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Article

Ecotourism Indicators for Sustainable Biodiversity Management in Malaysia

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Abstract: This study explores the contribution of ecotourism indicators to the conservation and sustainable management of Malaysia's biodiversity in terms of diverse ecosystems. Models of conservation and community development have extensively promoted ecotourism as a means of conserving and developing the community; however, the success of conservation and community development programs relies on indicators modifiable to local conditions. Based on a critical analysis of the present frameworks, policies, and case studies, this paper will identify and assess the availability of the various environmental and biodiversity indicators currently used in the ecotourism destinations in Malaysia. Special concern is placed on the ability of these indicators to measure ecological health, visitor effects, and involvement of communities. The results demonstrate the necessity of adaptive indicators as well as locally applicable indicators that incorporate ecological, socio-economic, and governance facets. By providing ecotourism parameters, policymakers, communities, and planners by approach the unique conditions can enhancing the decision-making process, improving biodiversity outcomes, and aligning with global sustainability goals. This paper will add to the body of research on ecotourism by highlighting the fact that viable ecotourism in the Global South was a realistic model achievable only by focusing on Malaysia.

Keywords: Ecotourism; indicator; biodiversity; decision making; environment

Introduction

Ecotourism stands out as one of the many processes that have been put in place as a reconciliation tool to balance conservation of biodiversity with socio-economic development. In Malaysia, among the leading countries of ecotourism in the world, ecotourism activities have become a significant source of revenue, livelihood, and environmental protection (Chandran and Bhattacharya, 2024). The industry development is also an indicator of the much bigger worldwide trend in which the function of tourism is no longer leisure-oriented, but rather as a way of promoting conservation and sustainability purposes (McCool & Mandic, 2024). Nonetheless, in order to really fulfil these promises, ecotourism needs quality indicators that are clearly defined and based on evidence so that they can focus on measuring the impact on the environment, community, and the general sustainability (GST Council, n.d). In the absence of these signs, ecotourism risks losing its potential to make a significant contribution to the protection of biodiversity (Bartula & Radun, 2023; Worldpackers, n.d.).

Although there are many national policies and international models, there is still a critical deficiency in the systematic application of locally-grounded and ecologically-relevant indicators to the Malaysian context. The indicators tend to be too broad (not capturing site-specific ecological conditions) or too disjointed across different agencies and initiatives, which impedes coherent monitoring and policymaking (McCool & Mandic, 2024). The implications of such a disconnect are severe: ecotourism projects can cause environmental degradation or a lack of fair distribution of community goods. This requires a stricter and context-based situational process approach in evaluating the efficacies of ecotourism practices in protecting biodiversity, but also in maintaining economic opportunities (Worldpackers, n.d.).

The current study fills this gap by exploring how ecotourism indicators could be developed and utilised to empower biodiversity conservation in Malaysia. In addition to the practical importance of site management, this study helps to develop theory because it advances the current understanding of the relationship between sustainability indicators and the ecological results of tourism practices (Adebayo et al., 2023; Nwaeze et al., 2023). It also carries significant policy consequences, with the results possibly being used to shape evidence-based adaptive frameworks in line with the country's National Policy on Biological Diversity (2016) and the international conservation targets (Ouboter et al., 2021). This study highlights the importance of indicators as essential instruments in attaining sustainable ecotourism, which ensures the benefits of people and nature (by placing indicators at the point of ecology, governance, and community participation) (Bartula & Radun, 2023).

Literature Review

1. Environmental Indicators

Environmental indicators are very important in evaluating the sustainability of ecotourism destinations as they measure how ecotourism will change the environment. Basic indicators that typically provide a view on environmental health are air and water quality, soil stability, and even wildlife habitat integrity (Kunjuraman & Hussin, 2019). These rural ecological processes have been factored into these sustainability indicators than the general sustainability elements, and they therefore fulfil the role of sensitive knobs of the impacts that tourism has on natural systems (Chan et al., 2020). They can be deployed not only to monitor conditions but are also applicable as a diagnostic which can quickly diagnose environmental stress factors.

