State of Nature Conservation in Malaysia 2025 • Volume 3

STATE OF NATURE CONSERVATION IN MALAYSIA 2025

Volume 3: Indigenous Peoples & Anthropocene



Edited by
Vivian Soon
Ng Sean Fong
Donovan Louis

PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

Published by
Malaysian Nature Society
JKR 641, Jalan Kelantan, Bukit Persekutuan,
50480 Kuala Lumpur, Malaysia.

www.sonc2025.my

Copyright © 2026 Malaysian Nature Society

All rights reserved. Reproduction of any part of this publication, including its articles, illustrations, and other contents is prohibited in any form or by any means, whether electronic, photocopying, mechanical, recording, or otherwise, without the written permission of the Malaysian Nature Society.

Illustration by Kheu Siek Er & Goh Xin Ling

State of Nature Conservation in Malaysia 2025

Volume 3: Indigenous Peoples & Anthropocene

Editors
Vivian Soon, Ng Sean Fong, Donovan Louis

Honorary Editors
A. Latiff, Dionysius Sharma, Reuben A. Muni, Ryan Foo J.E., G.W.H. Davison, J.I. Furtado & Gathorne Hardy-the Earl of Cranbrook

Malaysian Nature Society
2026


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY



TABLE OF CONTENTS

INDIGENOUS PEOPLES

			Page
1.	**Indigenous land rights and nature conservation laws in Malaysia: An evaluation of Indigenous powers of management**	*Yogeswaran Subramaniam*	*629–639*
2.	**Free, Prior, and Informed Consent (FPIC) and self-determination of Indigenous Peoples in the context of environmental conservation in Sarawak**	*Thomas Jalong, Celine Lim, Peter Kallang, Willie Kajan Ngang & Ng Sean Fong*	*641–653*
3.	**Indigenous knowledge on conservation**	*Gordon John Thomas*	*655–661*
4.	**Interaction between Indigenous Peoples' rights and conservation – A personal reflection**	*Wong Pui May*	*663–668*
5.	**The Enchanted Forest: Exploring Indigenous imaginaries and narratives of nature**	*Kamal Solhaimi Fadzil*	*669–677*

ANTHROPOCENE

1.	**State of the Malaysian rainforest 2025: Conservation outlook and emerging threats**	*Adam Farhan*	*679–685*
2.	**Connectivity science and the Central Forest Spine: Reconnecting a fragmented future**	*Agkillah Maniam, Samsudin Musa & Noor Azrien Zainon*	*687–699*
3.	**Seventeen years of Heart of Borneo: Research trends, progress, challenges, and pathways toward a connected conservation landscape**	*Jayasilan Mohd-Azlan, Muhd Amsyari Morni, Siti Nurbaidzuri Reli, Nor Izwan Hakimi Nor Azmi, Madeline George Pau, Jason Hon, Arthur Y.C. Chung & Jedediah F. Brodie*	*701–715*
4.	**Connectivity Science: Coral Triangle Initiative**	*Choo Poh Leem*	*717–727*



TABLE OF CONTENTS

			Page
5.	**Aligning Malaysia' protected area targets with global biodiversity goals: Directions, challenges, and initiatives**	*Khairul Naim Adham*	*729–735*
6.	**Other Effective Area-based Conservation Measures (OECMs): A critical pathway to 30×30 for Malaysia**	*Nadzirah Hosen & Amran Hamzah*	*737–745*
7.	**High Conservation Value (HCV) approach in Malaysia**	*Lisa Lok, Darshanaa Chellaiah, Sophia Chong, Melissa Chin & Surin Suksuwan*	*747–769*
8.	**Improving forest governance in Malaysia**	*Teckwyn Lim*	*771–780*
9.	**Wildlife trafficking in Malaysia: Current challenges and interventions**	*Serene C.L. Chng & Ramacandra Wong*	*781–788*
10.	**Dimensions of human-wildlife conflict in Peninsular Malaysia**	*Sharmini Julita Paramasivam, Benjamin Galea, Aini Hasanah Abd Mutalib, Susan Lappan & Nadine Ruppert*	*789–801*
11.	**Human-wildlife conflict: Perspectives from Sabah, Malaysian Borneo**	*John Payne & Zainal Zahari Zainuddin*	*803–807*
12.	**Zoonotic wildlife pathogens in Malaysia and the effects of anthropogenic landscape alteration on transmission dynamics and One Health**	*Reuben Sharma*	*809–835*
13.	**Soundscape research in Malaysia and its potential to support ecosystem conservation and planetary health**	*Yen Yi Loo, Noorul Ezyan Nor Hashim, Alaa'zain Al-Aabideen & Sithi V. Muniandy*	*837–857*
14.	**State of marine fish and fisheries in Malaysia**	*Chitra Devi Gopalakrishnan, Raymie Nurhasan, Fadzliee Asmat, Serena Adam, Alias Man & Nurfatin Wahida Puspa*	*859–875*
15.	**Freshwater ecosystems in Malaysia: Status, pressures and management priorities**	*Darshanaa Chelliah*	*877–890*



TABLE OF CONTENTS

			Page
16.	**High Seas Treaty: Our ocean and beyond Malaysian borders**	*Lai Yue, Ng Sean Fong, Rizza Sacra-Dejucos & Donovan Louis*	*891–900*
17.	**Disregarding our future: Malaysia's waste and pollution crisis**	*Mageswari Sangaralingam & Wong Pui Yi*	*901–919*
18.	**Malaysia's rare Earth gamble: A critical examination of its high-risk REE future**	*Theiva Lingam & A. Lalith Kumar*	*921–938*
19.	**Examining gaps in the EIA framework**	*A. Lalith Kumar, Theiva Lingam, Arhwin Kalai Chelvan, Sheelasheena Damian, Vanessa A. Jipiu, Maryell Irisha Hillarian, Weltson Dius, Prescilla Jane Peter, Esther Mawan, Standley Bawin Anak Bunsi & Nurfatin Wahida binti Puspa*	*939–950*
20.	**The need for an express right to clean, healthy environment**	*Kwong Chiew Ee, Abhilaash Subramaniam & Mohanasundari Mahalingam*	*951–958*
21.	**Gaps in environmental policy and legislation: Overview of the legislative and policy framework governing the environment**	*Arhwin Kalai Chelvan, Shantini Guna Rajan, Sheelasheena Damian, Vanessa A. Jipiu, Maryell Irisha Hillarian, Esther Mawan, Standley Bawin Anak Bunsi, Nurfatin Wahida binti Puspa, Aidil Iman Aidid & Lee Pei Xian*	*959–969*
22.	**Returning borrowed time: Rethinking progress in the context of Malaysia's gross domestic product (GDP)**	*Zara Phang, Shantini Guna Rajan & Nur Elisha Rehan*	*971–980*
23.	**Environmental Governance: Constitutional gaps and the need for a Federal Constitution adapted to planetary crisis in the 21st century**	*Ng Sean Fong*	*981–992*
24.	**Financing biodiversity conservation in Malaysia**	*Gopalasamy Reuben Clements, Tajang Jinggut, Devjit Roy Chowdhury, James Pilkington, Tan Kean Seng & Chun Seng Goh*	*993–1004*


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 629–639
doi: 10.62613/sonc2025.v3ipc01

CHAPTER 1

Indigenous land rights and nature conservation laws in Malaysia: An evaluation of Indigenous powers of management

YOGESWARAN SUBRAMANIAM[1,2]*

Abstract: Both international and domestic research and developments suggest that Indigenous Peoples are vital partners in the sustainable management of nature conservation. While recognition of Indigenous rights to their lands and resources may be warranted in this regard, the integration of legally enforceable Indigenous rights to land and conservation strategies has remained a challenge. This paper examines the principal Indigenous land rights and nature conservation laws in Malaysia with a view to determine the extent to which local Indigenous communities are formally empowered to manage nature conservation within their traditional lands and territories. It does so by analysing the relevant laws within the jurisdictions of Peninsular Malaysia, Sarawak and Sabah, state-led initiatives toward local Indigenous management of nature conservation, and key national policies and plans concerning conservation. Despite an increased role for local Indigenous participation in nature conservation efforts, legal powers of management and control over nature conservation remains stacked in favour of the governments concerned and their agencies. Significant national strategies appear mixed, suggesting uncertainty if there is concerted governmental intent to share effective legal power with Indigenous communities for the management of nature conservation within their localities.

INTRODUCTION

Global studies have consistently observed that the management of traditional areas by its Indigenous peoples would produce equal if not better outcomes for nature conservation (Stevens 2014; Errico 2017; WWF *et al.* 2021). Concurrent developments in international fora and law have also acknowledged and conceived 'indigenous', 'traditional' or 'local' people as vital partners for biodiversity conservation and propounded a rights-based approach to conservation and the management of protected areas that meet contemporary international standards, including those relating to sustainable development, alleviation of poverty and Indigenous rights (Painemilla *et al.* 2011; Sikor and Stahl 2011; Stevens 2014; WWF *et al.* 2021). Accordingly, Indigenous peoples and local communities warrant appropriate recognition of their rights and governance authority and support to equitably and effectively participate in efforts towards the conservation of the world's remaining natural landscapes (WWF *et al.* 2021).

However, effective integration of legally enforceable Indigenous rights to land and conservation strategies has proven to be easier said than done. For example, some states are reluctant to part with ownership and authority of protected areas in favour of Indigenous communities and even where there are formal arrangements for the participation of Indigenous communities in the management of such areas, the balance of power in many cases still does not lie with the Indigenous community (Stevens 2014).

This paper examines the principal Indigenous land rights and nature conservation laws in Malaysia with a view to determine the extent to which local Indigenous communities are formally empowered to manage nature conservation within their traditional lands and

[1] Centre forMalaysian Indigenous Studies, Universiti Malaya, Jalan 16/4, Seksyen 16, 46350 Petaling Jaya, Selangor, Malaysia.
[2] Malaysian Bar Council Committee on Orang Asli Rights, 50050 Kuala Lumpur, Malaysia.
***Corresponding author: subramaniam.yogeswaran@gmail.com**

territories. It begins by identifying 'Indigenous Peoples' within the Malaysian context before analysing the relevant laws within the jurisdictions of Peninsular Malaysia, Sarawak and Sabah. The paper then evaluates state-led initiatives toward local Indigenous management of nature conservation before concluding on the direction of the government on such matters with reference to key national policies and plans.

'INDIGENOUS PEOPLES' IN MALAYSIA

While the Malaysian Constitution does not define the term 'Indigenous Peoples', the document refers to four constitutionally privileged ethnic groups, namely, the Malays, natives of Sabah, natives of Sarawak and the peninsular Malaysia Orang Asli. Article 160(2) of the Federal Constitution states that a 'Malay' means a person who professes the religion of Islam, habitually speaks the Malay language, conforms to Malay custom and (i) was before 31 August 1957 born in Malaya or Singapore, or domiciled there on that day; or (ii) is the issue of that person. Article 160(2) of the Federal Constitution defines an Orang Asli as an 'aborigine of the Malay peninsula'. Section 3 of the Aboriginal Peoples Act 1954 (Malaysia) provides for detailed cultural and biological criteria for a person to be legally considered an Orang Asli subject to federal executive power to determine whether a person is an Orang Asli.

In Sarawak, state law defines whether citizens are 'native' (Article 161A(a) of the Federal Constitution). The Schedule to the Sarawak Interpretation Ordinance, 2005 lists 31 racial groups (and sub-groups) considered to be 'indigenous to Sarawak' and accordingly 'natives', including legal conditions for recognition as a native of Sarawak. Article 161A(b) states that the term 'native' in Sabah means a person who is a citizen, is the child or grandchild of a person of a race indigenous to Sabah and was born either in Sabah or to a father domiciled in Sabah at the time of the birth. Collectively, the natives of Sabah, natives of Sarawak and Peninsular Malaysia Orang Asli have been categorised into at least 84 heterogeneous ethnic and sub-ethnic groups (Nicholas 2023: p. 238).

For current purposes, the natives of Sabah and Sarawak and the Orang Asli are considered 'Indigenous Peoples'. While there is no international legal definition of the term 'Indigenous Peoples', these three groups have been regarded as such on the basis that local communities within these groups fulfil the characteristics contained in the widely accepted definition proposed by UN Special Rapporteur Jose Martinez Cobo (Cobo 1986, p. 29; Endicott 2003, pp. 145 – 146; SUHAKAM 2013, p. 6). These characteristics include: (i) historical continuity with pre-colonial societies that developed on their territories; (ii) self-identification as distinct from other sectors of prevailing society; (iii) a non-dominant or marginalised situation within prevailing society; and (iv) the determination to preserve and transmit to future generations, their ancestral territories and identity as peoples in accordance with their own cultural patterns, social institutions and legal system (Cobo 1986, p. 29). In addition to being early inhabitants of their respective traditional locales, these groups have developed rich, complex and diverse land and territorial connections and sustainable knowledge systems in and over these spaces through oral traditions and the domestic practice of customs and usages (SUHAKAM 2013, pp. 10, 20 – 33; Ministry of Natural Resources and Environmental Sustainability (NRES) 2022, pp. 35, 98).

In contrast, ethnic Malays have not self-identified with the above characteristics at international fora and more specifically, do not possess specific communal and cultural connections to particular tracts of land and the resolve to preserve and transmit them customarily (Endicott 2003, pp. 143 – 146; Subramaniam 2012, pp. 43 – 45; SUHAKAM 2013, pp. v, 6). The Human Rights Commission of Malaysia (SUHAKAM) has also viewed 'the mainstream, not minority' Malays as not within its inquiries into Indigenous peoples' land rights in Malaysia (SUHAKAM 2013, p. v). Accordingly, this paper will focus on rights of the Orang Asli, natives of Sarawak and natives of Sabah.

INDIGENOUS RIGHTS AND NATURE CONSERVATION LAWS BY JURISDICTION

Peninsular Malaysia, Sarawak and Sabah generally have distinct laws relating Indigenous land rights and nature conservation. Legally, this scenario is due to exclusive state jurisdiction over these matters. Items 2 and 3 of the general State List (List II of the Ninth Schedule) of the Federal Constitution confer exclusive state jurisdiction over land, and agriculture and forestry matters respectively. Item 13 of the Supplement to State List for States of Sabah and Sarawak (List IIA Ninth Sch of the Federal Constitution) provides for state government authority over native law and customs. Additional constitutional protection for Sabah and Sarawak compared to other states of the Federation emanating from the Malaysia Agreement 1963, including provisions in relation to federal land use, local government and development (Articles 88 and 95E of the Federal Constitution), have ensured that Indigenous land rights and nature conservation come under the purview of both Bornean state governments. Accordingly, the relevant laws from the three jurisdictions are examined separately.

Statutory position: Orang Asli

The legal status and land rights of the Orang Asli in Peninsular Malaysia are primarily governed by the *Aboriginal Peoples Act 1954* (*APA*). The *APA* has been criticised as 'static and outmoded' due to its paternalistic and protectionist framework (Hooker 1996), which grants the government extensive authority over the Orang Asli community and their traditional territories. Efforts are underway to amend the *APA* (Ministry of Economy, Malaysia 2025), but the Act remains in force.

The *APA* empowers the federal executive, specifically the Department of Orang Asli Development (JAKOA), with extensive control over Orang Asli and their traditional lands. This includes the power to legally define who qualifies as an Orang Asli [Section 3(3)], appoint or dismiss community headmen (Section 16), and exclude individuals from Orang Asli areas (Sections 14 and 15).

From an Orang Asli land rights perspective, a central failure of the *APA*, the *National Land Code 1965* (*NLC*) and other land-related legislation is the lack of formal statutory recognition for Orang Asli customary land tenure. Primary protection of Orang Asli traditional areas relies on State governments declaring specific parcels as 'Aboriginal reserves' (for example, *APA*, Section 7) or 'Aboriginal areas' (*APA*, Section 6) upon JAKOA's application.

However, these statutory protections offer highly insecure tenure. Written law permits these reserves and areas to be revoked by a notification in the State government gazette (see for example, *APA*, Sections 6(3) and 7(3); *NLC*, Section 64), making their existence dependent on executive fiat. Furthermore, statutory Orang Asli rights of occupancy within a reserve are restricted to that of a 'tenant at will' (*APA*, Section 8), meaning their land rights are terminable at any time by the State Authority.

The *APA*'s provisions for land loss are inadequate, offering no legal right to replacement lands and making compensation for lost land discretionary. Despite the government's mandate to protect these communities, land security outcomes are poor. As of 2018, only 25% of acknowledged Orang Asli lands had been formally reserved (Bernama 2018). Additionally, areas officially acknowledged by JAKOA represent only 17% of the actual customary lands claimed (SUHAKAM 2013, p. 133). Other resource laws, such the *National Forestry Act 1984* and the *Wildlife Conservation Act 2010*, offer limited exemptions for subsistence use but do not address customary land rights within these areas. National and state park legislation are notoriously silent on the rights of Orang Asli who have traditionally inhabited such areas. Section 23(1)(a) of the *Access to Biological Resources and Benefit*

Sharing Act 2017 (*ABSA*) provides for the free, prior and informed consent (FPIC) of the Orang Asli for local biological resources. However, the provision only applies to biological resources 'on land to which the community have 'a right as established by law', allowing potential disputations to limit the circumstances where FPIC of the Orang Asli community would be required.

Beyond the lack of security of tenure over Orang Asli traditional areas, there is also little incentive from the government for the Orang Asli communities to carry on their role as traditional custodians of their respective locales. Many Federal policies, such as the 2009 Land Titles Policy, fail to fully recognise communal customary lands and are geared towards granting Orang Asli individual interests over their traditional areas for the purpose of cash crop cultivation. Such policies are arguably inconsistent with nature conservation. Ultimately, the lack of statutory recognition of Orang Asli land rights allows communal lands to be perceived as 'empty and unused state land' facilitating 'legal' land grabs and exploitative activities such as commercial logging and mining (Subramaniam 2025).

Statutory Land Rights: Natives of Sarawak

In contrast to the Orang Asli, natives of Sarawak have historically enjoyed express statutory recognition of certain native customary rights (NCR) in and over land. The *Sarawak Land Code, 1958* (*SLC*), officially categorises Native Customary Land (NCL) and Native Area Land (NAL). NCL includes land where customary rights were created before 1 January 1958, communal reserves, and certain Interior Area Land where NCR has been established through a statutory permit.

