MAPPING ECOSYSTEM SERVICES' ASSESSMENTS: CURRENT PRACTICE AND FUTURE PROSPECTS IN MALAYSIA

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Abstract

Malaysia is one of the countries rich with biodiversity. Currently, the ecosystem services (ES) are found to be degraded in Malaysia and are expected to decline further over the coming century due to the changing political scenarios. The present study focuses on ES assessments in Malaysia, we systematically review literature to summarise achievements to date, identify key research gaps, and reveal pathways for policy uptake. Based on the findings, the current practices and developments in the mapping of ES assessment was identified. The results of research that incorporated practitioner engagement through interviews to learn about their perspectives on valuers' current practices related ecosystem service valuation were included as part of the research analysis. Analysis for this article also took into account conclusions from further semi-structured interviews with valuers working in the field of valuation as well as the most recent developments in application. Thus, we suggest that further research could focus on monetary valuation method. Economic valuation results will provide useful information about changes to welfare. Benefits transfer can be a practical, swift and cheap way to get an estimate of the value of ecosystems service, particularly when the aim is to assess a large number of diverse ecosystems.

Keywords: Ecosystem Service Methodology, Ecosystem Service Assessment, Ecosystem Service Valuation, Decision Making, Mapping, Malaysia

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INTRODUCTION

The Ministry of Natural Resources and Environment Malaysia, (2020) reported Malaysia is a megadiverse country. Malaysia is one of the countries of rich biodiversity together with another six countries in five nations (Brunei, Timor Leste, Indonesia, Philippines, and Singapore). Otherwise, Malaysia is included in Southeast Asia (SEA) known as a region of rich biodiversity. SEA includes four of the thirty-six global biodiversity hotspots according to the Conservation International. Agriculture, fisheries, and forestry play important roles in the economies of many SEA countries (Dang et al., 2021). Abdullah et al., (2015), reported the World Development Indicator recognised that Malaysia is one of the richest countries in the world in terms of biodiversity per unit area.

Valuing Ecosystem Service (ES) has been an important focus of economic analysis in recent decades. The numerous reviews have synthesised ES assessments by highlighting global distributions of ES economic valuation (Egan et al., 2022; Friess et al., 2020; Matthew et al., 2018; Nur Shafiza et al., 2023; Robles Zavala & Chang Reynoso, 2018). Millennium Ecosystem Assessment, (2005) shown the framework of ecosystem services (ES) for communicating links between ecosystems and human well-being is widely used (Bakar et al., 2017). The benefits of ES assessments are provided systematic information to mainstream ES into decision-making (Dang et al., 2021). The growing number of ES assessments globally demonstrates their importance.

The study, therefore, employed both a systematically review literature to summarise achievements to date, identify key research gaps, and reveal pathways for policy uptake and interview method, requiring face-to-face semi-structured interviews. In recent years, an important trend has emerged towards mapping and assessing ecosystem services in general (Mayer & Woltering, 2018). The mapping of ES assessment especially interm of monetary values for ES value has become an active research topic. Mapping and valuation offer the additional opportunity of analyzing trade-offs between different ecosystem services in a spatially-explicit form. In this paper we review studies that map assessment of ES in Malaysia. We define mapping of ES values as the valuation of ES in monetary terms across a relatively large geographical area that includes the examination of how values vary across space. Thereby, mapping of ES values reveals additional information as compared to traditional site-specific ES valuation, which is beneficial for designing efficient policies and institutions for maintaining ES supply. In addition, we make an interview to verify the current practice and get valuers' perspective on current ecosystem service valuation.

LITERATURE REVIEW
Review Framework for Ecosystem Service and Ecosystem Categories in Malaysia
Ecosystem Types
According to CAFF, (2015) reported TEEB database regarding ES as known as biomes. Biomes were classified based on the ecosystem classification of The Economics of ES and Biodiversity TEEB relished in 2010 with minor modifications: (1) combining marine and coastal ecosystems and (2) separating TEEB's cultivated ecosystem into agriculture and agroforest to better represent cultivation systems in SEA. Therefore, the ecosystem classifications used in this review include: (1) agriculture (rice, vegetation, and other crops etc.), (2) agro-forest (oil palm, rubber etc.), (3) forest, (4) inland water (lakes & rivers), (5) marine/coastal/island (coral reefs, seagrass, shores), (6) urban, (7) wetland (coastal wetland: mangrove & marsh and inland wetland: peatland & swamp), (8) mixed (research/publication comprises more than one ecosystem).