Researchers have highlighted the potential as well as the shortcomings of existing indicator frameworks. Bartula and Radun (2023) suggest that environmental indicators can serve as a kind of early alert mechanism, allowing managers to take action before the negative effects of environmental factors become permanent. However, as it is also found within the literature, a significant portion of studies are not consistent in the number and breadth of indicators used, and, therefore, the fragmented results cannot be compared across locations. Indicatively, Ocampo et al. (2018) in the Philippines, through the Delphi approach, showed how consensus among experts could enhance contextually relevant indicators, whereas Lucrezi (2021) highlighted the relevance of stakeholder knowledge in marine protected areas.

Nonetheless, such contributions are very much place-dependent and cannot be transferred to other contexts without additional modifications. This leads to one of the major issues, namely that indicators that are too strict can lead to critical reviews of different destinations, also demonstrating the developmental progress and unreliability of the indicators. Agyeiwaah et al. (2017) emphasised that common sustainability indicators can be used by enterprises as a starting point, but later studies in Serbia (Ristić et al., 2019) and Spain (Galindo-Pérez-de-Azpillaga et al., 2013) found that to be relevant, indicators must consider socio-cultural dimensions as well. In the same way, Latinopoulos and Vagiona (2013) and Castellani and Sala (2010) reflected on how the indicators of environmental capitalization are traded into the form of community empowerment and its orientation toward global sustainable development plans (Jamal and Stronza, 2009; Zhang et al., 2024), but there are only few and sparse applications of the approaches in Malaysia.

This misalignment in the employment of coherent indicators is particularly worrisome in terms of a country like Malaysia, where ecotourism is wholly interwoven with protecting biodiversity. Bartula and Radun (2023)

suggest some benchmarks that include 100% of the national water quality standards and no net deterioration of the conditions where wildlife lives, visitor satisfaction rates, and the list goes on. Although these kinds of quantitative targets provide clarity, they have not been operationalized in the Malaysian context. This paper thus contributes to the debate by critically evaluating the most practical, adaptive, and locally useful environmental indicators in the context of diverse ecosystems in Malaysia. By so doing, it helps in theoretical discussions on indicator design as well as policy-oriented approaches to enhancing the quality and strength of biodiversity-oriented ecotourism.

2. The Biodiversity Impact

There is no standard, universal unit upon which ecotourism on the ground can be measured, as far as biodiversity has an effect is methodologically problematic. Various indicator families, including metrics that use habitats, metrics that use species richness, and metrics that use intactness, can provide results that are often difficult to balance. Measures such as the Biodiversity Habitat Index or Biodiversity Intactness Index are valuable when used in scales requiring a broad view, but often do not map to scales of site-level management requirements (Biodiversity Indicators Partnership, 2020). This taxonomic focus, sampling effort, and temporal coverage heterogeneity result in bias (e.g., focus on charismatic taxa) and reduced comparability, thus impairing the ability of managers and policy-makers to identify trends, establish justifiable thresholds, or allocate priorities among sites affected by tourism.

On-site examples demonstrate how it can work and how much it can be. Intensive surveys and other monitoring programs, like those provided at Mount Kinabalu, are very informative about contagious taxa and are impossible to survive over long periods to record slow ecological feedback or the cumulative effects of tourism (NRES, 2016). Besides, most of these biodiversity measurements applied in these programs fail to directly incorporate pressures of tourism (tourist density, erosion impacts, disturbance regimes, species introductions), thus limiting their suitability in day-to-day ecotourism management. The institutional example of using biodiversity indicators to direct conservation planning illustrates that measures of biodiversity can serve as inputs to the operational working tourism management controls or rules that must be adjusted, but the implementation of ecological statistics into working tourism-management instruments (or ecological rules or triggers) is only patchy in Malaysian locations (Kwong et al., 2025).

At the policy and theoretical level, the fragmented indicator landscape calls for a multi-scale and integrative approach. National frameworks (e.g., the policy instruments of biodiversity in Malaysia) effectively are strategic directions but tend to be limited to the typifying operational pointers, standardised closing points, or mutual agency postulates-measures that are obligatory to common usage in ecotourism destinations (Tong, 2020). In response to this gap, this research critically examines which type of indicators for the ecotourism of Malaysia are practically implementable and less ecologically meaningless. The study intends to reconcile the theoretical debate surrounding the design of indicators, and to provide actionable policy yields, by suggesting a blurring of boundaries between traditional gauges of cross-site health and those more specifically relevant to ecotourism settings, through a philosophy that offers core paradigms of similarity in indicators across sites and updating of biodiversity indicators to be more defensibly pertinent and transparent perspectives on biodiversity in ecotourism contexts (Tong, 2020).

