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Catchment-to-Intake-Point Economic Valuation of Water Resources Using a Hybrid Method

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Abstract

Catchment-to-intake-point (CTIP) economic valuation of water resources is an important aspect of sustainable forest management. With a total of about 94,851 ha of forest catchment area, the state of Johor has among the largest inland water bodies and, thus, water resources in Malaysia. However, the economic valuation of CTIP water resources is rather undeveloped in this country. This paper introduces a hybrid method of CTIP economic valuation of water resources from forest catchment areas based on state-wide Cobb-Douglas translog production function and residual methods, by taking the state of Johor, Malaysia, as a case study. Data on Gross Domestic Product (GDP), labour (L), capital (K), water (W), energy (E), and raw materials (M) were collected for the state of Johor from various secondary sources. Using a pro-rata price in 2014, the total value of CTIP water resources for an assumed lease period of 60 years at 4% per annum is RM 70,272,825.14. This is equivalent to the use-value of water of RM 1,171,213.75 per annum which is an additional source of income to the state government.

1. Introduction

CTIP water resource valuation is an important component of forest management. It is an aspect that has not been given due attention in many countries, particularly in the preparation of forest watershed management plans. For countries that implement water resources valuation system, the rationale given for such a valuation is to achieve efficient allocation of water resources [1]. However, the context of discussion in many previous studies is focussed on the source of water for irrigation; CTIP context has never been featured in those studies, especially on the determination of water charges or price. In this case, water valuation CTIP is unique in the case of Malaysia.

Considered as a smart forest management policy, CTIP water resource valuation aims at increasing government's revenue from forest catchment areas. One study disclosed that the economic value of fresh water used by aboriginal communities in the forest areas is worth hundreds of millions of dollars based on the current market tariffs [2]. Based on the concept of scarcity, supply and demand, the efficient use of water is considered to occur if each unit of water supply equates the marginal revenue and marginal cost. Marginal cost arises from the costs incurred by water supplier while the marginal revenue is derived from water prices paid by consumers. In the economic terms, CTIP water has a certain value which can be determined based on the price to be paid for it. However, many consumer groups such as farmers and manufacturers extract water from the catchment area to their site of production without paying and this has directly or indirectly incurred revenue loss to the state [3].

In this context, what is the price of CTIP water that should be imposed by the State Forestry Department – the resource owner - to the state water services provider? Based on the principle of revealed preference, CTIP water is considered as an intermediate input in the production of value-in-use goods. CTIP water is also an environmental service whose price can be estimated even if there are no direct transactions in the market. Due to imperfect market, complete information is often unavailable to estimate the production function and the marginal value or the total value of water resource. Nevertheless, production function method can still be used using water-market data. Based on this method, the CTIP water price is determined using the concept of residual value. Besides, cost-based prices can be used to estimate CTIP water price.

This paper is important in two ways. First, CTIP water resource valuation study has never been conducted in the world and, thus, has never been discussed in the

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literature. State-wide production function technique has never been applied for water resource valuation other than that applied to irrigation water. The methodological and practical application of the method discussed in this paper can thus become a source of useful reference for future similar studies in water resource valuation.

2. Water Resource Valuation

2.1. The Current Method

The economic valuation methodology of water resources is quite complex whereby various methods have been proposed [4]. The general methodology of economic valuation is reflected in Figure 1.

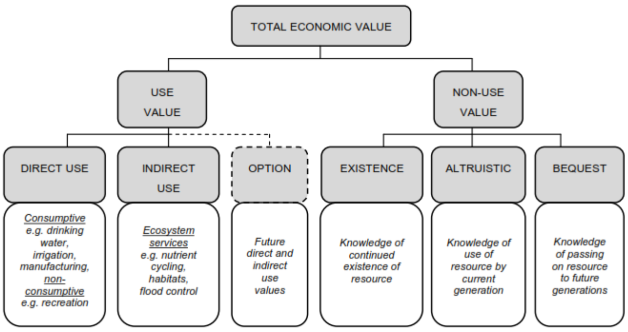

Figure 1: General methodology of economic valuation.

In theory, it is based on the concept of total economic value, which is divided into use value and non-use value. Under both categories of value, there is a breakdown of other concepts of value. However, none of these methods are suitable in all circumstances because the suitability of each method for use depends on many circumstances. The most important circumstance relates to pricing philosophy or policy that in turn determines water tariff system by the state water authority. Examples of such philosophy or policy include shown in Table 1 [4]:

Table 1: Pricing philosophy or policy.

Philosophy/ policy determination of tariff/ price	Basis of valuation
Cost recovery	Average cost
Efficient use	Marginal cost
Peak-demand differential price	Differential pricing (seasonal/non-peak)
Supply-based pricing	Dual pricing
Water availability constraints	Dynamic programming
Revenue generation in excess of long-term average price	Marginal cost

In Malaysia, water authority operates as an integrated water supply entity involved in sourcing raw water from catchment areas to intake points; treatment and distribution of potable water to residential, commercial, and institutional premises; and billing and collecting payments. It is also involved in the operation, maintenance, and development of water treatment, reticulation, and support systems. Each water authority in Malaysia has its own tariff schedule based on service-charge pricing. From Table 1, most states impose a minimum and average household water tariff rate of approximately RM 5.82 m-3 and RM 0.95 m-3, respectively. The lowest minimum tariffs for various other uses of water are more varied, but the average rate is RM 11.33 m-3. The average of mean tariff for various other uses of water is RM 1.1 m-3. The critical question is that, do the tariffs shown in Table 2 reflect what the market should be charging?

