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Total Economic Value of Marine Ecosystem Service in Malaysia: A Review

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ABSTRAC T

The marine ecosystem service in Malaysia offers wealth benefits, including fisheries resources, ecotourism, coastal protection, climate regulation, and nutrient recycling. However, the failure to impute the price of ecosystem services (ES) in marine ecosystem service would result in a misguided policy, and society would be detrimental as a result of the misallocation of resources. The full potential of these services has not been fully quantified in economic terms. This paper reviews the suitable indicators pertinent to a Total Economic Value (TEV) of marine ecosystem service to propose a conceptual framework for the TEV of marine ecosystem service in Malaysia. We conduct a comprehensive review of the marine ecosystem service components (2018–2023) of literature. Studies are categorised based on the TEV and ES components they refer to, as well as the different approaches to the use of ecosystems. This review aims to establish a standard for future research on the TEV of marine ecosystem services, as there is a lack of studies on this topic, and to raise community awareness of the value of protecting natural resources, inform policymakers, and aid in cost-benefit assessments of initiatives. The data will help demonstrate the benefits of protecting marine ecosystem services.

INTRODUCTION

Malaysia's coastal and marine regions are extremely rich in biodiversity. The Coral Triangle region, which includes coral reefs, mangrove forests, mud flats, sea grass areas, and sandy beaches, is considered to have the highest diversity of marine life in the world. Malaysia's Exclusive Economic Zone (EEZ) borders this region (Ministry of Natural Resources and Environment Malaysia, 2020). Ecosystem Services (ES), defined

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as the advantages of ecosystems for all people, are the subject of a lot of current research and policy initiatives (Lee et al., 2022; Dang et al., 2021; Nguyet et al., 2021; Abas et al., 2019). A new perspective on how the environment affects human well-being is encouraged by this evolutionary approach to nature (Rasheed, 2020; Tonin, 2019; Newton et al., 2018). In general, ESs are those that people in all civilisations benefit from and are supplied by the natural environment (Filho et al., 2022). The products or outcomes of ESs affect culture, the global economic system, and human well-being both directly and indirectly (Friess et al., 2020; Rasheed, 2020; Martino et al., 2019; Abas et al., 2019).

Even if ESs are crucial for everyone's comfort, it is challenging to quantify how they contribute to economic development. They are typically viewed as less significant or irrelevant in the process of formulating policy since they are not traded on trading markets (Lee et al., 2022; Mamat et al., 2020). Economic analysis is essential to getting the intended economic results and determining the probability of long-term financial gains for a project. Consequently, the final decisions may support the findings that ESs actually have commercial value by quickly substituting more economical ecosystem uses for inappropriate ones (Hermes et al., 2018; Arabamiry et al., 2013). Therefore, when making economic decisions, considerations related to monetary values must be included. ES estimation proponents contend that estimates can (i) improve our understanding of challenges and potential solutions (Filho et al., 2022; Mamat et al., 2020); (ii) be applied precisely to decision-making (Martino et al., 2019); (iii) illustrate profit allocation and thereby facilitate cost-sharing administrative actions (Hoyos & Mariel, 2010; Richard & Ostensson, 2003); and (iv) inspire the development of innovative organisational and market mechanisms that facilitate sustainable ecosystem management (Salinas et al., 2022; Loomis et al., 2019; Martino et al., 2019).

Benefits that people derive from ecosystems are included in ESs (Steenbeek et al., 2021). They consist of socio-cultural activities and supporting services needed to maintain the operation of the other services (Dang et al., 2021; Barbier et al., 2017; Failler et al., 2015). These amenities, which include everything from the regulation of waste treatment to the supply of enough food and water, are essential to human health and welfare. It is challenging to comprehend the causal relationships between environmental change and human health since they are frequently ambiguous, shifted over time and space, and dependent on a number of moderating factors (Azadi et al., 2021; Marcos et al., 2021; Rasheed, 2020). There may be major direct health implications for society if ESs are unable to address social demands (Mamat et al., 2020; Hermes et al., 2018). According to Langle-Flores & Quijas (2020) and Tokunaga et al. (2020), changes in ESs might indirectly affect jobs, livelihoods, local migration, and even political and social conflict. Thus, ESs support economic well-being in two ways: first, by helping to generate income and well-being, and second, by preventing damages caused by humans. In the end, the assessment of ESs through monetary valuation techniques can assist in two areas: 1) establishing if a policy excitement (which modifies the current condition of the ecosystem) benefits society overall (Loomis et al., 2019; Martino et al., 2019), and 2) determining who is responsible for the environmental harm (Rojas-Nazar et al., 2022). In addition, the application of economic concepts (including monetary and economic valuation techniques) has aided in our understanding of how human activity has affected the environment in Malaysia (Safuan et al., 2022; Kamaruddin et al., 2021; Crehan et al., 2019; Faridah Hanum et al., 2019; Himes Cornell et al., 2018; Koh et al., 2018; Menegon et al., 2018).