3. Integrating Biodiversity Management into Ecotourism

Effective management of biodiversity is the basis of sustainable ecotourism, but bringing this principle into reality has proved difficult. Although the literature points out that to develop conservation-based strategies, the operators need to comprehend the nature of ecosystems (Jin, 2024), a large proportion of the literature contains prescriptive (as opposed to evaluative) literature on the role of operators. Indicators intended to measure biodiversity states are often generic in nature and address broad parameters of ecological and environmental health without considering the direct impacts of tourism activities. Other ecotourism destinations. Case studies demonstrate that indicators based on a specific biodiversity, particularly its abundance or environmental soundness, can serve as

useful standards, although this will only be successful when included in a management framework with SDR definitions and enforcers in place (Jin, 2024). Such systematic alignment in Malaysia is underdeveloped, so that the ecotourism planning process cannot apply biodiversity indicators.

A variety of conservation approaches that could be embraced by the ecotourism operators are also covered in the literature, such as in-situ conservation and ex-situ conservation (Jin, 2024). Clearly, however, some critical situations exist: criticisms state that these solutions tend to be rolled out seriously in vacuums, where they can be connected to visitor management or community interaction models. Considering a case example, any action to protect habitats should not regard the issues of tourist carrying capacities, as undermining biodiversity achievements, nor ex-situ conservation efforts to promote site-level sustainability that are not part of long-term ecotourism goals. The data provided by other areas suggest that more resilient models of ecotourism were produced through a holistic approach involving the ecological, economic, and cultural dimensions (Chung et al., 2018). However, in the Malaysian context, the extent to which any such integrative frameworks have been established is amenable to change, and the depth to which any aspects of biodiversity are formalized into the tourism development plans is also unclear.

Another focus is on the need to ensure that biodiversity indicators reflect not only the ecological, but also the socio-economic and governance aspects. However, according to scholars, ecosystem services and community values should be reflected by the indicators, thus conservation outcomes are fortified by local ownership (Chan et al., 2012; Chung et al., 2018). Experience in other destinations shows that when communities are involved in setting and tracking biodiversity indicators, conservation policy becomes legitimate and sustainable. However, in Malaysia, the involvement of communities in the development of the indicators is not well distributed, with most cases based on consultation rather than co-management. Thus, this research adds value by exploring how the indicators of biodiversity can be localized to the context of Malaysian ecotourism, so that it introduces and incorporates ecological monitoring with community empowerment and policy alignment. It aims to bridge this divide by critically evaluating the contradictions between the biodiversity conservation discourses on one hand and the reality of ecotourism management on the other.

Methodology

This research uses an analytical approach intended to critically evaluate the ecotourism indicators that the present-day stakeholders and authorities in Malaysia commonly use. Based on the developed models of sustainability evaluation, the framework organises indicators on environmental, biodiversity, and socio-economic levels, but with special attention regards whether or not they could apply to ecotourism destinations. The results were organised in the form of tables to depict the number, scope, and context of the indicators and facilitate comparative analysis between sites and between levels of governance. Such an organisation highlights the gaps in current practice and provides a way of structuring the findings that should be used to determine which indicators are most relevant to ecotourism management within the Malaysian ecological context, as shown in Table 1.

In addition to providing a list of current instruments, the framework aims to be used as a guideline in assessing the compliance of indicators with the priorities of biodiversity and international sustainability. The research contextualises ecotourism evaluation within broader conservation governance frameworks by mapping the indicators to the authorities and policy frameworks to which they are accountable (MEET Network, 2018). This correspondence highlights the prospective of the framework not only as a feasible decision-making instrument at the site level and a theory in designing indicators in ecotourism studies. Significantly, the method enables the incorporation of global standards with measures specific to the area, and it remains flexible, but rigid enough to provide adaptive management direction, aiding policy alignment, and advancing academic discussions on operationalizing the concept of biodiversity conservation in ecotourism. Table 1 provides a summary of the locations and types of indicators utilized to assess biodiversity conditions.