Section 5 of the *SLC* regulates and limits the creation of NCR after 1958 (Section 5(1)). Section 5(2) recognises common methods for establishing NCR, such as clearing virgin jungle, planting fruit trees, or cultivation. However, this statutory recognition is primarily based on 'occupation' (Bulan 2012, pp. 118 – 120, 128) rather than traditional connections Indigenous communities have with their customary areas. The emphasis on occupation in Section 5(2) is more consistent with individual sedentary and agricultural use of native customary lands. From a conservation perspective, these rights fail to explicitly recognise native customs such as subsistence hunting and fishing, forest protection, subsistence forest produce collection, and ceremonial practices, that are more aligned with nature conservation.

However, the *SLC* was amended in 2019 to introduce Section 6A, allowing native communities to claim usufructuary rights up to 1,000 hectares—a limit viewed as 'short-changing' the many native communities who claim traditional areas far exceeding this limit (Nicholas 2019, p. 278). Additionally, the claims procedure for such areas is also subject to state executive determination (Section 6A(2)), raising concerns on the impartiality of the process.

Compounding these issues, formally recognised NCR lands remain legally vulnerable to State action. The government retains wide powers to extinguish NCR (see *SLC*, Section 5(3)) subject to compensation and often grants logging licenses or provisional leases for plantations over lands potentially subject to NCR without the local community's free, prior, and informed consent (FPIC). The theme of governmental control over the contours of NCR, and more broadly, over lands and natural resources in Sarawak can be seen in legislation relating to nature conservation.

Despite a measure of NCR recognition, the *Forests Ordinance 2015* (Sarawak) contains wide-ranging provisions for the executive extinguishment, regulation, and admission of native rights and privileges within areas proclaimed to be forest reserves and protected forests. In respect of national parks and nature reserves, the Controller of National Parks and Nature Reserves ('the Controller') and other state government officers have extensive powers

of control and management of such areas under Parts II and IV of the *National Parks and Nature Reserves Ordinance, 1998* (Sarawak) (*NPO*). NCR in these areas are limited to those rights and privileges recognised and admitted through a claims process determined by state government officers and are subject to regulation and extinguishment by executive order (*NPO*, Part III). The *NPO* is also restricted in terms of explicit provisions for native co-management of national parks and nature reserves. Section 8 of the *NPO* potentially allows native community representatives to assist the Controller in the management of a national park or a nature reserve provided that the Controller is so minded and wishes to constitute a Special Park Committee for the protection and management of a national park or a nature reserve, and to promote its public appreciation and enjoyment. The *Wild Life Protection Ordinance, 1998* (*WPO*) that governs the protection of wildlife and the establishment and management of wildlife sanctuaries, contains limited provisions in respect of native rights and privileges and an exemption for natives to possess wild animals for their own consumption or use (Section 37(1)). Despite the lack of express provisions recognising native co-management in Wildlife Sanctuaries, the Controller of Wildlife may, with the approval of the Minister, constitute a Special Wild Life Committee, which shall be headed by a Warden, to assist him in the supervision, control and management of a Wildlife Sanctuary and to protect the wildlife and their habitat [Section 9(1)]. Honorary Wildlife Rangers appointed under section 8 of the WPO include local natives who may also be a member of a Special Park Committee of a National Park or Nature Reserve, if constituted under Section 8 of the NPO (*NPO*, Section 8(2)).

The *Sarawak Biodiversity Regulations 2016* make FPIC as well as access and benefit sharing mandatory for projects involving biological traditional knowledge of natives utilising and managing biological resources and its environment for their community's general sustenance. While equitable benefit sharing agreements with natives are legally required, the Sarawak Biodiversity Council has broad powers to determine the terms of such arrangements in consultation with the Sarawak state government and the natives involved [Regulation 14(2)]. Essentially, it is the Sarawak Biodiversity Council, consisting of state government appointees, that has overarching control over access to biological resources and the associated traditional knowledge in Sarawak for research and commercial purposes (*Biodiversity Centre Ordinance 1997* (Sarawak), Part II).

The State government's wide-ranging legal powers enable it to mould NCR recognition and the nature conservation framework to its own priorities. Unfortunately for both natives and nature, resource exploitative activities such as forestry, mining and agriculture remain key economic sectors in Sarawak (Sarawak Government 2021). As for harnessing indigenous expertise, the legal framework places little emphasis on treating local native communities as equal partners in the sustainable management and conservation of nature.

Statutory land rights: Natives of Sabah

Like Sarawak, NCR are recognised but regulated by statute in Sabah. NCR in Sabah are primarily governed by the Sabah Land Ordinance (SLO). Section 15 defines NCR to include land under 'customary tenure', which includes areas with fruit trees, grazing land, cultivation, burial grounds, and related rights of way (Munang 2015, p. 139). 'Customary tenure' under Section 66 of the SLO means the lawful possession of land by natives either by continuous occupation or cultivation for more than three years or by native title issued under written law. Again, the primary recognition of NCR in Sabah centres around settled agriculture rather than the stewardship of broader customary territories found in many local Indigenous communities (SUHAKAM 2013, pp. 20 – 21).

Section 76 of the SLO that provides for native communal title is problematic. A legacy of British paternalism, a communal 'title' is not registered in the name of the native community, but in the name of the State Collector of Land Revenue 'as trustee for the natives',

suggesting the native community's lack of control over its 'titled' land. Furthermore, a 2009 amendment to the law allows the State to decide the plan and purpose of a communal title, often favouring joint-venture land developments over NCR-based claims (SUHAKAM 2013, p. 102). This policy approach to native communal ownership does not bode well for nature conservation.

Subject to modification or extinction by the State, natives may also possess rights or conceded privileges that survive the creation of a forest reserve according to Sections 12 and 14 of the *Forest Enactment, 1968* (Sabah) (*SFE*). Section 41 of the SFE provides limited rights to remove forest produce from State land and alienated land (with consent from the owner) for specified individual or communal subsistence purposes. Beyond these provisions, statutory control over the administration of forest reserves, protected areas and forests in the state not covered by other specific legislation lies in the hands of the Chief Conservator of Forests and other authorised officers appointed by the government (*SFE*, Section 4 and Part II). Local native communities do not possess express statutory rights of co-management over these areas under the *SFE*. However, section 3A empowers the Chief Conservator to appoint suitable persons (such as local natives) to be Honorary Forest Rangers to assist in carrying into effect the *SFE*.

Despite changes in the law to facilitate the better management of nature conservation within Parks and Nature Reserves in Sabah (Section 3A, *Parks Enactment 1984, Sabah* (*SPE*)), local native communities lack formal control and management within such areas aside from regulated rights and privileges conceded by the state government under the *SPE* (Sections 8 and 9). Express statutory power over the administration of national parks lies with the Board of Trustees of Sabah Parks (*SPE*, Parts III-VI) and the Director of Parks, who is appointed by the Board and functions as chief executive officer (*SPE*, Sections 41 and 43). However, their powers may be delegated to committees (*SPE*, Section 37) and Honorary Park Rangers or Honorary Park Wardens (Section 41A). This delegation has facilitated the controlled participation of representatives of local native communities in the management of national parks (Abu Bakar and Wall 2019).

Under the *Wildlife Conservation Enactment 1997* (WCE), the Director of Wildlife of Sabah possesses wide powers of administration and management relating to wildlife and areas declared to be Wildlife Sanctuaries, Conservation Areas or Wildlife Hunting Areas (Section 4). The WCE provides for regulated: (i) traditional or native hunting (Section 20 and 75); (ii) animal kampung hunting licenses for the benefit of a village (Section 32); or (iii) native collection of turtle eggs (Section 87). Section 5 of the WCE permits the appointment of community members as Honorary Wildlife Wardens, potentially integrating them into some conservation efforts. That said, the Enactment does not provide for the explicit recognition of native land rights or the mandatory inclusion of natives in decision-making regarding the management of areas they have traditionally inhabited.

Section 35 of the *Inland Fisheries and Aquaculture Act 2003* permits the creation of a Community Fisheries Management Zone that may include committee members from a local community provided the Director of Fisheries considers it expedient or necessary to involve members of a local community in the management and conservation of local fisheries resources.

The *Sabah Biodiversity Enactment, 2000* (SBE) states that the FPIC of the relevant native or local community shall be obtained for any access to: (a) a biological resource on land to which such native and local community have a right as established by law; and (b) associated traditional knowledge held by such native and local community (*SBE*, Section 24B). However, the phrase 'a right as established by law' subjects the enforceability of such consent to the State's legal dominance over the parameters of NCR. This limitation

potentially reduces the provision's scope and effectiveness. Furthermore, the Sabah Biodiversity Council (*SBE*, Part II), consisting of state government officers and appointees, and the Director of the Sabah Biodiversity Centre, a public servant (*SBE*, Part IIA), have legal control over access to biological resources and associated traditional knowledge for research and commercial purposes.

Despite encouraging legislative efforts to include natives in conservation efforts (Jumin 2025), the power balance for the recognition and exercise of native rights and nature conservation in Sabah remains heavily in favour of the state government, its agencies and officers. The reality is that the state's economy is still closely tied to natural resource exploitation and agriculture (Sabah State Government 2025), and the struggle to effectively balance commercial interests with environmental protection and the recognition of broader forms of NCR persists as an ongoing challenge.

Judicial Recognition of Indigenous Land Rights in Malaysia

Since the late 1980s, Malaysian Indigenous communities have successfully asserted their customary land rights by relying on common law principles and a liberal judicial approach, enabling them to operate outside the confines of codified law (Subramaniam 2025, pp. 297 – 303).

The courts began recognising these Indigenous land rights in 1996, drawing inspiration from international precedents like the Australian *Mabo* and *Canadian Calder* cases. The Federal Court later affirmed this doctrine in *Madeli bin Salleh* (2008) 2 MLJ 677, establishing that the State's ultimate ownership (radical title) is legally subject to Indigenous rights.

These customary rights are proven by Indigenous Peoples demonstrating prior and continuous occupation and/or oral histories relating to their connection with the area claimed (Subramaniam 2025, p. 299). Furthermore, the State governments are held to a fiduciary duty to protect these rights (Subramaniam 2025, p. 299). However, this protection is limited: the State retains the power to extinguish these rights through clear legislation, provided it pays just compensation under Article 13 of the *Federal Constitution* (Subramaniam 2025, p. 299). Thus, while the courts provide a vital avenue for justice, the State maintains ultimate control over the tenure security of these rights.

However, relying on the Malaysian judicial system to secure Indigenous land rights presents significant challenges. Procedurally, Indigenous communities face major hurdles due to the high costs, protracted litigation timelines (sometimes over a decade), and the adversarial court setting which conflicts with traditional dispute resolution methods (Subramaniam and Nicholas 2018, p. 72). Issues such as the burden of proof, language barriers, and limited funds for expert witnesses often put litigants at a disadvantage (Subramaniam and Nicholas 2018, pp. 72 – 73).

Substantively, more recent Federal Court decisions have restricted rights in Borneo. In *Director Of Forest, Sarawak* v *TR Sandah Tabau* [2017] 3 CLJ 1, the Federal Court ruling severely narrowed common law Native Customary Rights ('NCR') in Sarawak by excluding broader Iban communal territories (*pemakai menoa*). Other rulings such as *TH Pelita Sadong Sdn Bhd* v *TR Nyutan Jami* [2018] 1 CLJ 19 have allowed indefeasible land titles in Sarawak to override earlier acquired NCR, reducing redress to mere monetary compensation. In Sabah, the Court of Appeal in *Assistant Collector of Land Revenues* v *Alfeus Yahsu* [2016] 7 CLJ 848 essentially limited the common law NCR to statutory NCR rights available under the *Sabah Land Ordinance*. Common law Orang Asli rights in Peninsular Malaysia remain unscathed presumably because the Orang Asli do not possess statutory customary land rights (Subramaniam and Wood 2023). Consequently, these rights, while available, are subject to the vagaries of the court process and potential regression in future cases.

STATE-LED INITIATIVES TOWARD INDIGENOUS MANAGEMENT OF NATURE CONSERVATION

As observed in the previous section, the main thrust of the relevant laws governing Indigenous land rights appears to be slanted towards a settled existence and agricultural lifestyle for Indigenous Peoples and may not necessarily be compatible with nature conservation. Furthermore, legal power over the management of nature conservation is vested in the relevant governments rather than equitably shared with local Indigenous communities.

However, the recognition of traditional ecological knowledge and Indigenous connections to land as central to conservation (Abas *et al.* 2022; Mohammad Wahyu *et al.* 2022), an international shift in conservation paradigms from exclusion to inclusion (Wook 2023; Subramaniam 2025, pp. 303 – 305) and the self-motivated defence of their traditional territories (Amnesty International 2018) have led to the increased participation of Malaysian Indigenous communities in conservation efforts.

Notwithstanding community-driven conservation efforts, there are numerous state-led initiatives where Indigenous groups partner with state agencies. However, simply listing these programmes is of limited utility. For this paper, a pertinent question is whether these programmes formally empower local Indigenous communities as equal partners in the management of nature conservation. Effective empowerment of Indigenous communities from a rights-based perspective would also include the right to FPIC in matters concerning their immediate local environment, meaning their traditional lands, resources and territories. These issues are examined in turn.

Many state programmes actively involve Indigenous peoples but fall short of elevating local communities to manage nature conservation. Examples include the Biodiversity Protection and Patrolling Programme (BP 3) that provide for training of Orang Asli trackers to be part of anti-poaching patrol teams in Peninsular Malaysia and the participation of Sarawak native communities in the Forest Landscape Restoration programme that focuses on restoring environmentally degraded areas.

Indigenous management-wise, Section 36 of the Sabah Inland Fisheries and *Aquaculture Enactment 2003* allows the Director of Fisheries to appoint Indigenous community members to a committee that administers and undertakes the management and conservation of the fisheries resources within an area formally declared as a Community Fisheries Management Zone. This provision indirectly recognises the *Tagal* system, a traditional native fish resource management system (SUHAKAM 2013). However, the lack of express legal recognition of the *Tagal* as 'an Indigenous Peoples' system' has posed jurisdictional conflicts between the state and native communities (SUHAKAM 2013, p. 108).

As discussed above, the *Sabah Parks Enactment 1984* permits, at the discretion of the Sabah Parks management, native communities to participate in national park management through the Community Use Zones. However, studies such as those carried out on the Tun Sakaran Marine Park suggest that the park is administered by Sabah Parks despite clear plans for Indigenous co-management and the recognition of NCR (Abu Bakar and Wall 2019). Progressive models, such as Indigenous Peoples and Community Conserved Territories and Areas (ICCAs), that provide an opportunity for autonomous and collaborative Indigenous management of conservation areas, have generated support among local Indigenous communities (Bulan and Maran 2020). However, ICCAs are yet to see formal and consistent State-recognition despite several successful cases in Sabah and Sarawak (for example, the Sabah Bundu Tuhan Native Reserve) (Bulan and Maran 2020).

The right to FPIC and effective consultation for Indigenous communities is a crucial safeguard to ensure an equitable power balance in the Indigenous management of their traditional areas. More recently, these rights have been incorporated into laws governing biodiversity (for example, the *Access to Biological Resources and Benefit Sharing Act 2017*) and carbon credits (for example, the *Forests (Forest Carbon Activity) Rules, 2022* (Sarawak)). However, these provisions should be examined in light of the broader legal framework on Indigenous land rights and nature conservation that does not explicitly empower and entrust Indigenous communities with stronger rights over their traditional areas. As seen in the case of the *ABSA* above, the requirement for FPIC may be limited if an Indigenous community is legally deemed not to have rights over their traditional territory. This legal setting brings into focus whether there is governmental will to rigorously implement the FPIC principle in a manner that ensures Indigenous communities are active partners and primary stakeholders in any action affecting them and their traditional areas.

In summary, it is doubtful government conservation initiatives have produced effective and equitable conservation management arrangements that include local Indigenous communities while legally recognising and protecting their traditional land and resource rights.

CONCLUSION

Notwithstanding the benefits of Indigenous management of nature conservation, the legal regime governing Indigenous land rights and nature conservation does not expressly recognise Malaysian Indigenous Peoples as equal management partners. However, national policies and plans are varied in this regard. The National Policy on Biological Diversity 2022 – 2030 is the most progressive as it recognises Indigenous Peoples as stewards of nature and the importance of empowering them to help conserve biodiversity in their localities [Ministry of Natural Resources and Environmental Sustainability (NRES) 2022, p. 35]. Governmental action includes the review of all legislation, procedures and policies towards the management and conservation of biodiversity, strengthening the FPIC process in projects that affect Indigenous Peoples and local communities, enhancing capacity building and support with regards to the recognition of basic human and land tenure rights and recognising the rights of Indigenous peoples towards certain biological resources through customary laws (NRES 2022, pp. 35 – 36, 80). Comparatively, the *Malaysia Policy of Forestry 2021* seeks to encourage the participation of Indigenous communities in the protection, conservation and rehabilitation of forests undertaken by the governments of all three jurisdictions (Ministry of Energy and Natural Resources (MENR) 2021, p. 6), except perhaps for Sabah where policy objectives include strengthening the participation of local communities in the implementation of forest management activities and carrying out regular consultations and dialogues with local communities (MENR 2021, pp. 59, 73). The 2024 National Climate Change Policy 2.0 acknowledges the need to establish environmental and social safeguards to protect the rights of Indigenous communities, but does not recognise them as primary partners in local actions to combat climate change (NRES 2024, p. 32). The 13th Malaysia Plan 2026 – 2030 focuses on the socio-economic development of the Orang Asli and NCR lands rather than nature conservation [Ministry of Economy (MOE) 2025, pp. 3 – 19] and does not expressly include local Indigenous communities as partners in its strategies on climate change, environmental management and biodiversity conservation (MOE 2025, pp. 5, 22 – 23). This direction suggests that the economic system is struggling to achieve a sustainable balance between Indigenous livelihood needs and conservation goals. More generally, continued state dominance in formal conservation efforts throughout Malaysia raises the question of whether there exists domestic conservation colonialism, where exclusionary Western conservation models are utilised to override Indigenous rights. As policy signals from the government appear to be mixed, it remains uncertain whether there is concerted governmental intent to share effective legal power with Indigenous communities for the management of nature conservation within their localities.