Table 2: Comparison of water tariffs in Malaysia.

Type of premise State	**Household**		**Religious building**		**Volunteer organization**		**Government Building**		**Commercial**		**Construction**		**Swimming pool**	
State	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*
Johor	5.00	1.74	5.00	1.74	5.00	1.74	25.00	2.80	25.00	2.78	25.00	2.78	25.0	2.78
Negeri Sembilan	5.00	0.93	3.00	0.20	3.00	0.20	10.00	0.80	15.00	1.55	15.00	1.55	15.0	1.30
Selangor/K.L./Pjaya	6.00	1.20	6.00	0.46	6.00	0.58	17.00	1.61	36.00	2.18	36.00	2.18	21.00	2.00
Melaka	6.00	1.00	20.00	0.55	20.00	0.55	20.00	1.30	20.00	1.72	20.00	1.72	20.0	1.72
Terengganu	4.00	0.74	-	0.70	4.00	0.74	15.00	1.05	15.00	1.05	15.00	1.05	4.00	0.74
Perak	3.00	0.67	3.00	0.32	3.00	0.32	3.00	0.67	12.00	1.40	12.00	1.40	3.00	0.67
Perlis	4.00	0.73	4.00	0.73	4.00	0.73	4.00	0.73	6.50	1.20	6.50	1.20	6.50	1.20
Kelantan	4.00	2.20	-	0.35	6.50	1.20	6.50	1.20	12.50	1.25	12.50	1.25	12.5	1.25
W.P. Labuan	4.00	0.90	0.00	0.00	-	0.90	-	0.90	4.00	0.90	4.00	0.90	4.00	0.90
Kedah	6.00	0.90	6.00	0.78	6.00	0.78	6.00	0.90	NA	NA	NA	NA	NA	NA
Pahang	3.00	0.72	3.00	0.44	3.00	0.44	-	0.55	NA	NA	NA	NA	NA	NA
Pulau Pinang	26.00	0.61	26.00	0.61	26.00	0.61	26.00	0.61	NA	NA	NA	NA	NA	NA
Sarawak (Kuching)	4.40	0.65	4.40	0.65	4.40	0.65	20.35	1.40	20.35	1.40	NA	NA	NA	NA
Sarawak (Sibu)	4.40	0.65	4.40	0.65	4.40	0.65	20.35	1.40	20.35	1.40	NA	NA	NA	NA
Sarawak (Sri Aman, Miri, Limbang, Sarikei, Kapit)	4.40	0.65	4.40	0.65	4.40	0.65	21.63	1.33	21.63	1.33	NA	NA	NA	NA
Sarawak (Bintulu)	7.60	1.27	7.60	1.27	7.60	1.27	21.27	1.03	21.27	1.03	NA	NA	NA	NA
Sarawak (Other areas)	4.00	0.59	4.00	0.59	4.00	0.59	19.67	0.94	19.67	0.94	NA	NA	NA	NA
Sabah	4.00	0.90	0.00	0.00	4.00	0.90	4.00	0.90	4.00	0.90	NA	NA	NA	NA
Average	**5.82**	**0.95**	**6.30**	**0.59**	**6.78**	**0.75**	**14.99**	**1.12**	**16.88**	**1.40**	**16.22**	**1.56**	**12.33**	**1.40**

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2.2. The Proposed Method

In the context of economic valuation of CTIP water resources, value is estimated based on 'direct use', i.e. consumptive use value. The rationale is that clean water is directly used by consumers and it is charged by the state water authority at a monopolistic market rate based on the amount of metered water supply connected to premises such as businesses, households, and farms. Thus, valuation needs to consider CTIP water supply path as depicted in Figure 2. It shows a three-component water resource flow from the origins to the points of consumption, namely the source (C_O), treatment (C_T), and distribution (C_D).These three main components can be further broken up into smaller components, namely C_a = abstraction, C_t = treatment, C_n = transmission, C_p = operation, C_m = administration, C_c = cost of capital, C_f = fixed capital, and C_e = miscellaneous), respectively.