Therefore, to discover prospective indicators of marine ecosystem services for new TEVs, it is vital to integrate the components of ES (provisioning, regulating, habitat services, cultural and amenity services) with the actual TEV idea (use value, indirect use value, and non-use value). Therefore, the purpose of this paper is to determine the knowledge gaps in the TEV of the marine ecosystem service and to add to the body of knowledge by creating a comprehensive TEV framework that is based on the ES that support it.

The remainder of this paper is organised as follows. Section 2 presents the literature review on indicators for TEV of marine ecosystem service valuation. Section 3 explains the methodology of the

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research. Section 4 discusses the discussion of findings, and Section 5 concludes the paper by highlighting the need for further research.

TOTAL ECONOMIC VALUE (TEV)

TEV incorporates all components of utility resulting from the ecosystem services (ES) and engages a common unit of accounts, such as cash or any market-based unit of measurement that enables evaluations of the benefits of numerous products (Pascual et al., 2012). The TEV framework can be divided into use and non-use values, as indicated in Table 1. Within the 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: food, fibre and fuel, biochemicals, natural medicines, pharmaceuticals and freshwater supply.

Next, the indirect use value or ecological value is the benefit derived from the regulation services provided by species and ecosystems (Mehvar et al., 2018), which include air-quality regulation, climate regulation, water regulation, natural hazard regulation, carbon storage, nutrient recycling, and microclimatic functions, to name a few. The option value is denoted as the monetary value of individuals willing to pay for the conservation of recreational resources for the resource's sustainability (Pascual et al., 2012).

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 when identifying the environmental element, such as animal species, that will be preserved for present and future use (Baral et al., 2016). Some of these examples are landscape, heritage, and culturally based. The bequest value is the satisfaction that an individual gains upon knowing that the resources will be conserved for future generations (Lindberg et al., 2020; García-Llorente et al., 2011). Finally, the altruist value is the value attained by an individual by identifying that the resource will benefit others too.

Table 1. Valuing ecosystem services through the TEV framework

Elements/ Category	Services	Direct Use	Indirect use	Option value	Non-use value
Provisioning Service	Includes: food, fibre and fuel, biochemicals, natural medicines, pharmaceuticals, fresh water supply	*	NA	*	NA
Regulating Service	Includes: air-quality regulation, climate regulation, water regulation, natural hazard regulation, carbon storage, nutrient recycling, micro-climatic functions, etc.	NA	*	*	NA
Cultural Service	Includes: cultural heritage, recreation and tourism, aesthetic values	*	NA	*	*
Supporting/ Habitat Service	Includes: primary production, nutrient cycling, soil formation	Habitat services are valued through the other categories of ecosystem services			

Source: Pascual et al., 2012

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EXISTING INDICATORS FOR TEV OF MARINE ECOSYSTEM SERVICE

Marine ecosystems are one type of natural ecosystem that have different characteristics and serve different purposes. Many attributes and functions of these things are beneficial to human activities, communities, and industries. The advantages that people derive from the inherent qualities and activities of ecosystems are known as ecosystem services (ES). These advantages could be in the form of tangible products like food or intangible biological services like nutrient recycling and waste treatment. Table 2 illustrates the description and classification system for ES that the Millennium Ecosystem Assessment (MA) created. There are numerous methods for categorising ecosystem services. The Common International Classification of ES (CICES 2013), Economics of Ecosystems and Biodiversity (TEEB 2010), and Millennium Ecosystem Assessment (MA 2005) are the three primary classification methods used globally (Conservation of Arctic Flora and Fauna (CAFF), 2015; Weber, 2010; Millennium Ecosystem Assessment, 2005).