REFERENCES

Abas, A., Aziz, A. and Awang, A. 2022. A systematic review on the local wisdom of indigenous people in nature conservation. *Sustainability* 14(6): 3415.

Abu Bakar, N.A. and Wall, G. 2019. The importance of institutional support to sustain communities' livelihoods in marine protected area: Tun Sakaran Marine Park, Sabah, Malaysia. *ALAM CIPTA, International Journal on Sustainable Tropical Design Research & Practice* 12(2): 21–31.

Amnesty International. 2018. "*The Forest is Our Heartbeat": The Struggle to Defend Indigenous Land in Malaysia*. London: Amnesty International.

Bernama. 2018, March 5. 80% needs of Orang Asli community fulfilled: Ismail Sabri. *The Borneo Post*. http://www.rurallink.gov.my/wp-content/uploads/2018/03/E-AKHBAR-5-Mac-2018_opt.pdf.

Bulan, R. 2012. *The Legal Framework on Indigenous Land Rights in Malaysia: A Study to Contribute to the Suhakam National Inquiry into Indigenous Peoples Land Rights in Malaysia*. Kuala Lumpur: SUHAKAM.

Bulan, R. and R.G. Maran. 2020. Legal Analysis to Assess the Impacts of Laws, Policies and Institutional Frameworks on Indigenous People and Community Conserved Territories and Areas (ICCAs) in Malaysia. *ICCA Consortium*. https://www.iccaconsortium.org/wp-content/uploads/2021/06/malaysia_icca_legal-analysis_2021.pdf

Cobo, J.R.M. 1986. *Study of the Problem of Discrimination Against Indigenous Populations*. UN Doc E/CN.4/Sub.2/1986/7, Add.4.

Endicott, K. 2003. Indigenous rights issues in Malaysia. In *At the Risk of Being Heard: Identity, Indigenous Rights and Postcolonial States*, B. Dean and J.M. Levi (Eds). Ann Arbour: University of Michigan Press.

Errico, S. 2017. The rights of indigenous peoples in Asia: a human rights-based overview of national legal and policy frameworks against the backdrop of country strategies for development and poverty reduction. Geneva: International Labour Office, Gender, Equality and Diversity Branch.

Hooker, M.B. 1996. The Orang Asli and the laws of Malaysia: With special reference to land. *Akademika* 48: 21–50.

Wook, I. 2023. Indigenous Peoples in protected areas and equitable conservation: Recent legal and policy development in Malaysia. *Asian Journal of Law and Policy* 3(2): 49–64.

Jumin, R. 2025, January 6. 2024 in Review: Advancing Conservation in Sabah. *WWF Malaysia*. https://www.wwf.org.my/?33365/2024-in-Review-Advancing-Conservation-in-Sabah

Ministry of Economy (MOE). 2025. *13th Malaysia Plan 2026-2030: Melakar Semula Pembangunan*. Putrajaya: Ministry of Economy.

Ministry of Energy and Natural Resources (MENR). 2021. *Malaysia Policy on Forestry*. Putrajaya: Ministry of Energy and Natural Resources.

Ministry of Natural Resources and Environmental Sustainability (NRES). 2022. *National Policy on Biological Diversity 2022–2030*. Putrajaya: Ministry of Natural Resources and Environmental Sustainability.

Ministry of Natural Resources and Environmental Sustainability (NRES). 2024. *National Climate Change Policy 2.0 2024*. Putrajaya: Ministry of Natural Resources and Environmental Sustainability.

Mohammad Wahyu, D., Abas, A. and Sakawi. Z. 2022. Exploring the relevance of engaging the Orang Asli in Malaysia's forest management. *Frontiers in Forests and Global Change* 5: 1019994.

Munang, M.N. 2015. Land grabs in Sabah, Malaysia: Customary rights as legal entitlement for Indigenous Peoples – Real or illusory? In *Land Grabs in Asia: What Role for the Law?* C. Carter and A. Harding (Eds). London and New York: Routledge.

Nicholas, C. 2023. Malaysia. In The Indigenous World 2023, 37th edition, D. Mamo (Ed). Copenhagen: IWGIA.

Painemilla, K., Rylands, A.B., Woofter, A. and Hughes, C. 2011. *Indigenous Peoples and Conservation: From Rights to Resource Management*. Arlington: Conservation International.

Sabah State Government. 2025. Economy. The Official Website of the Sabah State Government. https://sabah.gov.my/en/content/economy

Sarawak Government. 2021. *Post-COVID Development Strategy 2030*. Kuching: Economic Planning Unit Sarawak, Chief Minister's Department.
Sikor, T. and Stahl, J. 2011. *Forests and People: Property, Governance and Human Rights*. New York: Earthscan.
Stevens, S. 2014. *Indigenous Peoples, National Parks and Protected Areas: A New Paradigm Linking Conservation, Culture, and Rights*. Tucson: The University of Arizona Press.
Subramaniam, Y. 2012. Orang Asli Land Rights by UNDRIP Standards in Peninsular Malaysia; An Evaluation and Possible Reform. PhD. Thesis. University of New South Wales.
Subramaniam, Y. 2025. Legal privileges and the effective recognition of Indigenous land rights: Lessons from Malaysia. In *Land Rights Now: Global Voices on Indigenous Peoples and Land Justice*, W. Nikolakis (Ed). Cambridge: Cambridge University Press.
Subramaniam, Y. and Nicholas, C. 2018. The courts and the restitution of Indigenous territories in Malaysia. *Erasmus Law Review* 18(1): 67–79.
Subramaniam, Y. and Wood, S.A. 2023. "Law" in the Malaysian Federal Constitution and Peninsular Malaysia Orang Asli Customary Land Rights at Common Law. *Malayan Law Journal* 1: cxlii-clxiv.
SUHAKAM (Human Rights Commission of Malaysia). 2013. *Report of the National Inquiry into the Land Rights of Indigenous Peoples*. Kuala Lumpur: SUHAKAM.
WWF *et al*. 2021. The State of Indigenous Peoples' and Local Communities' Lands and Territories: A technical review of the state of Indigenous Peoples' and Local Communities' lands, their contributions to global biodiversity conservation and ecosystem services, the pressures they face, and recommendations for actions. Gland: WWF *et al.*

Legislation

Aboriginal Peoples Act 1954
Access to Biological Resources and Benefit Sharing Act 2017
Biodiversity Centre Ordinance 1997 (Sarawak)
Biodiversity Enactment, 2000 (Sabah)
Biodiversity Regulations 2016 (Sarawak)
Federal Constitution
Forest Enactment, 1968 (Sabah)
Forests Ordinance 2015 (Sarawak)
Forests (Forest Carbon Activity) Rules, 2022 (Sarawak)
Inland Fisheries and Aquaculture Act 2003 (Sabah)
Interpretation Ordinance, 2005 (Sarawak)
Land Code, 1958 (Sarawak)
Land Ordinance (Sabah)
National Forestry Act 1984
National Land Code 1965
National Parks and Nature Reserves Ordinance, 1998 (Sarawak)
Parks Enactment 1984 (Sabah)
Wildlife Conservation Act 2010
Wildlife Conservation Enactment 1997 (Sabah)
Wild Life Protection Ordinance, 1998 (Sarawak)

Cases

Assistant Collector of Land Revenues v *Alfeus Yahsu* [2016] 7 CLJ 848
Director Of Forest, Sarawak v *TR Sandah Tabau* [2017] 3 CLJ 1
Superintendent of Land & Surveys Miri Division v *Madeli bin Salleh* [2008] 2 MLJ 677
TH Pelita Sadong Sdn Bhd v *TR Nyutan Jami* [2018] 1 CLJ 19


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 641–653
doi: 10.62613/sonc2025.v3ipc02

CHAPTER 2

Free, Prior, and Informed Consent (FPIC) and self-determination of Indigenous People in the context of environmental conservation in Sarawak

THOMAS JALONG[1], CELINE LIM[1], PETER KALLANG[1], WILLIE KAJAN NGANG[2] and NG SEAN FONG[3]*

Abstract: Nature conservation, in the context of establishing nature reserves, protected areas, and other forms of conservation areas, may result in potential conflicts with Indigenous Peoples (IPs), especially when no prior consultation took place, and the Indigenous Peoples' consent were not obtained. Prohibition that restrict IPs from accessing, harvesting resources from, or utilising surrounding forests that are demarcated as protected, are examples of how nature conservation has impinged upon the right for self-determination of the IPs. The principles Free, Prior, and Informed Consent (FPIC), explicitly outlined in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), highlights the importance of equitable and fair participation of the IPs in the governance, management, and use of surrounding lands. However, instances of misinterpretation and implementation of FPIC in bad faith continue to occur in Malaysia. This chapter examines both positive practices and challenges in the interpretation and implementation of FPIC in Sarawak, while highlighting instrumental role for safegauarding IP's rights and self-determination.

INTRODUCTION

"*Kalau berani, jangan takut; kalau takut, jangan berani.*"
— Adage repeated by Indigenous Leaders
during protests and blockades in Sarawak

Land is life. The customary land of the Indigenous Peoples (IPs) community function not only as their supermarket and hardware shop to obtain food and essentials, but also as a place of healing, learning, and a source of spirituality and beliefs. The IP community has learnt over generations, the ways of living in harmony with nature within their customary territories and roaming grounds. Their relationship with the land extends beyond meeting basic survival needs; they are deep-rooted with their identity and relationship with the natural environment.

From the land, the IP's language, culture, traditions, and spirituality are birthed. Through generations of observing the natural environment (the seen and unseen phenomena), accessing natural resources (e.g., food, water, medicine, and other materials), and engaging in activities closely connected to their territories, IPs develop a profound sense of attachment and affinity to their customary land. Land is much more than just a source of provision, as the fate and existence of the IP is intertwined with the land itself.

Broadly speaking, IP communities across Malaysia are highly communal. Successful hunts result in the meat being shared amongst the families in the community. In the event of a conflict, the community convenes at a common area for dialogue and seeks consensus to resolve the conflict. Communal resources, such as farmland are planted and harvested with the involvement of the entire village, men, women, and children together.

[1] SAVE Rivers, Miri, Sarawak, Malaysia.
[2] Long Terawan, Baram, Sarawak, Malaysia.
[3] Malaysian Nature Society, JKR 641, Jalan Kelantan, Bukit Persekutuan, 50480 Kuala Lumpur, Malaysia.
***Corresponding author: ngseanfong@gmail.com**

As Malaysia's urban centres—many of which are located along coastal areas and within floodplains—grow and expand outwards, available land for future development becomes increasingly scarce. At the same time, there is a growing recognition of the importance of undisturbed forests, coastal, and marine ecosystems towards planetary health and human wellbeing. These competing demands culminated in the expansion of gazetted and developed areas into the hinterlands where the IPs reside.

In the context of Sarawak, Native Customary Rights (NCR) land refers to the land owned by IP communities and is legally recognised by the legal system, whereas customary land is land that is utilised by IPs that is not necessarily legally recognised by the legal system. In most cases, NCR land represents a small portion of customary land that IPs use. This distinction becomes an issue when the Government of Sarawak only recognises NCR land, and considers customary land as state land, thereby undermining and extinguishing an Indigenous community's *de facto* rights over their land.

The encroachment, dispossession, and appropriation of Indigenous customary lands —whether attempted or actualised—in Malaysia is well documented. Cases such as the forced eviction of Temuans from Kampong Busut in Banting, Selangor for the development of the Kuala Lumpur International Airport (Nicholas 2010), the dispossession of land affecting numerous IP communities within the Upper Baram Forest Area in Sarawak (Lee *et al*. 2014), and the non-consultation of IP communities in signing of the Nature Conservation Agreement between the Sabah State Government and a foreign private entity (Channel News Asia 2022) highlight the lack of Free, Prior, and Informed Consent (FPIC) and the curtailing of self-determination by Indigenous communities, in matters concerning their customary land and their rights to it.

FPIC AND THE RIGHT TO SELF-DETERMINATION

Free, Prior, and Informed Consent (FPIC) is promulgated in two key international documents, which are the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) and the *Indigenous and Tribal Peoples Convention* (also known as *International Labour Organization Convention 169*, ILO C169). One key distinction between UNDRIP and ILO C169 is that UNDRIP is a declaration that can be adopted by a country, however the country is not legally bound to implement it in full, whereas ILO C169 is legally binding for signatory countries to ratify it. In Malaysia's case, the country has adopted UNDRIP, but has not signed onto ILO C169.

FPIC is both a principle and a process of continuous engagement and consultation between an external party and an Indigenous community, concerning any proposed activity or development that shall directly or indirectly impact the IP community (e.g., land, resources, cultures, or livelihoods). Before examining the individual components of FPIC in greater detail, it must be emphasised that FPIC should not be treated simply as a means for the external party to secure the consent of the IP community; instead, it is a neutral and participatory platform where the proponent and IP community can engage meaningfully. This process should enable the proponent to provide adequate information, seek community feedback, consider modifications to the original plan where necessary, and to reach a consensus or compromise with the IP community engaged. The process does not end there. The proponent should continue providing updates, collaborate, and establish appropriate mechanisms to address grievances. Importantly, the process must uphold the IP's autonomy and self-determination, including their right to withdraw their consent at any point in time and it must be rightly respected by the external party, without attempts to persuade or pressure the community into reversing its decision.

"*Free*" ensures that an Indigenous community is able to reach a consensus without being exposed to pressure, manipulation or intimidation. This may mean the IP community is accorded the space and time to deliberate and discuss on the matter. This includes consulting with the village shaman, conducting spiritual ceremonies to confer with and seek guidance from spiritual entities, and carrying out the aforementioned practices as many times as needed for the community to reach an organic conclusion together.

"*Prior*" ensures that an IP community is given adequate notice and space to form an opinion about the proposed activity and determine whether they wish to provide their consent, before the proposed activity takes place. Within this lies two aspects. Firstly, sufficient time and notice must be provided to facilitate the participation of all segments of the IP community (i.e., women and youth) in engagement session(s), with due consideration for the community's seasonal activities (i.e., avoiding sessions during farming or harvest periods). Secondly, consent must be obtained sufficiently in advance before the proposed activity takes place, as the FPIC process cannot be rushed and must allow ample time for deliberation by the IP community. The consent should not be regarded as permanent or irrevocable, as the IP community have the rights to withdraw their consent at any point of time afterwards, should they collectively decide they no longer agree with the proposed activity.

"*Informed*" means that the IP community receives sufficient information that is conveyed in a transparent, accurate, and understandable manner in order to make a fully informed decision about the proposed activity. This goes beyond presenting the technical details of the proposed activity, including its pros and cons, implementation timeline as well as the roles and responsibilities of parties involed. Equal consideration should also be given to the mode and method of how the information is delivered, such as using local and Indigenous languages, and appropriate printed media with clear and legible text font, among other measures, to ensure the IP community can fully understand the proposed activity and its potential impacts to them. The key distinction is for the proponent not merely inform the IP community of the proposed activity, but to actively engage with and consult with them throughout the process so they genuinely understand and informed of the situation before making a decision.

"*Consent*" means the Indigenous community has reached a consensus in agreement with the proposed activity. Consent may be given as it is, or it may be presented as conditional, where it will only be granted once certain conditions are fulfilled. Similarly, the IP community may withhold their consent or withdraw previously granted consent at a later stage, if the Indigenous community is no longer in agreement with the activity. The right to give consent, or to represent the community as a whole, may not necessarily be vested in the village headperson, to avoid misrepresentation of the Indigenous community.

Most importantly, FPIC as a principle and process must be undertaken in good faith, as a means for the Indigenous communities to exercise their right for self-determination. It is not a tool to be wielded in bad faith, solely to secure the perceived agreement/acceptance of the IP community to the proposed activity, irrespective of how it is secured.

CASES STUDIES: MISIMPLEMENTATION OF FPIC AND THE RIGHT TO INDIGENOUS SELF-DETERMINATION IN THE CONTEXT OF SARAWAK

Bakun and Murum Dam

The Bakun and Murum Dams are two of the multiple hydroelectric dams constructed in Sarawak. These dams are built in the interior watershed regions, which overlaps with customary and NCR land. For Bakun and Murum Dams, the inundation areas were 720 km^2 and 245 km^2 respectively, whereas the number of IPs forcibly displaced were approximately 10,000 and 1,400, respectively.

The Sungai Asap Resettlement Scheme housed the IPs displaced by the Bakun Dam. The displaced IPs found themselves in a precarious situation. Although they have received compensations, they were required to assume financial obligations as they now live in wooden houses (valued at RM52,000, to be borne in full with their names on the sales-and-purchase agreement) (Usit 2010). They also have to meet recurring expenses for basic utilities, or risk having their access to water and electricity cut off. While they had previously relied on hunting, fishing, and harvesting forest produce in the past, many now are increasingly dependent on purchasing and sundry from shops. Despite receiving cash compensation (up to RM100,000) for the loss of land and crops, this did not last for long when the IPs had to contend with the new expenses associated with the resettlement.

Each household was given a paltry three acres of land for cultivation. Some plots however, were unsuitable for cultivation, owing to its rocky or sandy composition, whereas some were located on swampy or steep terrains (Aiken and Leigh 2016). Other plots were located too far away from the access road, rendering it useless to the owners. Some IPs resorted to working at local plantations, where they received a daily pay of RM 20 – RM 30.

Some households chose to return to the inundated areas of their customary land, rebuilding their homes above the new waterline, where they are still able to remain and live on their land. For these IPs, their claims to compensation for the loss of land and crops were denied, as the State Government deemed them as squatters on state land (Kaur 2001).



Figure 1. Sungai Asap Resettlement Scheme as viewed from satellite imagery dated 26th of July 2024, where it is surrounded by plantations and large-scale land clearing. (Copernicus Data Space Ecosystem Browser 2025)

Baram Dam

The proposed Baram Dam was to be built on the Baram River, where it shall inundate an area of 400 km^2 and displace between 6,000 to 20,000 IPs from their customary lands. These communities, alarmed and aware of the history and plight that occurred during the development of the Bakun and Murum Dams, managed to coalesce into the Baram Protection Action Committee (BPAC). Communities of BPAC participated in engagement sessions organised by consultants carrying out the social and environmental impact assessment (SEIA), where one of its objectives was to seek the FPIC from the affected communities to the proposed Baram dam.

