The total economic value of forest ecosystem services in the tropical forests of Malaysia

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HIGHLIGHTS

- Estimation of the Total Economic Value (TEV) of a tropical forest comprised the Direct Use Value (DUV), Indirect Use Value (IUV) and Non-Use Value (NUV) components of the TEV.
- DUV was measured based on the timber and recreation values, which contributed the largest share of the TEV.
- IUV was measured based on the carbon sequestration and watershed services values, which contributed the second largest share of the TEV.
- NUV was measured based on the visitor's preferences regarding forest conservation and management aspects, which amounted to the least share of the TEV.
- Implications to policy makers on policy-relevant information for forest conservation and management purposes in Malaysia are presented.

SUMMARY

Direct and indirect use of values and non-use values from forest ecosystem services perform an invaluable set of functions that cater to the needs of both living and non-living things. The values include market services obtained from timber and non-timber forest products, and non-market services (recreation, watershed protection and conservation value) were identified as components of the Total Economic Value (TEV). However, it is difficult to assign a monetary value to all goods and services provided by the forest. Failure to conserve the national park will result in the degradation of the forest and a reduction in the contribution of the forest ecosystem services to the community. Based on the result of this study, the TEV value of forest ecosystem services was estimated at RM 13 billion, and the estimation provides policy-relevant information for forest management and conservation purposes in Malaysia.

Keywords: forest ecosystem services, total economic value, timber, non-timber products, recreation, watershed services

Valeur économique totale des services d'écosystèmes forestiers dans les forêts tropicales de Malaisie

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L'utilisation directe et indirecte des valeurs utilisables et non utilisables des services d'écosystèmes est un ensemble précieux de fonctions répondant aux besoins des entités vivantes et inertes. Ces valeurs incluent des services de marché en produits forestiers en bois et autres que le bois, et des services hors-marché (récréation, protection des bassins versants et valeurs de conservation), identifiés comme composites de la valeur économique totale (TEV). Toutefois, il est difficile d'octroyer une valeur monétaire à tous les biens et services fournis par la forêt. Echouer à conserver le parc national résultera en une dégradation de la forêt et en une réduction de la contribution des services d'écosystèmes forestiers à la communauté. Basé sur le résultat de cette étude, la valeur TEV des services d'écosystèmes forestiers était estimée à 13 milliards RM. Cette estimation fournit une information pertinente aux politiques de gestion forestière et aux buts de conservation en Malaisie.

El valor económico total de los servicios ecosistémicos en los bosques tropicales de Malasia

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El uso directo e indirecto de los valores de uso y los valores sin uso de los servicios ecosistémicos forestales desempeñan un conjunto inestimable de funciones que satisfacen las necesidades tanto de seres vivos como inanimados. Los valores, como los servicios de mercado obtenidos de la madera y de los productos forestales no maderables, y los servicios no comerciales (valores de recreo y de protección y conservación de cuencas hidrográficas) se identificaron como componentes del Valor Económico Total (VET). Sin embargo, es difícil asignar un valor monetario a todos los bienes y servicios que proporciona el bosque. Si no se conserva el parque nacional, se producirá una degradación del bosque y una reducción de la contribución de los servicios ecosistémicos forestales a la comunidad. Sobre la base de los resultados de este estudio, el VET de los servicios ecosistémicos forestales se estimó en 13.000 millones de MYR, siendo esta una estimación que proporciona información de interés para las políticas a efectos de la gestión y conservación de los bosques en Malasia.

INTRODUCTION

Tropical forests cover eight% of the surface of the earth and resources derived from them provide various benefits to humans and other living organisms (Adhikari and Baral 2018). Valuable resources that are derived from these forests include both tangible and non-tangible products of high economic values (Adhikari and Baral 2018). The tangible products include timber, while the non-tangible benefits consist of pollination, water and air purification, protection of the watershed, soil fertility renewal, climate regulation, protection of wildlife resources, recreation and tourism opportunities (Ahammad *et al.* 2019). Hence, the forests need to be valued and conserved for their potential ecosystem services rather than being demolished for physical development (Kalaba 2014).

The tropical rainforests in Malaysia are among the most complex systems in the region. One such notable rainforest is the Endau Rompin National Park (ERNP), the second-largest after Taman Negara (Desjardin *et al.* 2007). The ENRP has been gazetted as a protected area since the 1950s due to its unique ecosystem. As such, the economic value of the forest can provide valuable information to stakeholders regarding the forest's conservation value (Awang Noor and Ismail 2012). Therefore, it is important to understand the advantages of ENRP ecosystem, which could potentially generate a multiplier effect on the economy.

In terms of the theoretical gap, and based on the literature reviewed to date, there are several studies on both the tangible (market value) and intangible (non-market) value of the ecosystem services. However, few studies have applied the Total Economic Value (TEV) approach in Malaysia, particularly for a forest valuation per se. Examples of studies of the TEV of forests include those by Kumari (1995) and Mohd. Shahwahid (1997), who investigated tropical wetlands, and Sulaiman (2005), who studied sago forest harvesting regimes in Sarawak. Despite these earlier studies, few have examined the TEV approach relating to dipterocarp type forests in Malaysia.

In 1989, ENRP was gazetted as a national park under the Johor National Parks Cooperation Enactment. There has been minimal inventory pertaining to ENRP since and the Peninsular Forestry Department has no recent forest inventory for ENRP. According to a research officer in Johor National Parks Corporation (JNPC), there is not much-documented information on the value of the ecosystem services in the ENRP due to the limited amount of past research on the national park. Thus, the current study aims to generate documentation on the ecosystem services information on ENRP to formulate potential development policies and plans. Besides the lack of inventory, Awang Noor and Ibrahim (2008) have also mentioned that resources, i.e. the timber (a major aspect of the tropical forest) value in the ERNP, have been economically underestimated. Hence, during this research, further discussions were initiated to understand the specific problems influencing TEV components, which include the Direct Use Value (DUV) (i.e. consumptive and non-consumptive value), Indirect Use Value (IUV) and Non-Use Value (NUV) since no proper documentation of timber value is available for the ENRP.

Recreational values (non-consumptive value) are also discussed under the DUV. Table 1 lists the recreational value based on the inconsistent visits of visitors to the ERNP. In general, the number of visitors to the ERNP is very low as it is not a popular destination, unlike Taman Negara in Pahang. Besides that, the management has imposed a limit of only 120 visitors per day, in order to maintain the carrying capacity of the forest. Based on the available data, there is a reduction of 27% in the number of visitors to the ERNP, from 8 646 in 2013 to 6 284 in 2016. Similarly, the number of international visitors was low compared with than that of local visitors, with an average ratio of 0.18:1 between 2008 and 2016.

A DUV-consumptive ground forest inventory was performed by a previous study to determine the amount of biomass content in the trees. Only 60 out of 539 (11%) trees were identified to be suitable and selected with the low limit of the Diameter at Breast Height (DBH) criterion set at greater than 20cm (Zakaria *et al*. 2012). However, the study did not account for the monetary value of the carbon stock in order to justify its resource conservation.

Another important component under the IUV is the value of the watershed services in the ERNP. The value of the watershed services remains unknown in terms of the non-market valuation of the ecosystem services, pertinent to the NUV, which is related to the lack of market, market prices and other direct behavioural links. Rolfe *et al*. (2000) added that the NUV derived from the forest ecosystem remains unknown for the ERNP.

Regarding the NUV, the entrance fee is used as a proxy to estimate the benefit of visitors. A study by Samdin *et al.* (2013) argued that it is unclear whether the entrance fee charges are significant to the benefit attained by the visitors. The existing entry fee at the ERNP was not determined using any empirical analysis of the visitor's preferences according to the Assistant Manager of Endau Rompin Peta. Moreover, the entrance fee to this park has not been reviewed in the last 13 years. Although the purpose of an entrance fee is to cover the cost of the maintenance of the facilities in the ERNP, the park has not generated enough funds to sustain itself (JNPC 2016). Also, there is no specific funding for conservation purposes of the park according to the Assistant Manager of Endau Rompin Peta. As such, the suitability of the fee

TABLE 1 *Visitors to Endau Rompin National Park (2008–2016)*

Year	Local	International	Total
2016	5 352	932	6 284
2015	5 465	1 134	6 599
2014	7 123	1 218	8 341
2013	7 171	1 475	8 646
2012	5 844	1 168	7 012
2011	4 708	1 064	5 772
2010	7 393	1 666	9 059
2009	7 069	1 187	8 256
2008	5 749	1 978	7 727

Source: Johor National Park Corporation (JNPC) 2017
Note: ERNP is closed from November to February due to monsoon season

charged on the visitors to the ERNP should be relevant to the conservation and management attributes.

Furthermore, the knowledge on the improvements of the current resource conditions and the impact of improvements on visitor preferences remains unknown for the ERNP. Thus, this study aims to determine the market and non-market values of the forest ecosystem services. Limited studies have investigated the integrated ecosystem services framework with the TEV framework as proposed by Kumar (2010) and Ninan and Inoue (2013). Therefore, this study was carried out to provide a more holistic TEV framework in order to examine the economic value of the ecosystem services in the ERNP.