Table 1. Available indicators and the set of instruments developed

Journal/Research	Authors	Year of Introduction	Number of Indicators for Environmental Sustainability	Biodiversity Indicators	Focus on Environmental Sustainability	Location
Ecotourism Potentials in Malaysia	Mariapan et al.	1995	6	Use of moths and butterflies as ecological indicators of habitat health	Protecting forest ecosystems and natural park integrity through biodiversity-based monitoring	Nationwide
Ecotourism in Malaysia: Current Scenario	Mariapan et al.	1990	5	Species richness and endemism metrics highlighting sensitive flora and fauna	Integration of local ecological conditions into tourism planning to maintain ecosystem stability	Nationwide
Exploring Potential Ecotourism Products in Sabah	Kunjuraman, V., & Hussin, R.	2019	7	Marine biodiversity indices (coral and fish diversity) for assessing habitat resilience	Promotion of sustainable livelihood activities linked to biodiversity protection	Lower Kinabatangan, Sabah
Moving towards post-COVID-19: A Study of Ecotourism Destinations' Competitiveness in Sarawak	Jun Zhou Thong	2021	5	Visitor density and biodiversity impact assessment frameworks	Strengthening ecological recovery and sustainability of post-pandemic tourism	Sarawak
Ecotourism Development in Penang Hill	Salman Ahmad et al.	2021	4	Flora diversity and endemic species richness	Conservation of montane ecosystems and urban biodiversity within cultural tourism	Penang Hill
Ecotourism Potential Assessment	Zainal Abidin Othman et al.	2020	5	Vegetation cover and wildlife presence indicators	Community-led conservation planning integrating ecosystem health into tourism models	Sabah, Malaysia
Ecotourism in Malaysia: Current Scenario	Azlizam Aziz et al.	2020	4	Ecosystem integrity and biodiversity status tracking	Resource conservation through eco-based tourism and sustainable economic development	Perak, Malaysia
Wildlife Conservation through Ecotourism	Mohamad Abid Kamaruzzaman et al.	2015	6	Wildlife population trends and habitat connectivity measures	Minimising tourism-related disturbances and enhancing species protection	Sarawak, Malaysia

Ecotourism and Mangrove Conservation	M. Mohan et al.	2024 (in press)	7	Mangrove health and species composition as biodiversity proxies	Integration of coastal ecosystem protection with tourism management	Southeast Asia
Biodiversity Indicators for Ecotourism Development	Amirah Azizah Zakaria et al.	2015	3	Key species abundance and ecological index evaluation	Biodiversity as a benchmark for sustainable tourism success	Pulau Bidong, Malaysia
Community Participation in Ecotourism Development	Hasrulzaman Hassan Basri et al.	2015	5	Community-monitored biodiversity metrics (e.g., wildlife sighting frequency)	Enhancing conservation through participatory environmental stewardship	Sarawak, Malaysia
Socio-Economic Impact of Ecotourism on Local Communities	Sharifah Nur Hidayah Syed Alias et al.	2015	4	Species diversity linked with ecosystem service valuation	Integrating socio-economic growth with environmental sustainability goals	Terengganu, Malaysia
Potential of Ecotourism in Ramsar Sites	Nur Izzah Izzati Ahmad et al.	2020	6	Wetland biodiversity and migratory bird indicators	Conservation of wetland ecosystems within protected tourism areas	Sabah, Malaysia
Ecotourism and Environmental Sustainability Indicators	Azuan Roslan et al.	2015	8	Multi-taxa biodiversity indicators including vegetation and fauna	Establishing sustainability benchmarks for tourism environmental management	Terengganu, Malaysia
Ecotourism as a Tool for Conservation Education	Huda Farhana Mohamad Muslim et al.	2020	5	Biodiversity awareness and educational impact indicators	Promoting conservation knowledge as part of environmental education	Kedah, Malaysia
The Role of Tour Guides in Ecotourism Development	Muhammad Norshahril Iman Sulaiman & Siti Suriawati Isa	2020	3	Biodiversity interpretation indices used by tour guides	Strengthening sustainable practices through guided eco-education	Malaysia
Biodiversity Conservation through Community-Based Tourism	Fathihi Hakimi Rosmidi et al.	2016	4	Community biodiversity mapping and habitat protection indicators	Empowering locals to integrate biodiversity care in ecotourism ventures	Kedah, Malaysia
Evaluation of Ecotourism Impacts on Local Biodiversity	Gertrude David et al.	2016	5	Habitat degradation indices and species disturbance metrics	Reducing ecological footprints and sustaining biodiversity integrity	Terengganu, Malaysia
Ecological Footprint of Ecotourism Activities in Protected Areas	Nur Amalina Adanan et al.	2020	6	Ecological footprint and biodiversity loss assessments	Managing tourism intensity to maintain ecological balance	Sabah, Malaysia