In a fact-finding mission by Lee *et al*. (2014), they reported that communities were not provided full information about the proposed dam. The potential benefits of the project were upsold, while the impacts, such as which communities will be inundated, were withheld from the IP community. There were no attempts for negotiation nor consultation; instead, the purpose of the engagement sessions veered towards merely informing the IP communities about the project. In addition to voicing their non-consent to the project during engagement sessions, Indigenous leaders went to Miri to repeat their non-consent to the proponent of the Baram Dam, Sarawak Energy Berhad (SEB).

The IP communities had to contend with misrepresentation of their voices by external parties. Instead of being elected by IP communities themselves through community protocols, government-appointed spokespersons and leaders expressed support for the proposed dam on behalf of the IP communities, thereby contravening the IPs' genuine sentiment and consensus in opposing the Baram dam. Occurrences of sponsored festivities, as well as providence of gifts and cash handouts by SEB to the IP communities were reported as well. At the same time, land acquisitions were undertaken by the government through the application of the Sarawak Land Code, simultaneously ignoring the customary land rights of the IPs and their non-consent to the proposed project.

In some IP villages, consultants and SEB officials resorted to threats, intimidation, and coercion to compel the IPs' participation in surveys. The IPs were told that if they do not participate in the survey, they will not be eligible to receive compensation money for the project. Lastly, the IP communities' right to self-determination was denied as the proposed Baram Dam was planned in advance, with the assumption that the IP communities needed the Baram Dam and the potential development that may occur within the region. Instead of having the right to determine the nature and terms of development on their NCR and customary lands, the IPs were presented with a pre-ordained development plan, leaving them with little or no meaningful opportunity to negotiate or influence the proposed course of action at all.

It took concerted effort of multiple IP communities over seven years to see the cancellation of the proposed Baram Dam, where it was officially shelved by the Sarawak government in 2015, followed by the revocation of the government gazette that extinguished the recognition of NCR land within the dam reservoir area in 2016 (Malaysiakini 2016).



Figure 2. Indigenous leaders protesting against the Baram Dam at the venue of the International Hydropower Association World Congress 2013, held at the Borneo Convention Centre in Kuching, Sarawak. (Copyright: Save Rivers Sarawak).

Timber and monoculture industry

A study on forest cover change in Borneo elucidated that Sarawak has a total land area of 124,005 km^2, of which 92,152 km^2 were forest areas in 1973. With 1973 as baseline, Sarawak's logged forest area and forest area loss in 2010 was 52,681 km^2 (42.48% of total land area) and 21,309 km^2 (23.12% loss against forest areas in 1973), respectively (Gaveau *et al.* 2014).

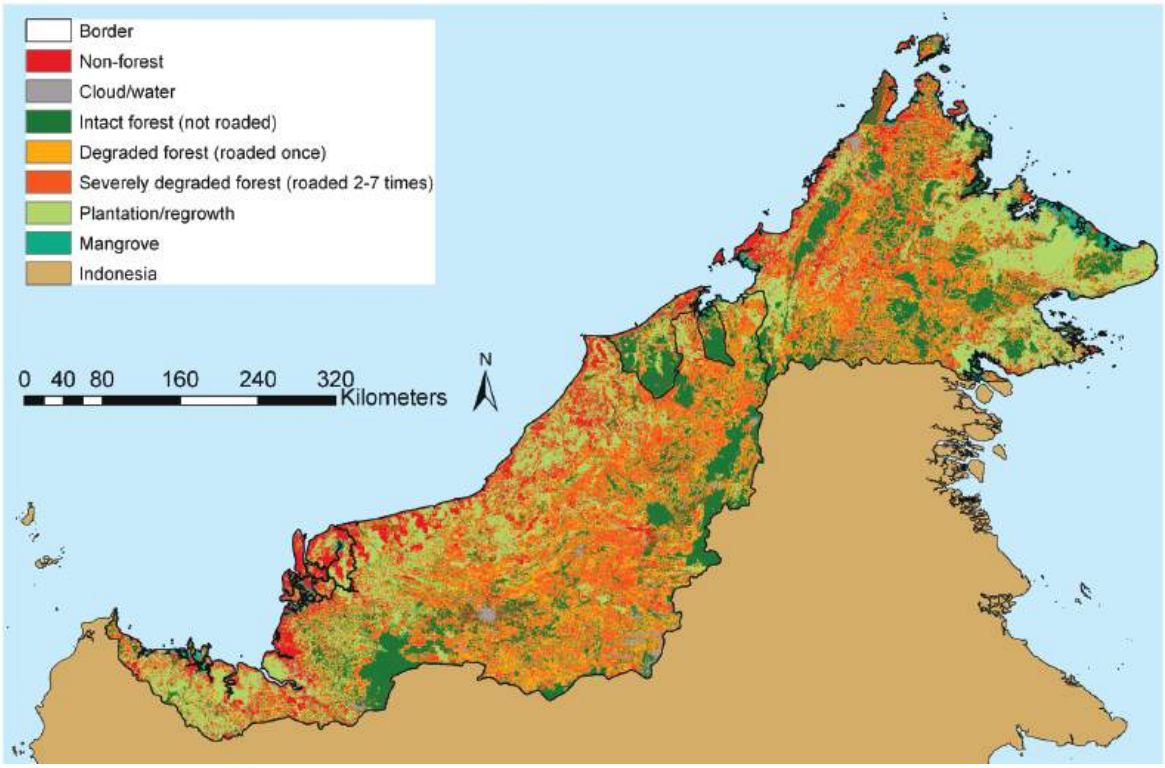


Figure 3. Very little intact forest (20% of land area) remains in Sarawak in 2009 (Bryan *et al.* 2013).

As encroachment, deforestation, logging, and monoculture plantations crept towards customary lands, the IP communities across Sarawak expressed their disagreement and rejection of such violations to their lands. Attempts for dialogue via correspondences, consultations and engagement sessions by the IP communities to the project proponent, consultants, and the authorities either fell on deaf ears, were brushed aside, or received a response that highlighted the benefits of logging instead (The Borneo Project and Bruno Manser Fonds 2023).

In response, the IP communities erected blockades at key entry points to block unauthorised vehicles and personnel from entering their customary lands. These blockages, constructed of wood, are manned by members of the IP communities. Food was either foraged from the surroundings, or purchased with the communities' money and contributions from external donors. Such blockades were often organised as peaceful and communal events, reflecting the community's solidarity and their determination to defend their customary lands.

Section 90B was then introduced to the *Forests Ordinance 1958*, outlawing (1) the construction of, (2) being present at, and (3) preventing the destruction of blockades. This empowered enforcement officers to detain Indigenous protestors and remove blockades,

with force if needed. This amendment was retained when the *Forests Ordinance 2015* came into force, under Section 102 (Offences relating to obstruction of road). However, this did not deter the IP communities from continuing to erect and maintain blockades even to this day, in order to prevent and protest against the unwanted entry of foreign parties into lands.

For legitimate NCR lands, some IP communities were approached by either the Sarawak Land Consolidation and Rehabilitation Authority (SALCRA) or the Land Custody Development Authority (LCDA) to develop the NCR land under a joint venture (JV), often for the cultivation of cash crops such as oil palm. For these JVs, shareholding is split, where 10% of shares is held by LCDA, 30% by NCR land owners, and 60% by the investors. The NCR land owners are deemed to have paid for their 30% share through the surrender of their NCR land to LCDA, which the latter is appointed a Trustee (with Power of Attorney) for the NCR land owners. The LCDA deals with the investors on behalf of the NCR land owners.

During the period of the JV—typically lasting 60 years, the NCR land owners were not permitted to utilise the NCR land surrendered for the JV, and they were allegedly not permitted to even enter the area. The NCR land owners also do not have any say in the management and benefits. There was no rescission clause in the JV agreement that allows the NCR land owners to request for the land back, prior to the completion of the JV. The perceived benefit of the JV, which is the disbursement of dividends to the NCR land owners, did not materialise in some cases. One IP community in particular joined a JV in 1993, but has not received a single dividend disbursement since 2013 (Human Rights Commission of Malaysia 2013).[a]



Figure 4. Berawan community in Mulu protesting against the development of facilities around Gunung Mulu National Park by Borsarmulu Park Sdn. Bhd., which is linked to the late Abdul Taib Mahmud, a former Yang di-Pertua Negeri and Chief Minister of Sarawak. (Copyright: Willie Kajan Ngang)

[a] The explanation given by SALCRA for this particular JV is that dividends will only be disbursed if there was profit.

Indigenous leaders, non-governmental organisations (NGOs), and community-based organisations (CBOs)—who drew attention to the issue, organised and empowered the communities to defend their rights and lands, and published reports and exposés—were targeted by both authorities and private sector alike. Indigenous leaders, including Thomas Jalong, Jok Jau Evong, Gara Jalong, Raymond Abin, and many others, were prevented from leaving Sarawak or Malaysia to raise awareness about deforestation and Indigenous issues at international events and conferences (Phoa 2009). Social activist, Bill Anak Kayong, was shot dead in Miri on the 21st of June 2016, with many suspecting his death was linked to his work with IP communities and the safeguarding of their customary land (Pearce 2017).

Save Sarawak Rivers Network (SAVE Rivers), a grassroots NGO working alongside IP communities affected by home encroachment and deforestation on their customary lands, was served with a lawsuit by Samling Plywood Miri Sendirian Berhad in June 2021. The lawsuit was filed on the grounds of alleged defamation. Samling demanded an apology, an injunction to stop SAVE Rivers from reporting community claims, and compensation amounting to RM 5 million (The Borneo Project and Bruno Manser Fonds 2023). The trial was rescheduled four times over the span of 25 months before the case was eventually withdrawn, resulting in considerable expenditure of resources and time (Keeton-Olsen 2023). This practice is commonly referred to as the Strategic Litigation Against Public Participation (SLAPP) and is utilised as a tool to silence activists, NGOs, andCBOs from exposing wrongdoings or advocating for the rights of the affected.

Fortress conservation

Indigenous communities whose lands are located within Sarawak's Totally Protected Areas (TPAs), which are categorised as National Parks, Wildlife Sanctuaries, and Nature Reserves face challenges pertaining to their customary lands as well. As the purpose of TPAs is primarily the conservation of biodiversity and the natural environment within its boundaries, this puts TPAs at odds with the forest resource utilisation of the IP communities. In the most extreme of cases, TPAs shall seek to minimise human presence within a park, including the removal of settlers, IP communities, and local communities that have long histories of living within the proposed TPA. This is known as fortress conservation. [b]

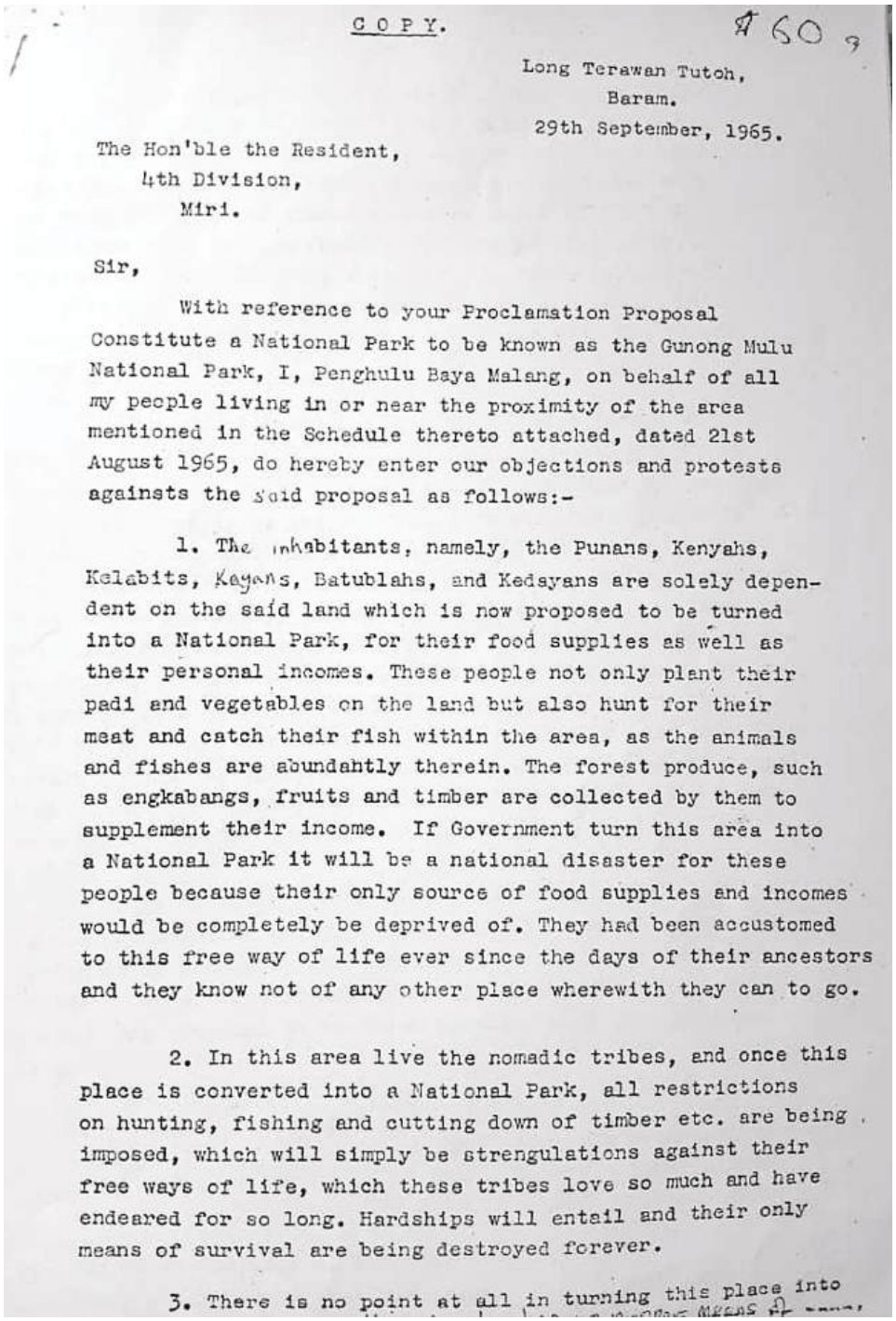
An example of fortress conservation in Sarawak would be the Gunung Mulu National Park (GMNP). While IP communities have long resided within the Mulu area, British explorers first set foot into the Mulu area in 1857 during their expeditions to the interiors of Sarawak. The route to the summit of Gunung Mulu was discovered by Tama Nilong, a Berawan from Long Terawan in 1920 (Wong *et al*. 2019). It would take more than 50 years before Gunung Mulu and its surrounding areas exceeding 50,000 hectares were gazetted as a National Park in 1974. Owing to its rich and endemic biodiversity, as well as the unique cave and karst formations, GMNP was designated as a UNESCO World Heritage Site in 2000.

Indigenous ethnic groups such as Penan, Berawan, Kenyah, Kelabit, and others have long inhabited within and around GMNP. This was recognised in the various scientific expeditions carried out in GMNP when it was first gazetted (Jermy 1983). It was important to note that in 1962, expedition researchers and administrative officers sought consent of the late Penghulu Baya Malang[c] to carry out scientific surveys around Gunung Mulu, where after several rounds of negotiations, the late Penghulu consented to allowing scientific

[b] For further reading on fortress conservation, refer to "*People, Parks, and Power: The Ethics of Conservation -related Resettlement*" by Maria Sapignoli and Robert K. Hitchcock.

[c] The late Penghulu Baya Malang was the elected Penghulu (Headman) for the Tutoh, Kenyah, and Penan houses in Apoh, back in 1959. *Sarawak Gazette* Vol LXXXV, No. 1220, 31st October 1959. https://pustaka-sarawak.com/gazette/gazette_uploaded/1411887107.pdf

expeditions to be carried out only within a set boundary (parts of the lowland, extending from the rivermouth to the foothills and to the peak of Gunung Mulu) established by the late Penghulu and agreed by the administration (Jacobs and Kajan 2019). It should be noted that the consent obtained from the late Penghulu was only for the scientific expedition, and not for any commercial endeavours at all (Figure 5).



COPY.

Long Terawan Tutoh,
Baram.
29th September, 1965.

The Hon'ble the Resident,
4th Division,
Miri.

Sir,

With reference to your Proclamation Proposal Constitute a National Park to be known as the Gunong Mulu National Park, I, Penghulu Baya Malang, on behalf of all my people living in or near the proximity of the area mentioned in the Schedule thereto attached, dated 21st August 1965, do hereby enter our objections and protests againsts the said proposal as follows:-

1. The inhabitants, namely, the Punans, Kenyahs, Kelabits, Kayans, Batublahs, and Kedayans are solely dependent on the said land which is now proposed to be turned into a National Park, for their food supplies as well as their personal incomes. These people not only plant their padi and vegetables on the land but also hunt for their meat and catch their fish within the area, as the animals and fishes are abundahtly therein. The forest produce, such as engkabangs, fruits and timber are collected by them to supplement their income. If Government turn this area into a National Park it will be a national disaster for these people because their only source of food supplies and incomes would be completely be deprived of. They had been accustomed to this free way of life ever since the days of their ancestors and they know not of any other place wherewith they can to go.

2. In this area live the nomadic tribes, and once this place is converted into a National Park, all restrictions on hunting, fishing and cutting down of timber etc. are being imposed, which will simply be strengulations against their free ways of life, which these tribes love so much and have endeared for so long. Hardships will entail and their only means of survival are being destroyed forever.

3. There is no point at all in turning this place into

Figure 5. Correspondence between Penghulu Baya Malang and the Resident of the 4th Division, where Penghulu Baya Malang expressed his disagreement with the proposal to establish the GMNP. (Copyright: Willie Kajan Ngang).