LITERATURE REVIEW

Total economic value of mangroves/wetlands and rainforests

Limited studies have been done on the TEV, and the following studies provide a review of previous TEV literature. A detailed literature review has also been published by the lead author of this paper (see Matthew *et al.* 2019b).

A review of valuation studies on mangrove forests indicate that mangrove forests are highly productive ecosystems that provide fish, shrimp, cockles, timber, and many other products. They also help to protect the area from flood and storm damage. Furthermore, the forests attract tourists and visitors (Ahmad 2009), which benefits the communities living near the mangroves and wetlands.

A study of the value of the mangrove area of Sarawak was carried out by Bennett and Reynolds (1993) with the aim to try and preserve the mangrove area from any further size reduction. The reserve originally covered 175 153 ha or 10% of the total area of the mangroves in Sarawak. However, by 1992 a mere 8 728 ha remained. The respondents in the study were the residents from 16 small villages (539 households) surrounding the mangrove area. Based on the data, the largest proportion of the TEV belonged to the fisheries, which were worth US$21 million p.a. and provided up to 3 000 jobs. Next was timber products, which was worth US$123 217, and third was the tourist industry, which was worth US$3.7 million. Nonetheless, several limiting factors have constrained the scope of the study, including that it only determined the DUV of the reserve and not the IUV or NUV that could be derived from the mangrove forest.

Besides that, another TEV study looked at the ecosystem which was threatened by shrimp aquaculture in Sri Lanka (Gunawardena *et al.* 2015). Similar to the earlier study, the findings justified conserving the mangrove area from further degradation. A proposal was made to expand the shrimp aquaculture industry which would have resulted in 21% of the mangrove areas being sacrificed to make way for 48 ponds. This study added on more components, such as firewood, fisheries, (shoreline stabilisation, erosion control and control of storm surges). In light of this, this study placed additional value on the IUV and NUV, thus implying the complete measurement of the TEV. Hence, the data required for the analysis was obtained from both the primary and secondary data. For the primary data, a systematic random sample was drawn from a list of 1 184 households representing the population of Rekawa provided by the local authorities.

A random sample of 205 households was drawn. The questionnaire investigated the range and quantities of mangrove products harvested. The respondents were also asked about their dependence on the lagoon and coastal fisheries. The secondary data were obtained from available government catch data and on the costs to implement erosion control structures. The TEV assessment of the Rekawa mangrove–lagoon ecosystem revealed a value per ha of US$1 088/ha/year, or US$217 600 per year, based on 200ha of mangrove. Similar to the findings from the earlier research, the largest component of the TEV belonged to the fisheries, which equated to 70% of the TEV of the ecosystem per year. The residuals (30%) belonged to benefits from forestry, lagoon fishery, erosion control and buffering against damage. However, the study did not determine habitat/supporting services.

Other research on the TEV of wetlands includes a study conducted by Emerton and Kekulanda (2003) on the monetary benefits of the wetlands. In comparison to an earlier study carried out on mangrove areas by Gunawerdana and Rowan (2005), here it is seen that the study has included more indirect uses of the value components. Hence, the TEV obtained from this study was US$2 700 per ha or US$8.1 million a year, which was lower than the US$1 088/ha/year or US$217 600 per year as found in the previous study. However, this could have been due to the differences in the characteristics of a mangrove vs. wetland forest. Furthermore, unlike in the previous study, the largest share of the TEV belonged to the waste and sewage treatment facilities.

Mangrove swamps and wetland forests were not the only categories studied, as some studies investigated tropical rainforests. Van Beukering *et al.* (2003) determined the economic value of the Leuser National Park in Sumatra, Indonesia. The main objective was to determine the TEV of the park, which was composed of the water supply, fisheries, flood and drought prevention, hydroelectricity, tourism, biodiversity, carbon sequestration, fire prevention, non-timber forest products and timber. Three types of scenarios were applied in the research: the value derived from the deforestation scenario, conservation scenario, and selective use. The first scenario represented the current situation in the park, the second one prohibited any logging practices in the park, while the final one allowed primary forest logging but no secondary forest logging. Among the techniques of the economic valuation used to determine the TEV were the production function, market function, human capital approach, market price, and CVM. With a 4% discount rate, the accumulated TEV for the ecosystem over the 30 years was US$7.0 billion under the 'deforestation scenario', US$9.5 billion under the 'conservation scenario', and US$9.1 billion under the 'selective utilisation scenario'. The main contributors in the conservation and selective use scenarios were water supply, flood prevention, and tourism. However, one limitation is that the study did not consider the cultural and habitat/supporting services, which is one of the components of the ecosystem services when holistically examining the TEV of the park.

Further studies on the rainforest TEV have been conducted locally in Malaysia by Othman and Mohd Zin (2013), where they determined the TEV of the Taman Negara Pahang, the first national park in Malaysia. The TEV was determined based on three scenarios: the full conservation (status quo), sustainable logging, and oil palm development scenarios. The purpose was to compare the present situation with the alternative land uses in the aspect of the losses (forgone benefits) to the respective state governments (Pahang, Terengganu, and Kelantan). The first option incorporated the benefits assessed under the carbon sequestration, recreation, and NUVs. Under this option, logging and harvesting of forest products (rattan) were strictly prohibited. The net benefits from timber and rattan were assumed to be zero while the erosion cost was not assessed as it occurs naturally in unlogged forest areas. The second option was inclusive of the assessment of the carbon value, timber stumpage value, rattan value, and erosion value. One of the differences between this research and the earlier discussed research at the Leuser National Park was that in this study the value of the timber stumpage was calculated based on the estimation of the areas only permitted by law for logging purposes. Hence, the size of the forest area presumably permitted for sustainable logging was identified as amounting to 385 214ha, while areas for sustainable logging and oil palm cultivation were 317 624ha and 67 590ha, respectively.

In contrast to the previous research, the study aimed to estimate the NPV, or the net benefit flow, for each forest management scenario. It was estimated for 56 years, which was more than the earlier studied (30-year period), and was based on two logging or oil palm harvest cycles. The arrangement of social discount rates from 2% to 15% was employed to obtain the NPV for each benefit type. The NPV for each service flow was then totalled in order to obtain the TEV for each forest management option. The study revealed that the potential economic loss incurred by the state government and local community for foregoing the sustainable logging and oil palm cultivation option was significantly higher than the full conservation and sustainable logging options. Nonetheless, the findings were subjected to some limitations. For example, the economic benefits of the water catchment regulation and medicinal plants were excluded in the first option while the rest of the options did not estimate the foregone benefits from the benefit of each commodity nor the potential job opportunities that may have been generated from the various sources. In addition, this study did not determine the cultural and habitat/supporting services values due to a failure to integrate the TEV with the ecosystem services concept.

