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TOTAL ECONOMIC VALUE OF ECOSYSTEM SERVICES IN MALAYSIA: A REVIEW

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Abstract: Southeast Asia contains the world's third largest tropical forests, currently experiencing a high deforestation rate, thus highlighting the need for conservation efforts. The full potential of ecosystem services in tropical forests has never been completely quantified in economic or monetary terms. This potential value is accessible by extraction of readily available information in both market and non-market terms. As such, an economic valuation approach is capable to estimate the full range of an ecosystem services benefits provided by a tropical forest. This paper reviews the suitable indicators pertinent to a Total Economic Value (TEV) of tropical forests to propose a conceptual framework for the TEV of Tropical Forest in Southeast Asia. The failure to impute price on ecosystems services in tropical forests would result in a misguided policy and the society would be in detrimental as a result of misallocation of resources.

Keywords: Indicators, conservation, economic valuation, ecosystem services, tropical forest.

Introduction

Forests are universally important actors as reservoirs, sources, and sinks of carbon. Given the apparent benefits from the forest, environmental economists had attempted to place economic values on tropical forest conservation endeavours (Adhikari, 2018).The economic valuation allots quantitative values to the goods and services provided by the ecosystem services, regardless of the availability of market prices in monetary terms (Zhang *et al*., 2017). Though valuation methodologies are exposed to an enormous range of errors, they are influential in high-level policy arenas (Richardson, 2010). The ecosystem service is valued based on the reflection by the society as well as the willingness to conserve these natural resources (Kumar, 2010). Furthermore, it provides indicators of the importance of the ecosystem to the society (Ahammad *et al.,*2019). Among the indicators, at the national level, the steps taken include efforts to reduce landslides and floods as well as upgrading of quality and supply of water; meanwhile, at the global level, the indictors include reduction of emission and carbon storage by restricting deforestation, increasing human health and food security (Ahammad *et al.*, 2019).

Amongst the issues underlying an economic valuation of the ecosystem services in forests *per se,* are missing markets, imperfect markets, and market failures (Rolfe *et al.*, 2000). Consequently, the value of many ecosystem services is often underestimated and even ignored in daily decision-making. Since ecosystem services are categorised as public goods, they tend to be over-consumed by society (Bujosa & Riera, 2010). Public goods share the characteristics of "non-rival" whereby these goods can be beneficial to the users without disrupting the benefits attained by other users(Hanley *et al*., 2007). For example, the magnificent scenery and the refreshing cool air of national parks can be enjoyed by the visitors at all times. As the amount of air inhaled and exhaled is uncountable, the value of environmental goods and services is unable to be determined, hence, leading to market

failure (Groot *et al*., 2012). Also, as related to national parks, the damages to ecosystem services are as a result of the attributes of public goods and externalities (Ezebilo, 2010). Externalities are often denoted to the after effect of human activities whereby the production of an economic agent is influenced by their undertakings (Hanley *et al*., 2007). Therefore, externalities are often not denoted in monetary terms.

Knowledge on the benefits forfeited when forest utilisation becomes unsustainable is important in making choices between conservation and restoration of forest ecosystems for the continued provision of valued ecosystem goods and services (Kalaba, 2014). The economic values of ecosystem goods and services should be evaluated and equated with the economic values of activities that have been compromised (Ahammad *et al*., 2019). Benefit is derived fromthe array of forest ecosystem goods and services, including extractive benefits, such as timber, non-timber, and medicinal plants, as well as non-extractive benefits like pollination, water purification, watershed protection, renewal of soil fertility and climate regulation, provision of wildlife resources, and recreation and tourism opportunities (Ojea & Martin-Ortega, 2015). Forests are often valued greater than the potential of the development compared to the ecosystem services provided(Sharma *et al.*, 2015); thus, necessitating the need for economic valuation of these resources. However, the economic valuation of these goods and services requires quantification and measurement which include demanding tasks (Kalaba, 2014).

According to Kalaba's (2014) conversion from the quantities of natural resources to economic value becomes difficult due to limited markets and market prices for ecosystem services. Consequently, there is limited information pertinent to the total economic value of the resources in tropical forest, *per se*. In seek of the theoretical gap, generally, previous studies had either focused on the market or the non-market valuation techniques ,there were limited studies on the TEV approach which accounts for both. Furthermore, limited studies have integrated the ecosystem services into the TEV (Kumar, 2010). Integration of the ecosystem services' components (provisioning, regulating, habitat services, and cultural and amenity services) with the actual TEV concept (use value, indirect use value, and non-use value) is important to identify for new TEV potential indicators of tropical forests. Thus, our aim in this paper is to identify the knowledge gaps in the TEV of the tropical forest ,and to contribute to the body of knowledge through the development of a holistic TEV framework derived from the underpinning ecosystem services.