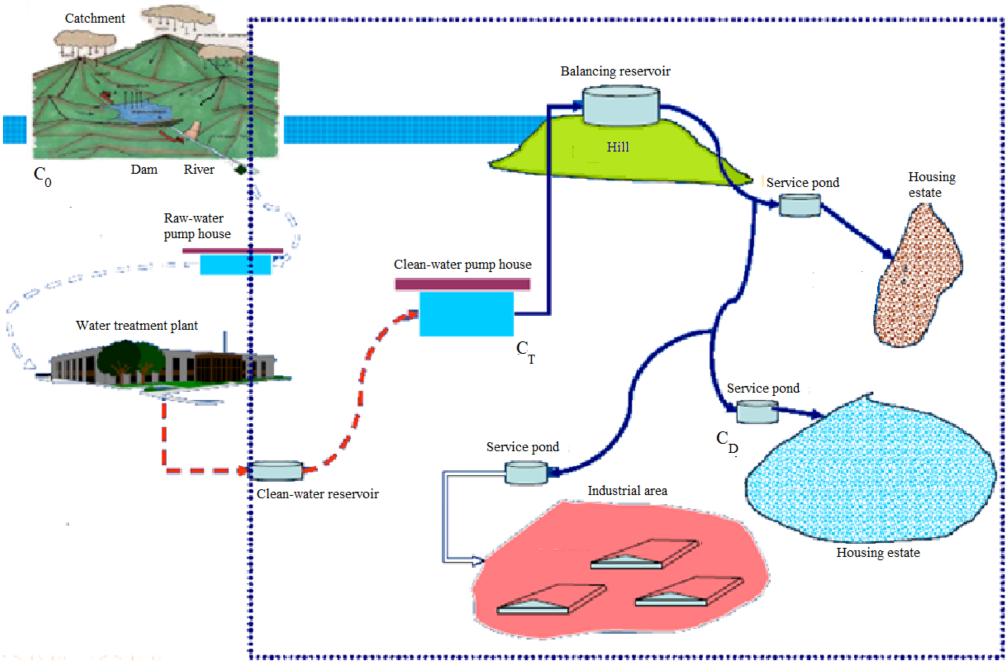

Figure 2: CTIP water supply path.

The sourcing component comprises catchment, river networks, dam, and raw-water pump house. The treatment component comprises water treatment plant, clean water reservoir, and clean water pump house. The distribution component consists of balancing reservoir, service pond, and consumption points such as agriculture, housing, industry, and so on.

Based on CTIP water supply path, a more sustainable economic valuation approach is the market approach. It is further divided into two methods, i.e. service-charge method and willing-buyer-willing-seller method. The first method is solely based on water tariff system as shown in Table 1.It is the simplest method. Based on Table 1, the price of water in the market can be in the range of RM 1.14 to RM 11.33 m^{-3}. In the context of willing-seller-willing-buyer principle, an agreed level of market price can be adopted and then be used as a benchmark for CTIP water pricing system.

However, we propose a hybrid method combining backward residual price calculation and production function method. This hybrid method assumes that the price of water resources at the catchment point is determined after deducting the costs of conversion, risk, and profit margins at the point of use from a certain level of market price.

$$P_R = P_M - (C_S + \pi) \quad (1)$$

Equation (1) above can be rewritten as follows:

$$P_R = P_M - (C_O + C_T + C_D + \pi) \quad (2)$$

Where P_R = residual price (CTIP water price); P_M = price of water in the market; C_S = the various components of the cost of supply, i.e. the costs involved in the sourcing, C_O; treatment, C_T; distribution, C_D; while π = operator's profit.

Based on the above approach, valuation CTIP should only be made based on the direct use of water alone. The data used should be empirical which are recorded based on the market. Thus, the above concept can be modified as follows:

$$V = P_M Q_W \quad (3a)$$

$$P_M = V/Q_W \quad (3b)$$

Therefore,

$$\Delta P_M = \Delta V/\Delta Q_W \quad (3c)$$

Where V = revenue from the sale of water; P_M = price per unit of quantity of water; and Q_W = the number of physical consumption of water.

We propose that the marginal productivity approach be used through production function

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specification. This is in line with the basic premise that marginal cost valuation is the most efficient method that can help to achieve efficient water use while generating revenue from water sources [4] [5]. In our case, this method can be implemented based on the production function of the economy of a state - Johor in this context. In this method, the economic output of a state is assumed to be using the basic factors of production such as labour, capital, water, and energy.

By using the production function, the contribution of factors of production can be estimated by regressing the economic output of a state against the factors of production concerned. The price of water for the sub-sector *j* is calculated as the water tariff or price of water sector based on the production function. Information about the amount of capital, labour, water, energy and raw materials is specified based on the Cobb-Douglas translog production function (TCDPF) as follows:

$$\ln V_j = \beta_0 + \beta_1 \ln K_j + \beta_2 \ln L_j + \beta_3 \ln W_j + \beta_4 \ln E_j + \beta_5 \ln M_j + \beta_6 \frac{\ln K_j^2}{2} + \beta_7 \frac{\ln L_j^2}{2} + \beta_8 \frac{\ln W_j^2}{2}$$
$$+ \beta_9 \frac{\ln E_j^2}{2} + \beta_{10} \frac{\ln M_j^2}{2} + \beta_{11} \ln K_j \ln L_j + \beta_{12} \ln K_j \ln W_j + \beta_{13} \ln K_j \ln E_j + \beta_{14} \ln K_j \ln M_j$$
$$+ \beta_{15} \ln L_j \ln W_j + \beta_{16} \ln L_j \ln E_j + \beta_{17} \ln L_j \ln M_j + \beta_{18} \ln W_j \ln E_j + \beta_{19} \ln W_j \ln M_j$$
$$+ \beta_{20} \ln E_j \ln M_j + \varepsilon \quad (4a)$$

Where ln V = log total value of production of state's economic sub-sectors (agriculture, housing, institutions, industry, and others); ln K = log of capital investment in the state; ln L = log of total number of employment in the state; ln W = log of the water used in the process of economic production in the state; ln E = log of state's energy consumption; and ln M = log of raw materials used in economic production in the state.