Ecosystem Services (ES)
According to the Millennium Ecosystem Assessment, (2005) ecosystem service strongly contributes to human well-being. Natural ecosystems produce various ecosystem services (ES) (CAFF, 2015). Nevertheless, due to the public good characteristics of many ES and their vulnerability to externalities, such as air, soil and water contamination, the costs of ES degradation are not sufficiently incorporated into individual or public decision-making. As a result, ES in all parts of the world is being degraded to a suboptimal extent, causing loss of ES supply. Various national and supranational policies have been introduced to protect natural ecosystems, which have only been partially effective (Suaree et al., 2023). For example, Tong, (2020) stated up to date, Malaysia has ratified approximately 17 biodiversity-related multilateral environmental agreements (MEAs) to provide protection for its biodiversity.

However, the declining forest cover and the relatively high number of threatened species in Malaysia may indicate that biodiversity conservation is not working. Other than that, Malaysia is a federal country with the Federal Constitution as the highest law of the land. Article 76(1) of the constitution provides the power for the federal and state governments to legislate laws in accordance with the division of powers specified under the Ninth Schedule. In theory, the Ninth Schedule provides clear demarcation of jurisdictions between the federal and state governments (Hoe et al., 2023). However, in practice, there appears to be overlapping jurisdictions, which complicate implementation and enforcement of these constitutional powers (Safuan et al., 2022). Reversing the degradation of ecosystems requires ''significant changes in policies, institutions, and practices that are not currently under way'' (Millennium Ecosystem Assessment, 2005).

One of the main challenges in designing effective policies derives from the complexity of integrating multidimensional environmental impacts into decision making processes. Typically, decisions are based mainly on information that is well understood and known with high certainty, for example information on readily observable financial or market transactions. Ecological externalities are typically insufficiently considered because of uncertain estimates regarding expected impacts, difficulties in interpreting results from various disciplines and difficulties in translating impacts into changes in social welfare. Monetary valuation of ES is a method to overcome such difficulties. It enables the aggregation of multidimensional costs and benefits of alternative measures within a one-dimensional welfare measure (Pearce et al., 2006). Although the practice of monetary valuation and its underlying framework are subject to debate and criticism (Spash and Carter, 2001; Sagoff, 2004), the concept of monetary valuation and cost-benefit analysis is widely accepted and subject to intensive research activity. The estimation of accurate ES values, however, is not straightforward, in part due to spatial heterogeneity in biophysical and socioeconomic conditions. The spatial perspective of variation in ES values is relatively new and has not been extensively researched. Insufficient knowledge exists about how ES values differ across space and what their spatial determinants are (Bockstael, 1996; Bateman et al., 2002; Plummer, 2009; De Groot et al., 2010).

Ecosystem Service Assessment Approach
A range of methods are available for assessing ES, from mapping and modelling the supply and demand of ES to evaluate the economic and non-economic importance (Dang et al., 2021). These assessment approaches were divided into four main categories:

1. Economic valuation included contingent valuation, travel cost, market price, choice experiment, benefit transfer, and other economic valuation methods.
2. Mapping included five categories: ES models (e.g., InVEST); other modelling approaches (e.g., hydrological models, species distribution models, agent-based modelling); statistical models (e.g., regression models); proxy mapping (e.g., matrix-based approaches or look-up tables to present ES based on land use/land cover maps); and other mapping approach (e.g., deliberative mapping, spatial interpolation).
3. Assessments of human perception included questionnaire surveys, observations, interviews, and focus groups. Which has been included in this review, studies must have delivered quantitative results such as maps, economic values or semi-quantitative results as scores or grading scales.

4. Other quantitative assessment methods are based on biophysical parameters and involve field measurements, monitoring, and modelling but do not generate a map or valuation of ES. From our database, the following methods are in this category: water balance models, dynamic coupled vegetation and global hydrology models, simple score tables, Bayesian Belief Networks, value quantification from interviews or references.