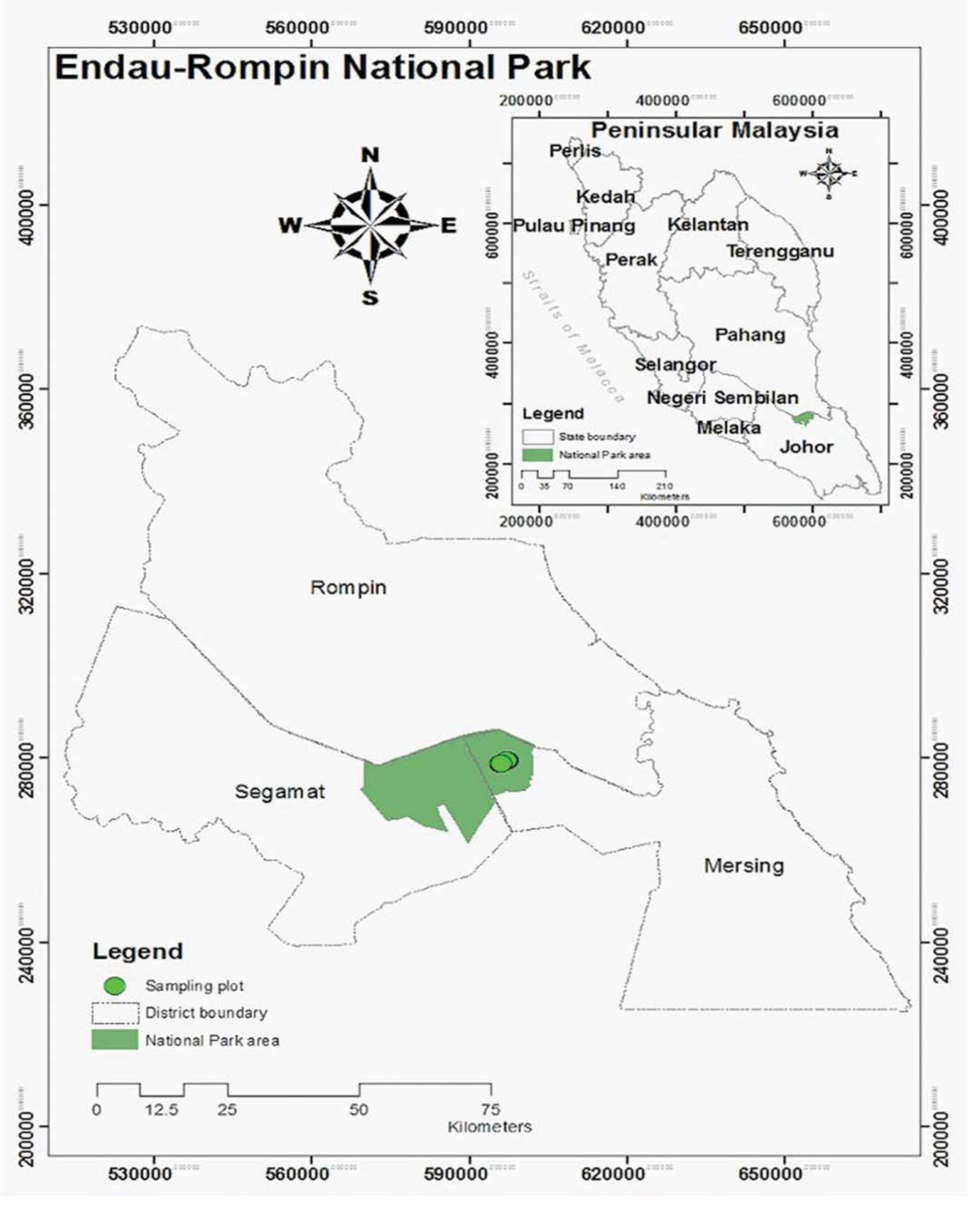
METHODOLOGY

Study site

Malaysia's forested area is estimated at 22 195 100ha comprising over two-thirds of the total land area of the country (Forestry Department of Peninsular Malaysia 2016). Based on the Malaysian constitution, forest land is placed under the jurisdiction of the respective State Governments (Yong *et al.* 2014). The ERNP among other national parks covers 48 905ha of forested area and is in the state of Johor. It produces various goods and services that contribute directly to the well-being of the people and is also contributes to the environmental conditions of Johor. The national park has an enormous amount of undisturbed natural vegetation in Peninsular Malaysia (MOCAT 2016). The ERNP was chosen as the study site because it is an area of mega-microbial diversity that is the second largest in the country after the Pahang National Park. The forest in the ERNP is dominated by lowland mixed dipterocarp forests that stand lower than 300 meters, and with hill dipterocarp forests of more than 300 meters (UNDP 2008). Existing for millions of years, it is one of the remaining large tracts of pristine lowland tropical rainforest and it has been recognised as a mega-microbial diversity area since the early 1950s because it contains unique biological diversity, wealth, and priceless natural beauty (Collins *et al.* 1991).

The ERNP is located at 2°34′N latitude and 103°11′E longitude, 428m above sea level (see Figure 1). The park is located in the southern part of Peninsular Malaysia. There are two entry points to the park namely, Endau Rompin Peta in the Mersing district and Endau Rompin Selai in the Segamat district. The ERNP forest is dominated by lowland (Department of Wildlife and National Parks 1980), mixed dipterocarp with an elevation below 300 m (DWNP 2001) and the edaphic hill (UNDP 2008) forests with elevation more than 300m. The climate is sunny and rainy throughout the year. The geology of ERNP consists of the earliest known volcanic outpour referred to as ash-flow eruption, which was estimated to have formed some 280 million years ago (Husain 2008). The park consists of many unique landforms and shapes of rocks formed due to the forces of water and wind (Davison 1988). The streams draining the area of Endau Rompin feed the rivers of Sungai Kemapan, Sungai Jasin, Sungai Endau, Sungai Selai, Sungai Marong and Sungai Kinchin. The mean annual temperature is approximately 27°C, with annual rainfall between 2 000 and 3 000mm (Tho 1988). Furthermore, the compact layered trees keep this park area moist throughout the year (UNDP 2008).

FIGURE 1 *Map of Endau-Rompin National Park*



Equations and model specification

In order to achieve the objectives of this study, several calculation formulas were employed to estimate the valuation of forest ecosystem services in Malaysia. Table 2 summarises the formula and equations used to determine the volume of trees in ERNP based on the Pre-Felling formula (Equation No. 1) and local volume equations (Equations 2 to 6) that were developed for the tropical forest reserves in the states of Pahang and Terengganu within Peninsular Malaysia (Awang Noor and Mohd Noor 2008, Awang Noor *et al.* 2000) to facilitate comparison.

Next, the stumpage value (SV) of the timber resources, i.e. the standing trees, were calculated using the Residual Value (RV) technique where it is a market-based valuation technique for timber (Awang Noor 2009). The SV was calculated by considering the difference between the selling value of the products made from it and the stump-to-market processing costs (including a margin for profit and risk) (Davis and Johnson 2000, Klemperer 2003). The following formula can be used to calculate the SV for each tree that is subjected to inventory (Awang Noor and Ismail 2012).

$$SV_{i,j} = (P_{i,j} - C - PM_{i,j}) * V_{i,j} \quad (1)$$

Where SV is the stumpage value per ha (RM), P is the ex-forest log price (RM/m^3), C is the logging cost (RM/m^3), PM is the profit margin (RM/m^3), V is the volume of the standing tree (m^3), i is the index of the species and j is the index of the diameter class. However, the profit margin is based on the following formula (Leuschner 1984):

$$PM_{ij} = (P_{ij} * PR) / (1 + PR) \quad (2)$$

Where PR is the profit ratio. The profit ratio used here is 0.3. On the other hand, the total SV was obtained by summing up individual SV for each tree in the study area. The ex-forest log price sold by timber operators per cubic metre has been reported for individual species and species groups. However, in the latest data of 2015, the information on the average log price was not available based on the DBH ranges, unlike in 2014. Hence, an adjustment was made to determine the log price based on the DBH ranges. Thus, using the average log price in 2016, the study portioned the value into the respective DBH ranges using the price factors following Awang Noor and Ismail's (2012) study. The average log price in 2016 was adapted from the monthly data on log prices was obtained from MASKAYU, the official bulletin of the Malaysia Timber Industry Board (2016). The prices of logs that belong to species that are not listed in the official bulletin were based on the Mixed Hardwood of the heavy, medium or light hardwood prices.

Furthermore, the data on logging costs were adapted from a study by Awang Noor and Ismail (2012). The average logging costs (including forest charges to the government) were estimated at RM191/m^3. Forest charges of RM67/m^3 were excluded from the logging cost to ascertain the net logging cost of RM124/m^3. However, over time, the timber harvesting cost per year increased at a rate of 2% as recorded by Awang Noor and Ismail (2012). Hence, the average logging cost in 2016 was estimated at RM161/m^3. Therefore, the total SV was obtained by summing up the SV for all individual trees in the study area using the formula below:

$$Total\ SV = \sum_{i=1}^{n}\sum_{j=1}^{k} SV_{i,j} = \sum_{i=1}^{n}\sum_{j=1}^{k}\left[\left(P_{i,j} - C - PM_{i,j}\right) * V_{i,j}\right] \quad (3)$$

Next, the entrance fee collection technique used by the Department of Marine Park Malaysia (2011), Rasid *et al.* (2014) and UNEP (2011) was used to determine the recreational value from the DUV (non-consumptive). This technique was adapted to the context of TEV of forest since it has not been considered in past studies on forests. The following formula was used:

[Number of visitor arrivals in the ERNP in 2016 × entrance fee by groups] (4)

Revenue from the entrance fee was determined based on groups since the charges differ for adults and others (graduates/students/children/retirees) for both international and local visitors, respectively. The information for the groups was obtained from the JNPC (2016).

The benefits of watershed services in the ERNP were determined in this study using the benefit transfer method. The value of the net water treatment cost was used as a proxy to determine the value of a catchment area from a study conducted by Yacob (2002) at the Muda-Peru forested catchment

TABLE 2 *Pre-felling volume formula and local volume equations*

Equation No.	Volume equation	Forest Reserve	Source
1	$V = \frac{\pi = urDBH^2 \times L \times f}{4 \times 10\,000}$ Where: V = Gross volume in m3, ϖ = 3.142, DBH= Diameter at breast height (t in cm) *f* = 0.65 (from factor) and L = merchantable height		
2	Vi = 0.000362954*DBHi2.2988	Pelangai, Pahang	
3	Vi = 0.0015086*DBHi1.882311	Tekai-Tembeling, Pahang	(Abdul Ghani Awang Noor *et al*. 2000)
4	Vi = 0.0010686*DBHi1.9876	Bukit Ibam, Pahang	(Abdul Ghani Awang Noor *et al*. 2000)
5	Vi = 0.000561*DBHi2.2236	Tembat, Terengganu	(Awang Noor and Khamuruddin 2008)
6	Vi = 0.000203*DBHi2.3966	Gunung Tebu, Terengganu	(Awang Noor and Khamuruddin 2008)

area, Kedah, Malaysia. This value was used to estimate the value of the watershed in the ERNP. Based on the findings, Yacob (2002) revealed the value of water catchment areas in three different scenarios, namely total protection, conventional logging and reduced impact logging. The present study, however, selected the total protection of the forest scenario, which amounts to RM128 841 265 for a total catchment area of 118 600 ha. Based on the benefits transfer technique, the value of RM1 086 per ha was applied to assume the same value in ERNP since both forests fall under the tropical forest category. However, using the most current CPI index (115.7) from October 2016, the study adjusted the value to account for the current inflation rate. Following the adjustment, the value of water for the water treatment was estimated at RM1 256 per ha.

