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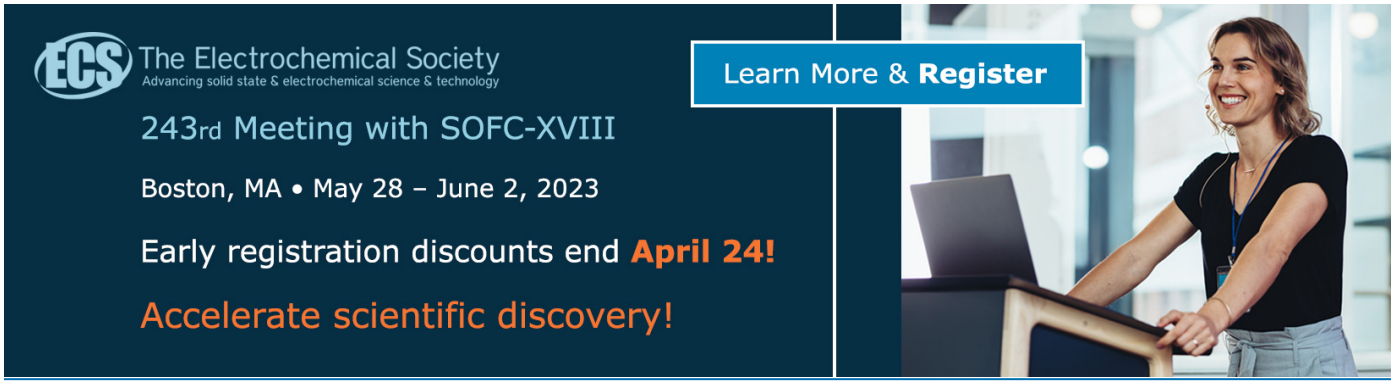

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Economic Valuation of Forest Ecosystem for Watershed Services in Kelantan, Malaysia

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Abstract. Preserving forest watershed areas has become crucial in capturing and storing water, contributing enough water supply for domestic and non-domestic purposes such as agriculture, recreation, and energy generation. Unlike primary goods such as food and fuel, most ecosystem services like watersheds do not have market values, where the protection of these services is barely considered in economic decisions. The study aims to estimate the value of the economic benefit of the forest ecosystem for watershed services in Kelantan by using the willingness to pay (WTP). The simple random method has been employed to collect the data via face to face to interviews with 1043 households in Kelantan. The finding of this study estimated the economic value of Kelantan's forest ecosystem for watershed services amounted to RM48 million annually, which could be worthwhile for protection or conservation fees. The public's interest in contributing to the forest watershed services in Kelantan indicates that relevant stakeholders need more collaborative effort, including non-governmental organisations and federal and state governments, to conserve and preserve the forest ecosystem in Malaysia, specifically for watershed services.

1. Introduction

Preserving forests has become Malaysia's agenda since Rio Earth Summit in 1992. Despite rapid development, the country is committed to ensuring that forest covers at least 50% of its land area. Forest ecosystems provide a wide range of services, including biodiversity, carbon sequestration, soil conservation, and watershed services. Healthy forest ecosystems function as pollutant filtration, regulate stream flow, and act as sponges that absorb heavy rainfall and gradually release water to the river, reducing the effects of floods and maintaining river flows during the dry season. As the population grows, demand for natural resources, especially water, will increase. In recent years, timber production activities to supply the needs of the timber industry are not the only agenda of forest management in Malaysia. Besides timber, water resource management has become the main agenda for preserving the reserved forest. Forest areas are an essential source of water supply for domestic, agricultural, industrial, and recreational purposes. However, forest areas face threats to land-use conversion due to development projects. As a result, the watershed areas are exposed to the same threat of danger. Recognising this threat, the Forestry Department Peninsular Malaysia (FDPM) has taken proactive steps to gazette the Permanent Reserve Forest (PRF) areas that supply water to river catchments as Water Catchment Forest (commonly referred to as a watershed). Until 2020, it is estimated about 1.23 hectares, which is 21.74% of the 4.81 million hectares of PRF areas in Peninsular Malaysia, have been identified as Water Catchment Forest [1]. In addition, the formulation of the National Water Resources Policy (NWRP) 2012 was held with the awareness to conserve water resources to ensure water supply for all consumer sectors, namely humans and the environment, so that their needs are met in terms of quantity and quality.