Ecosystem Service Valuation Approach in Malaysia
Most studies on ES valuation prior to 2009, according to Dang et al., (2021), concentrated on monetary valuation. Since 2009, there has been a change in the way that ES assessments are investigated; more studies are now utilizing both integrated approaches (ES mapping, modeling, assessments of human perception, and other quantitative assessments) and other assessment approaches (economic valuation and mapping, assessments of human perception and mapping, economic valuation and other quantitative assessments). The most popular economic valuation methods in the research ecosystem service sector are benefit transfer, market prices, and contingent valuation (Viti et al., 2022). Consequently, there has been an increasing focus on ES assessments in the scientific research and policies of the region; however, no comprehensive evaluations that track progress and set objectives for the upcoming ES assessments in Malaysia have been created (Lee et al., 2022).

From the overview, the valuation of ES is justified by the fact that, first, the worth of natural resources is not recognized (Leh et al., 2018), and second, human-caused damage is not documented (Abu Bakar & Wall, 2019; Yacob et al., 2009). The community's level of awareness of these issues is still minimal (Arabamiry et al., 2013). Furthermore, property rights and the cost of externalities that are not factored into resource pricing are not clearly defined ES, that support public goods. In the economic evaluation of ES, achieving a just balance between benefits and drawbacks is crucial since we live in a world of scarcity and have to make choices about how to effectively manage it. What level of benefit is required? And what sort of effect is expected? Economic valuation is responsible for determining the optimal combination of ecosystem service flows, provided that this combination optimizes the total value received by resource consumers (Perez Verdin et al., 2016).

RESEARCH METHODOLOGY
The methodology included a desk-study analysis of peer-reviewed and grey literature pertinent to ecosystem services in Malaysia (e.g., online databases and reference lists). The results of research that incorporated practitioner engagement through semi-structured in-depth interviews methods to learn about their perspectives on valuers' present practices related ecosystem service valuation

were included in the literature analysis. Analysis for this article also took into account conclusions from further semi-structured interviews with valuers working in the field of valuation as well as the most recent developments in application.

Desk-Study Analysis
The key review publications of the search strategy were using both online database and reference lists searching, First, the researchers searched on the ISI Web of Science with the following keywords: Malaysia country AND "ecosystem service*" in the title, keyword, and abstract, and published 2018 to July 2023 about 773 publications. The search strategy is as follows: TS = (ecosystem AND service AND in AND Malaysia*). The final number of publications selected for detailed review was 76 of which 6 publications included multiple case studies and only 10 publications reported on economic value. Review results were recorded and organised in an Excel database.

Face to face interviews Analysis
Three key government valuers, including representatives from JPPH Kuala Lumpur, JPPH Sabah, and JPPH Sungai Petani, were interviewed to understand their current practices in ecosystem service valuing. The snowball sampling method was used to gather data from experts in cost-benefit analysis, valuation, and ES officers. The interviews provided valuable insights for developing a comprehensive method for ES valuation, highlighting the importance of face-to-face, semi-structured, in-depth interviews (Urbis et al., 2019).

The concepts that define the current method of ES valuation were the focus of in-depth, semi-structured, open-ended interviews. The length (usually 25–30 minutes) allows for the emergence of complicated concerns (Creswell, 2013). "What are the key elements of ES value, in your opinion?" was the interview opening question. Next, the respondents were questioned regarding the method that was applied to carry out the ES valuation. Subsequent inquiries centered around suggestions for future actions.

ANALYSIS AND DISCUSSION
Quantitative Review on Mapping ES Values Studies in Malaysia
The on-going efforts on the mapping and assessment of ES are totally dependent upon reliable and scientific data. This action needs to integrate with growing scientific evidence on biodiversity as a key component for resilient ecosystems and delivery of ecosystem services. It is on the basis for valuing the multifunctionality of ecosystems for sustaining long-term human well-being. The present study has developed engagement with the scientific community and further strengthened the knowledge and evidence base for policy and decision-making. The function mapping is exploring the potential for valuation and natural

capital accounting at national level. This builds on the biophysical mapping and assessment of the state of ecosystems and of their services in the context of Biodiversity Strategy especially for marine ecosystem (Jabatan Taman Laut Malaysia, 2015) using latest developments on ecosystem accounts at global level and concrete examples of stakeholder (NK et al., 2019; Tong, 2020).