Elasticity of production on water resources, σ_W is calculated as:

$$\sigma_W = \frac{\partial \ln V_J}{\partial \ln W_J} = \beta_3 + \beta_8 \ln W_J + \beta_{12} \ln K_J + \beta_{15} \ln L_J + \beta_{18} \ln E_J + \beta_{19} \ln M_J \quad (4b)$$

Then, the marginal value of CTIP water resources (P_M as in Equation (1)) is estimated from the overall state's economy as follows:

$$P_M = \rho_W = \sigma_W \cdot \frac{\overline{V}_J}{\overline{W}_J} \quad (4c)$$

Where $\overline{V}_J$ and $\overline{W}_J$ are as defined in Equation (4a) but taken at sample's means, respectively.

The quantity in Equation (4c) is then inserted as a price element to compute the final residual price of water consumption in the economy as follows:

$$P_R = P_M - (C_S + \pi)$$
$$= P_M - (C_a + C_t + C_n + C_p + C_m + C_c + C_f + C_e + \pi) \quad (5)$$

Where all variables are as defined previously.

In general, P_R can be related to P_M as follows:

$$P_R = P_M - \frac{c}{100} x P_M \quad (6)$$

Where P_R and P_M are as defined above and c is the overall percentage of all water costs from the estimated market price of water use in the economy.

The economic value of CTIP water resources is then estimated as the total discounted future rights of residual water price that can be derived from each catchment area in a particular state. In our case, there are fourteen watersheds in the state of Johor with a total combined area of 94,850.88ha. The formula used for estimating the resource value is given as follows [6]:

$$V_E = Ax0.25 D_N x P_R x[1 - \frac{1}{(1+i)^t}] \quad (7)$$

Where V = economic value of CTIP water resources; A = the size of watershed area (ha); D_N = net discharge; P_R=residual price (as defined in Equation (6))

2.3. Data and Analysis Procedure

The study was conducted in the state of Johor covering fourteen forest catchment areas with a total of 94,851 ha. Nine of these catchment areas were physically inspected to gather basic site information (see Figure 3). With a total population of about 3.5 million people and a geographic area of 19,210 km^2, Johor is the fifth largest state in Malaysia. With this size of land, it has an enormous amount of water resources that become an invaluable environmental asset.

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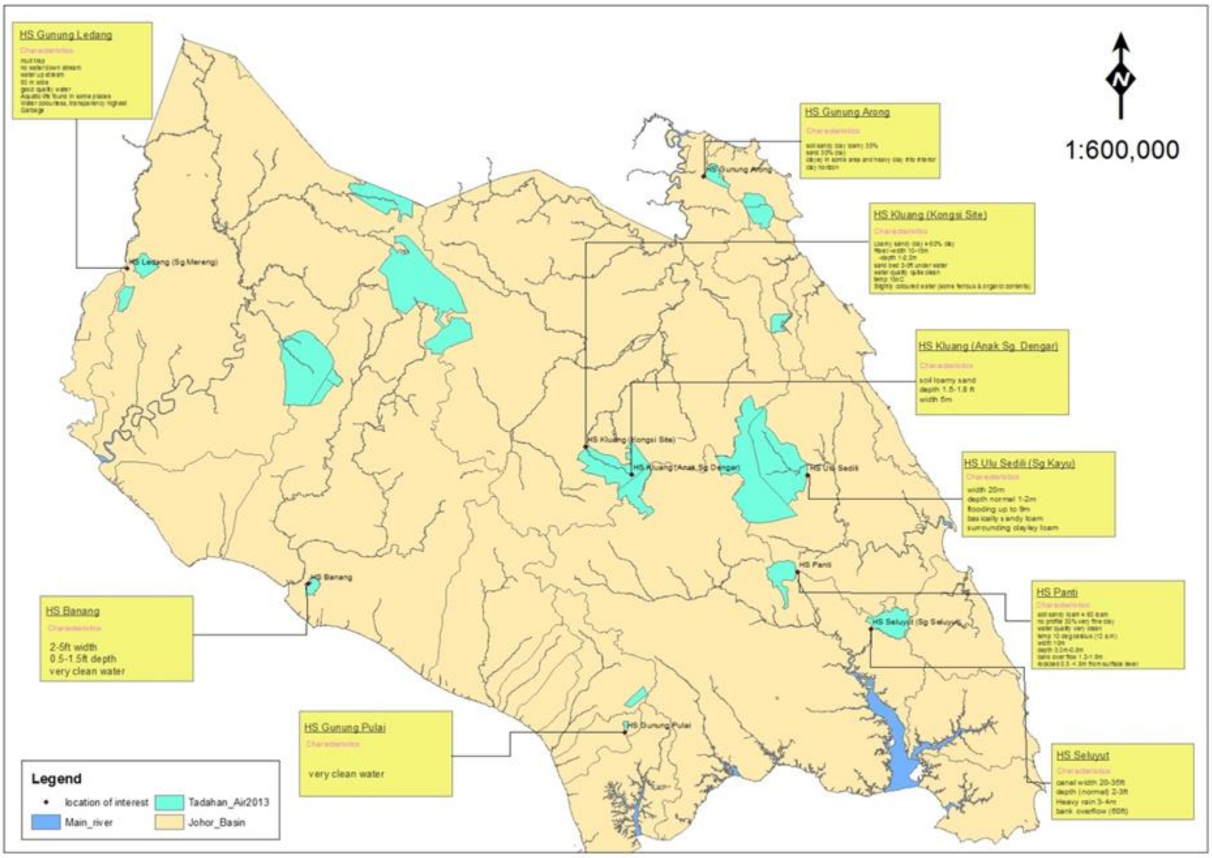