Table 2. Classification of ecosystem services

Provisioning Service	**Regulating Service**	**Cultural Service**
Products obtained from ecosystems e.g. • Food • Fresh water • Fuel wood • Biochemicals • Genetic resources	Benefit obtained from regulation of ecosystem processes e.g. • Climate regulation • Disease regulation • Water regulation • Water purification • Pollution	Non-material benefits obtained from ecosytems e.g. • Spiritual and religious • Recreation and ecotourism Aesthetic • Inspirational • Educational • Sense of place • Cultural heritage
Supporting Service Services necessary for the production of all other ecosystem service e.g • Soil formation • Nutrient cycling • Primary production		

Source: Millennium Ecosystem Assessment, 2005

This section reviews papers that either quantify the services offered by multiple ecosystems that were previously examined (with included studies that concentrate on marine protected areas) or simply refer to "marine and/or coastal ecosystems" without mentioning any particular kind of ecosystem. These investigations have been placed under the ecosystem heading "Coastal and Marine Ecosystems" as a result. It is anticipated that the review of this research would supplement earlier analyses regarding the importance of economic valuation for improved management of coastal and marine ecosystems, as well as the value of services these ecosystems provide.

Table 3 reports a list of ten papers presented in terms of their study object, the ES /s being valued (together with the Millenium Ecosystem Assessment (MEA) category/ies which they belong to), the types of value being estimated (together with the estimation technique/s), their main outcomes (indicating the year the monetary values refer to), and their main policy implications (Torres & Hanley, 2016).

Table 3. Overview of existing marine ecosystem service indicators

Author **Elements/ Category**	**Indicators**	**(Abas et al., 2019)**	**(Dang et al., 2021)**	**(Stoeckl et al., 2021)**	**(Lebreton et al., 2019)**	**(Pascoe et al., 2019)**	**(Martino et al., 2019)**	**(Friess et al., 2020)**	**(De Valck & Rolfe, 2022)**	**(Mehvar et al., 2018)**	**(Friess et al., 2020)**
Provisioning	Food	√	√		√			√		√	√

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Service	Raw Materials		√				√			√
	water		√					√	√	
	Genetic resources	√	√				√			√
	Medicine									
	Ornamental resources	√	√						√	
	Coral harvesting									
	Commercial fishing					√				
Regulating Service	Erosion prevention	√		√	√		√		√	
	Climate regulation	√	√	√				√	√	
	Biological control		√			√			√	
	Pollination	√	√						√	
	Air quality regulation	√	√		√	√	√			
	Regulation of water flows	√	√	√	√				√	
	Regulation of extreme events		√							
	Waste treatment	√	√			√				
	Storm surge protection	√							√	√
Cultural Service	Aesthetic information	√	√			√	√		√	√
	Recreation and tourism	√	√	√	√		√	√	√	√
	Inspiration for culture, art, design		√	√		√			√	
	Spiritual experience	√	√		√		√			√
	Information for cognitive development	√	√	√					√	
Supporting/ Habitat Service	Maintenance of life cycles		√	√	√	√			√	
	Maintenance of genetic diversity		√	√	√				√	
	Atmospheric O_2 production			√					√	√

Source: Researcher Analysis

Direct Use Value-Consumptive

(i) Food

Fish habitat is greatly benefited by coral reefs and the adjacent ecosystems, which include seagrass beds and mangroves. Malaysia has one of the highest per capita annual fishery product consumption rates in the world, at 56 kg. This demonstrates how valuable fish resources are to our people. Additionally, the fishing sector contributes 1.3% of the GDP of our country. Mangrove, seagrass, reef, and open sea ecosystems support the growth and reproduction of a variety of fish and invertebrate species that humans consume by offering the right conditions for reproduction and feeding. The services that one or more of these ecosystems give determine the productivity of a fishery. Numerous metrics can be used to quantify fishing, such as the number of fishermen, boats, kilograms of fish caught, or the number of fish consumed by households. Although these figures are without any commercial worth, they could be a useful indicator of how big of an ES it is. We now offer a method for

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calculating the yearly value of seafood harvests to enterprises engaged in fishing or to fishermen themselves (Salam et al., 2021).