From the gazettement of GMNP and the various scientific expeditions, the *Gunung Mulu National Park: A Management and Development Plan* (the Management Plan) was produced jointly by the Sarawak Forestry Department and the Royal Geographical Society in 1982. The Management Plan outlined, *inter alia*, the plans to rehabilitate the nomadic Penan into a more settled form of existence, where they were to gradually transition from their traditional hunting-gathering way of life, into a sedentary community based on agriculture, handicraft production, and settled domestic practices. The Management Plan highlighted the priority of nature preservation through the following statements[d]:

- "The protection of the park itself, and the fauna and flora therein, must be the primary consideration."
- "The most difficult problem concerning the management of the Park is the regulation, or overseeing, of the privileges of the local people."
- (The Penan) "should be given agricultural training"; develop their skills in their traditional handicrafts so as to enable them to earn ready cash"; and "teach them basic house-keeping and hygiene".
- (The prescribed hunting and foraging privileges of locals) "must be respected."
- "It is recommended that the reduction of the privileges of the Penan might be gradually implemented as follows: Closure of part or parts of the Park, particularly in lowland areas traversed by visitors, to the hunting of the more threatened species, notably monkeys and gibbons; Extension of the areas closed to the hunting of specified mammals and birds, and the number of protected species to be increased."

To the shock of the IP communities of Gunung Mulu, visitors began to arrive at GMNP in the 1980s, followed by the gradual development of hospitality infrastructures, including the Mulu Airport. This brought on an influx of outsiders onto the customary lands of the Indigenous communities. At the same time, the imposition of GMNP resulted in the local IP communities being given varying degrees of privileges to hunt wildlife and forage produce for sustenance, as opposed to their original unimpeded right to hunt and forage.

There was also the appropriation and commercialisation of Indigenous culture, including the construction of elevated walkways over the burial grounds of the IPs in the caves of GMNP. A study by DeLoach (2021) revealed that a request by the IP community in Long Iman for GMNP to contribute RM 2 to RM 5 per park guest to the Long Iman community went unanswered. In the context of IP communities working as nature guides, the study showed that many IPs of Mulu area face difficulties in passing the courses and examples required to become a licensed guide.

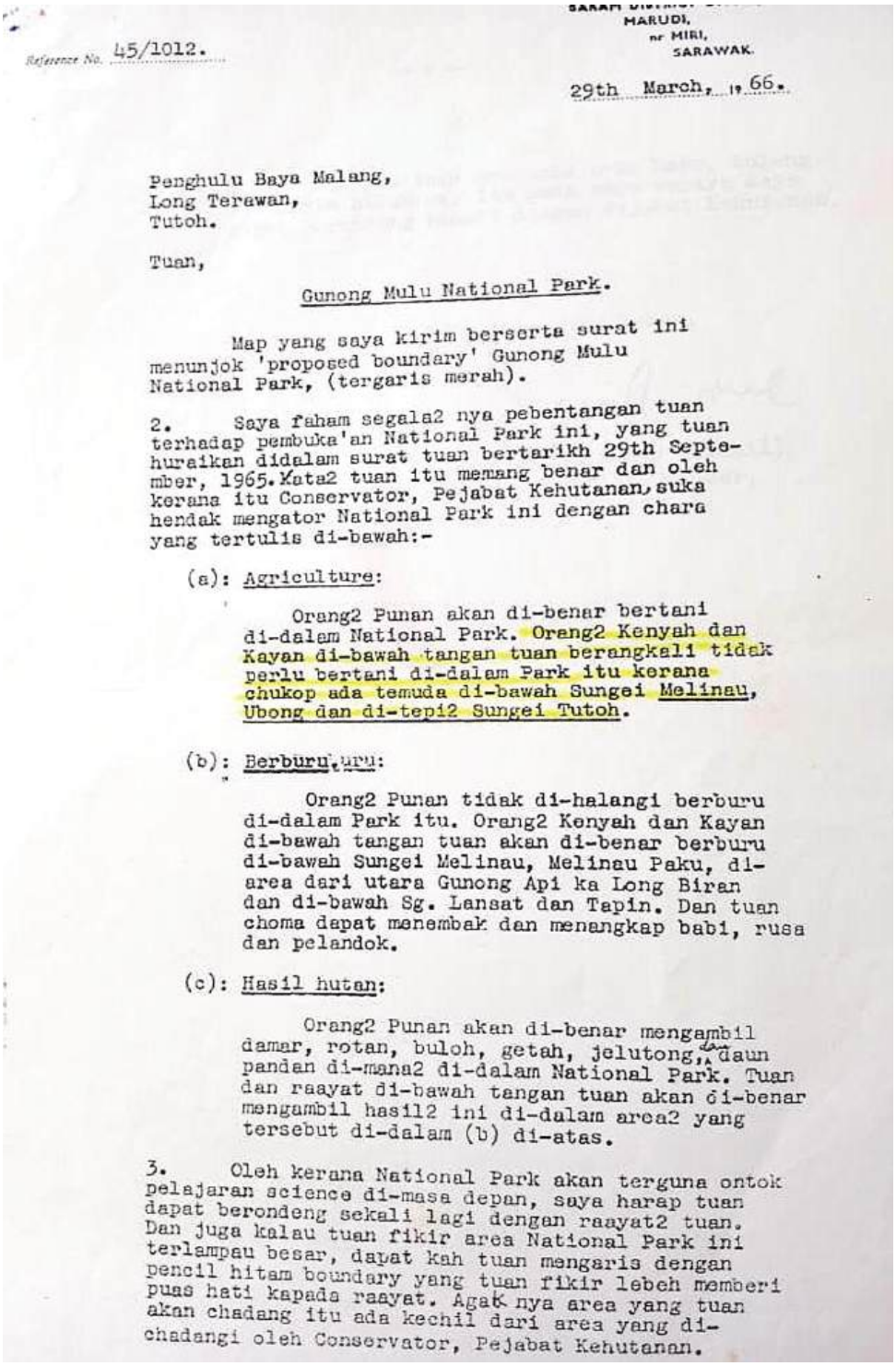
The Conservation Outlook Assessment on the GMNP was conducted by the International Union for the Conservation of Nature (IUCN) in 2025, where in its report stated that some IP communities continue in the non-recognition of the GMNP. An excerpt from the assessment on the topic of "Involvement of stakeholders and rightsholders, including Indigenous Peoples and Local Communities, in decision-making processes" states:

"... After significant land clearing and construction of some 20 shelters in Extension 1 of the national park the group responsible were challenged to explain themselves and the spokesperson's reply was "this is our hunting land. It was made a national park without our consultation or agreement."

– International Union for the Conservation of Nature and Natural Resources (2025).

[d] The Gunung Mulu National Park: A Management and Development Plan can only be found in select libraries around the world and not available online. These quotes are referenced through a postdoctoral Master's thesis "*The Park is the People: (Mis)representations of Nature and Indigeneity at Gunung Mulu National Park in Malaysia*" by Haley R. DeLoach (2021).

While tourism may have contributed to the source of income for IP communities of GMNP, it cannot be denied that the establishment of GMNP did not bear the FPIC of the IP communities, and it has denied the Indigenous communities' right for self-determination.



MARUDI,
MIRI,
SARAWAK.

Reference No. 45/1012.

29th March, 1966.

Penghulu Baya Malang,
Long Terawan,
Tutoh.

Tuan,

Gunong Mulu National Park.

Map yang saya kirim berserta surat ini menunjok 'proposed boundary' Gunong Mulu National Park, (tergaris merah).

2. Saya faham segala2 nya pebentangan tuan terhadap pembuka'an National Park ini, yang tuan huraikan didalam surat tuan bertarikh 29th September, 1965. Kata2 tuan itu memang benar dan oleh kerana itu Conservator, Pejabat Kehutanan, suka hendak mengator National Park ini dengan chara yang tertulis di-bawah:-

(a): Agriculture:

Orang2 Punan akan di-benar bertani di-dalam National Park. Oreng2 Kenyah dan Kayan di-bawah tangan tuan berangkali tidak perlu bertani di-dalam Park itu kerana chukop ada temuda di-bawah Sungei Melinau, Ubong dan di-tepi2 Sungei Tutoh.

(b): Berburu, uru:

Orang2 Punan tidak di-halangi berburu di-dalam Park itu. Orang2 Kenyah dan Kayan di-bawah tangan tuan akan di-benar berburu di-bawah Sungei Melinau, Melinau Paku, di-area dari utara Gunong Api ka Long Biran dan di-bawah Sg. Lansat dan Tapin. Dan tuan choma dapat menembak dan menangkap babi, rusa dan pelandok.

(c): Hasil hutan:

Orang2 Punan akan di-benar mengambil damar, rotan, buloh, getah, jelutong, daun pandan di-mana2 di-dalam National Park. Tuan dan raayat di-bawah tangan tuan akan di-benar mengambil hasil2 ini di-dalam area2 yang tersebut di-dalam (b) di-atas.

3. Oleh kerana National Park akan terguna ontok pelajaran science di-masa depan, saya harap tuan dapat berondeng sekali lagi dengan raayat2 tuan. Dan juga kalau tuan fikir area National Park ini terlampau besar, dapat kah tuan mengaris dengan pencil hitam boundary yang tuan fikir lebeh memberi puas hati kapada raayat. Agak nya area yang tuan akan chadang itu ada kechil dari area yang di-chadangi oleh Conservator, Pejabat Kehutanan.

Figure 6. Correspondence between the authorities and Penghulu Baya Malang regarding the allowable activities to be undertaken by the Indigenous communities within and around GMNP. (Copyright: Willie Kajan Ngang)

CONCLUSION

This Chapter seeks only to highlight the fundamental rights and connection of the IPs to their land and fate, how it was disrespected and denied time and time again over the decades, and the lessons that must be learnt from it. One must not assume what should or needs to happen pertaining to IPs. Instead one should engage in dialogue in good faith, and achieve mutual understanding regarding what the IPs want and allow to happen on their lands. History has shown that there are no shortcuts in recognising and respecting the FPIC right to self-determination.

Acknowledgements: The writer sincerely acknowledges and thanks the contribution from reviewers such as Adrihani Rashid, Ayesha Keshani, Donovan Louis, Mark Bujang, and Celine Lim that provided factual corrections, clerical edits, and streamlining the content flow of this Chapter. The writer also expresses his thanks for the time, trust, and courtesy given to him by Uncle Thomas, Miss Celine, Uncle Peter (and his family), Uncle Willie, Miss Beatrice, and others during his visit to SAVE Rivers in Miri, Sarawak.

REFERENCES

Aiken, S.R. and Leigh, C.H. 2016. Dams and indigenous peoples in Malaysia: Development, displacement and resettlement. *Geografiska Annaler: Series B, Human Geography* 97(1): 69–93. https://doi.org/10.1111/geob.12066

Bryan, J.E., Shearman, P.L., Asner, G.P., Knapp, D.E., Aoro, G. and Lokes, B. 2013. Extreme differences in forest degradation in Borneo: Comparing practices in Sarawak, Sabah, and Brunei. *PLoS ONE* 8(7): e69679. https://doi.org/10.1371/journal.pone.0069679

Catama. 2025. *Aram Bekelala: Community Engagement Guide*. Sarawak: Catama and British Council. https://arts.britishcouncil.org/resources/community-engagement-guide-aram-bekelala

Channel News Asia. 2022. Sabah 100-year carbon trading deal: Controversy as indigenous communities bemoan lack of consultation, details. *Channel News Asia*. https://www.channelnewsasia.com/asia/sabah-nature-conservation-agreement-carbon-trading-hoch-standard-singapore-2562841

Copernicus Data Space Ecosystem Browser. n.d. Copernicus Data Space Ecosystem Browser. *Copernicus Data Space Ecosystem Browser*. https://browser.dataspace.copernicus.eu/?zoom=12&lat=3.04115&lng=113.91964&themeId=DEFAULT-THEME&visualizationUrl=U2FsdGVkX1%2FByvdhc%2BeZlXU%2F3Dp8QscwKT6MhhxhxORrnmfkILA87clyn4BCCVPS0ic%2B3tfeKR0atnYjrPbLxnXfq7S%2BquBv8JzjBGT01B0ZHmMGfpNrb7F4o7axibK8&dat

DeLoach, H. R. 2021. 'The Park is the People': (Mis)representations of nature and indigeneity at Gunung Mulu National Park in Malaysia. Master's thesis. Georgia: University of Georgia.

Durin, X.O., Moi, B.X.M., Karunakaran, P.P., Leong, L.W.S., Afrouzi, H.N. and Mehranzamir, K. 2022. A comprehensive review of the environmental impacts of hydropower projects in Sarawak, Malaysia. *Future Energy* 1(3): 1–10. https://doi.org/10.55670/fpll.fuen.1.3.1

Gaveau, D.L., Sloan, S., Molidena, E., Yaen, H., Sheil, D., Abram, N.K., Ancrenaz, M. *et al.* 2014. Four decades of forest persistence, clearance and logging on Borneo. *PLoS ONE* 9(7): e101654. https://doi.org/10.1371/journal.pone.0101654

Human Rights Commission of Malaysia. 2013. *Report of the National Inquiry into the Land Rights of Indigenous Peoples*. Kuala Lumpur, Malaysia: Human Rights Commission of Malaysia. https://suhakam.org.my/wp-content/uploads/2023/11/NI.pdf

IAITPTF and IPF. 2021. *Handbook on Free, Prior and Informed Consent for Practical Use by Indigenous Peoples' Communities*. Nairobi: International Alliance of Indigenous and Tribal People of the Tropical Forests (IAITPTF) and the Indigenous Peoples' Foundation for Education and Environment (IPF).

Intergovernmental Panel on Climate Change. 2023. Summary for Policymakers. In *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, H. Lee and J. Romero (Eds.), pp. 1–34. Geneva: Intergovernmental Panel on Climate Change. https://doi.org/10.59327/IPCC/AR6-9789291691647.001

International Union for the Conservation of Nature. 2025. *Gunung Mulu National Park 2025 Conservation Outlook Assessment*. Gland: International Union for the Conservation of Nature. https://worldheritageoutlook.iucn.org/node/1103/pdf?year=2025
Jacobs, J. and Kajan, W. 2019, April 1. Taking Action For Mulu. *BFM Earth Matters*. https://www.bfm.my/content/podcast/em-taking-action-mulu.
Jermy, C. 1983. Gunung Mulu National Park, Sarawak. *Oryx* 17(1): 6–14. https://doi.org/10.1017/S0030605300018329
Kaur, A. 2001, July 14. Bakun dam natives: S'wak minister's apathy rapped. *Malaysiakini*. https://www.malaysiakini.com/news/3874
Keeton-Olsen, D. 2023, October 4. Small wins for Indigenous Malaysian activists in dispute with timber giant. *Mongabay*. https://news.mongabay.com/2023/10/small-wins-for-indigenous-malaysian-activists-in-dispute-with-timber-giant/
Lee, T., Jalong, T. and Wong, M.-C. 2014. *No Consent to Proceed: Indigenous Peoples' Rights Violations At The Proposed Baram Dam In Sarawak*. Miri: Save Sarawak Rivers Network (SAVE Rivers). https://www.forestpeoples.org/fileadmin/uploads/fpp/migration/publication/2014/08/noconsenttoproceedbaramreport2014-1.pdf
Malaysiakini. 2016, March 22. Controversial Baram Dam cancelled, natives rejoice. *Malaysiakini*. https://www.malaysiakini.com/news/334694
Nicholas, C. 2010. *Orang Asli Rights Problems Solutions: A Study Commissioned by SUHAKAM*. Kuala Lumpur: Human Rights Commission of Malaysia.
Pearce, F. 2017, March 24. Murder in Malaysia: how protecting native forests cost an activist his life. *The Guardian*. https://www.theguardian.com/environment/2017/mar/24/in-malaysia-how-protecting-native-forests-cost-an-activist-his-life
Phoa, J. 2009. Protecting Native Customary Rights: Is Legal Recourse Viable Alternative? *Akademika* 77: 69–89. https://journalarticle.ukm.my/607/1/akademika78%5B03%5DA4.pdf
Sovacool, B.K. and Bulan, L.C. 2011. Behind an ambitious megaproject in Asia: The history and implications of the Bakun hydroelectric dam in Borneo. *Energy Policy* 39(9): 4842–4859. https://doi.org/10.1016/j.enpol.2011.06.035
The Borneo Project and Bruno Manser Fonds. 2023. *Lost in Certification: How forest certification greenwashes Samling's dirty timber and fools the international market*. Berkeley: The Borneo Project; Basel: Bruno Manser Fonds. https://borneoproject.org/wp-content/uploads/lostincertification.pdf
Usit, K. 2010, May 5. Shadow of Bakun looms over Sibu. *Malaysiakini*. https://www.malaysiakini.com/news/130982
Wong, S.Y., Boyce, P.C., Aisahtul, B.W. and Chai, S.K. 2019. Araceae of Mulu National Park I: Four new species of Schismatoglottis (Araceae). *Nordic Journal of Botany* 37(11): 1–10. https://doi.org/10.1111/njb.02566
Wook, I., Nordin, R. and Hassan, M.S. 2022. *The Rights of Indigenous People in Malaysia: The United Nations Declaration on The Rights of Indigenous Peoples (UNDRIP) and The Law in Malaysia*. Kuala Lumpur: SUHAKAM.


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 655–661
doi: 10.62613/sonc2025.v3ipc03

CHAPTER 3

Indigenous knowledge on conservation

GORDON JOHN THOMAS*

Abstract: Indigenous knowledge (IK) is deeply rooted in the intergenerational practices, customary laws, spiritual beliefs and connections to ancestral territories. These knowledge systems shape how the Indigenous communities interact with their surrounding environments and natural resources. This chapter explores the principles Indigenous-led conservation practices, such as the *Tagal* or *Bombon* system of fisheries management, the *Tovol* system of customary forest resource regulation, the *Sogindai* and *Sogian* traditional zoning practices, and the *Turugan* rotational farming system. However, these practices are facing growing threats from insecure customary land rights, development pressures, exclusionary conservation policies and erosion of traditional knowledges. Upholding the Free, Prior and Informed Consent (FPIC) and recognising Indigenous Community Conserved Areas (ICCAs) are important in safeguarding Indigenous communities and their traditional knowledge.