Figure 3: Forest catchment areas visited in the study.

1=HS Gunung Pulai; 2 =HS Seluyut; 3= HS Banang; 4=HS Gunung Ledang ; 5=HS Ulu Sedili; 6=HS Panti; 7=Gunung Arong ; 8, 9=HS Kluang.

State-wide quarterly production data for the period of 1996-2009 were used in calculating the economic value of CTIP water resources for the state of Johor. Time series data were used since cross-sectional data were unavailable. Furthermore, the 'historical data' that were used represent the actual market data linking economic factors of production (including water) with the economic outputs of the state. These time-series data were collected to estimate the translog Cobb-Douglas production function as shown in Equation (4a) above. In our study, V as in equations (3 to 4) was replaced by the economic outputs expressed as Gross Domestic Product (GDP). Data for L, K, W, E, and M were collected for the state of Johor from various secondary sources, including the Department of Statistics Malaysia (DOSM), Monthly Bulletins of Statistics, Economic Reports, Five-Year Malaysia Plans, and National Water Services Commission (SPAN). Excel was used to produce the desired regression outputs as well as to make computation of variables shown in Equations (4) to (6).

3. Results and Discussion

Table 3 shows the basic statistics of the sample, while Table 4 shows the regression outputs for the state of Johor.

Table 3: Basic sample statistics (n = 54).

	GDP	L	C	W	E
Mean	3.73E+10	113249.8	455120.4	2.86E+08	723.2619
Standard Error	1.9E+09	1487.218	1903.942	7707943	21.65126
Median	3.69E+10	114712.8	448181	3.05E+08	730.195
Mode	#N/A	91337.5	479680	#N/A	953.97
Standard Deviation	1.4E+10	10928.77	13991.06	56641581	159.1036
Sample Variance	1.95E+20	1.19E+08	1.96E+08	3.21E+15	25313.97
Kurtosis	-1.62994	-0.24425	-1.02669	-1.44766	-1.28884
Skewness	0.135136	-0.65351	0.746784	-0.24485	-0.06713
Range	3.76E+10	39655.66	40193	1.61E+08	528.76
Minimum	1.94E+10	90702.94	440564	2.1E+08	441.19
Maximum	5.7E+10	130358.6	480757	3.71E+08	969.95
Sum	2.01E+12	6115489	24576501	1.55E+10	39057.14

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Table 3: (Continue)

	ln GDP	lnL	lnC	lnW	lnE
Mean	24.2689	11.63253	13.02786	19.45216	7.558729
Standard Error	0.053522	0.01367	0.00414	0.028202	0.031187
Median	24.33222	11.65017	13.01295	19.53681	7.593278
Mode	#N/A	11.42232	13.08087	#N/A	7.860632
Standard Deviation	0.393301	0.100456	0.030421	0.207245	0.229179
Sample Variance	0.154686	0.010091	0.000925	0.042951	0.052523
Kurtosis	-1.63644	-0.00229	-1.05566	-1.49125	-1.1261
Skewness	-0.09833	-0.84337	0.726748	-0.38498	-0.32531
Range	1.075713	0.362699	0.087306	0.568488	0.787769
Minimum	23.69043	11.41535	12.99581	19.16378	6.089476
Maximum	24.76614	11.77804	13.08312	19.73227	7.877245
Sum	1310.52	628.1568	703.5044	1050.416	354.1714

Table 4: Regression outputs of translog Cobb-Douglas production function for the state of Johor.