(ii) Raw Materials

Materials (biotic) that are used directly or employed in the manufacture of goods. For example, genetic breeding uses plant genetic resources as the starting point to develop traits like disease resistance and higher productivity. The increased variability of weather patterns observed in recent times has frequently been linked to climate change on a global scale. In many nations, there has been a discernible increase in the frequency and intensity of droughts and floods. Plants that could resist floods and droughts would be able to maintain food production and guarantee food security (Martin, 2023).

(iii) Water

Malaysia is extremely privileged to have an abundance of biodiversity, particularly in its seas, which make up about 60% of its entire land and sea area. The marine ecology includes a wide range of habitats, but the coral reefs are home to 612 species of coral, which accounts for 77% of all known coral species globally. Furthermore, the privilege of the marine region is strategically important since scientists have determined that it is part of the Coral Triangle (Asian Development Bank, 2019).

(iv) Genetic Resources Medicine

Natural products are used as biochemical, medicine and/or cosmetics (Snäll et al., 2014). This idea relates to the genetic diversity within a species. A single individual never possesses all the genes found in a species: various individuals within the same species have a large number of distinct genes in addition to numerous identical ones. Genetic diversity is essential for the ability to adapt to shifting environmental factors. When a species loses genetic diversity, its ability to adapt to new environments is either completely destroyed or significantly hampered (Loevei et al., 2010).

(v) Ornamental Resources

Harvest of seafood/algae from marine and terrestrial aquaculture farms. Harvest of berries, mushrooms, (edible) plants, hunted wild animals, fish catch from recreational fishing, semi-domestic animal husbandry and collection of natural ornaments (e.g., seashells, leaves and twigs for ornamental or religious purposes) (Salcone et al., 2016).

(vi) Coral Harvesting

An estimated 3,600 km2 of coral reefs exist in Malaysia, most located on the eastern coast of Peninsular Malaysia, in Sabah and Sarawak. With over 550 species, Eastern Malaysia has the greatest diversity of coral. Nevertheless, a multitude of environmental hazards confront the nation's coral reefs. In Peninsular Malaysia, agricultural expansion raises the rates of sedimentation and nutrient runoff relative to what would otherwise occur. Destructive fishing methods, including cyanide fishing, are common in East Malaysia, especially in Sabah. River sedimentation is the main danger that coral reefs in Sarawak confront. In general, resource-use conflicts and deficiencies in institutional ability for management and enforcement are the main causes of inadequate coral reef conservation (Asian Development Bank, 2019).

(vii) Commercial Fishing

Fishing for the purpose of selling or exchanging seafood for money is known as commercial fishing. In many Pacific Island nations, commercial fishing plays a significant role in the economy. The value of commercial fishing is the whole of the value that fisheries provide to

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companies, people, and consumers who buy and consume fish. The producer surplus is computed by deducting the fishing expenses from the total revenue received by fishermen (Salcone et al., 2016).

All pertinent agencies would have a platform to join if a long-term master plan on the management of fishery resources was developed and institutionalised. The Fisheries Act of 1985 really specifies the requirement for such a master plan; however, it has not yet been created. The design would prevent the haphazard licensing and resource allocation decisions that beset fisheries management today. For the master plan to be genuinely effective, all states would need to sign on to it, and habitat health would need to be considered (Saad et al., 2012).

Direct Use Value for Non-consumptive or Non-extractive

(i) Aesthetic Information

A study indicates that healthy, functioning ecosystems and human perception of beauty are closely related. A property's aesthetic value is recognised by the World Heritage system as having exceptional universal importance. Properties listed according to natural criteria must meet integrity requirements in addition to having values. Thus, it is important to preserve these regions in order to maintain their integrity and sustainability. The Marine Ecosystem Service Area's primary draw for visitors from around the globe is its extremely great aesthetic value. These values are priced in accordance with the coral reef area and the density of fish population in the islands, based on the information that is currently available. As a result, the importance of the marine ecosystem service as a support system for marine biodiversity in Malaysia is still demonstrated by its high aesthetic value over other commercial benefits. The Department of Marine Malaysia bears a tremendous deal of responsibility for safeguarding our marine environment and ensuring its sustainability (Zhou et al., 2020; Urbis et al., 2019).