In the total 76 publications analysed, which include 70 separate case studies. The studies differ significantly with respect to their spatial scope, the ES assessed and the methodologies applied. Figure 1 shows the spatial distribution of the case studies across the nation. The colour indicates the type of research study area.
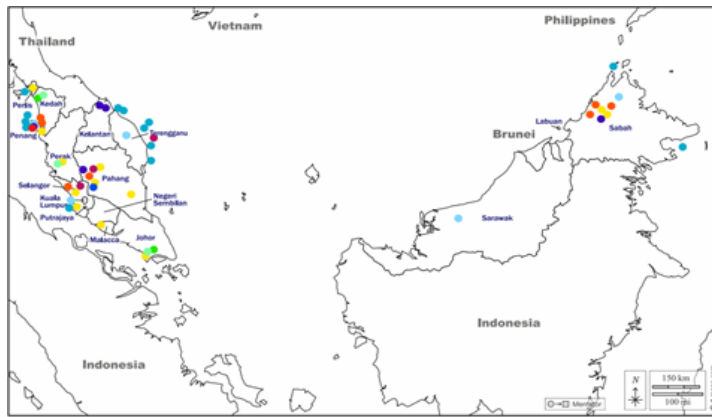

Figure 1: Spatial distribution of case study areas of ES in Malaysia
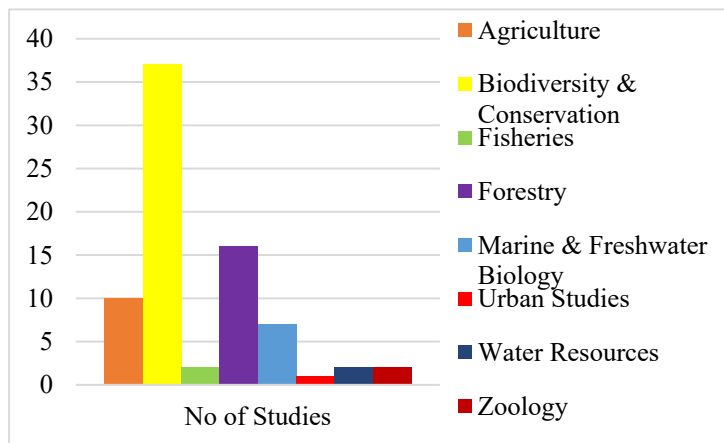*Source: Author Analysis*

Figure 2: Number of ES mapped per case study in Malaysia
Source: Author Analysis

Most studies focus on biodiversity and conservation as shown in Figure 2, which is various purposes of finding and method used. On average, each study maps values for eight ES. Many studies focus on biodiversity and conservation about (37) such as coral conservation. Teh et al., (2018), reported conservation value could be partially funded from tourism. In addition, some studies aim to investigate the diversity and abundance of corals (Khodzori et al., 2019). The findings can help and provide useful information on the current status of corals for a better management plan and by showing the substantial economic value, it can provide an important incentive for protecting biodiversity especially in Malaysia and worldwide. Second followed by forestry about (16) research. Dang et al., (2021), mentioned current government policies more concerning conservation strategy and Malaysia focused on the forest and agro-forest systems. For instance, Malaysia and Indonesia are the largest producers of palm oil in the world. As shown in Figure 3, forest research is about second lower than mangrove research in Malaysia. The frequency with which each ES has been mapped is shown in Figure 2. Moreover, fishermen face difficulties because of mangrove deforestation. Mangrove forests are important to fishermen for sustaining rich seafood supplies as a source of income (Zaiton et al., 2019). Economic Valuations are crucial in providing information for better policy options to decision-makers in designing sustainable ES management for the benefit of the future generations in Malaysia (Matthew et al., 2019).
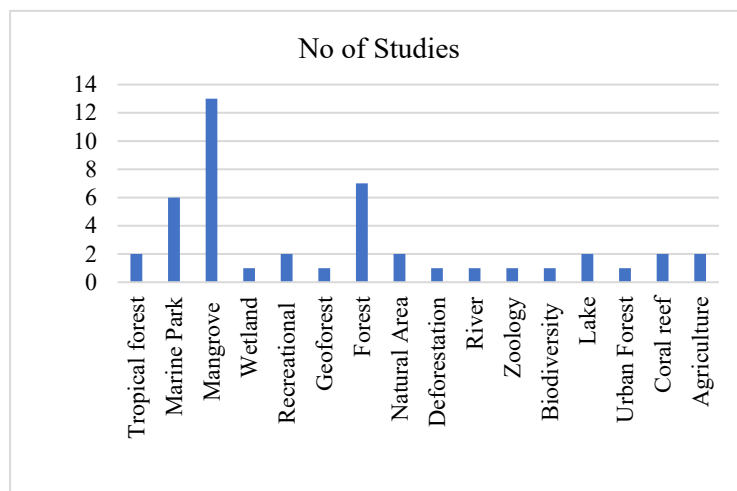