Multiple R	0.998901					
R Square	0.997804					
Adjusted R Square	0.997015					
Standard Error	0.021487					
Observations	54					
ANOVA						
	Df	*SS*	*MS*	*F*		
Regression	14	8.180345	0.58431	1265.537		
Residual	39	0.018007	0.000462			
Total	53	8.198352				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-31489.6	5872.87	-5.3618**	3.98E-06	-43368.6	-19610.6
lnLAB	545.7128	161.2579	3.3841**	0.001639	219.5379	871.8876
lnCAP	4579.707	834.2736	5.4894**	2.65E-06	2892.229	6267.184
lnWAT	-155.062	60.48415	-2.5637**	0.014326	-277.402	-32.7208
lnENE	-6.09743	51.49814	-0.1184	0.906358	-110.262	98.06738
0.5x(lnLAB)2	-5.76065	2.061447	-2.7945**	0.008021	-9.93032	-1.59098
0.5x(lnCAP)2	-303.443	59.28142	-5.1187**	8.61E-06	-423.351	-183.535
0.5x(lnWAT)2	4.499533	2.956292	1.5220	0.136072	-1.48013	10.4792
0.5*(lnENE)2	3.013538	2.863214	1.0525	0.299047	-2.77786	8.804935
lnLABxlnCAP	-49.017	12.09864	-4.0514**	0.000235	-73.4888	-24.5452
lnLABxlnWAT	8.704577	2.245507	3.8764**	0.000395	4.162611	13.24654
lnLABxlnENE	-1.38009	1.947679	-0.7086	0.482798	-5.31964	2.559461
lnCAPxlnWAT	-2.68231	0.639011	-4.1976**	0.000151	-3.97483	-1.38979
lnCAPxlnENE	0.055177	0.011067	4.9857**	1.31E-05	0.032792	0.077563
lnWATxlnENE	0.172502	2.830466	0.0610	0.951714	-5.55265	5.897659

**Significant at 5% level.

Based on Tables 3 and 4, and taking into account the factors of production, W, K, L, and E at the sample mean of Equation (4b), the elasticity of production of water is given as follows:

$$\sigma_W = \frac{\partial \ln V_j}{\partial \ln W_j} = \beta_3 + \beta_8 \ln W_j + \beta_{12} \ln K_j + \beta_{15} \ln L_j + \beta_{18} \ln E_j$$

= -155.062 + 4.499533x lnW + 8.704577x lnL – 2.68231x lnK + 0.172502x lnE
= 0.043959

Subsequently, based on the figures for the factors of production in the sample mean, the price of water CTIP is estimated as follows:

$$P_M = \rho_W = \sigma_W \cdot \frac{V_j}{W_j}$$

= 0.043959 x (37,306,323,148)/(286,312,277.777)
= RM 5.73 m^{-3}

The relatively high figure reflects the importance of water as a factor of production in the economy of Johor. However, this figure is usually being offset by the total cost of providing clean water, C_T. However, the actual data for the C_T hard earned with accurate and detailed information from state water authorities because of the confidentiality of information.

Nonetheless, we discovered that the total cost of the supply, profit margins, and the risk can be up to 96% of the overall market price of water. In other words,

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service-charge pricing charged by the contractor for the supply of water to consumers have about the real price of water. At this stage, we make the assumption that the risks and benefits as in equation (6.6) is estimated at approximately 24% of the PM (RM 1:36 m-3. Hence, other cost, CT, is estimated at RM 4:31 m-3. With this arrangement, the estimated price of water CTIP (at sample mean) that may be imposed by the Johor State Forestry Department is:

$P_R = P_M - (C_T + \pi)$
$= 5.73 - (4.31 + 1.36)$
$= \text{RM } 0.06 \text{ m}^{-3}$

Various factors influence the C_T directly and indirectly. Size, capacity, type, and the location of the sourcing facility, treatment and distribution of water supply are among the main factors that influence C_T. Because watershed and supply facilities of raw water are sited in different locations across the country, the price of CTIP water is spatially differentiable. In other words, spatial price differential can be computed for the CTIP water resources. However, this requires further study with the help of geographic information system software and using more comprehensive data. Generally, we can construct a table CTIP water prices based on Equation (4a) above in Table 5.

Table 5: Simulation of CTIP water prices based on the percentage of C_T for the state of Johor.

% (C_T+ π) from P_M, c	Water tariff CTIP (RMm^{-3})*
0	5.730
5	5.444
10	5.157
15	4.871
20	4.584
25	4.298
30	4.011
35	3.725
40	3.438
45	3.152
50	2.865
55	2.579
60	2.292
65	2.006
70	1.719
75	1.433
80	1.146
85	0.860
90	0.573
95	0.287

* 1 litre = 0.001 m^{-3}

From Table 5, the price of CTIP water resources can be increased if the costs can be reduced and vice versa. If the current cost structure is maintained, producer's surplus based on the price of CTIP water is RM (5.73 – 4.31 – 1.36) = RM 0.06 m-3. However, the price of water CTIP estimated in the above calculation needs some adjustment due to two factors. First, the data used were 14-year time series data without deflation. Second, the figures used in the calculation were average figures and do not reflect the current situation. With the dynamically changing economy, economic shifters of the reversed supply curve must be accounted for. Based on data in Appendix 2, the GDP figure of about RM 37.306 million reflects the economic level in 2002 and it increased after that period (Figure 4).