(ii) Inspiration for Culture, Art, and Design

Marine Ecosystem Services Department In order to maintain the sustainability of our marine natural resources, Malaysia has been tasked with managing and conserving the marine region in Malaysia. To that end, research, regular monitoring, and conservation initiatives are carried out. The department works tirelessly to conduct research, support studies, and keep an eye on surveys that may be useful for managing our marine resources and tracking changes to our marine ecosystem. Funding for the department is consistently provided (Rojas-Nazar et al., 2022; Ministry of Natural Resources and Environment Malaysia, 2020).

(iii) Spiritual Experience

Spiritual or emotional benefits that people attach to local environments or landscapes due to religious and/or spiritual experience. Spiritual well-being in terms of mental fulfillment, which includes social and cultural elements like positive relationships and the values they uphold, as well as freedom and choice. In other words, it is a blend of subjective and relational well-being (He et al., 2021).

(iv) Information for Cognitive Development

The potential for environmental education, i.e., out of a formal school's context, and the knowledge in terms of traditional knowledge and specialist expertise arise from living in a particular environment. Marine ecosystem services provide unique, unaltered locations for education and research, especially for comparison with places affected by human activity. Education values give chances for marine ecosystem service research (Marcos et al., 2021).

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(v) Recreation and Tourism

The approach used to collect fees for entry and visitor direct spending can be used to calculate the non-consumptive value of recreation and tourism. Only a small number of research utilising the first method to calculate the TEV were conducted in Malaysia. A study carried out by DMPM (2011) in the Pulau Payar Marine Park (PMPM), Kedah, Malaysia, made use of this methodology. The analysis involved multiplying the entire number of people who arrived at the park in 2010 by the price of entry, which came to RM480,485 in total. On the other hand, studies that utilised the second approach in Southeast Asia include an investigation by Van Beukering et al. (2003). By adding up the real amount of money visitors spent at the Leuser National Park in Sumatra, Indonesia, on both their entrance charges and other expenses, the recreation value was calculated. Opportunities for outdoor activities and tourism in the environment or landscape include sports, leisure and outdoor pursuit (Ismail & Goeden, 2022; Ali et al., 2013; Yacob et al., 2009).

Indirect Use Value

Regulating Service

(i) Erosion Prevention

Coral reefs act as inherently protective barriers against storm surges, which have the potential to severely damage communities and coastlines. It has been stated that the mangroves and coral reefs lining our coastal zones can serve as barriers against storms, tsunamis, and coastal erosion. This was demonstrated by the fact that mangrove tracts in the Straits of Melaka were unaffected by the 2004 tsunami (Bryan-Brown et al., 2020; Remoundou et al., 2015).

(ii) Climate Regulation

Ecosystems' long-term capture and storage of greenhouse gases relieves pressures caused by atmospheric CO2 concentrations, slowing the dynamics of global climate change. Control operations include optimising local living circumstances and regulating local climatic components like wind, precipitation, temperature, or radiation due to ecosystem features (Onofri & Nunes, 2020).

(iii) Biological Control

It is generally acknowledged that maintaining biodiversity and the habitat of species is one of the primary purposes of marine biological control. Constanza et al. (1997) asserted that these functions, in turn, produce goods and services that benefit human populations. Numerous endangered species can be found in Malaysia due to marine biological management. A few examples of endangered species that are automatically protected include sharks, dugongs, gigantic clams, and sea turtles. This area provides food, cover from predators, an area to grow out, and a habitat for breeding (Panyawai & Prathep, 2022).

(iv) Pollination

Assistance in plant reproduction and fruit growth by bees, birds, bats, moths, flies, and wind can provide food and biodiversity for plants. According to Perez-Verdin et al. (2016), agriculture requires pollination, biological pest control, and sufficient water for crop production.

(v) Air Quality Regulation

Gathering, absorbing, and filtering dust, gasses, and chemicals from the air as a result of eco-chemical processes that benefit society by, for example, improving the health of individuals

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by cleaning the air. Freshwater ES are extremely valuable and extend much beyond the surface area they cover. They are essential in linking habitats. Preserving the watersheds that are essential to habitats ensures their biodiversity and the continuous provision of ES (Lehtoranta & Louhi, 2021).

(vi) Regulation of Water Flows

Management of water cycle activities, such as buffering and storing water, prevents droughts and allows natural drainage. Supplying water and water products in useful amounts and ratios will help society. For instance, the amount of wastewater entering the wetland has greatly expanded above its ability to absorb the additional contaminants before they reach the ocean (Gelo & Turpie, 2021).