Integrating Local Knowledge into Ecotourism Planning	Mohammad Akmal-Syafriq Rushisham et al.	2019	4	Indigenous biodiversity indicators and traditional ecological knowledge	Applying local knowledge systems to promote ecosystem resilience	Sarawak, Malaysia

Source: Google Scholar (2025)

Table 2 summarises the main national policies and strategic documents in Malaysia that incorporate biodiversity and sustainability indicators relevant to ecotourism management. These policies, such as the National Policy on Biological Diversity and the Sixth National Report to the CBD, establish measurable frameworks to track conservation progress, ecosystem health, and community participation.

Table 2. National policies that have an indicator

Source	Number of Indicators	Focus Area
Sixth National Report of Malaysia (2021)	6	Biodiversity awareness and conservation efforts
National Policy on Biological Diversity 2022-2030	15	Overall biodiversity conservation and management
National Policy on Biological Diversity 2016-2025	5	Ecosystem health and sustainable use of resources
MyBIS Report (2023)	3	Sustainable tourism and community participation
Ecotourism in Malaysia: Current Scenario (2020)	4	Ecotourism management and resource protection

Source: Google Scholar (2025)

Discussion

The ecotourism destination of Malaysia has internationally recognised biodiversity. There are thousands of endemic species in the country that hold interest among nature-borne tourists, such as the tropical rainforests, coral reefs, among others (NRES, 2020). It does, however, seem that this industry is becoming increasingly unsustainable, as current indices that measure both environmental performance and biodiversity are too fragmented and sometimes even superficial. Even though there are generalised approaches that, among industrial sectors and policies with valuable information, could be useful in the ecotourism area, such as the Biodiversity Habitat Index or the Biodiversity Intactness Index (Biodiversity Indicators Partnership, 2020). On a regional level, it is not quantitative enough and context-specific to be applied in Malaysian ecotourism sites. In the absence of stronger, more regionally-focused instruments, the ability to connect the sustainability of tourism with the sustainability of biodiversity is lean, therefore posing perceived risks to the business viability and the sustainability of ecotourism destinations in Malaysia (Razali & Ismail, 2022).

To fill this gap, indicators based on the ecological and cultural diversity of particular areas must be used. Indicators applied to conserve mangrove ecosystems can serve as a particular example, because conservation in the highlands of Peninsular Malaysia is generally not relevant to conservation issues; often, generic indicators are used, and thus they cannot capture these differences (Tong, 2020). The relevance of localization based on other settings can be demonstrated: Ocampo et al. (2018) applied the Delphi approach in the Philippines to narrow down the list of indicators mirroring the local conservation situation, and Ristić et al. (2019) came up with 20 indicators specific to the rural settlements within the Serbian preserved lands. In Malaysia, however, much of the use of indicators remains associated with top-down policy projects with little regard to regional ecological and socio-cultural variations. The basis of one-size-fits-all validity is also a danger in ignoring site context dynamics, including site vulnerable species or site dependence on ecosystem functions, all to the detriment of conservation success (Convention on Biological Diversity, 2021).

A further limitation is the disjointed engagement of stakeholders in the development of indicators. National policies highlight the need for community engagement; however, in practice, most ecotourism indicators were developed by government agencies or conservation organisations with few or no community links (Convention on Biological Diversity, 2022). Comparative research suggests that participatory frameworks are vital: Lucrezi (2021) highlighted the value of stakeholder knowledge and networks in managing marine protected areas, while Agyeiwaah et al. (2017) discussed how common indicators created with input from the enterprise and community provide a more stable base for sustainable tourism. In Malaysia, local participation is almost entirely limited to consultation, limiting the social legitimacy of indicators and both a drawback and a consequential shortfall from the effective operationalization of indicators.