INTRODUCTION

The Indigenous Peoples of Malaysia, collectively known as Orang Asal, comprise approximately 3.7 million people, representing about 13.8% of the national population. They are broadly categorised into three regions. In Peninsular Malaysia, they are known as the Orang Asli and consist of 18 sub-ethnic groups, including the Negrito, Senoi, and Proto-Malay. In Sarawak, they are referred to as Orang Ulu or Dayak, encompassing around 28 groups such as the Iban, Bidayuh, Kenyah, Kayan, and Penan. In Sabah, they are recognised as Natives or Anak Negeri, made up of 39 distinct groups, including the Kadazandusun, Murut, Bajau, Rungus, and Orang Sungai. Legally, the Federal Constitution refers to Indigenous Peoples in the Peninsula as "aborigines" and those in Sabah and Sarawak as "natives." Despite these differing labels, they share deep historical, spiritual, and cultural connections to their ancestral lands and natural resources.

Indigenous knowledge

Indigenous knowledge (IK), also referred to as Traditional Ecological Knowledge (TEK), is a collective, intergenerational system of wisdom rooted in direct experience and spiritual values. Rather than being a collection of abstract facts, IK is a way of life encoded in oral traditions, rituals, and lived practices that guide how a community interacts with its ancestral territory.

At the core of Indigenous knowledge systems is the principle of interconnectedness, where humans, nature, and the spiritual realm are understood as deeply and inseparably linked, both physically and spiritually. This worldview shapes how communities relate to their environment, emphasising balance, respect, and responsibility in all interactions with the natural world. One key expression of this philosophy is *Gompi-Guno* (Use and Protect), a guiding principle especially prominent in Sabah. It reflects the belief that natural resources are gifts that must be used according to need while being carefully protected for future generations. This approach promotes restraint, stewardship, and long-term sustainability rather than exploitation.

PACOS Trust, Taman Flash Gordon, Kg. Kivatu, KM18 Jalan Tambunan, 89507 Donggon, 89507 Donggongon, Sabah, Malaysia.
***Corresponding author: gordonjohnthomas@gmail.com**

Spiritual governance also plays a central role in regulating human behaviour. Many Indigenous communities believe that elements of the natural environment, such as rocks, trees, and water sources, are inhabited by spiritual guardians known as *Moinat* or *Penjaga*. This belief creates a form of "sacred geography," where specific places are governed by taboos and customary rules to ensure respect and harmony. These practices help maintain what is understood as cosmic balance, often referred to as *Osogit*.

Within this system, consequences are closely tied to actions. Mismanagement of resources or disrespect toward nature is believed to result in *Ohusian*, which may manifest as misfortune, illness, or natural disturbances. This belief functions as an internal regulatory mechanism, reinforcing sustainable practices and encouraging individuals and communities to act responsibly toward the environment.

Indigenous knowledge forms the backbone of ICCAs (Territories and Areas Conserved by Indigenous Peoples and Local Communities), often referred to as "territories of life." This is also reflected in the Kunming-Montreal Global Biodiversity Framework, which emphasises respect for Indigenous rights. Specifically, Target 3 requires that all actions taken to protect 30% of the world's land and sea must respect the rights of Indigenous Peoples and local communities over their traditional territories. In Malaysia, these are categorised by three pillars: a deep connection to the territory, community-led governance power, and positive conservation outcomes. Examples include the Bundu Tuhan Native Reserve, where 60% of the land is a community-managed forest, and the Kiau Community Forest, governed by the GOMPITO organisation to protect traditional knowledge and biodiversity.

ICCAs or territories of life are not limited to the settlement or village area only. It is only one part of this system. Surrounding it are forest areas that provide essential resources such as medicine, wild food, and materials for daily use, while also holding sacred sites that are protected through cultural beliefs and practices. These forests are not just physical spaces, but spiritual landscapes that are respected and carefully managed.

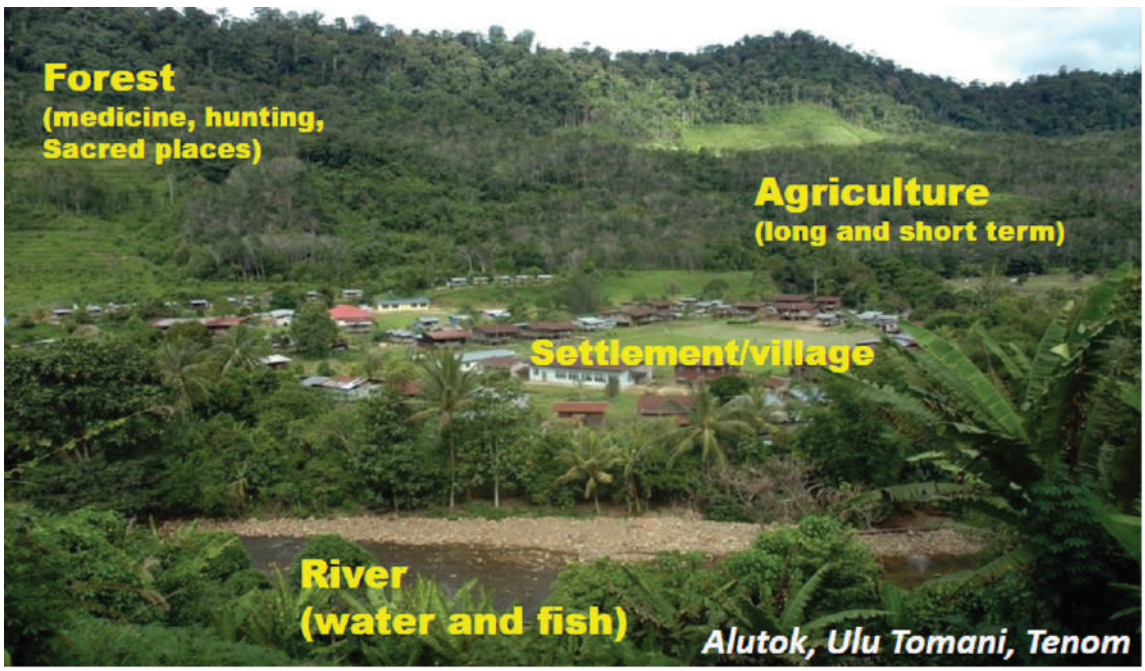


Figure 1. The way Indigenous Peoples see their traditional territories, which consist of forest, river and agriculture area.

Agricultural areas extend beyond the village and include both long-term and short-term land use. Long-term crops such as rubber and fruit trees contribute to livelihoods over many years, while short-term practices like rotational farming support the cultivation of rice and other food crops. This shifting cultivation system allows the land to rest and regenerate, maintaining soil fertility and ecological balance.

Water bodies, such as the river shown in the foreground, are equally vital. They provide water for daily use and serve as an important source of protein through fishing. In coastal areas, similar roles are played by mangroves and the ocean. Altogether, this landscape reflects a holistic view of territory where forests, farms, rivers, and settlements are interconnected and collectively sustain the community's survival, culture, and identity.

THE ROLE OF INDIGENOUS KNOWLEDGE IN INDIGENOUS PRACTICES AND LIVELIHOODS

In daily life, IK underpins survival and self-reliance across multiple dimensions. In many Sabahan communities, for example, the concept of consent extends beyond social agreement to include spiritual permission. Communities such as the Sungai and Tombonuo perform rituals like *Etus*, *Mamason*, and *Mamatang* to seek approval or consent from both the community and *Moinat* or *Penjaga* (spiritual guardians). Sustainable resource use is guided by principles such as *Gompi-Guno* (use and protect), ensuring that natural resources are utilised responsibly while being conserved for future generations. Traditional healthcare systems, led by healers like the Bobolians, rely on deep knowledge of herbal medicine to treat illness and restore balance. Agricultural practices are guided by lunar phases and environmental indicators, supporting *Turugan* (rotational farming systems) that maintain soil fertility through fallow periods of 7 – 10 years. Social governance is embedded in *Adat* (customary law), with mechanisms such as *Sogit* (compensation) used to restore harmony when rules are broken.

Nature itself serves as a key indicator within IK systems. Many communities rely on the phases of the moon to determine optimal planting periods that reduce pests and disease. Among the Murut Tahol, the chirping of the *Kongkongkaput* (Indian Cuckoo) signals the beginning of the fruiting season; the frequency and intensity of its calls are believed to indicate the abundance of fruit harvests.

Cultural-based solution in conservation

Indigenous conservation practices are deeply rooted in cultural systems. The *Tagal* or *Bombon* system is a well-known community-based fisheries management approach where certain river zones are declared off-limits to fishing, allowing fish populations to recover. Similarly, the *Tavol* system practiced by the Murut Tahol restricts resource collection in designated forest areas to ensure sufficient resources for cultural ceremonies.

Traditional zoning systems such as *Sogindai* and *Sogian* further illustrate Indigenous conservation strategies. *Sogindai* areas are strictly protected zones, often due to spiritual, ecological, or historical significance, such as primary watersheds or sacred groves. These areas function as biodiversity refuges and are preserved through strict customary rules. In contrast, *Sogian* areas are communal use zones managed collectively under *Adat*, where controlled activities like hunting, gathering, and small-scale farming are allowed under strict guidelines.

Table 1. Functional zones based on customary governance.

Area	Classification	Description
Sogindai	Strictly Protected	"No-go" areas for spiritual or ecological reasons (e.g., watersheds, burial grounds). Access is often forbidden under *Adat*.
Sogian	Communal Use	Areas managed for hunting, foraging, and logging. Governed by strict protocols to prevent "open-access" depletion.

Traditional agriculture cycle often referred to as *Turugan* or rotational farming, is a sustainable system practiced by Indigenous communities that stands in contrast to modern monocultures. This method involves small-scale farming followed by long fallow periods frequently spanning 7 – 10 years to allow soil fertility and ecosystem health to recover naturally. Within this cycle, hill rice fields are assigned specific names that correspond to their current stage of cultivation or regeneration.

Table 2. Stages of rotational farming for Dusunic, Murutic and Paitanic Indigenous groups.

Stage	Dusunic	Murutic	Paitanic
Active Cultivation	*Tumo*	*Umo*	*Umo*
Early Fallow (1–5 years)	*Tomulok*	*Amug / Naumoh*	*Repa*
Late Fallow (5–10 years)	*Kapanggor*	*Katanaan*	*Nokakas*

A prominent example of Indigenous conservation in Sabah is the *Tagal* system, which demonstrates effective community-led river management. Under this system, communities designate sections of rivers as no-fishing zones for a set period, allowing fish populations to regenerate. This approach has proven highly successful in restoring fish stocks and ensuring long-term food security. Its effectiveness led to formal recognition under the *Sabah Inland Fisheries and Aquaculture Enactment 2003*, although its strength continues to depend on community governance and adherence to *Adat*.

Another important case is the *Tavol* system practiced in areas such as Alutok by the Murut Tahol community. *Tavol* regulates access to forest resources within *Iningaan Mai* (customary territories) to ensure sustainability and support important cultural events. Its implementation requires community consensus and is often linked to ceremonies such as weddings or mourning rituals. Enforcement is strict, with violations resulting in *Sogit* (customary penalties), reflecting the seriousness of maintaining ecological and social balance.

KEY CHALLENGES

Indigenous Peoples in Sabah face a complex and interrelated set of systemic, legal, and environmental challenges that continue to undermine their traditional conservation practices and threaten their ancestral territories. These challenges are not isolated; rather, they are deeply interconnected, ranging from legal invisibility and external development pressures to the gradual erosion of IK systems.

One of the most critical issues is the lack of formal legal recognition of Native Customary Rights (NCR) to land and resources. Existing statutory frameworks, many of which are rooted in colonial-era policies, often fail to reflect the realities of Indigenous land use and management. For example, the *Sabah Land Ordinance* defines land ownership

based on continuous cultivation, which excludes traditional rotational farming practices such as hill rice cultivation that involve fallow periods of 3 –10 years. As a result, these lands are often not recognised as being actively used. In addition, the administrative process for claiming NCR is typically long, costly, and complex, with communities facing delays and limited transparency. Even when court rulings favor Indigenous claims, these decisions are not always consistently implemented at the administrative level, further weakening land tenure security.

At the same time, Indigenous territories are increasingly subjected to what is often described as "development aggression." Large-scale economic activities such as logging, mining, and industrial plantations including oil palm, rubber, and acacia have replaced extensive areas of biodiverse rainforest, resulting in environmental degradation and loss of customary lands. Infrastructure projects also pose serious threats; for instance, the proposed Kaiduan or Papar Dam risks displacing entire communities while destroying sacred sites and vital ecosystems. In coastal and riverine areas, large-scale aquaculture activities such as shrimp farming in places like Sungai Eloi, Pitas have led to the destruction of thousands of acres of mangrove forests, directly impacting the livelihoods and food systems of communities in the area.

Conflicts also arise from state-led conservation approaches, often referred to as "fortress conservation," which historically exclude Indigenous Peoples from decision-making processes. When areas are designated as Forest Reserves or Protected parks, traditional practices such as hunting, gathering, and small-scale farming are frequently prohibited. In some cases, communities have reported enforcement actions that include the destruction of homes and crops for allegedly encroaching on land that they have inhabited for generations. Additionally, many ICCAs overlap with state-designated protected areas without obtaining Free, Prior and Informed Consent (FPIC) from the communities. While mechanisms such as Community Use Zones (CUZ) exist, they are often limited in scope and do not adequately accommodate traditional subsistence activities.

Another major challenge is the erosion of IK and TEK. This knowledge is increasingly at risk due to multiple modern pressures. Formal education systems tend to prioritise standardised curricula that exclude traditional skills and knowledge, while younger generations often migrate to urban areas for employment, creating a gap in knowledge transmission between elders and youth. Social stigma also plays a role, as traditional beliefs and practices such as Momolianism are sometimes dismissed as outdated or unscientific. Furthermore, environmental degradation contributes directly to knowledge loss, as the plants, animals, and ecosystems that form the basis of traditional medicine and cultural practices disappear.

Governance challenges, particularly related to FPIC, further compound these issues. In many cases, governments and private sector actors fail to conduct meaningful consultations with Indigenous communities before initiating projects on their lands. When consultations do occur, they are often limited to selected or government-appointed leaders who may not fully represent the broader community. At the same time, state control over the appointment of traditional leaders can weaken customary governance systems, reducing leaders' independence and shifting their role away from being custodians of Adat toward acting as intermediaries for government interests.

Finally, Indigenous communities face growing economic and climate-related vulnerabilities. The increasing reliance on a cash-based economy places pressure on communities to shift from sustainable subsistence practices toward commercial monoculture, which can lead to overexploitation of natural resources and long-term financial instability. Climate change further intensifies these challenges, as unpredictable weather patterns

including floods, droughts, and shifting seasons disrupt agricultural cycles, reduce crop yields, and threaten overall food security. Together, these pressures create a highly uncertain environment for Indigenous communities striving to maintain their traditional ways of life and conservation practices.

RECOMMENDATIONS AND THE WAY FORWARD

Indigenous Peoples in Malaysia and across the broader Asian region emphasise the need to secure legal recognition of their rights, adopt a human rights-based approach to conservation, and ensure that IK is passed down effectively across generations. These priorities reflect a holistic vision where environmental sustainability, cultural continuity, and social justice are closely interconnected.

A key priority is legal and institutional reform to formally recognise the distinct status and rights of Indigenous Peoples. This includes the establishment of an independent National Commission on Indigenous Peoples (NCIP) to advise governments, monitor development activities on Indigenous lands, and safeguard fundamental rights. There is also a strong call for constitutional and legislative reforms to recognise Indigenous customary land rights as fundamental rights, ensuring that laws such as the *Sabah Land Ordinance* and *Sarawak Land Code* are aligned with Indigenous concepts of land use, including territorial domains and foraging areas. In addition, judicial reforms are needed, such as the creation of a specialised Indigenous Land Tribunal or Native Title Court to address land disputes more efficiently, with judges who are knowledgeable about local customs and traditions.

Equally important is the implementation of a human rights-based approach in both conservation and development. This approach requires a shift away from top-down decision -making toward inclusive systems that treat Indigenous Peoples as equal partners. Central to this is the legal enforcement of FPIC for any project affecting Indigenous territories. Conservation efforts should also adopt a more inclusive "whole-of-society" framework that recognises Indigenous lands as legitimate and effective conservation areas alongside state-designated protected areas. At the same time, governments must ensure the protection of environmental defenders, safeguarding them from harassment, discrimination, and criminalisation.

Strengthening customary governance systems and supporting ICCAs is another critical step. Community-led conservation plays a vital role in maintaining biodiversity and cultural identity. Recognising ICCAs through frameworks such as Other Effective Area-based Conservation Measures (OECMs) can provide legal support without forcing communities into state-controlled models. It is also important to support communities in developing and documenting their own protocols, which articulate their values, rules, and stewardship practices to external stakeholders. Empowering traditional leaders, including figures such as Bobolians, Batins, and village chiefs, is essential to ensure that customary laws continue to guide conservation and resource management.

In terms of conservation and resource management practices, government policies need to shift toward supporting, rather than penalising, traditional livelihoods. Rotational farming, often misunderstood as inefficient, should be recognised as a sustainable agroforestry system that contributes to biodiversity conservation and carbon storage. There is also a need to implement genuine co-management arrangements in protected areas, allowing Indigenous Peoples to participate meaningfully in decision-making while maintaining access to resources for sustainable use. Furthermore, investing in research to document and validate traditional practices, such as the *Tagal* river management system, can help integrate Indigenous approaches into formal policy frameworks.

Ensuring the intergenerational transfer of knowledge is crucial to sustaining Indigenous cultures and conservation systems. Education systems should be reformed to include Indigenous knowledge, languages, and cultural practices, particularly in rural and Indigenous communities. Community Learning Centres can serve as important spaces where elders share knowledge on traditional medicine, crafts, and oral traditions such as ritual poetry with younger generations. In addition, digital tools and social media platforms offer new opportunities to engage youth and promote the relevance of traditional knowledge in contemporary contexts.

Finally, accountability and redress mechanisms must be strengthened to address historical and ongoing injustices. This includes establishing legal provisions for the restitution of lands that were taken without consent, or providing fair compensation and alternative land where restitution is not possible. Robust monitoring systems, led by rights-holders themselves, are also essential to assess the impacts of conservation and development initiatives on Indigenous communities, ensuring that their rights, well-being, and environmental stewardship are fully respected.