Total Economic Value

TEV incorporates all components of utility resulting from the ecosystem services and engaging a common unit of accounts ,such as cash, or any market-based unit of measurement that enables evaluations on the benefits of numerous products (Kumar, 2010). The total economic value framework can be divided into use value and non-use value. Withinthe use value, one of the elements is the direct use value. It comprises the consumptive and non-consumptive categories. This value is derived from the use of environmental resources; as the use of timber, rattan, bamboo, fisheries, wild foods, medicinal plants, housing materials, and recreation. Next, the indirect use value or ecological value is the benefit obtained by the human from the ecological services (Groot *et al*., 2012), which include flood control, watersheds, water quality, supplies, and wildlife habitats. The option value is denoted as the monetary value of individuals who are willing to pay for the conservation of recreational resources for the resource's sustainability (Traeger, 2014).

On the contrary, the non-use value comprises the existence value, bequest value and altruist value. The existence value signifies the satisfaction obtained by an individual on identifying the environmental element, such as animal species, that will be preserved for present and future use (Boontho, 2008). Some of these examples are landscape, heritage,

and culturally based. The bequest value is the satisfaction that an individual gain upon knowing that the resources will be conserved for future generations (Diafas et *al.*,2017). Finally, the altruist value is the value attained by an individual by identifying that the resource will benefit other individuals too.

Therefore, the TEV is made up of the following:

$$TEV = UV(DUV + IUV + OV) + NUV(EV + BV + AV) \quad (1)$$

In which, DUV represents the direct use value, IUV the indirect use value, OV the option value, EV the existence value, BV the bequest value and AV the altruist value.

Existing Indicators for TEV of Tropical Forest

Table 1shows the TEV indicators used in past studies specifically for tropical forest valuation in the world. Many studies were conducted on the timber logs and non-timber logs which belong to the Direct Use value (DUV)-(Consumptive / Extractive) component in the TEV framework. Another component, the capture fisheries indicator, belongs to the studies on the wetland ecosystem services. For the Direct Use value (DUV)-(Non-consumptive/Non-extractive), limited studies have determined the aesthetic value, and the research and education values in a forest ecosystem, *per se*. On the other hand, there are ample studies on the IUV emphasis on the carbon sequestration value, following with the watershed services and the non-use value was determined by asking the respondents on their willingness to pay for conservation.

Many studies have been conducted on valuing forest, *per se*. These include studies conducted in Southeast Asia by Hanum *et al*. (1999); Awang Noor and Ismail (2012); Abdullah *et al*. (2016) on the value of timber resources; valuation on non-timber forest products by Kumari (1995); Awang Noor and Shahwahid (1997a); Othman and Mohd Zin (2013); Awang Noor and Shahwahid (1997b). Among others, there were studies conducted on medicinal herbsvalue assessments by Mohd Azmi *et al*. (2002); carbon sequestration values by Van Beukering *et al*. (2003); Dirocco (2012); Hamdan *et al*. (2014); Eswani *et al*. (2017). Moreover, studies were also conducted on watershed services value , as inFrancisco and Espiritu (1999), Krieger (2001), Pattanayak (2004) and Soussan and Sam (2011);estimation value of soil erosion by Baharuddin *et al*. (1996); Shahwahid *et al*. (1997). Other studies included support assessments to the downstream and upstream fisheries by Bennett and Reynolds (1993) and non-use-value of the forest by Jamal *et al*. (2004); Thalany (2014); Malik *et al*. (2015).

However, the approach of TEV to determine the total value of ecosystem services in the tropical forest is pertinent. Table 1 shows thirteen studies conducted on tropical forest in all over the world.

The following indicators which were identified from the existing literature review are plausible to be used in determining the suitable indicators for a more holistic approach of TEV on tropical forest in Malaysia.