(vii) Regulation of Extreme Events

Growing ecotourism is seen as a means of bringing the advantages of ecosystem preservation into the realm of the economy, raising the establishment of ecosystem conservation's value and bringing economic generation and ecological protection together. Numerous research on the preservation of ecosystems offer insightful scientific benchmarks that can be used as trend regulators and as the foundation for comprehending the wider effects of human-caused hazards. Restricting extractive activities, such as fishing and the exploitation of other marine organisms, will damage the marine ecology and, if not managed sustainably, lead to the industry's demise. To guarantee that our marine ecosystem service continues to be the top option for tourists and environment enthusiasts, sustainable tourism management is crucial (Remoundou et al., 2015).

(viii) Waste Treatment

Control of organic material decomposition and filtration in soils and water, including safe disposal and breakdown of human waste. Ghani (2017) stated that trash treatment has an economic worth of RM 2,363,334.

(ix) Storm Surge Protection

Each of these ecosystems offers a wide range of ecological and ES, and each has its own distinctive, exceptional biodiversity. Seagrass beds, mangrove forests, and coral reefs are interdependent ecosystems that safeguard coastal regions. Reefs made of coral can lessen the wave energy that hits the shore. The existence of mangrove forests and seagrass reduces this energy even further. In a similar vein, these ecosystems act as organic defences against storm surges and wave erosion, which can result in significant harm (Vásquez et al., 2022; Koh et al., 2018; Torres & Hanley, 2016).

Habitat Service

(i) Maintenance of Life Cycles

The marine parks in Malaysia are sections of the ocean devoted to preserving and protecting biodiversity together with natural and cultural processes. Many of the items on which we rely every day are made of materials or components that come from the sea. The marine ecology will eventually completely collapse if our marine resources are overfished or poorly managed (Boero et al., 2019).

(ii) Maintenance of Genetic Diversity

Human health is protected from pests and diseases by genetic changes in plants and animals that make them less susceptible to disease, as well as by the acts of predators and parasites

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(Lavoué et al., 2022). This idea relates to the genetic diversity within a species. A single individual never possesses all the genes found in a species: various individuals within the same species have a large number of distinct genes in addition to numerous identical ones. Genetic diversity is essential for the ability to adapt to shifting environmental factors. According to Loevei et al. (2010), a species that has lost its genetic variety is either unable to adapt to new environments or can only do so very poorly.

(iii) Atmospheric O_2 Production

Carbon sequestration plays a critical role in maintaining the life of the global community by controlling temperature. Mangroves, seagrass beds, and coral reefs can catch and store carbon dioxide. These coastal regions are frequently home to these ecosystems. These ecosystems work together to sustain one another, maintain a balance in CO2 emissions, and slow down the warming effect of CO2 (Perez-Verdin et al., 2016).

Non-Use Value Conservation

(i) Conservation Value for Recreation and Ecotourism

Marine life abounds in the ocean and coastal regions surrounding Malaysia, including coral reefs, mangrove forests, and seagrass beds. These habitats and the resources they contain sustain while providing people access to a wide range of goods and services, such as seafood, recreational areas, tourist destinations, opportunities for research and education, coastal protection, and much more. Furthermore, the creation of a marine protected area could ensure the preservation of all marine assets and habitats for future generations. Another crucial role of the marine ecosystem is the utilisation of its resources for future generations. While it is challenging to put a monetary value on these resources, they are nonetheless very significant.