Figure 3: Methodologies used to assess ecosystem in Malaysia
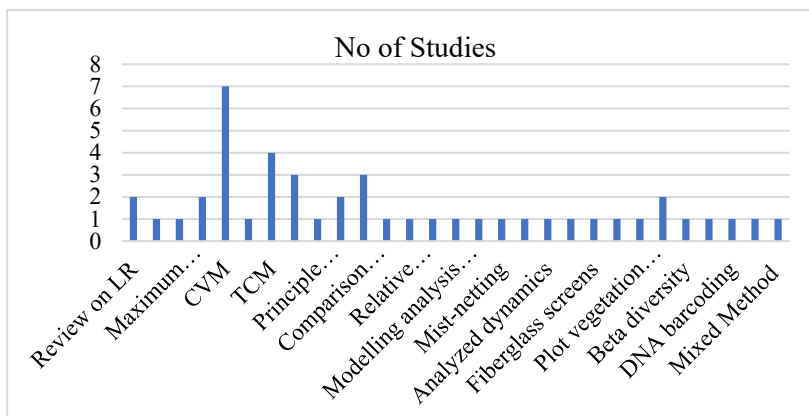*Source: Author Analysis*

Figure 4: Methodologies used to assess ecosystem in Malaysia
Source: Author Analysis

The literature lacks consensus on the best ES mapping method for specific purposes and circumstances. Factors like data availability, ES variables, study area characteristics, resources, policy context, and scientific purpose determine the choice. The advantages and disadvantages depend on the study's quality and background. Diversification of ES mapping can strengthen data-bases for ES assessments, providing a range of potential outcomes in Malaysia and contributing to global ES assessments. The present study identified twenty-nine methods (Figure 4), of which the methods can be categorised in four different assessment approaches.

1) Economic valuation approaches which included contingent valuation (Abdulkarim, 2017; Abdullah et al., 2015; Chong Leon et al., 2005; Hassin et al., 2020; Mamat et al., 2020; Musa et al., 2020; Samdin, 2008; Vianna et al., 2018; Yacob et al., 2009; Zaiton et al., 2019), travel cost (Leh et al., 2018; Matthew et al., 2019; Othman & Jafari, 2019; Solikin et al., 2019), choice management experiment (Arabamiry et al., 2013), benefit transfer (Salisu Barau & Stringer, 2015), and other economic valuation methods. Prior to 2009, studies primarily focused on monetary valuation of ES. However, since then, there has been a shift towards using other assessment approaches, including ES mapping, modelling, and human perception assessments (Dang et al., 2021). Malaysia's most commonly used economic valuation methods include contingent valuation, market price, and benefit transfer, primarily used for cultural services and supporting/habitat services. Contingency valuation is widely used due to its flexibility and ability to estimate total value, including non-use value. Market price is used for monetary valuation of provisioning services, while benefit transfer is

used for regulating services like climate regulation. Benefit transfer offers a quick assessment of economic value.

2) Mapping included five categories: ES models (DNA barcoding)(Lim et al., 2016); other modelling approaches (e.g., hydrological models (Faridah Hanum et al., 2019), species distribution models (Wilkinson et al., 2018), agent-based modelling (Pariatamby et al., 2020); statistical models (e.g., regression models); proxy mapping (e.g., matrix-based approaches or look-up tables to present ES based on land use/land cover maps) (Shehab et al., 2021) ; and other mapping approach (e.g., deliberative mapping, spatial interpolation).

3) Assessments of perception included questionnaire surveys, observations, interviews, and focus groups. To be included in this review, studies must have delivered quantitative results such as maps, economic values or semi-quantitative results as scores or grading scales. (1) The 'observation method' directly looks at human actions and behaviour. For instance, Otero et al., (2018) observed people who are engaged in a particular activity such as mangrove, representing forest monitoring and management. (2) The 'document method' estimated ES values from certain individuals or groups by analysing texts, images, or other forms of materials (Lee et al., 2022; Matthew et al., 2019). To assess ES, this method often integrates social media with interviews, questionnaires, etc. (Salisu Barau & Stringer, 2015). Human perception assessments have been integrated with ES mapping in Malaysia to create realistic future scenarios for ES assessments. This information informs land use planning and identifies areas directly affected by ES decline.