Figure 1 shows the proposed TEV conceptual framework of a national park's tropical forest in Southeast Asia. The proposed conceptual framework has integrated the ecosystem service components within the TEV. The inclusion is to derive at a more holistic model to explain the entire ecosystem services valuation of the intended tropical forest. Additionally, the study also took into account the applicability of the economic valuation exercise conducted in another area of research, for example, marine and agro-forestry parameters that fits into the proposed framework. The specific discussion for each of the indicators is as follows:

Direct Use Value-Consumptive

Timber

The first identified indicator is the timber log. Previous studies had employed two types of data to determine the stumpage value, namely, secondary data from forest inventories and in-depth ground forest inventory. Jamal and Ahmad

(2013) used secondary data obtained in Taman Negara Pahang, Malaysia in their examinations. Furthermore, secondary data on timber had also been obtained from a third forest inventory as provided by the Peninsular Malaysia Forestry Department. The information acquired from the hill forest inventory includes the area size, type of trees, forest type, average annual growth, size in diametersand the average hectare yields, and others. This study determined the value of the timber based on the market price. The price of a log per cubic meter ranged between RM315 (low) to RM379 (high). While studies which were conducted on the in-depth ground forest inventory which include a survey was done by Hanum*et al*. (1999), the forest inventory surveys took place at about a 1-ha plot in UluMuda Forest Reserve, Kedah. A total of 909 trees were enumerated and grouped according to species; 177 species in 92 genera and families, and 44 different families. The stumpage values of the timber in the hilly rainforest were found to be between RM8707.52 and RM17514.12 per ha, based on below and upper cutting limits. The total stumpage value was found to be RM 26,221.64 per ha. The findings revealed that the timber that belonged to the *Sapotaceae* family contributed the largest share of stumpage value. The commercial group's nyatoh (*palaquium*) and kedondong (*spondiasdulcis*) accounted for 52% and 25% of the total stumpage value, respectively.

In a later study, the stumpage value determination was made at the hill forest in the Temenggor, Forest Reserve in Perak by the same researcher, Awang Noor and Ismail (2002). The same method was employed as in their previous research, the study used the in-depth ground forest inventory to identify and measure the diameter at the breast height (dbh) for each timber species. In terms of sample choice, a larger cutting point was set as compared to the earlier study (trees with greater than 25 cm in dbh). This had resulted in thirty-five trees being sampled along the trails of the Temenggor, Forest Reserve which were randomly chosen. The researchers then applied the Residual Value Technique (RVT) to determine the stumpage value. In a more recent study, the same researcher had conducted an in-depth ground forest inventory at the northern part of Peninsular Malaysia at the PasirTengkorak Forest Reserve, Langkawi, Kedah, being done byAbdullah *et al*. (2016). This study was conducted out to investigate the tree composition and evaluate the economic value of timber resources in a lowland coastal forest. The survey was conducted at an area measuring to 4 ha with one plot/ha (100 x 100 m) along with a line transecting at an elevation of 130-300 m above sea level. The distance between each plot was 50 m along the line. Inorder to make the enumeration process more efficient in every plot, sub-plots of (10 x 10 m) were established. The tree enumeration involved the identification of the timber species, height, and diameter of the trees. The survey resulted in the determination of 13,543 tree individuals with a diameter above 1 cm which belonged to 50 families, 113 genera, and 236 species. The stumpage value was 289.17 m^3 per ha.

Non-timber Forest Products

The second indicator under the consumptive value is the non-timber forest products. This covers the literature on rattan, bamboo, wild fruits, *gaharu* (agarwood) and cinnamomun bark and medicinal plants. Rattan has value in Southeast Asia markets, commonly in Malaysia. The examinations of the rattan stocks economic value of in the Pasoh Forest Reserve located in Negeri Sembilan, which is mainly covered with lowland and hill dipterocarp forests was estimated by Awang Noor and Shahwahid (1997). Using the residual value technique (RVT), the value of rattan was determined to be RM942.52 (USD248.03) per hectare or RM2, 882,066 (USD758, 438.42) for the total area of the study site. Likewise, in a more recent study, Othman and Mohd Zin (2013) had determined the value of rattan in Taman Negara (National Park) using a similar RVT method. The data on the quantity of rattan were obtained from the inventory of the second forest provided by the forestry department. The Net Present