The challenge is further complicated by the ecological complexity/operational strategy trade-off. Quality biodiversity measurements like those at Kinabalu Park raise worthwhile information, but are costly and extended in their upkeep and not sustained. Castellani and Sala (2010) warn that excessively complex indicators might not impact tourism management unless they are viable within operational frames, but Latinopoulos & Vagiona (2013) have shown that locally focused but simplified indicators can effectively be integrated in local governments. The solution in the case of Malaysia will be a compromise between the strength of ecological indicators and their managerial utility: indicators have to be both rigorous to reflect the dynamics of biodiversity and, at the same time, affordable and easy enough to use, especially by local operators, tour guides, and local community organisations.

It is also important that biodiversity indicators be integrated into governance and political structures. Despite the many positive conservation objectives established in the National Policy on Biological Diversity of Malaysia (CBD, 2022), it is unsurprising that their indicators are not methodically used to plan or regulate ecotourism. An example of this is that visitor carrying capacity limits are not commonly applied, with managers on the ground given the responsibility to ensure short-term tourist income takes precedence over long-term environmental health. Contrary, Galindo-Pérez-de-Azpillaga et al. (2013) demonstrated that sustainability indicators that operated in the Spanish protected geographic areas were able to steer both conservation and community wellbeing outcomes effectively through their official incorporation into policy tools.

Ultimately, the variation and application of tailored, participatory, and policy-relevant indicators will influence the future of ecotourism in Malaysia. As Bartula & Radun (2023) point out, biodiversity loss intrinsically diminishes tourism value, and hence early-warning indicators are becoming more of a necessity rather than an option. Additionally, by including community knowledge (Agyeiwaah et al., 2017), ecological monitoring (Zhang et al., 2024), and governance (Castellani & Sala, 2010) into indicator frameworks, Malaysia can create a combination of solidarity and science to produce tools that generate scientific credibility and social legitimacy.

1. Decision-Making

Evidence-based and adaptive decision-making processes play a critical role in successfully managing the ecosystems that support ecotourism because biodiversity changes at a low rate and is extremely sensitive to human and natural pressures like climate change, habitat degradation, and pollution. Any drops in ecological integrity not only compromise conservation goals but also reduce the attractiveness of destinations, since tourists will appreciate cleaner environments more (Bartula and Radun, 2023). Indicators developed during this research were meant to address these issues by providing an organized outlook of the process of monitoring the ecology of health, visitor influences, and the interaction of communities. As Table 1 demonstrates, the indicators of biodiversity contextuality are required to make the work of both government agencies and local operators as effective as possible, through ensuring that the real-time results of controlling biodiversity can be observed, followed by modification of management practice. This is reminiscent of earlier results by Castellani and Sala (2010), who highlighted the value that indicators serve in linking ecological observation with policy action, and by Latinopoulos & Vagiona (2013), who indicated how such technologies enhance local-scale governance of the condition of protected lands.

Meanwhile, successful decision-making means the indicators should be adjusted according to the ecotourism destination operation conditions. Government agencies have a duty to protect long-term ecosystem potential, but at the same time, operators rely on vibrant and biologically oriented sightseeing spots to draw in tourists and keep the revenue streams flowing. Not striking a balance between these requires indicators as not necessarily diagnostic instruments, but as instruments to develop tourism, as well as to contribute to its conservation. Agyeiwaah et al. (2017) show evidence that shared indicators are based on ecological and socio-economic dimensions and could form legitimacy among the stakeholders, and Zhang et al. (2024) proved to be useful towards the convergence between local and global practices toward sustainability. The integration of these types of adaptation and participation indicators into decision-making models can propel Malaysian ecotourism toward a governing structure that conserves the biodiversity yet maintains the economic and cultural health of the sector.