Most recently, Choice Experiment (CE) practitioners have started to employ the Latent Class Model (LCM) as an alternative model accounting for the preference heterogeneity to estimate the conservation value for the NUV. The latent class is used to divide the respondents into classes based on their preference. The probability value (PrbCls) shows the class in which the majority of respondents fell. This model considers heterogeneity as a discrete distribution, a specification based on the concept of endogenous (or latent) preference segmentation (Bhat 1997). The basic LCM was estimated several times by increasing the number of classes to get the desired model with significant classes. Log-likelihood, ρ2, AIC and BIC statistics were the key parameters utilised for determining the required number of classes (Hanley *et al.* 2001, McFadden 1974). However, the determination of the optimal numbers of classes requires a balanced assessment of the statistics (Log-likelihood, ρ2, AIC and BIC information criteria). In this study, a two-class (Latent Class Model 1 and Latent Class Model 2) solution was identified to provide the best fit to the data, even though the AIC, BIC and ρ2 statistics increased when more classes were added to the model (Hanley *et al.* 2001, McFadden 1974).

Marginal willingness to pay can be determined using the following formula.

$$MWTP = \frac{-bc_a}{b_P} \tag{11}$$

Where b_c is the coefficient of attribute a and b_p is the coefficient of the monetary attribute (price). These ratios are known as implicit prices representing the marginal rate of substitution between the changes in the monetary value concerning attributes linked to the environment (Bennett and Blamey 2001).

Choice attributes selections

In this study, the attribute levels for the CE were identified by reviewing past literature on the CE methodology and by a focus group with experts in the field of resource management and economics. The experts comprised: 1) JNPC park managers and assistant park managers at both Peta and Selai (four individuals), 2) Academicians from tourism and environment (three individuals), 3) Research officers (two individuals), and 4) Wildlife Conservation Society members (two individuals).

Latent class model specifications

There was a need to set the base level for each attribute (Thalany 2014). In this case, each attribute is used as a base in Level 1. Level 1 is also considered as the status quo, which is the current situation in the park. Hence, the LCM incorporating the level model becomes:

$$\begin{aligned} U = {} & \beta_0 + \beta_1 NOV2 + \beta_2 NOV3 + \beta_3 BIO2 + \beta_4 BIO3 \\ & + \beta_5 EAM2 + \beta_5 EAM3 + \beta_6 ENV2 + \beta_7 ENV3 \\ & + \beta_8 Price + \varepsilon \end{aligned} \tag{12}$$

Where:

U = Utility
NOV2 = Additional increment of 10% in visitor's arrival/year (7 250 visitors)
NOV3 = Additional increment of 20% in visitor's arrival / year (8 000 visitors)
BIO2 = 20% improvement in the number of threatened species (from threatened to non-threatened level, 42 (Fauna = 14, Flora = 28 species))
BIO3 = 40% improvement in the number of threatened species (from threatened to non-threatened level, 32 (Fauna = 11, Flora = 21 species))
EAM2 = Additional increment of 40% workforce enforcement and monitoring (14 people)
EAM3 = Additional increment of 80% workforce for enforcement and monitoring (18 people)
ENV2 = Additional increment of 40% institutions visiting (20 institutions)
ENV3 = Additional increment of 80% institutions visiting (25 institutions)
Price = Entrance permit fee
β0-β8 = Coefficients to be estimated
ε = Random error

For interaction purposes, the socio-demographic variables cannot be entered directly into the model since the coefficients for these variables cannot be estimated in the utility functions as they do not vary across decisions (Thalany 2014). If they are included directly, this would give rise to the problem of Hessian Singularities (Thalany 2014). Therefore, 14 variables were used in this study as the interaction variables, such as the socio-demographic variables that include gender, age, education, income, occupation and marital status. Besides that, there were travel-related characteristics variable such as time spent in the park and environmental-related variables such as awareness, NGO memberships and watching documentaries. Also, the interaction variables included the perception of the role of the ERNP towards environmental sustainability and the satisfaction on the facilities and recreational activities. These interaction variables were included to improve the model fit (Thalany 2014). Hence, the following interaction variables adapted from Thalany (2014) and Matthew *et al.* (2019a) were included in this study:

1) Age
2) Watching documentary (DOC)
3) Gender
4) Level of importance of managing the park's sustainably (MIL)
5) Education level
6) Level of satisfaction with the facilities and services (MFC)
7) Income
8) Level of satisfaction with the recreational activities (MAC)
9) Marital status (Ms)
10) Time spent
11) Awareness (AW)
12) Membership with NGOs (NGO)

Reliability and validity

A minimum level of 0.7 for the Cronbach's alpha value was suggested by Nunnally (1978). Therefore, the pilot study and a reliability test were performed for this study using the Likert scale (section C on why ERNP should be managed sustainably). The Cronbach's Alpha value for the construct was 0.92, which shows that all of the items included in the section are reliable. In quantitative research, the validity determines whether the research truly measures that which it is intended to measure or how truthful the research results are (Joppe 2000). Content validity was done with three experts in the field of economics. Improvements to the questionnaire were made following their suggestions.

Data collection

The data collection for the choice survey was conducted twice. The first data collections at Peta and Selai were conducted for two weeks in May 2016 (peak time), while the second collection was in August 2016 for one week (off-peak time). Peak and off-peak times are related to the level of congestion. Taking data from users at both times accounts for the effects of congestion/crowding at the site.

In Peta, the survey distribution mainly took place at the Nature Education and Research Centre (NERC), camping areas of *Kuala Jasin* and *Kuala Marong*, and at the cafeteria. While, in Selai, it was distributed over the visitor complex, *Lubuk Merekek* (camping and fishing area) and the cafeteria. A total of six enumerators, who were postgraduates of UPM, were involved in the survey. To ensure that the enumerators had a real understanding of the questions drafted in the questionnaire, they were subjected to a one-day training course conducted a day before the departure for the survey. The training material covered the topics of research, objectives of the survey, explanation of each question in the questionnaire, ways of approaching the respondents, including methods of introducing themselves and conducting the interviews. Also, on the day of the actual survey, the enumerators were equipped with a set of instructions as well as the procedures of conducting the interviews to ensure quality responses from the respondents.

Data from the ground forest inventory were collected from the east section of ERNP, at Endau Rompin Peta, which is the core zone. The plots were chosen based on ease of accessibility and compatibility in the forest. Trees with DBH less than 15cm were not chosen since the sampling area was chosen at the core zone of the forest which is compact with trees. The number of trees with DBH less than 15cm was assumed to be minimal. This implied that the bias of carbon stock value was minimal by excluding trees with DBH <15cm. Therefore, the scope of the study focused on trees categorised with commercial values only, which included trees with DBH between 15cm and 44cm. In total, 184 trees were enumerated with the help of the forester who aided in the species' identification. The total area of investigation was 0.6ha for a survey rate of approximately 0.002%. Six plots of 0.1ha (50m by 20m) each were established along a line transacted at an elevation of 150 to 400m above sea level based on the accessibility in the forest (Figure 2). Plots were separated by a gap of 50m along the line. Each plot was further divided into 10m by 10m subplots for specimen and data collection.

Sampling technique

Random sampling was applied to determine the six plots in the ERNP for the ground forest inventory. As for the visitor's survey, the purposive sampling technique was used since the purpose of the study was to identify the utility derived precisely from the local visitors. The selected respondents were above 18 years of age to ensure that they were able to understand the items in the questionnaire (Do and Bennett 2009). Only the head of the family or group was chosen among the respondents belonging to the same family in order to avoid redundancy. Due to the low number of international visitors to the ERNP between 2008 to 2016 (0.18:1), they were excluded from the study.

Data analysis

This study employed a quantitative method and a total of 350 respondents participated. The sample size was determined based on a sampling table Zikmund (2010). Since the total visitor arrivals in 2015 were 5 465, the suggested sample size was 303. However, in order to avoid uncertainties (in terms of unusable questionnaires or irrelevant answers) this study collected 350 questionnaires, of which 50 were excluded because they were incomplete. Twenty respondents with genuine zero-bid were retained (Kaffashi *et al.* 2015). This group of respondents comprised of those who "agreed with improvements but could not afford to pay" and "preferred to spend that money on other things" (Kaffashi *et al.* 2015). The quantitative method employed in this study included normality, multicollinearity and heteroscedasticity tests to investigate the presence of any influential cases and/or outliers.

1) Test 1. The descriptive statistical analyses were utilised for the preliminary analysis purpose. The descriptive analyses consisted of frequency distributions, cross tabulations, while the central tendency

comprised of mean, median and mode measures of spread using the variance and standard deviations.

2) Test 2. As for Choice Modelling (CM), the LCM analysis was conducted using the LIMDEP (NLogit 4 software) to determine the relationship between the levels of attributes and interaction variables.
3) Test 3. The timber valuation data analysis was conducted using the Microsoft Excel Spreadsheet Software and SPSS (Statistical Package for Social Sciences) version 25. This analysis involved the calculation of the volume and SV of the trees using the respective formulas. In addition, the data was organised based on the SV of the DBH, species and family of trees.
4) Test 4. The LCM analysis was conducted using LIMDEP to determine the relationship between the conservation and management attribute levels and the utility of visitors.