Table 1: Existing Indicators for TEV of Tropical Forest

Components	Bennett and Reynolds (1993)	Vincent *et al.* (1993)	Anon (1994)	Kanta Kumari (1995)	Shahwahid *et al.* (1996)	Kanta Kumari (1997)	Jamal *et al.* (1998)	Woon *et al.* (1998)	Camille (1999)	Van Beukering *et al.* (2003)	Sulaiman (2005)	Emerton and Kekulandala (2013)	Jamal and Ahmad (2013)
Direct Use value (DUV)-Consumptive / Extractive)													
• Timber	Y		Y	Y	Y	Y	Y	Y			Y	Y	
• Non-timber forest products		Y		Y				Y			Y		Y
• Fish	Y		Y	Y			Y		Y			Y	
• Endangered species		Y		**Y**									
• Hydrological			Y	Y					Y		Y		
• Domestic water				**Y**	**Y**	**Y**							
Direct Use value (DUV)- Non-consumptive / Non-extractive)													
• Research and education													
• Recreation / ecotourism	Y			Y		Y	Y		Y	Y	Y	Y	Y
Indirect Use Value (IUV)													
• Carbon sequestration		Y	Y	Y					Y		Y	Y	Y
• Watershed services										Y		Y	
• Shoreline protection									Y				Y
• Support to downstream and upstream fisheries												Y	
Non Use Value (NUV)													
• Conservation value for recreation/ecotourism			Y				Y	Y			Y		Y

Value (NPV) of rattan was determined based on the discounted rates varying from (2%-15%), which are based on the sustainable logging management option that amounted to only 0.2% of the TEV.

Likewise, bamboo, of another non-timber forest product which had also been valued earlier, had utilisedthe same RVT method.The estimate of the bamboo stocks economic value in the Pasoh Forest Reserve, Negeri Sembilan ,was done by Awang Noor and Shahwahid (1997). The data of the bamboo stocks was obtained from the forest inventory conducted by the forestry department of Peninsular Malaysia. The price of the stocks was then determined based on the market price available on the forestry department's official website. The study had found that the total value of bamboo was lower in virgin forest, RM23,175 (USD6,098.68) as compared to logged over forests, RM155,099 (USD40,815.52). In the forests, there is also another valuable non-timber resource ,namely petai (*parkia speciosa*) (wild fruit). The economic value of petai (*parkia speciosa*) was estimated by Woon (2001) in various tropical forests in Peninsular Malaysia. The economic value was estimated to be RM12.97 (USD3.41) per hectare. It was determined based on the estimated stock numbers and multiplied with the market price. The agarwood species is also included in the non-timber resources. Agarwood value was found to be at RM19 (USD7.60) per ha for the *Aquilaria malaccensis* agarwood species type; and at RM4.50 (USD1.18) per ha for *Cinnamo mummollissimum* species type, in the Pasoh Forest Reserve. On the other hand, the value of medicinal plants per hectare was found to be in the ranged from RM26 (USD10.40) - RM445 (USD178) at the North Selangor peat swamp forest in a study conducted by Kumari (1995).

Handicrafts

One of the main featuresof the Malaysian tropical forest is the presenceof the aborigine communities. Their living sites are commonly found adjacent to or within the national park. For instance, the Jakun (aborigine) community chose to livein the adjacent area to the Endau Rompin National Park (Endau Rompin NP), in the state of Johor. The Park is the oldest tropical jungle in the world (Siti Aminah & Ta, 2014). This Jakun tribe community live at Kampung Peta, had been directly involved with the socio-economic development of the national park (Siti Aminah & Ta, 2014). Some of the local entrepreneurs from the tribe sell handicrafts made from the forest products to the park visitors. Handicrafts products, which are the actual Jakun tribe's traditional games, include 'kercang', 'kercangtipahtertipu', 'kercang kahwi'n', 'kercangdualubang', 'kercangwa' and 'kercangrama-rama'. Hence, the value of these handicrafts can be determined by identifying the selling price and the cost to make the respective handicrafts, against the number of handicrafts sold per year.

Captured Wildlife

A study was conducted at the Mukah sago peat swamp forest in Sarawak, Malaysia by Sulaiman (2005) to determine the value of captured wildlife.They were wildlife such as species of wild boar, deer, and mouse deer, being the localsof the forest. This was made possible by enquiring the local communities living adjacent to the forest about their hunting activities (for self-consumption purposes) using a questionnaire instrument. Questions on how often they went hunting, the type of animals captured, how many animals were caught each trip were forwarded. On later assessments, the values of the captured wildlife were determined by the respective species market prices.

Hydrological

The hydrological or domestic water benefit is the next indicator under the consumptive value. Such studies conducted in Southeast Asia include a research conducted by Sulaiman (2005) at the sago forest harvesting regionin Sarawak, Malaysia. The study used the market price valuation method to determine

the hydrological value. The data on the water consumptionsfrom the peat swamp to meet the domestic requirements of the residents in Mukah was obtained from the Sarawak water board authority. The estimated domestic water benefits per hectare were based on a projected annual increase of 2% in the annual volume of water consumed from the swamps and increments in the water treatment cost. The present values for the benefits of domestic water at 8% and 4% discount rates were calculated at RM4,232 per ha and RM7,774 per ha, respectively.

