reservoir was secondary school educated (Figure 1).

The age level of respondents in Sembrong lake were older adults at the

age of 51-60 while the age levels of respondents in Chenderoh and Bukit Merah were younger adults between the 21-30 years (Figure 2).

Figure 1. Educational levels of respondents.

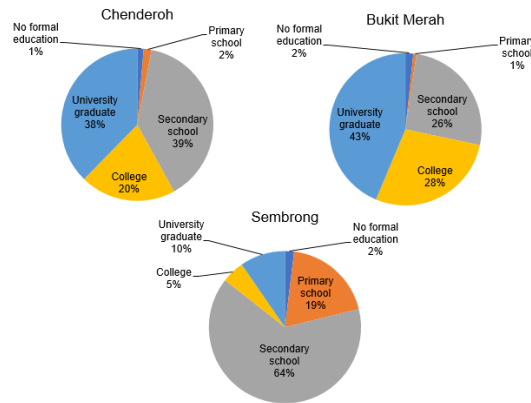
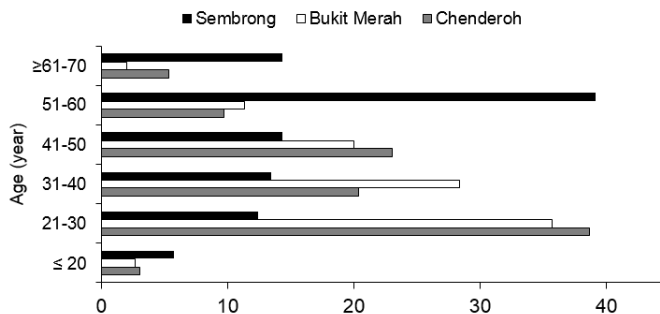


Figure 2. Age levels of respondents.



3.1 Contingent valuation methods

Bukit Merah Lake has the highest WTP values compared to Chenderoh and Sembrong lake (Table 2). The total economic value derived from WTP contributed with more than USD90 million for Bukit Merah Lake if the lake is conserved. WTP for Tasik Bukit Merah is affected by income and the level of education of the respondents ($p < 0.05$). WTP increased with the increase in income and the education levels of the respondents.

WTP for Chenderoh Lake is affected by age and income of the respondents ($p < 0.05$). WTP for Sembrong Lake is affected by marital status ($p < 0.05$). Married respondents were more willing to pay for conservation of the lakes.

Table 2. *Economic values for each lake.*

Lake	WTP, RM (USD) /yr	Economic values, RM (USD) million/yr
Chenderoh	15.76 (3.75)	131.0 (31.2)
Bukit Merah	17.20 (4.10)	381.6 (90.9)
Sembrong	15.19 (3.60)	78.6 (18.7)

Note: 1USD=RM4.20

The main reason for the majority of the WTP in Sembrong Lake is to avoid further deterioration of the lake for future generation uses. On the other hand, the reasons for WTP in Bukit Merah and Chenderoh Lake was to enhance the management of the lake and their biodiversity. As for not being willing to pay, more than half of the respondents in all study areas agreed that the maintenance cost should be borne by the government.

Half of the respondents agreed to pay higher tax if the fund is channeled to intensify management and maintenance of Sembrong Lake; this percentage is higher for Chenderoh Lake (62%) and Bukit Merah Lake (72%) of the total respondents. Generally, the Malaysian community depends on the government efforts to manage and maintain facilities including lakes [10]. As such a tremendous amount of funding has interminably been provided by the government towards this end.

In contrast to developed countries such as Japan and USA, community awareness was strong and they became part of the group to undertake management, restoration and maintenance of lakes [13] [14] [15]. Such WTP using CVM surveys has also been undertaken in other Asian and African lakes where a similar positive response of the community willingness to pay for conservation efforts was recorded [16] [17].

The WTP found in these three lakes were much higher than the one

recorded in Putrajaya Lake (RM14.60) (Table 3) possibly due to lower sense of belonging of community in the latter. In terms of total economic values, the values in all three lakes were lower than Putrajaya Lake (RM1,027 billion) possibly due to their smaller population compared to Klang Valley.

The WTP in this study was much higher than in some other African lakes such as Chamo Lake and urban lake in the Philippines.

Table 3. *Comparison of WTP in few selected lakes.*

Lake	WTP, USD/yr	Source
Chenderoh, Malaysia	3.75	This study
Bukit Merah, Malaysia	4.10	This study
Sembrong, Malaysia	3.60	This study
Putrajaya, Malaysia	3.50	Majizat et al. 2015
Paya indah, Malaysia	1.70	Siew et al. 2015
Chamo, Africa	0.51	Asmamaw et al. 2018
Urban lake, Phillipines	2.63	Bueno et al. 2016
Dalai, China	10.72	Wang & Jia 2012

3.2 Travel cost methods

The TCM analysis indicated that the mean recreation benefits per visitor were RM36 (~USD9) for Sembrong, RM294 (~USD70) for Bukit Merah and RM197 (~USD47) for Chenderoh, respectively. Higher recreational values for Bukit Merah is due to its various attractive sites. The lake has Laketown Resort and Chalet with Waterpark, Ecopark and Adventure park for different recreational facilities to attract visitors. Additionally, there are also Orang Utan sanctuary island and Arowana sanctuary in different parts of the lake. Similarly, Chenderoh Lake has Tasik Raban Resort and few other traditional chalets besides located nearby the Lenggong Valley which is a UNESCO World Heritage Site. Sembrong Lake lacks tourism facilities and only attracts anglers.