2. Essential Biodiversity Indicators for Ecotourism

Since Malaysia is classified as one of the megadiverse countries in the world, the need to develop the indicators of the essentials of biodiversity is as inevitable as it is necessary to implement such a policy. Guyana achieved an almost unique environment and ecosystem; the rainforests, mangroves, as well as coral reefs are home to an incredible number of species, of which many are endemic to the country (Tong & Gani, 2024; Von Rintelen et al., 2017). Measures like the City Biodiversity Index (CBI) have been advocated as a tool to monitor the health of urban biodiversity (Norziana et al., 2022), whereas larger-scale analyses serve as snapshot measures of understanding ecosystem health at the national scale. Nonetheless, critics note that these tools are frequently too generalized and, therefore, would not adequately reflect spatial and context-specific pressures on tourism in biodiversity. Indicators should be used as early-warning tools, as Bartula and Radun (2023) suggest. Bartula and Radun (2023) claim that Malaysia presently operates under frameworks that pass infrequent threshold tests linking ecological degradation to tourism actions.

Another effective dimension to biodiversity indicators is governance. Policy statements and interventions like the National Policy on Biological Diversity 2022-2030 (CBD, 2022) offer significant guidance at the strategic level, but their conversion into measurable actions and enforcement is insufficient. To address this gap, governance indicators that measure the levels of institutional strength, policy implementation or enforcement, and stakeholder on board are needed. It has been demonstrated that the introduction of sustainability indicators into the decision-making process leads to better accountability and conservation performance (Castellani and Sala, 2010; Latinopoulos & Vagiona, 2013). In addition, inviting the indigenous communities whose ecological knowledge has promising insights in local biodiversity management is frequently more of a symbol than a reality in the Malaysian practice (Teow et al., 2023). Such a loophole undercuts the validity and sustainability of conservation policies. Emboldening of the governance pointers incorporating the institutional performances in unison with the communities is thus vital in seeing to it that the biodiversity management surpasses the paper undertakings (Hasana et al., 2022).

Another area where crucial indicators may be employed to convert biodiversity targets into actual outcomes is ecotourism. Millions of tourists come to Malaysia annually because of its natural wealth, but in the absence of well-thought-out indicators, nature becomes a victim of tourism. Competitiveness and sustainability of tourism will be ensured by effectively using ecological, social, and economic indicators. As Agyeiwaah et al. (2017) observe, the general sustainability signposts available translate enterprises into an evaluation framework by which they gauge improvement, with Sheena et al. (2015) observing the essential nature of ecotourism planning as a solution to implementing biodiversity principles. Where there is a more organized development of methods in this regard in Malaysia, the indicators may not be merely technical means, but also processes of creating an administrative attitude between the people of the land and the visitors themselves.

3. Scope and Application of Indicators

Biodiversity and ecological indices remain dominant in consideration of whether the activities advanced by ecotourism projects in Malaysia are part of sustainability objectives. The indicators used include species diversity, habitat integrity, and ecological distinctiveness, which provide insight into the well-being of ecosystems and the interaction of conservation and tourism goals with each other. As the Sukau and Kampung Batu Puteh case studies indicate, biodiversity has become a conservation agenda, as well as a tourism resource, as the flora and fauna of the Kinabatangan River lie at the heart of its ecotourism market strength (Tshin & Bagul, 2018). However, according to Bartula and Radun (2023), the advantage of these indicators is that they can act as preventive management indicators, but not as descriptive indicators. This poses important challenges to how indicators are operationalised within the Malaysian destinations, where biodiversity monitoring generally lacks clear boundaries or uniform implementation across locations.

Measuring ecological performance thus demands a mechanised but adaptable calculation balancing ecological and socio-economic aspects. In Sabah, a study has found seven key indicators, specific to the biodiversity, site attractiveness, cleanliness, service quality, repeat visitation, community involvement, and replacement of resources, which can be used in combination to create a comprehensive evaluation. An analogous problem. In other places, such attempts underscore the necessity of localization: Ristica et al. (2019) are working on 20 indicators of rural settlements, whereas Agyeiwaah et al. (2017) consider that common indicators of the sustainability of the enterprise mean much. In the case of Malaysia, a mix of four to seven locally adjusted indicators per location would achieve the goals of the National Ecotourism Plan regarding balancing between protection of biodiversity and economic growth, and the assimilation of the cultures.