4) Other quantitative assessments included methods based on biophysical parameters and involve field measurements (Wilkinson et al., 2018), monitoring (Lavoue et al., 2022), and modelling (Shehab et al., 2021) but do not generate a map or valuation of ES.

Ecosystem Service Valuation Approach in Reality

The main results are Malaysia's government system was extremely well-organized and controlled, although method adaptation was not widely implemented. According to the informant, the benefits that humans receive from the environment, whether they be provisional (such as food, timber, raw materials, and medicinal products), regulating (such as mitigating extreme events, controlling water quality, and sequestering carbon), cultural (such as recreation, spirituality, and aesthetics), or supporting (such as habitat conservation and primary production), are collectively referred to as ecosystem services. A fish aquarium, for example, is a tiny ecosystem with services for humans. The challenge to economists is to assign "correct" monetary value of environmental

service flows. If these values are priced "correctly" long term social benefits will be sustened? There are three approach of economic value which are market-based approach, revealed preferred approach (surrogate market) and stated preference approach. These approaches are applied for a particular type of economic value. In addition, ES are the contribution that ecosystem make to human well-being (Borger et al., 2014; Jabatan Taman Laut Malaysia, 2015; Mamat et al., 2020). All classifications make a distinction between "provisioning", "regulating", "supporting (habitat)", "cultural" services. Although the idea of ES value adaptability was frequently and readily brought up in workshops and interviews, it was actually seldom included in the main ecosystem service valuation (Celliers et al., 2020). Mamat et al., (2020) added that economic benefits of ES are not readily quantified because of the unavailable market price. Therefore, in order to address these issues, it becomes imperative to re-define and co-construct knowledge on the allocation and access to ES valuation (Barau & Stringer, 2015). Vianna et al., (2018) suggested more standardise valuation studied becomes available, these data may assist the development of models that could predict the potential of ES value.

CONCLUSION
In the present study, 67 publications on Ecosystem service (ES) assessments in Malaysia were reviewed with a focus on their assessment approaches. Since 2018, the growing methodologies used in ES assessments in Malaysia have diversified with increased stakeholder participation and a growing number of spatially explicit assessments and how their results support decision making in the nation.

To fully recognize the advantages of ES, it is also critical to assess its economic value through expert analysis. The multifunctionality and complexity of many environmental resources make it challenging to predict how the wide range of goods and services that they offer will affect human welfare. Although the capitals' data and information were instantly helpful, local government representatives were able to question their goals regarding ES valuation through the engagement process itself.

This paper's analytical approach served as both a tool for increasing awareness of the activities and conditions necessary for local governance in ES management and a crucial channel for discussion amongst local government officials. The evaluation ought to be a tool for insight. Creating such a tool is a component of the capital framework's upcoming study. The researchers' and the municipal employees' frequent interaction facilitated learning and the application of adaptive management. This approach's strength, particularly the traffic-light system, lies in its limited responses and very simple implementation. If valuers are not used to test and update the categories, this could potentially be seen as a vulnerability.

However, ES assessments in Malaysia still face geographical bias, thematic bias, data constraints and limited coverage of some spatial and temporal scales. Biodiversity governance in Malaysia is still complicated regarding delivery of the National Policy on Biological Diversity 2016–2025 with the involvement of different ministries and agencies, especially with the changing political scenario. Management approaches, priorities in planning and decision-making, and fiscal and budgetary structure vary from ministry to ministry (Tong, 2020).

Otherwise, data constraints in Malaysia have led to a preference for proxy-based ES assessments, which provide limited information for policy makers. The lack of multi-spatial and temporal scale analyses, particularly high-resolution ones, may hinder decision-making. To improve policy support, Malaysia needs more evidence-based assessments with trade-off analyses and validation, aided by ES modelling.

The study suggests that standardised ecosystem services (ESs) assessments can be improved by providing guidance on mapping and assessing ESs, adopting ES assessments into planning and decision-making, improving data accessibility, creating science-policy dialogues, and enhancing stakeholder engagement. Further research could focus on monetary valuation, which can provide valuable information about welfare changes and benefit transfer for assessing diverse ecosystems.

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