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The forest ecosystem as a watershed service has been one of the significant contributors to the clean water supply in Malaysia. Thus, the purest water supply comes from rain filtered through forests and ends in rivers. One of the benefits of watershed service in terms of water quality is reducing the cost of water treatment. This service is straightforward: water that flows or is being absorbed through forests or other natural ecosystems tends to be less polluted than water discharged by agriculture, urban or industrial landscapes. Therefore, the contaminated water needs more treatment before it is safe to be supplied. Recognising this vital benefit, the watershed should not be involved in commercial harvesting activities, typically in high-altitude areas. To prevent such threats, an economic assessment of the forest ecosystem as watershed services is needed to determine the monetary value of the forest ecosystem as watershed services to ensure continuous conservation efforts of the forests.

Therefore, there is a need to integrate economic policy into forest management and planning. To do that, the economic analysis of the forest ecosystem for watershed services must be conducted and documented. A 2019 case study was conducted to value the economic benefits of the forest ecosystem for watershed services, specifically at Kelantan.

2. Methodology

2.1 Sampling method

Sample design: The process of deciding on target groups to interview and the number of respondents [2]. The process is to select a group of the population such that the result can be repetitive to the entire population. Residents of Kelantan was chosen as sample (respondent) for this study. Other than that, sampling for this study was designed by the Department of Statistics Malaysia (DoSM) by using stratified random sampling.

Sample size: The sample size is essential in estimating the economic value using econometric tools such as the Contingent Valuation Method (CVM) and Choice Modelling (CM). The larger the sample size, the more reliable values are expected. However, the larger sample size is costly and requires a more significant number of enumerators. In considering a few demographic parameters, a total of 50 sampling blocks and 20 samples for each block were generated as samples for this study by DoSM. The parameters adopted in the determination of the sample are based on strata or status of the area, whether urban or rural. **Table 1** shows sampled details.

Table 1. Summary of the selected respondents

District	Sampling Blocks	Sample
Kota Bharu	9	191
Tanah Merah	5	108
Jeli	1	20
Pasir Mas	7	144
Bachok	5	106
Tumpat	5	110
Pasir Puteh	5	100
Kuala Krai	6	122
Machang	4	82
Gua Musang	3	60
Jumlah	50	1,043

2.2 Valuation method

Watershed service is one of the environmental goods and services provided by the forest ecosystem. Unlike timber, this service does not have a price and is not traded in the market. As stated by [3], estimating the economic value of natural resources might reveal areas of the market where goods and services are presently underpriced. Various techniques to quantify the economic value of environmental goods and services. Several methods are adopted to estimate the economic values of non-marketable goods and services like watershed services. The selection of measuring methods depends on the goods and services and the study's objective. Different goods used different approaches to estimate their value. However, a method can be used to measure marketable goods and services, such as the Contingent Valuation Method (CVM). Hence, CVM is a method of estimation for non-market goods and services of environmental features or amenities, such as the value of particular places, the status of endangered species, recreational opportunities, scenic resources, and others [4], [5]. This method is closely related to the individual's behaviour in a hypothetical setting. This method also is based on "price observed" for the goods to be valued. Ideally, CVM is the only valuation method capable of capturing all advantages, including use-value, non-use value, and even existence value [6]. This clearly shows that the value of the watershed can be assessed through CVM. Therefore, this study applied CVM to determine the economic value of the forest ecosystem as a watershed service, specifically at Kelantan. This economic study involved a single and double-bounded dichotomous choice survey to empirically investigate the public's willingness to pay (WTP) for conserved watershed areas. The advantage of using this technique is that it can be determined from the data where the maximum WTP value is based. A reasonably estimated value sufficient to be used in judicial proceedings for assessing natural resource damage can be produced by a CVM technique that is well-structured and applied [6].