4. Dynamics of the Indicators

Indicators for assessing ecosystems, environments, and biodiversity must be recognised as dynamic rather than static tools. Naturally occurring processes and anthropogenic forces will always interact to influence ecosystems such that species share, ecological processes, and habitat integrity will vary (Oliver et al., 2021; Noss, 1990). Biodiversity responds to climate change, land-use change, and pollution in non-linear and complex ways, usually undermining both resilience and stability (Cleland, 2011; Oliver et al., 2021). Nevertheless, as an example, the change in forest processes and trophic forms with the increase in variables such as temperature and drought cannot be reflected by the use of the normal static indicators. This mobile nature highlights the importance of indicators that are shaping within the changing ecology and are therefore capable of inciting anticipatory and situation-specific information as opposed to some a priori scales, which are likely to become irrelevant at any time (Shukor et al., 2023).

In addition, research also shows some generic pointers to the indication of a given indicated site might obscure certain facts, and that could be counterproductive to monitoring and management. According to Failing and Gregory (2003), poorly considered indicators are seen as a form of muddling through the decision-making process, and Bartula and Radun (2023) express indicators as an early warning mechanism to managers. Generic captures fail in Malaysia, with its ecosystems such as coastal mangroves, coral reefs, and inland rainforests experiencing other stressors. Case studies in other settings showed that case participatory methodologies could be applied to improve indicators in order to better capture the actual on-the-ground reality (Ocampo et al., 2018).

The creation of such dynamic structures involves the need to compromise between worldwide comparability and local specificity. Global indicators or core indicators are those that are cross-site comparable, like the abundance of a species or a water quality indicator, whereas locally-specific indicators reflect ecological, cultural, and socio-economic dynamics (Miller et al., 2018; Tonkin et al., 2019). With a combination of all these approaches, a comprehensive monitoring can be conducted in a scientifically rigorous and contextualised manner. Studies by Castellani and Sola (2010) and Latinopoulos & Vagiona (2013) demonstrate the effects of locally relevant indicators to enhance governance and community inclusion, and to keep monitoring systems and policies sensitive to real ecological and social contexts. In the case of Malaysia, combining community-based knowledge and the science of biodiversity would enhance the flexibility and acceptability of ecotourism indicators.

Simultaneously, the resource consumption of continuous monitoring is quite high, and sensitive to be considered invasive by operators. Agyeiwaah et al. (2017) express the idea that sustainability indicators should be manageable to be adopted over the long term, whereas Wang et al. (2019) state that simplified and easily accessible indicators may reflect key dynamics within the ecosystem. Mariapan et al. (2017) propose that the application of practically meaningful and scientifically sound indicators in Malaysia may be more useful in managing ecotourism by enabling stakeholders to monitor time variation changes without stressing local capacity. Adaptive indicators can maintain the presence of biodiversity and, at the same time, promote ecotourism development by harmonising green science and exploitation economics.

Conclusion

To conclude, this study shows that the usefulness of biodiversity indicators in ecotourism settings is reliant on the fact that such indicators must be adapted locally and context-specific. The fact that Malaysia is a megadiverse country underscores the need to develop site-specific indicators that can quantify the ecological, cultural, and socio-economic processes occurring in different ecosystems. Many indicators, which are generic and useful, give an overview but are not usually useful in making meaningful conservation or management decisions. Indicators are accurate, relevant, and actionable, thanks to tailored methods established in consultation with local biodiversity experts and based on community involvement.

The implications of the findings are significant both in policy and theory. Policymakers can close the gap between conservation objectives and tourism practices by incorporating adaptive indicators into national strategies and plans like the *National Policy on Biological Diversity* and the *National Ecotourism Plan.* This would make biodiversity monitoring more institutionalized and effective in terms of governance and enforcing long-term sustainability. Theoretically, the study makes progress in terms of the dynamic aspect of indicators by highlighting indicators as dynamic and adaptable tools, instead of being rigid values used in their research, in keeping with the postulates of adaptive management in ecotourism studies.

In practice, site-level decision-making can be improved by introducing customised indicators. Alternatively, eco-tourism sites in highlands might aim to enhance soil health and support or preserve plant biodiversity, whereas marine and coastal destinations must aim at water quality, coral welfare, and fish density. Implementing this degree of particularity in the context of monitoring systems not only amplifies the conservation achievements but also improves visitor experience and neighbourhood gains. Finally, dynamic and contextual indicators may help make ecotourism a factor in biodiversity stewardship as well as sustainable development in Malaysia.

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