METHODOLOGY

The study was conducted through an extensive analysis of the literature on the identification and classification of primary valuation studies in the marine ecosystem service, which was undertaken to determine the use and effect of different biodiversity. This study reviewed 'all studies' that estimated elements of the economic value of marine ecosystem service through the full or partial application of the TEV and ES frameworks. The resources for the study were mostly journal articles, conference proceedings, and existing guidelines from leading databases such as Scopus, Web of Science, Taylor & Francis, Google Scholar, and Academic Search Premier. The search was conducted in the database by applying the following keywords: "indicators", "ES", "economic valuation," and "marine biodiversity" and limiting results to Malaysia. These were mainly 'drawn from the period 2018 to 2023' to ensure only the most up-to-date data on marine ecosystem services were used. They were compiled from both international and local contexts since research conducted in Malaysia regarding this field is rather limited. The article search was then limited to the categories by TEV and ES components. Each study was then thoroughly reviewed and categorised by TEV and ES components in the global and Malaysian contexts. Based on the review of the current scenario and existing literature, the components of marine ecosystem service were then analysed. Conservation of Arctic Flora and Fauna, (2015); Maes et al., (2013); Millennium Ecosystem Assessment (2005) listed ES based on their biophysical properties (biotic or abiotic) and according to four categories: (a) Provisioning (e.g., food), (b) Regulation (e.g., climate regulation), (c) Servicing (e.g., maintenance of life cycles) and (d) Cultural (e.g. recreation). The benefits generated by different ES can be identified and combined. This approach has been applied, among others, to marine biodiversity (Dang et al., 2021; Canonico et al., 2019; Tonin, 2019), coastal and marine habitats (O'Connor et al., 2020; Lebreton et al., 2019; Menegon et al., 2018), and coral reefs (De Valck & Rolfe, 2022; Edward et al., 2020; Failler et al., 2015). All studies presented in this review rely partially or entirely upon the TEV and ES frameworks to

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approach the value of marine biodiversity. The four categories described by previous studies of marine ecosystem service are based on the articles reviewed for this study from both international and local sources.

DISCUSSION

The present review had successfully identified four categories of indicators for a valuation of marine ecosystem service. Seven indicators were for the DUV-consumptive that belonged to the provisioning services. The indicators include food, raw material, water, genetic resources, medicine, ornamental resources, coral harvesting and commercial fishing. For the DUV-non-consumptive, which belonged to the cultural services, five indicators were identified: aesthetic information, inspiration for culture, art, design, spiritual experience, information for cognitive development and recreation and tourism.

Six (6) indicators belonged to IUV, whereas four indicators, namely erosion prevention, climate regulation, biological control, pollination, air quality regulation, regulation of water flows, regulation of extreme events, waste treatment and storm surge protection, belonged to the regulating services. Meanwhile, the other three indicators, which are maintenance of life cycles, maintenance of genetic diversity, and atmospheric O_2 production, were used for habitat and supporting services. Finally, one indicator, namely the conservation value for recreation and ecotourism, whereby the altruist/ existence or bequest value measures the NUV belonged to the cultural services.

Identification of the indicators as well as potential indicators in valuing marine ecosystem service was possible through a thorough review of past studies conducted on marine biodiversity. The studies include 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 marine ecosystem service.

This study has also encompassed new potential variables for a TEV of marine ecosystem service. Integration of the ES’ components (provisioning, regulating, habitat and servicing services, and cultural and 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 marine ecosystem service. For example, the review identified indicators like endangered species such as turtles or dugongs, mangroves, food services, soil prevention, genetic diversity, nursery services, and indigenous cultural commoditisation. Hence, the proposed framework is deemed to reflect a comprehensive measurement of the TEV of marine ecosystem service, as displayed in Figure 1.

Given the scarcity of natural resources, the devaluation or deterioration of marine ecosystem services has significant costs to society and policymakers. Therefore, economic valuation of marine ecosystem services is essential (Salinas et al., 2022; Loomis et al., 2019). Hence, one of the most important steps in preserving ES involves evaluating them (Rojas-Nazar et al., 2022). Consequently, the policy would be misguided, and society would suffer from the misallocation of resources if the price were not recognised (Mamat et al., 2020). Another crucial aspect of economic valuation includes implementing pricing schemes, such as charging an entry fee since it allows for the effective distribution of resources at a certain location (Tonin, 2018).