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 663–668
doi: 10.62613/sonc2025.v3ip04

CHAPTER 4

The intersection between Indigenous Peoples' rights and conservation – A personal reflection

WONG PUI MAY*

Abstract: Are upholding Indigenous Peoples' rights and conservation of nature inherently incompatible or is it a false dichotomy? What is conservation? Who can protect the forest better? Who does the forest belong to? In this chapter, I reflect on my experience as a conservation practitioner working with and learning from conservation biologists, wildlife managers, as well as Orang Asli colleagues and friends, to explore potential answers to these questions. What I discovered was the importance of learning to walk in another's footsteps (and planning for the time needed) and that we are more similar than different. Indigenous People and conservationists ultimately share similar goals as environmental and social justice are inextricably linked, and we can achieve more together.

INTRODUCTION

In 2016, as a post-graduate student, I found myself in a room with 19 other early-career conservationists from 19 countries, discussing the definition of "conservation". Coming from years of working on Malayan tiger conservation, I thought conservation was about protecting wildlife. Imagine my surprise when everyone else mentioned people in their definitions.

There has been some debate over traditional (biology, wildlife-focused) and new (market-based approaches, etc.) conservation (Soulé 2013; Marvier 2014; Sandbrook 2015), but the definition of conservation for each person is inadvertently influenced by their values. Conservationists, while generally having similar ideals, do not possess the same values (Sandbrook *et al.* 2011). This impacts how they think about Indigenous rights.

Leader-Williams *et al.* (2010) proposed that conservation comprises "actions that directly enhance the chances of habitats and species persisting in the wild". Sandbrook (2015) later proposed a broader, inclusive definition which considers the varying values held by conservationists – "actions that are intended to establish, improve or maintain good relations with nature". Sinclair-Brown (2003) cites Bill Adams, former Moran Professor of Conservation and Development at the University of Cambridge, who succinctly stated that conservation is about negotiating human impact on nature, not so much about stopping it or resisting change.

Many conservationists/biologists I know would prefer to work in a remote area far away from people. Perhaps that is one reason why it took conservation so long to engage with Indigenous rights in Peninsular Malaysia. By nature of their work, conservation biologists will inadvertently interact with rural people, including some who have very little material wealth. It is impossible not to feel for the local community when times are hard.

Rachel Carson Center for Environment and Society, Ludwig Maximilians University of Munich, Germany.
***Corresponding author: wongpuimay@hotmail.com**

This chapter is intended to be a case study. The following records my experiences and perspectives as a conservation practitioner who has been learning from Orang Asli since 2018, specifically Batek people in Kelantan and to a lesser extent, Semaq Beri in Terengganu. Between 2018 and 2023, I was working on a conservation project in Kenyir, Terengganu related to protected area management. As a relative rookie, do excuse any deficiencies.

There are two Orang Asli villages close to the protected area, and we wanted to explore ways to collaborate towards a common goal of safeguarding the forest and wildlife in perpetuity. But first, we needed to get to know people, especially since the communities were known to be wary of outsiders. Fortunately, a friend trusted by the villagers was willing to make an introduction. There was no blueprint for this work, so I turned to books, published literature, news articles and reached out to anthropologists and anyone with relevant experience.

It was shocking to read a (highly misguided) quote in a news article saying that Orang Asli children were running around with nothing in their heads, just because they were not in formal education. That was a big contrast from anthropologists, who wrote about Orang Asli as people with a unique culture, deep knowledge of nature and curious yet analytical views on outsiders. We decided to adopt an anthropological approach to get to know the communities slowly. Coincidentally, in 2022, a toolkit on using ethnography in conservation was published following research on human-orangutan-conservation interactions in Borneo (Chua *et al.* 2022). Turns out we weren't too far off the mark.

Getting to know you

John Slimming, who was appointed Assistant Protector of Aborigines around the mid-1950s, wrote *Temiar Jungle: A Malayan Journey* (1958). It was his account of the time he conducted a survey of Temiar swidden farms west of Gua Musang, near the Kelantan-Perak border. Sadly, the land has changed so drastically that it would be unrecognisable to him.

This paragraph below made me laugh out loud because it mirrored the challenges I sometimes faced speaking with Batek friends. I could hardly believe that the experiences of a British officer over 60 years ago would resonate with me. A big part of getting to know a community is to get used to their figures of speech, or how they could mean something different despite using a common language.

> *Since some of Tengah's people were still with us I traced some more genealogical tables before going to sleep but no question ever received a direct answer and even the most simple facts had to be extracted slowly and laboriously.*
>
> *"Where was your father born, Aluid?"*
> *"Tuan, I don't know. He was born before I was born."*
> *"Of course," said Chabok, wisely.*
> *"Well, have you always lived in the Betis valley, Aluid?"*
> *"Yes, Tuan. And so did my father. My father's father lived here also but I don't know where he was born, nor where my father was born."*
> *"Well, did your father have his own family saka (traditional family area), Aluid?"*
> *"Oh, yes, Tuan. The Sungei Rumpai belonged to him but now it belongs to Tengah!"*
> *"Why the Rumpai?"*
> *"Because the kuala of the Rumpai was his birthplace, Tuan."*
> *"But, Aluid, you… Your father was born at the mouth of the Rumpai?"*
> *"Yes, Tuan!"*

Same park, different approaches

I was told this story years ago by a long-time staff of the Department of Wildlife and National Parks Peninsular Malaysia (PERHILITAN). In the 1990s, the northern entrance (Kuala Koh, Kelantan) of Taman Negara was remote and uncontactable. The only means of communication they had was via radio to the then Department of Orang Asli Affairs (JHEOA) office in Gua Musang. Now it takes only 90 minutes to drive from Gua Musang to Taman Negara Kuala Koh, on a tarred road which cuts through rolling hills of oil palm.

Whenever there were emergencies, the PERHILITAN staff had to radio JHEOA and request that they pass the message to the PERHILITAN office in Gua Musang. Therefore, the closest people who could help during emergencies were the Batek who lived there. Perhaps because of necessity, the relationship between park authorities and locals were convivial. He recounted a funny story about how he was watching television one day and noticed a Batek person peering in from his doorway. He pretended to shoo the man away and proceeded to move the television set to the doorway. Within a short time, a sizable group had gathered outside to watch television.

In the 2010s, the initiative I was working on then was focused on the forests outside the western entrance (Merapoh, Pahang) to Taman Negara. An incident caused an uproar among the Batek people (or Manya') (Tacey 2018) living nearby as a PERHILITAN staff threatened to shoot the villagers if he ever saw them "trespassing" in Taman Negara. Fortunately, the general approach to indigenous rights among conservation practitioners in Peninsular Malaysia have changed a lot since then, though the laws have not caught up.

Hypothetically, who does Taman Negara "belong" to? The Orang Asli or the park authorities? In answering this question, Dr. Colin Nicholas (2005) was ahead of his time, at least in Malaysia. Since 2018, I have had many opportunities to walk with Batek people in the forest, which is a real privilege. It is humbling, to say the least. Walking together with Batek adults, I am at best, equivalent to a 7-year-old child. Once, we were stopped by community rangers who wanted to search our bags. The atmosphere instantly became tense. Of course, we weren't poaching and they were friendly enough but suddenly, I had a small taste of what it feels like to be policed and searched in your own home.

Same same but different

Going back to Kenyir, as part of efforts to include the Orang Asli communities, representatives from both villages were invited to attend management plan stakeholder workshops held in Kuala Terengganu. While one village had a Department of Orang Asli Development (JAKOA) officer on hand to drive the villagers an hour and a half to Kuala Terengganu, the other village had no means to travel two and a half hours to Kuala Terengganu. Villagers also had no formal clothes.

Sometimes engagement involves taking care of the little things: like logistics; suitable clothing to ensure that community representatives do not feel even more out of place than they already were, and; for those who have never stayed in a hotel, things like pressing elevator buttons or navigating a hotel room. They were about as lost as I'd be in the middle of Taman Negara, which was nothing to be ashamed about.

The more I get to know the Batek, the more I admire their resilience and ability to adapt and survive in adverse environments. They have this incredible ability to just get on with life. I also realised that we are more similar than different, in our shared humanity. People often forget that simple fact and fail to afford Batek people the basic courtesies that they would offer other people with whom they share more similarities.

Once, I observed a group of people who drove into the village in a four-wheel drive (4WD). They disembarked from the vehicle, distributed small cakes and sweets in plastic packaging to the children (which ended up all over the ground), took a selfie with the backdrop of a beautifully made bamboo house, then got back into the vehicle and drove off. They did not make eye contact nor speak to any adults, and did not ask for the headman. How rude!

Another time, a fresh graduate asked me: "how does one get to know an Orang Asli?" My answer - smile and introduce yourself. However, the next step of asking for someone's name proved to be a little more complicated as I was often greeted with a bashful look rather than the straightforward answer you'd expect. So perhaps that could be left for later.

Following behind (*Ikut belakang*)

To "follow behind" someone, could mean many things to Batek people. It could mean to literally walk behind them in the forest, to observe and learn, or be born after. This heading refers to the second definition. They rarely teach or instruct, it is up to the student to learn. To work with a community, first we need to walk in their footsteps and understand their reality. For they are the experts of their lived experiences and situation.

There is a manganese mine near the village. Work has stopped now but there was a time when lorries heavily loaded with manganese ore would trundle out of the mine, through the plantation and towards the port. Manganese is one of the materials in aluminium cans, needed for canned drinks to cool one down on a hot day. It strengthens steel, needed to build strong pillars to hold up skyscrapers. But who bears the price of modernity, of industry?

Living cocooned in the city, away from the frontiers of resource extraction, it is too easy to forget that all resources come at a cost. Even self-professed conservationists often forget. Swept up in the story we've been fed since birth, of growth, of aspiration, of wealth, we forget that planetary resources are finite. A famous message from the people of Ladakh, India that circulated online a few years ago captures the need for change in a sentence, "*please live simply, so we may simply live*".

One morning in the village, a friend asked if I wanted to join them on a fishing trip for the day because someone wanted to harvest bamboo to make a raft, and suitable bamboo groves were upstream. Of course I did! After a light breakfast, we set off. We walked for a long time upstream, up and down hills in our flip flops. Once we reached the intended spot, some in the group started harvesting bamboo, while others fished using rods fashioned out of palm fronds, fishing line and metal hooks. The baits were winged ants, collected the night before, and earthworms expertly dug from the riverbanks.

Once the raft-making group had formed a basic raft, comprising large and long sections of bamboo lashed together with rattan, a couple of people climbed on and started punting downstream. The others waded downstream, fishing along the way. We stopped at more bamboo groves along the way, and the raft was strengthened until it could take the weight of all the people and our belongings.

This went on the entire day. The adults did not stop to eat but someone brought some rice and cooked it for the toddlers who came along. The children sometimes played at the riverbank, or they were strapped to their mothers using *batik sarongs*. They might be strapped to the back for a nap, or to the front to nurse. Talk about bringing your children to "work"!

By the time we returned to the village, it was dusk and I was famished. Fish caught were distributed to kin who live in the immediate vicinity, and what remained for dinner was rice and a tiny fish or two. Sometimes I joke that if someone had roasted some wild game then, I'd probably have eaten it!

Outsider challenges and concerns

A main concern is the fear of causing harm to a community. Within conservation literature, there are well-documented accounts of failed community conservation initiatives, where the community ended up being worse off (Spiteri and Nepal 2006). Interventions by external parties and the injection of funds could lead to elite capture of resources, which increases inequality in the community. It could create complacency or a sense of entitlement. It could create jealousy. It could cause the collapse of existing social structures. So many things could go wrong.

Research indicates that when a local community has a secure tenure of, or at least, unharassed access, of their customary areas or Territories of Life, they are more inclined to manage resources sustainably over the long-term. Traditional concepts of not taking more than you need, inherent in many, if not all, Orang Asli cultures, are more likely to be followed. However, this could also lead to the honeypot effect, which draws more people to the area to exploit the resources (Hutton *et al.* 2005).

Listening to Batek people talk about the various projects that are planned for the village, it seemed to me that they only have real freedom inside the forest, where they have the confidence to make decisions for themselves and live the way they want to. Only in the forest do they have agency, beyond the prying eyes of outsiders (and perhaps, pesky conservationists). However, there are also people who prefer life at the village, for easy access to healthcare and donated items. It is tough to live a mobile life. Women told me that they used to carry all their belongings on their back and their child in a *sarong* across their chests while they move.

When something is set up by the government or brought in by outsiders, Batek people feel no sense of ownership. For example, there was a time when there were not enough funds to pay for diesel to run the generator for the large water pump constructed by the government. The contractor tried to negotiate and asked the Batek people to pay half the cost and he would cover the other half. The villagers refused because the well belongs to the government and therefore the government should take care of it. The little money that they earn should go towards food, medicine and other necessities or desires.

One could argue that this is a case of the community being complacent and avoiding responsibility, but they do have a point. It was the government who destroyed nature and the free ecosystem services it provides, and also the government who decided to put in place an expensive, high maintenance, top-down solution.

Towards a good life for all

In mediation for conflict resolution, the main process is to convince the opposing parties to shift from respective positions and move towards their actual interests. I believe that Indigenous People and conservationists ultimately share similar goals and overlooking that would be missing the forest for the trees. However, much capacity building and open communication will be required on all sides (along with a hearty dose of critical self-reflection) as the process is neither quick nor straightforward. It will require patience and the understanding that environmental and social justice are inextricably linked.

REFERENCES

Chua, L., Schreer, V. and Thung, P.H. 2022. *Using Ethnographic Research for Social Engagement: A Toolkit for Orangutan (and Other) Conservationists*. London and Cambridge: POKOK; Global Lives of the Orangutan. https://doi.org/10.17863/CAM.86774

Hutton, J., Adams, W.M. and Murombedzi, J.C. 2005. Back to the barriers? Changing narratives in biodiversity conservation. *Forum for Development Studies* 32(2): 341–370. https://doi.org/10.1080/08039410.2005.9666319

Leader-Williams, N., Adams, W.M. and Smith, R.J. 2010. *Deciding what to save: Trade-offs in conservation.* Oxford: Blackwell Publishing Ltd. https://doi.org/10.1002/9781444324907.ch1

Marvier, M. 2014. New conservation is true conservation. *Conservation Biology* 28(1): 1–3. https://doi.org/10.1111/cobi.12206

Nicholas, C. 2005. The Orang Asli: First on the land, last in the plan. *Kajian Malaysia: Journal of Malaysian Studies* 21(1&2): 315–329.

Sandbrook, C. 2015. What is conservation? *Oryx* 49(4): 565–566. https://doi.org/10.1017/S0030605315000952

Sandbrook, C., Scales, I.R., Vira, B. and Adams, W.M. 2011. Value plurality among conservation professionals. *Conservation Biology* 25(2): 285–294. https://doi.org./10.1111/j.1523-1739.2010.01592.x

Sinclair-Brown, N. 2003. Regulatory design. In *The Trade in Wildlife: Regulation for Conservation*, S. Oldfield (Ed.), p. 34. London: Earthscan Publications Ltd.

Slimming, J. 1958. *Temiar Jungle: A Malayan Journey*. London: The Travel Book Club.

Soulé, M. 2013. The "new conservation". *Conservation Biology* 27(5): 895–897. https://doi.org/10.1111/cobi.12147

Spiteri, A. and Nepal, S. K. 2006. Incentive-based conservation programs in developing countries: a review of some key issues and suggestions for improvements. *Environmental Management* 37(1): 1–14. https://doi.org/10.1007/s00267-004-0311-7

Tacey, I. 2018. Animism and interconnectivity: Batek and Manya' life on the periphery of the Malaysian rainforest. PhD Dissertation. Helsinki: University of Helsinki.

State of Nature Conservation in Malaysia 2025, 669–677
doi: 10.62613/sonc2025.v3ipc05

CHAPTER 5

The Enchanted Forest: Exploring Indigenous imaginaries and narratives of nature

KAMAL SOLHAIMI FADZIL*

Abstract: With the looming threat from destruction of natural landscapes from mineral prospecting, logging, plantations, and others, perhaps it is about time conservationists recognise a true ally in Indigenous communities. Overlapping landscapes that serve both conservation visions and Indigenous claims for rights are grounds for collaboration. A true alliance has to be premised on respect for diverse 'rationales' on understanding nature and the recognition of Indigenous rights. This chapter explores themes on Orang Asli re-claiming authority and legitimacy for Indigenous knowledge in the discourse on nature through (re)telling stories of encounters in an animated landscape.

INTRODUCTION

"*There is a battle 'for truth' or at least 'around truth'—it being understood again that by truth I do not mean the 'ensemble of truths which are to be discovered and accepted', but rather 'the ensemble of rules according to which the true and the false are separated and specific effects of power attached to the true'*."

(Adapted from Olsson 2010, p. 67 [citing Foucault, in Rabinow 1984, p. 418]).

"*These relations (between the Batek and the environment) actively alter ecological composition and contribute to the apparent diversity of the forest and might thus be incorporated into resource-management programs. But such possibilities are excluded from official representations of the national park. Because the park originated as a wildlife reserve, people can only be seen as an annoyance and a potentially destructive force*."

(Lye 2011, p. 56).

How do we move towards developing a 'true' collaboration between conservation actors with Orang Asli communities? Borrowing from Foucault (Olsen 2010) and Lye (2011), this paper asks conservationists to reassess Western authoritative knowledge on nature, reconsiders human networks in framing relationships between people and nature, and discusses the contemporary goals of conservation in Malaysian conservation discourse. It suggests that we look to Indigenous knowledge for an alternative truth or knowledge towards reimagining an alternative discourse on nature as new ways to understand these relationships. Looking at their way of 'knowing' nature, and how they understand human relationships with nature, a different way of conservation can be envisioned.

By recognising the legitimacy of Indigenous knowledge about nature, we are not proposing the rejection of Western discourse, but rather recognising the role of power and/or politics in the conventional discourse on nature, and attempting to change how we see the relationship of power between human and nature, as well as between different human actors in conservation/customary landscapes.

Department of Anthropology and Sociology, Faculty of Arts and Social Sciences, Universiti Malaya, Jalan Ilmu, 50603 Kuala Lumpur, Malaysia.
***Corresponding author: kamal@um.edu.my**

Conventional conservation discourse talks about building partnerships with Orang Asli in conservation. However, without recognition of Indigenous knowledge as a regime of truth, how do we move towards actual and effective collaboration between conservation NGOs and Indigenous Peoples?