RESULTS AND DISCUSSION

Families of timber species

Table 3 depicts the segregation of the timber tree species based on their respective family groups, which generally belong to either the dipterocarp or non-dipterocarp category. Based on the observation, 65% of the tree species present in the sampling plot area belonged to the non-dipterocarp category while 35% belonged to dipterocarps. The dipterocarp category is comprised of one family called Dipterocarpaceae (35%) whereas the non-dipterocarp was dominated by Lauraceae (27.2%), followed by Myrtaceae (10.9%) and Moraceae and Sapotaceae (5.4%) families. Similarly, Kochummen *et al.* (1990) also found that the Dipterocarpaceae was the largest family identified in their study area comprising of 16.14%. Symington (2004) indicated that such a finding is common since Malaysian forests are frequently known as dipterocarp forests.

TABLE 3 *Summary statistics of trees based on families*

Family group	No. of trees
Dipterocarp	
Dipterocarpaceae	65(35%)
Non-Dipterocarp	
Anacardiaceae	1(0.5%)
Annonaceae	1(0.5%)
Apocynaceae	5(2.7%)
Burseraceae	3(1.6%)
Celastraceae	1(0.5%)
Dilleniaceae	7(3.8%)
Ebenaceae	1 (0.5%)
Euphorbiaceae	2 (1.1%)
Fabaceae	1 (0.5%)
Fagaceae	3 (1.6%)
Gittiferae	2 (1.1%)
Lauraceae	50 (27.2%)
Moraceae	10 (5.4%)
Myrtaceae	20 (10.9%)
Sapotaceae	10 (5.4%)
Total Non-Dipterocarp	119 (65%)
Grand total	184 (100%)

Timber volume

Table 4 shows the timber volume that compares the timber volume for timber species based on the dipterocarp and non-dipterocarp groups based on the local volume equations. The timber species are also classified based on Heavy Hardwood (HHW), Medium-Heavy Wood (MHW), and Light Heavy Wood (LHW) (Table 3). This categorisation was made based on the global wood density database constructed by Zanne *et al.* (2009). Following the categorisation, the data collected in this study was compared with two other reserved-forests' data using the local volume equation table developed for the states Pahang and Terengganu in Malaysia. The forests located in these two states were also dominated by dipterocarps. On the other hand, using the same data collected from the ground forest inventory in the ERNP was also used to identify the differences in timber volume with the local volume equations. The discussion on the timber volume was based on the dipterocarp and non-dipterocarp families of the trees. Firstly, the discussion focused on the findings of the timber volume specifically in the ERNP based on the Pre-F formula used.

The timber volume recorded for the dipterocarp family included the Mersawa Kuning (*Anisoptera laevis Ridley*) at 26.8m^3, followed by Resak (*Vatica maingayi*) at 18.9m^3 and Keruing Kipas (*Diptrocarpus*) at 16.3m^3. Whereas, for the non-dipterocarp family, the largest share of the volume was recorded for the species Medang (*Litsea costata*) at 52.6m^3, followed by Simpoh Gajah (*Dillenia reticulate King*) at 21.0m^3 and Kelat (*Syzygium*) at 17.2m^3.

The overall timber volume recorded for the ERNP was the lowest (35.5%) compared to the other local volumes. The lower timber volume for both dipterocarp and non-dipterocarp in ERNP could most likely be due to the differences in the equations or formulas used or differences in the timber price. However, the percentage of timber volume recorded for the non-dipterocarp was higher than that of the local volume, at 65%.

Timber volume by diameter at breast height

Table 5 lists the volume of the tree species for the DBH range. The discussion comprises of details of the timber volume entitled for commercial logging (trees with DBH > 44cm) and future logging (DBH < 45cm). As for the ERNP, the

TABLE 4 *Timber volume (m3) by species*

Tree species (local name)	Scientific name	Family	Classification	No. of trees	Pre-F	Local volume equation				
					ERNP	Pelangai	Tekai Tembeling	Bukit Ibam	Tembat	Gunung Tebu
Dipterocarp										
Damar hitam	*Shorea sp.*	Dipterocarpaceae	LHW	8	2.5	5.2	5.9	4.9	5.2	3.8
Kapur	*Dryobalanops aromatica*	Dipterocarpaceae	HHW	7	8.4	12.1	16.9	14.7	12.8	12.1
Keruing kipas	*Diptrocarpus sp.*	Dipterocarpaceae	MHW	12	16.3	19.9	29.4	25.9	21.5	21.6
Meranti rambai daun	*Shorea sp.*	Dipterocarpaceae	LHW	6	6.5	8.6	11.3	9.6	9	7.7
Meranti sarang punai	*Shorea parvifolia* Dyer	Dipterocarpaceae	LHW	4	3.3	4.7	5.8	4.9	4.8	3.9
Meranti tembaga	*Shorea leprosula* Miq.	Dipterocarpaceae	LHW	1	2.5	2.9	4.2	3.6	3.1	3
Merawan jangkang	*Hopea nervosa* King	Dipterocarpaceae	MHW	2	4	5.3	7.2	6.2	5.6	5.1
Mersawa kuning	*Anisoptera laevis* Ridley	Dipterocarpaceae	LHW	17	26.8	33.2	48.6	42.6	35.9	35.5
Resak	*Vatica maingayi*	Dipterocarpaceae	HHW	8	18.9	19.4	29.1	25.6	21.1	21.4
Sub-total				65 (35.5%)	89.1 (37.8%)	111.3 (37.4%)	158.4 (38.2%)	138.1 (38.4%)	119.0 (37.6%)	114.0 (38.7%)
Non-Dipterocarp										
Bintangor	Calophyllum sp.	Clusiaceae	LHW	2	3.8	4.3	6.3	5.5	4.7	4.6
Ipoh	Antiaris toxicaria Lesch.	Moraceae	LHW	2	6.7	6.6	10	8.8	7.2	7.4
Jelutong	Dyera costulata	Apocynaceae	LHW	1	1.9	2	2.7	2.3	2.1	1.9
Kandis	Garcinia dioica	Gittiferae	LHW	2	4.4	5.4	7.8	6.8	5.8	5.6
Kayu arang	Diospyros pilosanthera	Ebenaceae	LHW	1	0.6	1.1	1.3	1.1	1.1	0.8
Kedondong	Canarium sp.	Burseraceae	LHW	3	10.7	10.2	15.8	14	11.2	11.8
Kelat	Syzygium sp	Myrtaceae	LHW	20	17.2	25.8	33.4	28.4	26.8	22.8
Keledang	Artrocarpus rigidus	Moraceae	LHW	2	1	2.1	2.6	2.2	2.2	1.7
Kerdas	Pithecellobium bubalinum Benth.	Fabaceae	LHW	1	0.1	0.4	0.4	0.3	0.3	0.2
Medang	Litsea costata (Blume) Boerl.	Celastraceae	MHW	50	52.6	71.7	96.5	83	75.4	67.3
Mata ulat	Kokoona littoralis	Lauraceae	LHW	1	0.5	0.9	1.1	0.9	0.9	0.7
Mempening	Lithocarpus lucidus (Roxb.)Rehder	Fagaceae	MHW	3	3.9	5.6	7.6	6.6	5.9	5.3
Mempisang	Monocarpia marginalis	Annonaceae	LHW	1	0.8	1	1.2	1	1	0.8
Nyatoh taban merah	Palaquium sp.	Sapotaceae	LHW	10	7.3	10.4	12.9	10.9	10.7	8.6
Pulai	Alstonia scholaris	Apocynaceae	LHW	5	2.1	3.9	4.5	3.7	3.9	2.9
Rengas	Gluta sp.	Anacardiaceae	LHW	1	0.2	0.5	0.5	0.4	0.4	0.3
Sebasah daun besar	Aporosa arborea	Euphorbiaceae	LHW	1	2.5	2.5	3.5	3.1	2.7	2.5
Sesenduk	Endospermum diadenum (Miq.) Airy Shaw	Euphorbiaceae	LHW	1	5.7	4.6	7.3	6.5	5.1	5.5
Simpoh gajah	Dillenia reticulate King	Dilleniaceae	LHW	7	21	22.2	33.6	29.7	24.2	24.8
Terap	Artocarpus elasticus Reinw. Ex Blume	Moraceae	LHW	3	3.5	5.3	7	6	5.5	4.9
Sub-total				119 (65%)	146.4 (62.2%)	186.2 (62.6%)	255.8 (61.8%)	221.1 (61.6%)	197.1 (62.4%)	180.5 (61.3%)
Total				184 (100%)	235.5 (100%)	297.5 (100%)	414.2 (100%)	359.2 (100%)	316.1 (100%)	294.5 (100%)

TABLE 5 *Volume of tree species by DBH*

Row Labels	Sum of Pre-f (ERNP)	Sum of Tekai Tembeling	Sum of Tembat	Sum of Pelangai	Sum of Bukit Ibam	Sum of G tebu
Future logging (DBH < 45cm)						
15–30	22(10%)	46(16%)	53(13%)	43(12%)	46(15%)	33(11%)
30–44	64(27%)	98(33%)	126(31%)	107(30%)	102(33%)	86(29%)
Total future logging	86(37%)	144(49%)	179(44%)	150(42%)	148(48%)	119(40%)
Commercial logging (trees with DBH > 44cm)						
45–50	17(7%)	22(7%)	30(7%)	26(7%)	23(7%)	21(7%)
50–60	33(14%)	38(13%)	56(14%)	49(14%)	41(13%)	40(14%)
>60	97(41%)	90(31%)	145(35%)	130(37%)	100(32%)	111(38%)
Total commercial	147(62%)	150(51%)	231(56%)	205(58%)	164(52%)	172(59%)
Grand Total	233(100%)	295(100%)	410(100%)	356(100%)	313(100%)	291(100%)

largest share of volume belonged to the commercial valued trees (62%), whilst, the volume of trees for future logging amounted to 38%. Based on the comparison with the other local volume charts, the ERNP yielded the lowest volume share for both commercial and future logging categories. Consequently, the total volume of timber in the ERNP (233m^3) was the lowest compared to the others.