Factors influencing TCM varied between lakes (Table 4). Generally, visitors to Bukit Merah and Chenderoh Lake are mostly families of outside residents that are willing to travel for two hours using a car and van for

recreational purposes. Visitors to Sembrong were mostly local anglers that travel by motorcycle and spent longer time for their angling activities.

The main factors influencing TCM for Tasik Bukit Merah and Chenderoh were the travel cost, income, household size and the number of days allocated for recreation ($p < 0.05$). Marital status, gender, and the level of education also affected TCM for Bukit Merah. TCM for Chenderoh Lake was also influenced by age, and the job type while TCM for Sembrong Lake is only influenced by the year of education.

Table 4. *Factors influencing TCM for each lake.*

Factors	Chenderoh	Bukit Merah	Sembrong
Average time spent	~ 2 hours	~ 3 hours	~ 4 hours
Mode of transport	Car/van (96%)	Car/van (89%)	Motorcycle (74%)
Travelling time	2 hours (45%)	2 hours (>50%)	30 minutes
Travelling companion	Family (59%)	Family (60%)	Friends (53%)
Distance travel (<50 km)	68.7%	16%	>70%
Main purpose	Recreation (>50%)	Recreation (>50%)	Angling (>55%)

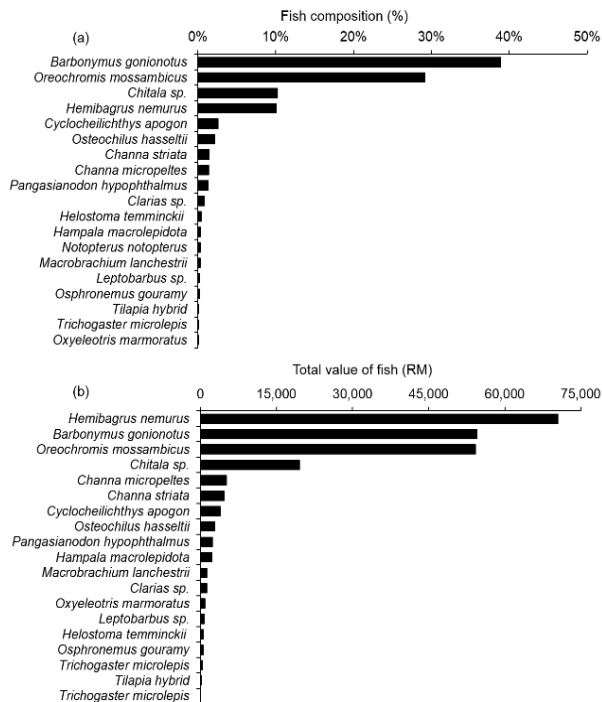
The recreational values from TCM estimation in these three lakes were much lower than the one recorded in Putrajaya Lake (RM304.30).

3.3 Direct values

The direct values for Sembrong Lake were RM384.3 million (USD91.5 million) with flood mitigation contributing 62% of the values. Flooding is one of the common issues in Malaysia, the construction of Sembrong Dam was to mitigate flooding to downstream areas of Batu Pahat. Sembrong Dam has been serving the downstream areas of Batu Pahat since its establishment in 1984. There is no record of major flooding in the areas during the period of 22 years from 1984 to 2006. The only flood occurred was in 2006-2007 where

the whole Malaysia in general and Johor State experienced the worst flood events [18] [19]. The estimated cost for road repair including bridges and hydraulic structures for Batu Pahat District was RM 13.6 million and RM 63.3 million, respectively. By estimating the total damage from flood, it is only 5% of the total worth of economic loss during the flood occurrence and at a discounted rate of 8% (USD57.2 million).

Figure 3. (a) Fish composition. (b) Total value of fish in Sembrong Lake.



The water rent contributes 20.4% while fish rent contributes 17.6%. With daily extraction of 58 MLD of water for domestic supply, the water rent at discounted rates of 8% was estimated at USD18.9 million.

The most dominant fish species in Sembrong lake is *Barbonymus gonionotus* followed by *Oreochromis mossambicus* contributing 68% of the fish harvested by fishermen for this study (Figure 3). *Barbonymus gonionotus* is the most common freshwater Asian carp found in Malaysia. In terms of fish price, the most expensive fish were *Oxyleotris marmoratus* (USD14.30/kg)

followed by *Hampala macrolepidota* and *Hemibagrus nemurus* (USD2.50/kg). Based on the total value of fish and fish harvest in a year, the fish rent at discounted rates of 8% was estimated at RM65.6 million (USD15.6 million). This value is much larger than the fish value recorded in Putrajaya Lake [4] [5] probably due to lake longer existence, larger size and major rivers influence. Sembrong Lake was also occasionally stocked with fish fry by the Fisheries Department to reduce the eutrophication level.

4. Conclusion

Bukit Merah Lake has the highest economic values (CVM and TCM) among the three lakes. The economic values of ecosystem services of the three lakes were substantial and provided a significant welfare contribution to the society. Lake managers and decision-makers should give high priority to the management and conservation of lakes in order to enhance lake ecology that ensures long-term benefits to society.

Acknowledgements

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