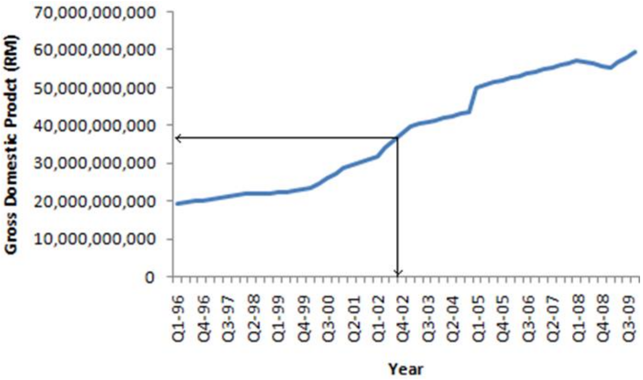

Figure 4: Profile of the Malaysian economy (1996-2009) based on the GDP.

To consider this phenomenon, the time-value of money factor can be considered as:

$$P_A = [P_M - \frac{c}{100} x P_M](1+i)^t \quad (8)$$

Where i is rate of change in the economy as reflected by bank lending rate, t denotes time period, P_A is price-adjusted CTIP at time t, PM is current market price of water, and c is percent of C_T and π from the current market price of water.

By taking 4% of government bonds as a factor times the money for twelve years (2002-2014), the price of water CTIP can be adjusted in 2014 to be:

$0.06 \text{ x } (1.04)^{12}$
$= 0.06 \text{ x } 1.60103$
$= \text{RM } 0.096 \text{ m}^{-3}$

CTIP water price in the past 35 years, the rate of long-term bank loans, estimated:

$0.06 \text{ x } (1.04)^{33}$
$= 0.06 \text{ x } 3.64838$
$= \text{RM } 0.219 \text{ m}^{-3}$

From both equations above, it can be concluded that CTIP water price, based on a straight line increase is between RM 0.096 m^{-3} in 2014 and RM 0.219 m^{-3} in the year 2035. Annual price increase is estimated at CTIP RM (0.219-0.096)/21 = RM 0.006 m^{-3}. Using a pro-rata price in 2014, the total value of CTIP water fora lease period of 60 years at 4% per annum is RM 70,272,825.14. This is a use-value equivalent of water of RM 1,171,213.75 per annum which is a source of income to the state government.

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4. Conclusion

This paper discusses how CTIP water resources are priced and value as part of forest watershed management plan. The main function of resource valuation in our case is to estimate the economic value of water resources that flow from the forest catchment areas to the point of intake before it is distributed to the point of consumption in various parts of the state. CTIP water resource valuation seeks to improve the efficiency of water resource use and increase revenue to the state government.

A hybrid method based on translog Cob-Douglas production function and residual method has been applied to calculate water resource value in the Johor state. Quarterly time series data of the economic production of the state of Johor (1996-2009) were used to compute the value with the dependent variable taken as the Gross Domestic Product (GDP) for the state of Johor, while the independent variables taken as employment, capital investment, water, and energy.

Our proposed CTIP water resource valuation method can be used as a starting point for the dynamic pricing and management of water resources in any state in Malaysia as well as in other countries.

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Appendix 1: Value estimates of water resources in the forest catchment areas in the state of Johor.

No	Water catchment	Area (ha.)	Nett yield (mm)	Pro-rata price (RM/m^3)	Perpetuity economic value @ 4% (RM/m^3)
1	Banang	547.47	1,029	0.096	305,876.80
2	GunungArong	4,626.21	1,964	0.096	4,933,301.63
3	GunungLedang 1	2,367.84	798	0.096	1,025,949.74
4	GunungLedang 2	1,262.83	895	0.096	613,675.48
5	GunungPulai 1	1,515.14	1,888	0.096	1,553,193.62
6	GunungPulai 2	183.37	1,342	0.096	133,613.90
7	Mersing	3,529.25	1,794	0.096	3,437,761.20
8	Labis	18,982.23	1,096	0.096	11,296,102.61
9	Maokil	16,450.81	882	0.096	7,878,194.79
10	UluSedili (belumwarta)	23,034.31	1,889	0.096	23,625,336.80
11	Kluang	10,250.48	1,337	0.096	7,441,259.55
12	Panti	2,947.24	1,391	0.096	2,225,940.11
13	Seluyut	3,747.34	1,816	0.096	3,694,960.38
14	Sg. Segamat (Labis Utara)	5,406.36	718	0.096	2,107,658.52
Value of 60-year lease					*70,272,825.14*
Annual value equivalent					*1,171,213.75*

Note: The figure in the purchase of 60 years (t = 60) at a rate of 4% (i = 0.04) is: YP = [1-1 / (1 + i) t] / i = 22.6235. The economic value of watershed = Area x 0.25 x net discharge x Price x YP prorated. [The 0.25 figure is used to correct for possible data over estimation due to various factors such as evaporation, surface run-off, seepage, Catchment-to-Intake-Point Economic Valuation of Water Resources Using a Hybrid Method Catchment-to-Intake-Point Economic Valuation of Water Resources Using a Hybrid Method Catchment-to-Intake-Point Economic Valuation of Water Resources Using a Hybrid Method leaching, etc.]