Stumpage value

Table 6 summarises the comparisons of the SV by tree species in the ERNP and the local volume equation based on the dipterocarp and non-dipterocarp family categories. The total SV for the dipterocarp family in the sampling plot area amounted to RM67 659, or a 44% share. The results further indicated that the largest share of the SV for the dipterocarp family belonged to Mersawa Kuning (RM25 022), followed by Resak (RM12 644) and Keruing Kipas (RM8 605). Whereas, the lowest share belonged to Damar Hitam (RM755). As for the non-dipterocarp family, the largest share of the SV in the sampling area belonged to Medang (RM29 585), Simpoh Gajah (RM15 118) and Kelat (RM8 926).

The SV values recorded for the dipterocarp family in the ERNP exhibited the lowest share of 44% compared to the local volume equation, while for the non-dipterocarp family, it amounted to the highest share (56%) compared to the local volume equation. These findings suggested that the ERNP was richer in terms of the non-dipterocarp timber species than the dipterocarp species compared to the local volume equations. The total SV for dipterocarp (RM67 759) and non-dipterocarp (RM86 474) for the ERNP were higher compared to the local volume equations.

Stumpage value by diameter at breast height

Table 7 lists the total SV by tree DBH categories. Based on the results, the share of the SV derived from the commercial valued trees (RM114 202) was larger than that of the SV for future logging trees (RM40 033). Subsequently, the total SV (RM154 235) for both commercial and future logging trees were the lowest for the ERNP compared to the local volume equations. This finding indicated that the timber resources in the sampling area are less rich compared to the other sites.

Based on the total SV in the sampling area of 0.6ha (RM154 235), the overall for 48 905ha was estimated at RM12 572 252 875. Hence, the per ha value was RM257 075.

Table 8 summarises the difference between DBH and Merchantable Height (MH), and the total SV (Pre-F) between the six plots. The results revealed significant differences between the three aspects.

Table 9 exhibits the correlation between the DBH, MH and SV (Pre-F). A significant relationship was identified between the three variables.

Direct use value – non-consumptive

Recreation

Table 10 demonstrates the total revenue from entrance fee collection to the ERNP in the year 2016. The total value amounted to RM38 856. Of the total amount, the amount contributed by the international visitors (RM16 700 or 43%) based on 738 visitors (RM 20/adult) and 194 children or retirees was comparatively lower than that of the local visitors (RM22 158 or 57%) based on 3 051 visitors (RM5/adult) and 2 301 children or retirees (RM 3/pax).

Watershed services

The area of watershed services (see Figure 2) in ERNP was determined using Google Earth and ArcGIS map version 10 map applications. Additionally, the images for the sub-basins (secondary and tertiary rivers) were obtained from the Digital Education Database (V4.1). Meanwhile, Shuttle Radar Topography Mission (SRTM 90m) was processed using the ArcGIS map to generate a high-resolution digital topographic database of Earth, following Rexer and Hirt (2014), as the land data only provided the image for the main

TABLE 6 *Stumpage value by species and local volume equation*

Local name	Scientific name	Pre-F	Local volume equation				
		ERNP	Pelangai	Tekai Tembeling	Bukit Ibam	Tembat	Gunung Tebu
Dipterocarp							
Damar hitam	*Shorea sp.*	775	1 207	1 511	1 278	1 243	1 012
Kapur	*Dryobalanops aromatica*	8 029	10 801	15 579	13 619	11 601	11 281
Keruing kipas	*Diptrocarpus sp.*	8 605	8 330	12 843	11 384	9 140	9 595
Meranti rambai daun	Shorea sp.	5 416	7 154	9 451	8 089	7 490	6 511
Meranti sarang punai	*Shorea parvifolia Dyer*	1 479	3 140	3 570	2 956	3 138	2 279
Meranti tembaga	*Shorea leprosula Miq.*	2 724	3 931	4 887	4 125	4 041	3 261
Merawan jangkang	*Hopea nervosa King*	3 065	3 532	5 157	4 510	3 815	3 733
Mersawa kuning	*Anisoptera laevis Ridley*	25 022	29 564	44 561	39 309	32 204	32 932
Resak	Vatica maingayi	12 644	14 087	21 708	19 269	15 432	16 286
Sub-total		67 759 (44%)	81 746 (45%)	119 267 (45%)	104 539 (45%)	88 104 (45%)	86 890 (46%)
Non-dipterocarp family							
Bintangor	*Calophyllum sp.*	2 341	3 367	4 614	3 979	3 566	3 235
Ipoh	*Antiaris toxicaria Lesch.*	4 168	3 390	5 397	4 811	3 761	4 082
Jelutong	*Dyera costulata*	452	985	1 205	1 013	1 007	797
Kandis	*Garcinia dioica*	2 648	2 895	4 362	3 843	3 156	3 213
Kayu arang	*Diospyros pilosanthera*	270	482	587	493	492	388
Kedondong	*Canarium sp.*	7 701	7 054	11 130	9 904	7 802	8 387
Kelat	*Syzygium sp*	8 926	12 375	16 523	14 187	12 989	11 474
Keledang	*Artrocarpus rigidus*	451	816	942	782	819	605
Kerdas	*Pithecellobium bubalinum Benth.*	37	98	98	79	94	59
Medang	*Litsea costata (Blume) Boerl.*	29 585	36 661	51 085	44 288	38 982	36 275
Mata ulat	*Kokoona littoralis*	150	248	294	246	252	192
Mempening	*Lithocarpus lucidus (Roxb.) Rehder*	2 057	2 890	3 599	3 040	2 971	2 406
Mempisang	*Monocarpia marginalis*	359	471	571	479	480	376
Nyatoh taban merah	*Palaquium sp.*	4 890	4 834	7 290	6 422	5 273	5 366
Pulai	*Alstonia scholaris*	688	721	984	847	763	688
Rengas	*Gluta sp.*	48	124	129	105	121	79
Sebasah daun besar	*Aporosa arborea*	1 609	2 422	3 237	2 777	2 546	2 241
Sesenduk	*Endospermum diadenum (Miq.) Airy Shaw*	3 165	3 843	5 556	4 848	4 139	4 002
Simpoh gajah	*Dillenia reticulate King*	15 118	15 775	24 060	21 250	17 266	17 819
Terap	Artocarpus elasticus Reinw. Ex Blume	1 811	1 773	2 524	2 195	1 900	1 804
Sub-total		86 474 (56%)	101 224 (55%)	144 187 (55%)	125 588 (55%)	108 379 (55%)	103 488 (54%)
Total		154 235 (100%)	182 970 (100%)	263 454 (100%)	230 127 (100%)	196 483 (100%)	190 378 (100%)

TABLE 7 *Comparison of the stumpage value with the local volume equations*

Item	Values (RM)					
Row Labels by category	**Sum of Pref (Endau Rompin)**	**Sum of *Tekai Tembeling***	**Sum of *Tembat***	**Sum of *Pelangai***	**Sum of *Bukit Ibam***	**Sum of *G Tebu***
Future logging						
15–30	7 015	14 735	16 645	13 762	14 700	10 590
30–45	33 018	51 186	65 699	55 859	53 125	44 575
Total future logging	40 033	65 921	82 344	69 621	67 825	55 165
Commercial						
45–50	11 783	14 743	20 532	17 769	15 694	14 509
50–60	26 460	30 025	44 065	38 580	32 483	31 980
>60	75 959	72 280	116 512	104 159	80 482	88 722
Total commercial	114 202	117 048	181 109	160 508	128 659	135 211
Grand Total	154 235	182 969	263 453	230 129	196 484	190 376

TABLE 8 *Comparison of diameter at breast height and merchantable height in six sampling plots*