The first stage in conducting a CVM study is setting up a hypothetical market. A hypothetical market for the environmental services flow must be set up in the question, describing how funds will be raised for these services. The payment vehicle in forms of payment (bid) are taxes, utility bills, entrance fees, or thrust fund payments that must be decided in this stage. Where this study applied the annual conservation fund as a payment vehicle, a survey must be conducted to obtain a bid. This survey can be through face-to-face, telephone, or mail interviews. In this stage, respondents were asked to state their maximum WTP, and the dichotomous choice technique was applied in this study. After the survey, the mean WTP is estimated. At this stage, protest bidders are excluded from the analysis. Protest bids mean respondents refuse to place on value services offered during the survey. Estimating bid curves, including determining the variables (determinants) that influence the WTP bids, help aggregate and assess the CVM exercise's validity. Lastly, aggregation of data. Collection refers to the proses whereby the mean bid is converted to a population total value figure. The summary of the approach conducted in this study as Table 2.

Table 2. Summary of approaches applied.

Questionnaire Design	Dichotomous choice – single and double bounded format. Six different bids were given randomly. Each respondent only has to say 'yes' or 'no' to the bid posed. Bids used: RM10, RM30, RM50, RM100, RM150 and RM200.
Econometric Models	Logistic and Biprobit model: This model was chosen because of its ability to deal with a dichotomous dependent variable and a well-established theoretical background.

2.3 Economic Valuation Analysis

Respondents were asked to indicate their willingness to pay (WTP) for forest ecosystem as a watershed service in the State of Kelantan. The analysis revealed that 83.6% of respondents were willing to contribute to conserving forest ecosystems as a watershed service through an annual conservation Fund. Most respondents believed that the public had a responsibility to promote conservation. The minority of those unwilling to pay thought the government should pay for the conservation impact because they could not pay any of the amounts offered. Frequency analysis shows the level of WTP for the conservation fund ranged between RM2.00 to RM200.00 annually, with an average WTP of RM54.90 annually. The dichotomous choice was used for estimation in this study. The analysed explanatory variables are displayed below. These variables were partially incorporated into the models because they were considered significant WTP predictors. The variables used in the analysis are listed below:

$$\text{Willingness} = \alpha + \beta_1 \text{xtvtPRF}_i + \beta_2 \text{VisitPRF}_i + \beta_3 \text{Aget}_i + \beta_4 \text{INC}_i + \beta_5 \text{expEnvn}_i + \beta_6 \text{Flood}_i + \beta_7 \text{LBD}_i + \beta_8 \text{BD2}_i$$

Where:

Willingness	= Dependant variable (1=Respondent willing to pay for the bid; 0=0therwise)
xtvtPRF	= Respondents involved in forest and its related activities (1=Yes; 0=No)
VisitPRF	= Respondents visited PRF in Malaysia (1=Yes; 0=No)
Age	= Actual age of respondents
INC	= Respondents actual income (RM)
ExpEnvn	= Respondents effort to increase knowledge of the environment
Flood_i	= Respondents' perception of PRF as flood mitigation
LBD	= Dichotomous-choice bid assigned
BD2	= Follow-up bid assigned

3. Results and Discussion

3.1 Socio-demographic background

Out of 1,043 respondents, more than half of respondents (60.8%) were females with the frequency of 634 respondents, while the other balance of 39.2% were males (Table 3). Descriptive analysis shows that 43.1% of the respondents received higher education until secondary school. This finding is in line with Malaysia's rural education. Hence, the average monthly income was RM2,163. Another socio-demographic sample is presented in Table 3.

Table 3. Socio-demographic background of the respondents

Socio-demographic background		**Frequency (f)**	**Percentage (%)**
Gender	Male	409	39.2
	Female	634	60.8
Age	Mean	47.9 years old	
	<21 years old	22	2.1
	21-30 years old	157	15.1
	31-40 years old	182	17.4
	41-50 years old	215	20.6
	50-60 years old	227	21.8
	>61 years old	240	23.0