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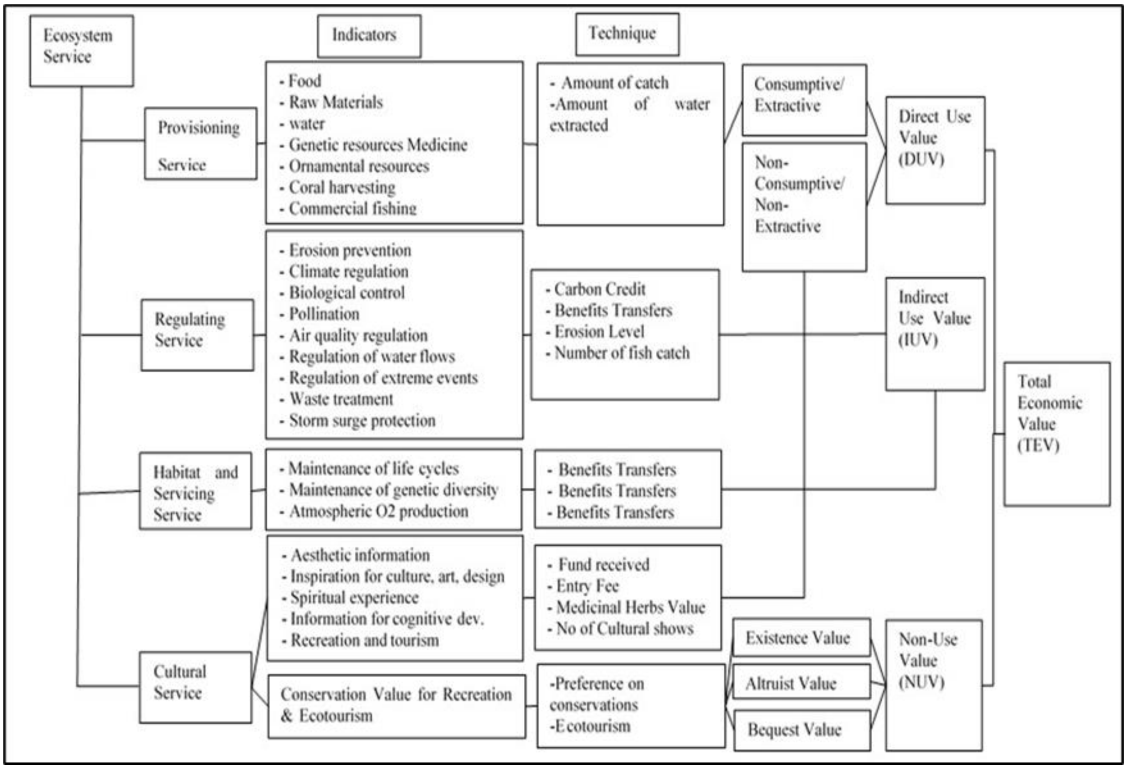

Fig. 1. Proposed Conceptual Framework for the TEV of Marine Ecosystem Service in Malaysia

Source: Researcher Analysis

CONCLUSION

The study of economic assessment of marine ecosystem services is primarily focused on the ES provided by Malaysia. It has enabled us to draw the conclusion that the services provided by the marine ecosystem are valued and advantageous to people both locally and worldwide. Despite a variety of underlying problems, including conflicts between conservation and development demands, a lack of clearly defined limits and scientific justification, and inadequate financing sources, marine ecosystem services, in particular, were identified as having high conservation value. By addressing stakeholder groups who might not be especially interested in environmental conservation per se, an economic valuation assessment like this one can help address these problems by indirectly raising environmental awareness by disseminating easily readable figures. This evaluation can also be used to demonstrate that money allocated for the management of marine ecosystem services can yield returns that are more profitable than the initial investment. Furthermore, can people in Malaysia and around the world benefit from the economic surplus.

The review carried out in this work will serve as a standard or point of reference for future research on the TEV of marine ecosystem services. This comes after an insufficient number of studies have been carried out on disclosing the TEV of marine ecosystem services to inform resource conservation decision-making (Torres & Hanley, 2017). It is intended that the identification of the TEV will raise community awareness of the value of protecting the natural resources that support marine ecosystem services. In addition, it can serve as a reference for policymakers and marine ecosystem service managers who make decisions related to the growth and effective administration of the area. Moreover, results from the TEV's financial benefits

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can be used in cost-benefit assessments (CBA) of initiatives run by public and private sector entities (Tavárez & Elbakidze, 2021). This data will be helpful in demonstrating the advantages of protecting the resources that support marine ecosystem services above the returns from alternative development initiatives. Additionally, in order to predict the net present value of the resources, natural resource accounting requires valuation (Matthew et al., 2019).

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits or commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Wan Nur Ayuni Wan Ab Rashid researched, wrote, and revised the article. Junainah Mohamad anchored the review and revisions and approved the article submission. The third co-author, Mohd Azhar Hamzah, also reviewed and recognised the paper submission.

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