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Appendix 2: Basic data for CTIP water resources for the state of Johor.

Year	Quarter	GDP	Labour	Capital	Water	Energy
		RM mil	*('0)*	*RM mil*	*('000 m^3)*	*Ktoe*
1996	1	19,436,700,000	997.7	440,564	210,244,000	441.19
	2	19,726,500,000	1012.1	440,694	210,550,000	458.74
	3	20,016,400,000	1027.6	440,825	210,855,000	477.30
	4	20,306,200,000	1043.0	440,955	211,161,000	493.85
1997	1	20,596,000,000	1058.4	441,085	211,466,000	511.40
	2	20,919,500,000	1050.6	441,331	211,761,000	517.88
	3	21,243,000,000	1042.7	441,577	212,056,000	522.36
	4	21,566,500,000	1034.9	441,822	212,351,000	527.85
1998	1	21,890,000,000	1027.0	442,068	212,646,000	533.33
	2	21,984,200,000	1027.5	442,318	212,898,000	540.20
	3	22,078,500,000	1028.0	442,569	213,149,000	547.08
	4	22,172,700,000	1028.5	442,819	213,401,000	553.95
1999	1	22,266,900,000	1029.0	443,069	213,652,000	560.82
	2	22,556,400,000	1070.6	443,798	213,897,000	573.97
	3	22,846,000,000	1112.2	444,528	214,141,000	587.11
	4	23,135,500,000	1153.8	445,257	214,386,000	600.26
2000	1	23,425,000,000	1195.4	445,986	214,630,000	613.40
	2	24,739,900,000	1205.5	446,159	234,387,000	624.36
	3	26,054,800,000	1215.7	446,332	254,143,000	635.32
	4	27,369,600,000	1225.8	446,505	273,900,000	647.27
2001	1	28,684,500,000	1235.9	446,678	293,656,000	657.23
	2	29,497,000,000	1232.5	446,769	295,301,000	668.04
	3	30,309,500,000	1229.1	446,859	296,945,000	678.86
	4	31,121,900,000	1225.7	446,950	298,590,000	689.67
2002	1	31,934,400,000	1222.3	447,040	300,234,000	700.49
	2	33,937,000,000	1234.0	447,496	302,262,000	712.37
	3	35,939,600,000	1245.7	447,953	304,290,000	724.25
	4	37,942,200,000	1257.4	448,409	306,318,000	737.14
2003	1	39,944,800,000	1269.1	448,865	308,346,000	748.02
	2	40,444,700,000	1260.0	449,348	308,848,000	758.17
	3	40,944,600,000	1250.9	449,831	309,351,000	768.32
	4	41,444,400,000	1241.7	450,313	309,853,000	778.47
2004	1	41,944,300,000	1232.6	450,796	310,355,000	788.62
	2	42,527,200,000	1233.7	453,811	310,876,000	797.96
	3	43,110,200,000	1234.9	456,826	311,398,000	807.30
	4	43,693,100,000	1236.0	459,841	311,919,000	817.64
2005	1	50,058,000,000	1237.1	462,856	312,440,000	825.98
	2	50,678,250,000	1242.4	463,416	316,364,000	834.63
	3	51,298,500,000	1247.6	463,977	320,288,000	843.27
	4	51,918,750,000	1252.9	464,537	324,211,000	851.92
2006	1	52,539,000,000	1258.1	465,097	328,135,000	860.57
	2	53,075,500,000	1265.3	467,882	333,063,000	871.86
	3	53,612,000,000	1272.4	470,666	337,990,000	883.15
	4	54,148,500,000	1279.6	473,451	342,918,000	894.44
2007	1	54,685,000,000	1287.7	476,235	347,845,000	905.73
	2	55,261,250,000	1286.0	476,827	350,583,000	913.80
	3	55,837,500,000	1285.3	477,419	353,320,000	921.86
	4	56,413,750,000	1284.5	478,011	356,058,000	929.92
2008	1	56,990,000,000	1283.8	478,603	358,795,000	937.99
	2	56,559,500,000	1289.4	479,142	360,073,000	945.98
	3	56,129,000,000	1295.1	479,680	361,350,000	953.97
	4	55,698,500,000	1300.7	479,680	364,270,000	953.97
2009	1	55,268,000,000	1307.3	480,219	367,738,000	961.96
	2	56,620,750,000	1334.4	480,757	371,206,000	969.95

Source: Various data from secondary sources, including the Department of Statistics, National Water Management Commission (SPAN), States Air Johor (SAJ), Ranhill Utilities.

Note: All figures tabulated were based on actual annual data and were then interpolated quarterly using the 'average smoothing' to increase the number of observed data points.

FDI - Taken from various sources such as the Johor State Investment Centre, Department of Statistics Malaysia, Malaysian Industrial Development Authority (MIDA), Abdul-Hamid and Md-Elias (2007), Shahid and Nabeshima (2009), newspaper reports and internet sources. Several assumptions and extrapolations of information were also made.

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