Direct use Value for Non-consumptive or Non-extractive

Education and Research

Limited studies were found in determining the value of education and research as part of the tropical forests TEV indicators in Southeast Asia. Hence, an example of how this indicatormeasured was referred to in a study in valuing Gazi Bay, Kenya mangroves. In the study, the value of the money obtained for education and research purposes amounting to USD114,000/year was used to measure the indicator proposed by UNEP (2011). Also in a study of marine TEV, the value of the research expenditure incurred at the Bohol Marine Triangle (BMT), the Philippines, by the relevant government agency was used to determine the indicator in a research done by Samonte-Tan *et al*. (2007). The research value of the BMT was estimated at USD9,259 per annum. Furthermore, the value of the research budget allocated for the Pulau Payar Marine Park (PPMP), Kedah, Malaysia in 2010 by the ministry of higher education was used as the proxy value to measure the indicator(DMPM, 2011).

Recreation and Tourism

The non-consumptive value for recreation or tourism can be determined by basing on the entrance fee collections approach, and the direct spending of the visitors. There were limited studies done in Southeast Asia that have used the first approach to determine the TEV. A study conducted in the Pulau Payar Marine Park (PMPM), Kedah, Malaysia by DMPM (2011) had utilised this approach. In the study, the total number of visitor arrivals to the park in 2010 was multiplied against the entrance fee amount imposed on the visitors, which amounted to a total of RM480,485. On the other hand, studies that utilised the second approach in Southeast Asia include an investigation done byVan Beukering *et al*. (2003). The recreation value was determined by accumulating the actual spending of the tourists on both the entrance fee and their spending at the Leuser National Park in Sumatra, Indonesia.

Tropical Ethnobotany

The example of tropical ethno botany in this discussion refers to the medicinal herbs used by the Jakun tribe aborigines in the Endau Rompin National Park. The common herbs include the *tongkat Ali (Eurycoma longifolia), akar Ipoh (Strychnos ignatii) and kacip Fatimah (Labisia pumila)* (Perbadanan Bioteknologi & Biodiversiti Negeri Johor, 2008). The value of medicinal herbs can be measured by determin ingthe resources amount extracted from the forest (Mohd Azmi *et al*., 2002). For example, in the Endau Rompin National Parkthe medicinal herbs are sold in packets with each amounting to RM15 to the visitors (Awang, 2015). The processing and packaging cost is estimated to be at 10% of the sale price. Hence the profit will be RM14 for each packet sold. Each packet may contain more than one herb.

Indigenous Cultural Commoditisation

The cultural aspect of the indigenous tourism is a well-known research area which highlights the indigenous people's unique and authentic lifestyle (Hinch & Butler, 1996). Culture is a substantial attraction for tourists as well as entrepreneurs, government agencies, and academic researchers (Hinch & Butler, 1996). Many scholars agree that cultural product has demonstrated to be an intermediary in advancing tourism development (Cohen, 1988; King, 1993; Liu, 2008; Brown & Cave, 2010). In addition

to all this, tourism is seen as medium to made known the indigenous culture globally, and lead to its sustainability. Nonetheless, many studies had indicated that commoditisation is one of the ways to promote the indigenous culture to tourists (O'Gorman *et al*., 2007). Based on the cultural tourism perspectives, commoditisation assist in enhancing local economic growth and developing traditions by reducing poverty levels and increasing the essential value (UNWTO, 2004).

Cultural value is also one of the components of the TEV that belongs to the cultural and amenity services (Kumar, 2010; Plottu & Plottu, 2007). Not many studies have revealed the value of cultural and spiritual values. Following that, the native Jakun culture in the Endau Rompin NP is unique and provides an interesting destination to be visited and is seen as attention-grabbing by the visitors (Kamaruddin, 2008). Cultural aspects have been studied by Siti Aminah and Ta (2014) in the park. The authors discovered that a material culture is being produced, performed, and practiced in the forms of artefacts, handicrafts, food, and dance exhibitions; as well as a non-material culture of beliefs, taboos, traditional and customary marriages. In this case, the cultural value of the aborigines of the *Jakun* tribe in the park can be determined, for example, by accumulating the revenue from the cultural show charges (example: *tariansewang*). The charge for the (*tariansewang*) is RM800 for a 2-hour show (Awang, 2015). Therefore, the total number of shows performed in 2016 can be used to identify the benefit of the cultural value.