Education	No formal education	90	8.6
	Primary school	185	17.7
	Secondary school	609	58.3
	Diploma/STPM	94	9
	University	65	6.3
Monthly income	Mean	RM2,163 / month	
	Less than RM1,500	491	47.1
	RM1,500 - RM3,500	389	37.3
	RM3,501 - RM5,500	94	9.0
	RM5,501 - RM7,500	37	3.5
	RM7,501 - RM9,000	14	1.3
	More than RM9,001	18	1.8

Respondents were asked about their knowledge and involvement in forests and other forest-related activities. More than half (68.6%) of respondents had been involved in forest-related activities. Surprisingly, 85% of the respondents were also familiar with the Permanent Reserved Forest (PRF), which means although respondents did not involve in forest-related activities, they knew about the PRF. This indicates that the public is aware and knows about PRF's existence in Malaysia, specifically at Kelantan. Descriptive analysis showed from 1,043 respondents, 54% of them visited the PRF all around Malaysia at least once in a lifetime. Most of the respondents agreed that the conservation of PRF should be given priority, especially in the state of Kelantan.

3.2 Results of Economic Valuation

As expected, the bid offered (LBD) coefficients are inversely correlated with the probability of acceptance for both models' logistic (using initial bid) and biprobit models. The negative and statistically significant coefficients on bid suggested that the higher the amount respondents were asked to pay, the less likely they would pay at a 1% significant level (Table 4). The results show a positive relationship between xtvtPRF and WTP, which is significant at the 1% level. The results from both models also show a negative relationship for variable Age. That means the age of respondents does not influence the probability of accepting the bid, and 5% is statistically significant. The respondents' actual income (INC) and the bid assigned for conservation fee is positively related for both logistic and biprobit models and statistically positive at a 1% significant level. This finding is in line with few studies in the past [7], [8], [9]. Those studies also indicate a positive relationship between income and WTP.

Table 4. Estimated parameters of the models

Variable	Logistic	Biprobit	
		WTP1	WTP2
LBD	-0.0258	-0.015	
	(0.0017)***	(0.000878)***	
BD2	-	-	-0.0096
			(0.00095)***
xtvtPRF	0.684	0.3671	0.6904
	(0.2148)***	(0.1204)***	(0.1076)***
VisitPRF	-0.5954	-0.3092	-0.55436
	(0.2031)***	(0.1138)***	(0.09907)***
Age	-0.0148	-0.0086	-0.0034

	(0.0060)**	(0.0034)	(0.0029)
INC	0.00015	0.00076	0.000028
	(0.000049)***	(0.000026)***	(-0.000018)
expEnvn	0.3746	0.1942	0.1284
	(0.1945)*	(0.1105)*	(0.0954)
flood	0.5232	0.2275	-0.0202
	(0.2377)**	(0.1288)**	(0.0916)
Constant	2.774	1.6658	0.4582
	(0.4246)	(0.2366)	(0.2100)
-2 log-likelihood	370.85	891.14	
No. of obs. (n)	872	872	
Pseudo R^2	**0.36**	-	

Note: *10% significant; **5% significant level; ***1% significant level

Table 5 shows the results of the differences between the mean and median WTP for different models. The Logistic model's mean WTP offers a slightly higher WTP than another model with a WTP of RM131.66 per month. In order to accumulate the WTP for the forest ecosystem of watershed service at Kelantan, the individual WTP obtained from the analysis was multiplied by the number of households at Kelantan. The yearly calculated economic value for forest ecosystem as a watershed service based on the mean willingness to pay computed for 2019 was RM44.9 million to RM47.6 million. The highest amount identified in this study was RM139.43 per year, which would be proposed as a contribution fee (for example, in the form of tax) to the conservation fund. The authorities can use this fee to determine the conservation / appropriate conservation fees of the forest ecosystem for watershed services.

Table 5. An estimated value for forest ecosystem as watershed service

Model	**Mean (RM)**	**Median (RM)**
Logistic	131.66	130.38
Biprobit	139.43	130.64
	112.06	65.86

4. Conclusion

The public placed greater interest and willingness to pay for conserving the forest ecosystem as a watershed service. The most significant implication of this study concerns the conservation fee and new financing mechanism for the state of Kelantan, such as payment for ecosystem services (PES) can be further explored and implemented where appropriate for the benefits of present and future generations.

Acknowledgement

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