	DBH(cm)	**Merchantable Height (m)**	**Pre-F**
Chi-Square	172.688	109.335	163.440
Df (n-1) (sampling points = 6)	5	5	5
Asymp. Sig.	.000	.000	.000

a. Kruskal Wallis Test
b. Grouping Variable: Plots

TABLE 9 *Pearson correlation*

		DBHcm	**MerchantableHeight (m)**	**Pre-F**
DBHcm	Pearson Correlation	1	.808**	.907**
	Sig. (2-tailed)		**.000**	**.000**
	N	184	184	184
MerchantableHeight (m)	Pearson Correlation	.808**	1	.742**
	Sig. (2-tailed)	**.000**		**.000**
	N	184	184	184
PreF	Pearson Correlation	.907**	.742**	1
	Sig. (2-tailed)	**.000**	**.000**	
	N	184	184	184

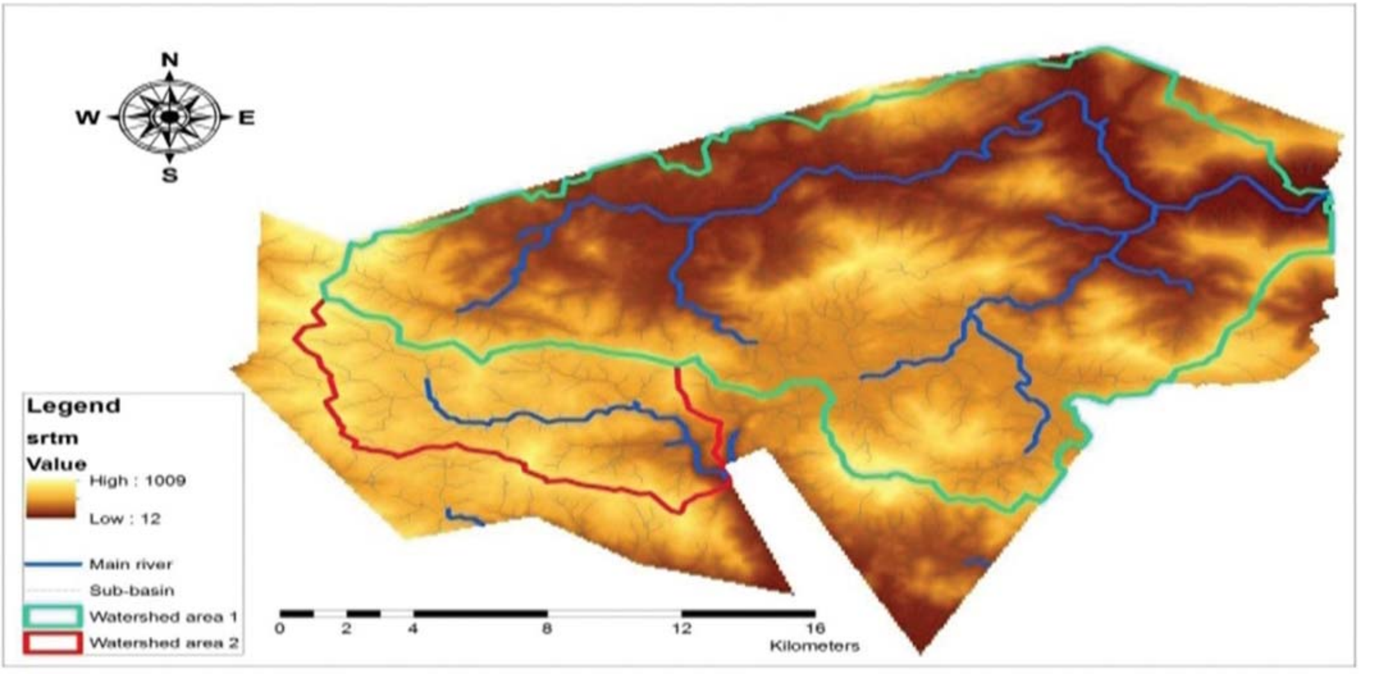
**. Correlation is significant at the 0.01 level (2-tailed).

TABLE 10 *Revenue from entrance fee collection to the ERNP in 2016*

Groups	**Local visitors**			**International visitors**			**Revenue**
	Total	**Entrance fee (RM)**	**Total amount (RM)**	**Total**	**Entrance fee (RM)**	**Total amount (RM)**	**Total RM**
Adult	3 051	5	15 255	738	20	14 760	30 015
Graduates/student/ children's/retirees	2 301	3	6 903	194	10	1 940	8 843
Total	5 352		22 158	932		16 700	38 858

Source: (JNPC 2016)

FIGURE 2 *Map of the watershed boundary in Endau-Rompin National Park*



river. SRTM illustrates the contour layer of the area (Rexer and Hirt 2014) to identify hilly areas to set the boundary for the watershed area for the rivers in the national park. Hence, the boundary of the watershed was established based on the primary, secondary and tertiary rivers (sub-basins) connected from the hilly/peak areas. Moreover, the water treatment value was adapted from a study conducted by Yacob (2002) at the catchment area of Muda-Pedu forested catchment in the state of Kedah in Malaysia to estimate the value of watershed services in ERNP, since both forests fall under the dipterocarp forest category. However, the per ha value of RM1 086 obtained from the study was adjusted using the October 2016 CPI (115.7) to account for the present value, amounting to RM1 256/ha. Figure 2 indicates that the areas inside the green and red boundary as the watershed areas in ERNP. The estimated size for watershed area 1 was 30 081ha, while watershed area 2 was 5 910ha. Hence, the total watershed services value was estimated at RM45 247 885 for a total of 35 991ha.

Non-use value – conservation

Latent class interaction model

Table 11 lists the latent Class 1 and Class 2 interaction of level 2 and level 3 of the choice attributes and interaction variables. The respondents' distribution based on classes was determined based on their probability score. Furthermore, the lower part of Table 4 represented the probability of belonging to each class. It revealed that 77% of the sample belonged to Class 1, while only 23% belonged to Class 2. The model fitness was obtained as Log-likelihood function (-1295.649), Log L fucn No coefficients (-1977.5021), R-squared (.24025) and RsqAdj (.22976).

Based on LCM, all attributes were found to be statistically significant at 1%, 5% and 10% confidence level (CI) with very few insignificant values. The output from Class 1 indicated that four out of the nine main attributes on the price were significant. Here, the price attribute denoted by BID and BIO3 were significant at 1% CI, NOV2 at 5% while EAM3 significant at 1% CI. In addition, the BID yielded a negative coefficient sign consistent with the demand theory and was also statistically significant (1%) in Class 1 and Class 2. Hence, when the monetary contribution increases the respondent is less likely willing to pay. As for the negative BIO3, the respondents were not keen to accept an additional 40% reduction in the number of species (flora and fauna). Likewise, the negative NOV2 indicated that the respondents were not in favour of an additional increment of 10% in visitor's arrivals per year as compared to the status quo (6 500 arrivals). On the other hand, the positive coefficients for EAM3 indicated that visitors agreed to an additional increment of 80% in the number of workers required compared to the status quo.

As for the interactive variables, only five out of 14 were found significant. This is where NOV3 (Gender) and BIO3 (Education) were found significant at 1% CI, while BIO2 (Gender), NOV2 (Mean satisfaction on facilities) and EAM (Mean satisfaction on recreational activities) were found significant at 10% CI. The negative coefficient for NOV3 (Gender interaction) indicated that the male respondents are less keen with the increase in the number of visitor arrival to the park compared to the females. The positive BIO3 (Education) revealed that the respondents are keen to see an additional 40% reduction in the degradation of the number of species (flora and fauna). A negative sign for the interaction with the BIO2 (Gender) indicates that the male respondents are less keen with the 20% improvement in the number of

TABLE 11 *Latent class interaction model*

Variable	Latent class 1 Interaction model			Latent class 2 Interaction model		
	Coefficient	Standard error	P-Value	Coefficient	Standard error	P-Value
BID	-.02793311	.00716935	.0001	-.05617826	.01243462	.0000
ASC	-2.47077559	.25132894	.0000	1.15139120	.28165245	.0000
NOV2	-2.4695	1.17352234	0.0353	0.9605025	0.8712233	0.2703
NOV3	0.08818	0.10425738	0.3977	-0.760735	0.28782497	0.0082
BIO2	0.39722	0.34095331	0.244	0.4897951	0.25868505	0.0583
BIO3	-2.2231	0.51750051	0.0000	-3.989438	1.01963459	0.0001
EAM2	0.14909	0.56316356	0.7912	-0.855413	0.72860311	0.2404
EAM3	0.69777	0.38560464	0.0704	1.22083553	0.736399	0.0973
EAN2	0.72891	0.78188305	0.3511	2.00155	0.780887	0.0104
EAN3	0.30581	0.25564976	0.2316	2.216731	0.69643974	0.0015
BIO2_Gender	-0.8398	0.47512939	0.0771	-0.6973	0.366415	0.057
NOV3_Gender	-0.4643	0.14510016	0.0014	0.66977	0.334217	0.0451
NOV2_Age	0.03439	0.02185925	0.1156	0.01255	0.02022	0.5347
EAN3_Age	0.00265	0.00788902	0.7369	-0.0809	0.02534	0.0014
BIO3_Education	0.50102	0.10841652	0.000	0.67728	0.169902	0.0001
EAM3_Income	0.329441	0.31045300	0.2886	0.71867	0.566511	0.2046
EAM3_Marital status	-0.0557	0.13843354	0.6872	-0.2116	0.24494	0.3876
BIO3_Time spent	0.05582	0.04809288	0.2457	-0.1104	0.094166	0.241
EAM2_Ngo	0.12761	0.38329078	0.7392	-0.4309	.62993714	0.4939
BIO3_Awareness	0.10907	0.07848814	0.1647	0.39486	0.162846	0.0153
EAM2_Documentary	-0.0918	0.16627376	0.5811	0.30161	0.21976	0.1699
EAN2_Mean importance level	-0.1606	0.18983875	0.3974	-0.4289	0.181685	0.0182
NOV2_Mean satisfaction on facilities	0.50006	0.28165125	0.0758	-0.4177	0.227528	0.0664
EAM3_Mean satisfaction on recreational activities	-0.1601	0.09649974	0.0971	-0.4208	0.18012	0.0195
Log-likelihood function					-1502.411	
Log L fucn No coefficients					-1977.5021	
R-squared					0.24025	
RsqAdj					0.22976	
PrbCls_1			.77063508	.04933537	15.620	.0000
PrbCls_2			.22936492	.02564397	8.944	.0000