Indirect Use Value

Carbon Sequestration

Van Beukering *et al.* (2003) estimated that the marginal damage costs to the Leuser National Park in determining the carbon value costs due to forest loss. The estimated carbon value ranged between USD6.3 and USD228 per tonne. Whereas, in a more recent study, the carbon value in Taman Negara, Pahang was determined by Jamal and Ahmad (2013) using a different approach, i.e. the mitigation method. The study utilised the information on the biomass and carbon content of the forests and oil palm cultivation from past studies to reach a modest price of carbon value ranging from USD5 (low) - USD9 (high) per tonne. Under sustainable logging and oil palm cultivation, it was found that the carbon value accrued 71.9 per cent of the TEV of Taman Negara, Pahang.

This was also followed by a study conducted by Eswani *et al.* (2017) on carbon estimation of Nypafruticans (Thunb.) Wurmb in Marudu Bay, in the state of Sabah, Malaysia. This study was conducted to develop an allometric model of N. fruticansto estimate total carbon stock including the TEV for carbon in a Nypa forest at Marudu Bay mangrove forest, Sabah. Total carbon stocks were estimated at 1.43 tC/ha, and the TEV of carbon stocks in N. fruticans ranged from RM 18.93/ha to RM 3,180.63/ha.

Watershed Services

Another indicator under the Indirect Use Value is the watershed services benefits. Forested watersheds capture and store water (Ninan & Inoue, 2013). Studies in the Southeast include a study in Cambodia by Soussan and Sam (2011) who estimated the watershed services' provision by the wider Mekong Region using the WTP concept. The value of the watershed services was estimated to be (USD188/ha/year) in the study. Alternatively, unlike in Southeast Asia, Krieger (2001)utilised the amount of spending to protect their watersheds in Portland, Oregon, amounting to USD 920,000 and in Portland, Maine to USD 729,000 per year as the measure for the watershed benefits.

Soil Erosion

The third indicator is the value of soil erosion prevention. The erosion occurring in logged areas are related with skid trails and roads. Consequently, in a study in Taman Negara Baharuddin *et al*. (1996) found that the bulk density of the ultisol soil increased from the condition without erosion (1.1 Mgm-3) to between the range of (1.5 and 1.6 Mgm-3), Additionally, the researchers noted a decrease

in porosity of 62 and 69% in the soil. In a later study, a benefit transfer method was deployed in a study at Taman Negara, Pahang to estimate the effect of soil erosion as a consequence of logging activities by Jamal and Ahmad (2013). With this, the value of soil erosion per ha was retrieved from a study conducted by Shahwahid *et al.* (1997), and then the value was apportioned based on the size of the area of Taman Negara, Pahang in the study.

Support to the Downstream and Upstream Fisheries

The third indicator is the support to the downstream and upstream fisheries. The importance of mangroves to coastal and offshore fisheries is widely recognised (Yulianto *et al.*, 2016). A locally conducted study on the value of a Mangrove Forest Reserve in Sarawak was conducted by Bennett and Reynolds (1993). The study estimated the mangroves support for the fisheries by obtaining the data on the divisional income from the fisheries in 1989 that was USD19.3 million. On the other hand, studies conducted internationally on mangroves include a study on estimating the value of the mangrove ecosystem endangered by shrimp aquaculture in Sri Lanka by Gunawardena *et al.* (2015). The secondary data were obtained from the available government catch data.

Genetic Diversity

The biological diversity of a forest is divided into different levels, including the ecosystem, landscapes, species, populations, and genetics (FAO, 2001). The diversity of a forest's genetic resources permits the potential for a species to familiarise to climatic changes and related future challenges, such as temperature changes, drought, pests, diseases, and forest fires (Fussi *et al.*, 2016). In this regard, the average estimates of the genetic diversity specifically for the tropical forest based on the values of the 2007 price levels per ha amounted to USD23 per ha. Limited studies have addressed the economic value of a forest's genetic diversity (Groot *et al*., 2012).

Nursery Services

Forests, for instance, the mangrove forests, are home to a large variety of fish, crab, shrimp, and mollusk species (UNEP, 2011). These fisheries form an essential source of food for thousands of coastal communities around the world (UNEP, 2011). The forests also serve as nurseries for many fish species (Ninan & Kontoleon, 2016). Nursery functions occur when ecosystems provide breeding and nursery areas for species (Notte, 2017). Nursery services are value-added to the inshore and offshore production of fish (Emerton & Aung, 2013). Studies on habitat service valuation studies including, valuations of wetland and forest ecosystems have been extensively studied; nonetheless, there are scarce studies on nursery services (Notte, 2017). For example, the average estimates of the nursery services specifically for the tropical forest based on values of the 2007 price levels per ha amounted to USD16 per ha (Groot *et al*., 2012).

Non-Use Value

Conservation Value Ecotourism

The non-use value is composed of either the altruist value, existence value or bequest value. Of the popular methods for environmental valuation, the contingent valuation method and choice modelling method have been recently used by researchers to value the tropical forests in Southeast Asia. Contingent valuation (CVM), and Choice Modelling (CM) are the methods used to assess non-use values for measuring both large discrete and marginal changes in ecosystem goods and services (Nijkamp *et al.*, 2008). The CVM includes the use of surveys to obtain responses about their maximum willingness-to-pay (WTP) or willingness-to-accept (WTA) for hypothetical changes in environmental quality (Resende *et al.*, 2017). Whereas, the CM method can estimate values for alternative multi-attribute resources using options and marginal changes in each attribute(Shin *et al.*, 2017).

Discussion

The present review had successfully identified sixteen indicators for a valuation of tropical forests. Five indicators were for the DUV-consumptive that belonged to the provisioning services. The indicators include the timber logs, non-timber forest products, handicrafts, endangered species, and hydrological services. For the DUV-Non-consumptive, which belonged to the cultural and amenity services, four indicators were identified include, education and research, recreation and ecotourism, tropical ethnobotany, and indigenous cultural commoditization. Six indicators belonged to IUV, whereby four indicators, namely carbon stock and sequestration, watershed services, soil erosion, and support to downstream and upstream fisheries belonged to the regulating services; while the other two indicators, which are genetic diversity and nursery services were for the habitat and supporting services. Finally, one indicator, namely the conservation value for recreation and ecotourism, whereby the altruist/existence/bequest value that measures the NUV belonged to the cultural and amenity services.

Identification of the indicators as well as potential indicators in valuing tropical forests was possible through a thorough review of past studies conducted in the tropical forest. The studies include on mangroves, peat swamps, wetlands, hill and lowland dipterocarp, and agriculture-based forests both in Southeast Asia and other parts of the world. Additionally, this study included potential indicators from TEV studies conducted in marine valuation studies, such as biodiversity, education, and research that are potential to be included in the TEV framework of tropical forests.

This study has also, encompassed new potential variables for a TEV of tropical forests. Integration of the ecosystem services' components (provisioning, regulating, habitat services, and cultural and amenity services) with the actual TEV concept (use value, indirect use value, and non-use value) has allowed for the identification of new potential indicators for a TEV of tropical forests. For example, the review identified indicators like endangered species, handicrafts, hydrological services, soil erosion, genetic diversity, nursery services, tropical ethnobotany, and indigenous cultural commoditization. Hence, the proposed framework is deemed to reflect a comprehensive measurement of the TEV of tropical forests.

Conclusion

Economic valuation of forest ecosystem services is vital to the society in general, and policy making, specifically as natural resources are scarce the devaluation or degradation associate prices to society (Pearce, 2001). Hence, the measurement of ecosystem services is a fundamental step in conserving them. Failure to impute the price would misguide the policy and society would be worse off as a result of the misallocation of resources (Pearce, 2001). Another importance of economic valuation includes implementing pricing schemes through an implementation of an entrance fee which in turn can efficiently allocate the resources available at a particular site (Ahmad, 2011). Besides that, the government can utilise the findings from ecosystem valuation to justify conducting conservation programs pertinent to biodiversity conservation efforts in a particular site (Kumar, 2010). Furthermore, the benefits associated with ecosystem services are directly juxtaposed with the economic value of alternative resource use in options specifically by assigning monetary values to biodiversity, (Matthew *et al.*, 2013).