Note: ***Significant at 1%, **Significant at 5%, *Significant at 10%

threatened species as compared to the female respondents. A positive coefficient for NOV2 (Mean satisfaction on facilities) indicated that the higher satisfaction among the respondents resulted in the 10% increment in visitor arrival to the park. In addition, a negative coefficient for interaction between EAM3 (Mean satisfaction on recreational activities) indicated that respondents who were satisfied with the recreational activities were not keen towards increasing the workforce in the park by 80%.

The output from Class 2 revealed that seven out of the nine main attributes on the price were significant at 1% CI (NOV3, BIO3, EAN2, EAN3) except for BIO2 and EAM3 that were significant at 10% CI. Whereas, only seven of the 14 interaction variables were significant.

Overall, EAN3 Age (-), BIO3 Education (+), BIO3 Awareness (+), EAN2 Mean importance level (-) and EAM3 Mean satisfaction on recreational activities (-) were found significant at 1% CI; NOV3 Gender (+) was significant at 5% CI; BIO2 Gender (-) and NOV2 Mean satisfaction on facilities were found significant at 10% CI. All the significant interaction variables had an inverse relationship with the attributes except for the interactions between the education, awareness and gender. Negative coefficients observed among the respondents in Class 2 indicated that they were inclined towards the proposed attributes level and vice versa for positive coefficients.

Latent class 1 marginal model

The marginal rate of trade-offs for the attributes is aimed at showcasing a preference in the change of attributes and their marginal willingness to pay value. The statistical results reported in Table 12 indicated that the value for the increase in visitor's arrival is higher for NOV2 (Class 1 = RM88.40) while lower for a higher increment to NOV3 (Class 2 = RM27.20). The respondents also indicated their readiness to pay higher for highest improvement in the biodiversity conservation services greater than BIO3 (Class 1 = RM79.60, Class 2 = RM142.80) than at the lower level (Class 2= RM17.50).

Similarly, in the improved enforcement and monitoring attributes, the respondents indicated their highest Marginal Willingness to Pay (WTP) where EAM3 (Class 1 = RM25, Class 2 = RM43.70), while it was not significant for both EAM2 (Class 1 = not significant, Class 2 = not significant). Besides that, for Environmental and Nature Education, the respondents showed high willingness to pay higher at the highest level of improvement EAN3 (Class 1 =, Class 2= RM79.35) as compared to EAN2 (Class 1 = not significant, Class 2 = RM71.65). The marginal logit model highlighted that the calculated value indicated partial monetary trades off, whereby the respondents were willing to pay for changes on attribute levels. A negative marginal value implies a decrease in utility, whereas, the positive value implies an increase in utility.

Based on the results, the latent class model 2 achieved the best model fit compared to the latent class model 1. This is evident from the table, whereby the result shows a higher value rate of substitution in Table 12. The visitors' total welfare value was calculated by multiplying the number of local visitors in 2016 (5 352 visitors) with the compensating variation surplus value (RM64.02 × 5 352) amounting to RM342 635.

Table 13 lists the TEV values based on its components. The DUV holds the major share of TEV (96%), followed by IUV (3.7%) and NUV (0.3%). This observation was comparable to the findings documented by Othman and Zin (2013) who stated that the DUV components hold the largest share of TEV in the tropical forests.

TABLE 12 *The marginal rate of substitution*

Atributes	Latent class model 1	Latent class model 2
NOV2	88.40	ns
NOV3	ns	27.20
BIO2	ns	17.50
BIO3	79.60	142.80
EAM2	ns	ns
EAM3	25.00	43.70
EAN2	ns	71.65
EAN3	ns	79.35

ns= Not significant
Overall mean latent class model 1: RM 64.33; Overall mean latent class model 1: RM 63.70; Average for Model 1 and Model 2: RM 64.02

CONCLUSIONS

This study highlighted the value of forest ecosystem services in the ERNP. Hence, this study assessed the value of timber and recreation (DUV), the benefits from watershed services and carbon sequestration (Matthew *et al.* 2013), IUV and NUV based on the estimation of the LCM. This information is crucial for the justification of conservation of forest ecosystem services in the ERNP.

The production theory was applicable in this research and provided meaningful evidence. The study revealed the value of timber amounted to RM154 235. Furthermore, the actual fee imposed on the visitors was based on the market price that was used to determine the non-consumptive benefits to the users. Finally, the benefits transfer approach was used to calculate the benefits of watershed services. The specific watershed areas in the ERNP were identified using the mapping tools (ArcGIS, Google Earth and SRTM 90m). However, this figure only represents the benefits of forest ecosystem services. In addition, it does not consider the negative externalities such as soil erosion and forest fires.

The findings from this study provide several managerial implications and guidelines to stakeholders and policymakers, particulalry to the Ministry of Natural Resources and Environment (MNRE) and the national park authorities of Malaysia. In the case of the ERNP, the Johor State government and

TABLE 13 *TEV of Forest Ecosystem Services in 2016*

TEV components	Value (RM) per year
1) DUV- (Consumptive)	
Timber	1 257 225 286
2) DUV- (Non-Consumptive)	
Recreation	38 856
Total DUV	1 257 264 142
3) Indirect Use Value (IUV)	
Carbon Sequestration	431 920 646
Watershed services	45 247 885
(Total IUV)	477 168 531
4) Non-use Value (NUV)	
Conservation value (Total NUV)	1 538 431
Total Economic Value	13 050 998 687

* The carbon sequestration value were obtained from (Matthew *et al.* 2018)

MNRE play a vital role as policymakers in conserving the forest. This study recommends that visitor entrance fees should be revised to increase revenue for sustainable financing of conservation initiatives and possibly reduce congestion. Based on the results of the LCM model of the latent Class 1 and Class 2, respondents wanted (i) improved biodiversity by creating a 40% improvement in the number of threatened species (from threatened to non-threatened level, 32: Fauna = 11, Flora = 21 species) for enforcement and monitoring attributes; (ii) additional increment of 80% workforce in enforcement and monitoring (18 people), environmental and nature education attributes; (iii) additional increment of 80% for visiting institutions (25 institutions); and, (iv) the number of visitors contributes for an increment of 20% in visitors arrival per year (8 000 visitors).

Information on the value of forest ecosystems services in the ERNP will be useful in several ways. First, the findings will create awareness to the community regarding the importance of conserving forest resources in the national park. In respect of this, failure to conserve the national park will result in the degradation of the forest and reduction in the contribution of the forest ecosystem services to the community. Moreover, these findings will help the Johor National Park Corporation to justify the financial allocations for the national park to the public on the maintenance of the facilities, recreational activities and conservation efforts of the national park. Also, this research can contribute to the existing literature on the value of forest ecosystem services. However, failure to determine the TEV of the forest can underestimate its benefits to the community (Kalaba 2014). Therefore, this study provides some comparative analysis for the future conservation of ERNP.

Several suggestions for future research have also been identified such as timber valuation and conservation. Previous literature has determined the Net Present Value (NPV) value of forest ecosystem services while this study did not. Moreover, new studies are needed to estimate the SV using the hedonic pricing technique which facilitates comparisons among geographic locations, especially looking at the differences in the nature of the timber logs (Awang Noor and Ismail 2012). However, in 2017, the values of forest types per ha (mangroves, wetlands, rainforests, temperate coniferous, temperate deciduous, tropical evergreen and tropical deciduous) were still low compared to the mixed dipterocarp forest even after inflating the values to the current CPI index. Another aspect is the difference in the number of TEV components measured in forest ecosystem services. In general, the findings show that the TEV of forest ecosystem services in ERNP are high.

Like most studies, this study is not without limitations. In terms of the methodological limitations, some components of the TEV were not considered such as soil erosion, air quality, support to downstream and upstream fisheries, gene pool protection, soil formation, nutrient cycling, genetic resources, seed dispersal and pollination. This was due to the limited data and the difficulties to measure certain aspects. Furthermore, the TEV that is presented in this study is based on the present value rather than the net present value.

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