The review conducted in this paper will act as a guideline or reference for studies on the TEV of tropical forests. This is following the fact that very limited studies have been conducted on divulging the TEV of tropical forests for decision-making purposes with regards to the conservation of the resources. An identification of the TEV is hoped to alert the community regarding the importance of conserving the natural resources in tropical forests. Besides that, it can be used as a guideline to the decision makers, namely, the policy makers and park managers pertinent to the development and

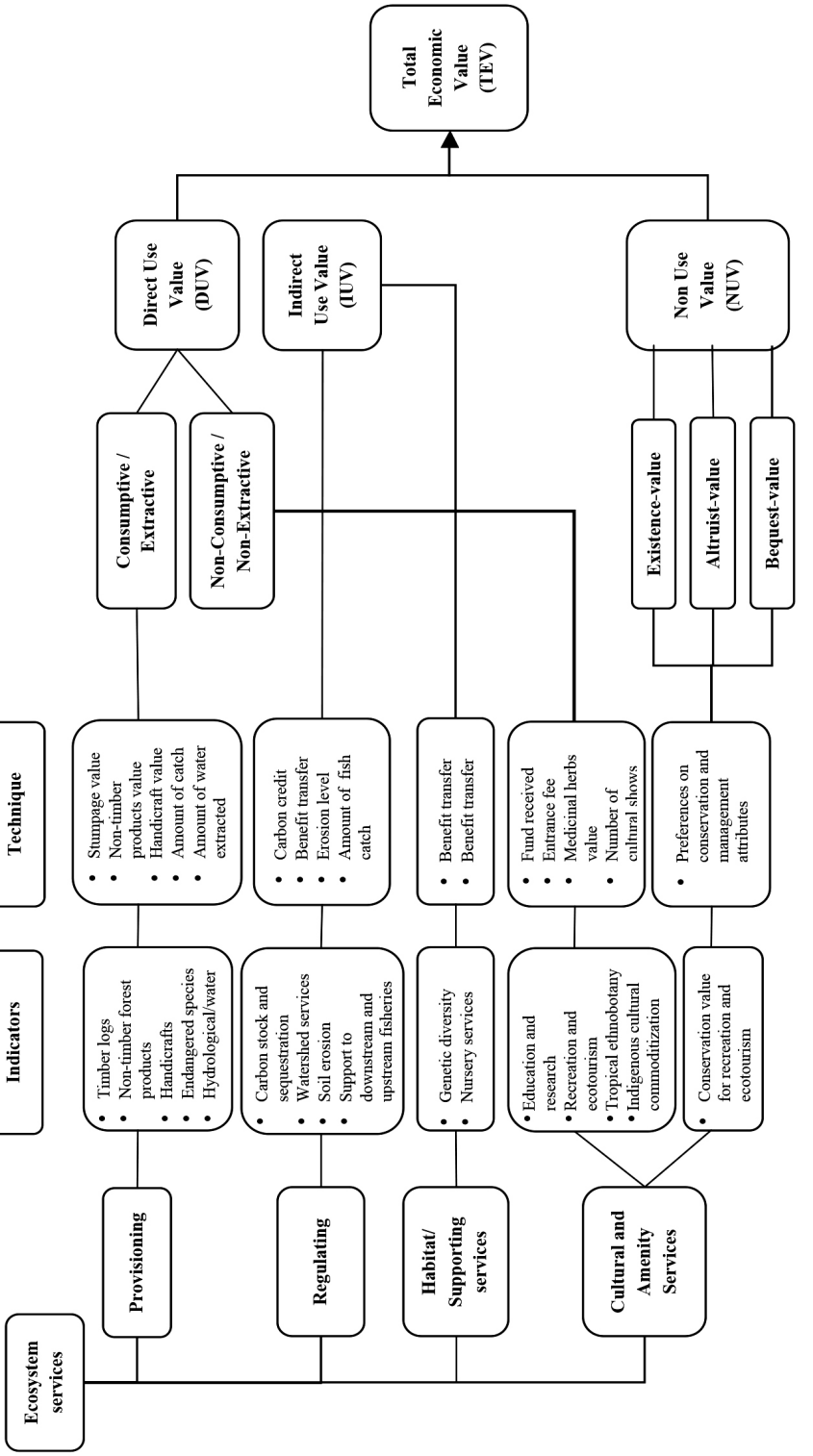

Figure 1: Proposed Conceptual Framework for the TEV of Tropical Forest in Malaysia

efficient management of the park. Furthermore, findings from the benefits of the TEV in the monetary value can be applied in cost-benefit analyses (CBA) of government and private organisation's projects. This information will be useful to show the benefits from the conservation of the tropical forest resources as compared to the return from the alternative development projects. Furthermore, valuation is a must to arrive at the natural resource accounting to project the net present value of the resources (Kumar, 2010).

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