Looking at Indigenous narratives, it is easy to see that Orang Asli paints nature as being an animated space that can be understood as fanciful. However, nature provides interactive spaces—where human beings, flora, and fauna co-exist without necessarily placing one on top of the other in a rigid hierarchy.

Drawing from different sources, this paper aims to offer a decolonised perch from which to engage a new discourse on nature, albeit one more local and inclusive. The discussion centres on materials from three academic references which focuses on the narrative by a Semai elder of the Eagle *gunig*, the Jahai narrative of the *Ceboh* tigers, and a community leader from Kampung Kejar, on his account of the Jahai's experience in the Royal Belum State Park. The source for discussion include:

i. A Semai narrative of visiting a spirit familiar in the forest in Geruntum, adapted from Kamal (2024) *An Enchanted Landscape: Rethinking 'irrational ideas' of human relations to nature*;
ii. Tiger tales from the Jahai in Royal Belum, adapted from Hamzah *et al.* (2023) *'Tigers are our sons': Jahai perspectives in understanding tiger conservation in the Royal Belum State Park, Perak, Malaysia*; and,
iii. A village leader's narrative of Jahai living in the Royal Belum State Park, adapted from Kamal (2020) *Conflicts between Orang Asli Rights and Needs, Economic Development, and Conservation in Peninsular Malaysia*.

THE STORY OF THE EAGLE *GUNIG*

The following story was narrated by a Semai elder from Kampung Geruntum, who as a child visited his grandfather's *gunig* (spirit guide). His grandfather was a *pawang* (shaman), and the *gunig* was an eagle by the name of "*Wah Se Ngayun*", who lived in a large *Ara* (fig) tree in the forest. It was after a healing ritual that they asked if they could visit the *gunig* at her home. She said that they could. The next day, a small group came along to visit the *gunig*. The elder explains that the forest then had a clear path, because the community actively opened *selai* (orchards), and he remembers seeing big trees along this forest path. Upon reaching the *Ara* tree, his grandfather gave out a cry (*ki-ah*) and the surroundings transformed into a beautiful space with a big house. They were greeted by *Wah Se Ngayun*, who took the form of a beautiful, well-dressed woman who wore "… a fine kebaya". Inside the house, the grandfather asked about *Wah Se Ngayun*'s husband, to which she replied that he was away at sea and her daughters were locked in their rooms. Bah Singung looked up to me and explained, "*Anak-anak perempuan dia lawa, tapi hantu* (the daughters were pretty but they were ghosts)!"

The house was described as big and beautiful, while underneath it, ducks and geese were reared in cages. The group were invited to a feast. When asked what the food was like, his face lit up. "*Sedap* (tasty)!" After a few hours, the group got up to leave. The *gunig* invited them stay a bit longer, until five in the evening. But his grandfather decided to leave because he did not want to be there after it got dark as he was scared. A few steps away from the house, the grandfather gave another *ki-ah* cry. Now the surroundings transformed back into forest. He looked back in the direction of the house and instead saw a large *Ara* tree with bees buzzing around it.

CEBOH TIGERS: THE SONS AND PROTECTORS OF THE JAHAI

The term '*ceboh*' for the Jahai refers to a magical stone with healing and supernatural powers. They narrate that only shamans can acquire *ceboh* and transfer the powers to other human and non-human beings. *Ceboh* is described as 'cooling', 'located in the heart' and 'able to help with sickness and protection'. A shaman usually first acquires or transfers the healing and supernatural powers via a ritual called *sewang* or *pinglun* which is performed communally. During *pinglun*, a shaman enters and travels through a magical realm via dreams. In this dream-like realm, the shaman meets with spirits of animals and past shamans. Through this ritual, a shaman can transfer the *ceboh* to animals in the forest (e.g., deers, elephants, and tigers) to protect Jahai people in the forest from dangers including threats from materially real and deadly animals. In transferring *ceboh* to a tiger cub, a shamans 'adopts' the cub, taking care of their *ceboh* tiger 'sons' and training them with spiritual powers to become their protectors. Tigers who have acquired *ceboh* are considered as 'tamed' and will follow orders given by their 'fathers' (i.e., shamans). The *ceboh* tigers are said to 'stay with their fathers'—though not seen in physical form—at night and go roam in the forest during the day following the instructions or protection tasks given by their 'fathers'.

A COMMUNITY LEADER'S ACCOUNT OF HOW THE JAHAI EXPERIENCE THE ROYAL BELUM STATE PARK

The community leader explains the Jahai imaginary of the creation and rights of Jahai in the Belum landscape. He explained that long ago there were no trees in the Royal Belum State Park and that the Creator had ordered their ancestors to grow trees. The same was done for populating the streams with *kelah* and *tengas* fish. He goes on to explain, as if to reinforce, that the true Belum is not here but somewhere else, and that those who know the truth are the true custodians. The Jahai are thus considered the true custodians and others should not venture deeper into the Belum.

He considers tourists, park officials, as well as anyone who enters without permission from the Jahai as trespassers. He explains that outsiders come to the landscape and set up there with lies told to officials far away in Kuala Lumpur, without consent from him or the people living there. But he explains further that the Jahai do not like to fight. He described the soil as a carpet or mat that they do not fight over. The land in his opinion belongs to the Almighty as with every other resource in the landscape. He reminds me that we only live here on this planet on borrowed time and space, and when the time comes, the Raja Tanah will revoke our rights to the land. Then we can only lift our hands in despair.

To him the forest is populated by spirits. These can be malevolent or benevolent spirits, where some cause harm, while others bring about the flowering of fruit trees. Tigers are not simply predators, but are regulators ensuring order in the chaotic landscape of the forest.

The Jahai live within the customary rules of the landscape, by what the creater has prescribed. They take what is allowed for them to eat and sell which forms part of their livelihood. He reiterates that others should stay out of their area. He does not like that the Orang Asli are being referred to as poachers when he feels that armed poachers enter the State park through the Banding jetty. He uses exageration as a narrative tool to reemphasise the real threat to conservation is outside encroachment and that these armed poachers hunt barking deer and other animals in the forest to extinction. They also observe prospectors going deeper into the landscapes diving in the river with torchlights to look for minerals. He denies the claims that Orang Asli benefit from eco-tourism in the Royal Belum. Rather, he says they simply get the crumbs of what is left.

He further claims that the landscape is theirs and that from colonial rule, they were entrusted to look after the area. He ends by simply reasserting their rights over Belum as their customary landscape. They want to continue to express their rights to hunt, fish, and to gather natural resources in the landscape. They also want to be able to sell these resources as a source of income for their families and the communities. He reemphasises, "We provide for ourselves by gathering. We gather *ubi garam*, *ubi kapor*, *ubi thali*, whether life is hard, whether we are poor, we follow our customary ways. Those who help the government get the incentives and those who do not help the government receive nothing in return. Nevertheless, it is okay, we rely on gathering. Our natural resources should not be restricted; we don't like hearing these things."

DISCUSSION

Adapting Ingold's (2011) 'meshwork' metaphor of life, the Orang Asli imagination of nature necessitates that humans recognise the lived life as aligned with being a part of the construction of nature, and that the threads or lines on which nature draws itself is the very path on which humans traverse, and give human life its meaning. Take away nature and we are left with a devoid life. Life has no way of making its existence beyond the 'meshwork' that exists along these lines of nature. What are these threads or lines which define nature? I would suggest it is the sum that makes up the world which occupies space and time. Humans cannot exist by themselves, while nature cannot exist as merely inanimate objects at the service of humans. Human life necessarily occurs as we move along these lines of an animated nature. Thus, the Orang Asli enchantment of nature gives back to us our experience of being alive.

We must do away with the false dichotomy of Nature versus Culture or Animal/Plant versus Humans, as one cannot exist if the other is not experienced. The experience between these categories is not dissimilar to how we experience a friendship—both having agency, the choice on how to engage and to have the ability to take away from the experience—something we may think of as what makes us human, as being alive. The shift from looking at nature as sub-ordinate and inanimate, to one of having the capacity for life (not just agency), changes our view of nature. Nature is not something we catalogue and define external to ourselves, but should be a conscientious entity we engage with, seek for consent, and offer rights and recognition. This way, we appreciate nature, and not just the iconic forms of nature, such as an apex predator, or what some term "high valued ecological sites", but to recognise all nature as life and to accord respect for them in the same way we accord respect for our friends and fellow humans. This is not simply making "human" of the "non-human", or the anthropomorphisation of things, but perhaps the inverse of it, to see that all we consider "human", exists in a fundamental form of life in all objects of nature.

The first and second narratives on the eagle *gunig* and tiger *ceboh* offer us a different way of 'seeing' relationships between inhabitants of the forest, the forest, and the people. In the first narrative, the story is narrated by a Semai elder based on his personal experience when he was a child following his grandfather to visit the *gunig*'s domicile. At the command of the grandfather, the *Ara* tree transforms into a mansion and the eagle becomes a woman. He describes the story from the perspective of a first-hand account. The narrative is not symbolic or metaphorical, rather explained as a matter of fact. Similarly, the tiger *ceboh* continues as practice rooted in the practical demands to co-exist with tigers in the rainforest. The Jahai narrating on the adopted spectral tigers do so with sincerity and clarity. This is their truth. The truth imagined of the forest, the plants, animals, and people, which exist as a meshwork centred on the central conception of life.

The third narrative on the Jahai in the Royal Belum State Park is strategic and political. Through the researcher, the community leader speaks directly to power. The narrative is clearly crafted to draw on legitimacy of claims from knowledge (knowing the true name and true place of the landscape) and to draw legitimacy from time — of how the Jahai created the landscape which made the Royal Belum State Park so attractive for eco-tourism, ultimately tracing a lineage of authority legitimising Jahai claims of rights in the landscape. He doesn't just tell us a story—a version of 'Indigenous traditional knowledge'—rather he crafts for us a narrative as deeds of claims. Drawing claims of the Jahai people as custodian of the Belum forest, he invokes God and British colonial authority, to assert his statement, which essentially is, '*Stay out, this is my peoples land*.' His narrative reminds of Foucault's approach to discourse as power, in which power is relational and fluid. In providing the narrative of Belum, the community leader questions the authority of the Perak State Parks Corporation (PSPC) over the Royal Belum State Park by offering an alternative narrative.

The Jahai narrative challenges the authoritative regime of 'truth' by offering an alternative discourse. By claiming the name is misplaced, but by also refraining to offer the correct name to avoid misappropriation, he challenges the authenticity of authority while protecting the Jahai's political leverage over the landscape. He then further undermines the conventional narrative of power by drawing on an earlier 'social contract' (between the Jahai and the Creator). Later, he draws on another social contract, one of a more recent timeline (between the Jahai and the British colonial authority). The narrative, supported by proof of claims such as knowing the true name of the landscape, of having the story of origins of the landscape, and from a British colonial badge *in lieu* of a '*surat kuasa*' (power of attorney) as authorising the Jahai to oversee the landscape, reinforces an alternative discourse of the Jahai people as custodians of the customary landscape.

This narrative addresses the landscape as being neither devoid or unclaimed, but having meaning and place to a specific people and with clearly understood and established relations. The Jahai exists within the same narrative of the creation of land. The battle over claims and rights, are not simply old, but have adapted to time, framed within the contemporary notions of being Indigenous. The Jahai claim to the landscape is being the first and original settlers, and as being custodians because they are allies to those imbued with power, be it the Almighty creator or the British colonial government, are founded on a moral authority. Their claims to rights are based on their social contract with the creator, the feudal authority and colonial authority. Their rights are as Indigenous Peoples who continue to practice their traditional way of life that is embedded and dependent on the landscape. The landscape they claimed as their customary land and territory is a specific ecological space which is clearly demarcated and separated from other customary claimed areas.

In looking at the state of conservation in the 21st century, Malaysian conservationists need to ask themselves about what they do and how they do conservation today. Have we done enough and are we framing conservation in the best possible way with the aim of safeguarding our collective future? Seeing conservation as something instrumental to human survival lacks the moral authority and positionality for deeper engagement with nature. However, borrowing from the Orang Asli worldview, which frames their culture—a holistic view of their religion, customary knowledge, and relationships—recognises a fundamental truth, whereby nature is enchanted. As Lye (2011) points out, the challenge with collaboration between conservation authorities, conservation NGOs, and indigenous communities lies now with those in authority. Policies need to be formulated and rights recognised to bring both nature and Indigenous peoples to the conversation (Sheema *et al.* 2013). This is not a new concept, but it will be a paradigmatic shift for our policymakers and civil society actors.

CONCLUSION

"*It all began with the question of what it means to say of human beings that they are the producers of their lives. But I did not cease thinking about this question as it gave birth to another: how is it that, in producing their lives, humans create history? How, if at all, is this history to be distinguished from the process of evolution in which all living creatures are supposed to be caught up? Nor did I cease thinking about history as I began to see, in what I called the perspective of dwelling, a way to overcome the entrenched division between the 'two worlds' of nature and society, and to re-embed human being and becoming within the continuum of the lifeworld. And I have not ceased thinking about dwelling in my current explorations in the comparative anthropology of the line, which grew from the realisation that every being is instantiated in the world as a path of movement along a way of life.*"

(Ingold 2011, p. 4).

The significance of customary land to the Indigenous person has often been explained and easily understood in a material sense, as a living pharmacy, an open grocery store, a tool shed, and much more. But customary landscapes are also spaces where memories are created and embedded across time. Names of places, avoidance taboos, originate from actual events, which over time become mythologised. Knowing the landscape is also rooted in sensory experiences. Walking, touching, and talking about the landscape, such as the Semai elder account from his childhood, opens a floodgate of images of a landscape which today has been transformed. Yet not only has the landscape changed, the man himself has also changed. Thus, the encounter of the Indigenous with nature is also one which is non-material. Ingold's (2011) terms to understand the human experience as producers, on dwelling and the lifeworld invites us to reflect further on the meaning and experience of being alive.

Applying a critical lens (possibly post-modern/post-colonial) offers potentially creative ways for us to understand nature. It moves away from the objectification and disenchantment of nature and realises creative and critical ways to see human relations with the natural world. The Orang Asli ontology of nature returns the enchantment into ways we understand, experience, and appreciate the aesthetics of nature. Looking at 'life' as the central concept holding all beings together, rather than to project human traits onto the natural world to give agency to animals and plants, changes how we imagine relationships across species and with non-animated objects. A life has agency, whatever form it may exist. The freedom to interact and behave as we do with other humans, takes place in dreams, where the life-force of beings, both animate and non-animate, can interact with one another, closing the gap not just between things, but also between beings across time. Thus, in dreams one can speak to ancestors, to elephants, to plants, etc. One communicates, interacts, and learns from the other without any one necessarily being superior or inferior. If there are hierarchies, these are relational rather than fixed categories imposed. The world in dreams is not divided between humans and the rest, rather it is a space of meshwork holding one and all together in a messy entangled relationship of life.

This way of seeing nature and humans away from the binary opposition recognises co-dependency and much more. One of it being that humans are intricately and intrinsically part of the imagination of nature. Humans like other beings are (in)formed by life, and from which gives meaning and value to existence. The modernist discourse in insisting upon binary oppositions, such as separating people from nature, parks from productive landscapes, is artificial and false. We can learn from the Orang Asli in that what we seek to protect through sustainability and conservation is not separate from us. It is part of an intricate meshwork of lines which, when untangled, reveals how deeply our experiences and identities are connected to the survival of ourselves, our families, communities, societies, nations, and ultimately, our species.

REFERENCES

Edo, J. 1998. Claiming Our Ancestors' Land: An Ethnohistorical Study of Seng-oi Land Rights in Perak, Malaysia. PhD Dissertation. Canberra: Australian National University.

Gomes, A. 1994. Modernity and Semai ethnogenesis. In *Modernity and Identity: Asian Illustrations*, A. Gomes (Ed.), pp. 176–191. Victoria: La Trobe University Press.

Hamzah, N., Jani, J.M. and Kamal, S.F. 2023. 'Tigers are our sons': Jahai perspectives in understanding tiger conservation in the Royal Belum State Park, Perak, Malaysia. *JATI-Journal of Southeast Asian Studies* 28(2): 80–107.

Ingold, T. 2011. *Being Alive: Essays on Movement, Knowledge and Description*. London: Routledge.

Kamal, S.F. 2020. Conflicts Between Orang Asli Rights And Needs, Economic Development, And Conservation In Peninsular Malaysia. PhD Dissertation. Kuala Lumpur: University Malaya. [unpublished.]

Kamal, S.F. 2024. An Enchanted Landscape: Rethinking 'irrational ideas' of human relations to nature. In *A Malaysian Ecocriticism Reader: Considerations of Nature, Culture, Place and Identities*, A.S.K. Yeow and W.L. Tham (Eds.), pp. 125–139. Singapore: Palgrave Macmillan Singapore.

Lye, T.-P. 2002. Forest people, conservation, boundaries, and the problem of 'modernity' in Malaysia. In *Tribal Communities in the Malay World: Historical, Cultural and Social Perspectives*, G. Benjamin and C. Chou (Eds.), pp. 160–184. Singapore: ISEAS Publishing.

Lye, T.-P. 2011. The wild and the tame in protected areas management, Peninsular Malaysia. In *Beyond the Sacred Forest: Complicating Conservation in Southeast Asia*, M.R. Dove, P.E. Sajise, and A.A. Doolittle (Eds.), pp. 37–61. Durham: Duke University Press.

Nicholas, C. 2002. Participation and recognition of Orang Asli as stakeholders in protected areas management. Paper presented at the National Workshop on Protected Areas Management: Directions of the Future. 14–16 January 2002, Kuala Lumpur.

Olsson, M.R. 2010. Michael Foucault: Discourse, Power/Knowledge, and the Battle for Truth. In *Critical Theory for Library and Information Science: Exploring the Social from Across the Disciplines*, G.J. Leckie, L.M Given and J.E. Buschman (Eds.), pp. 63–74. London: Bloomsbury Academic.

Sheema, A.A., Gopalasamy, R.C., Rayan, D.M. and Preetha, S. 2013. Why conservationists should be concerned about natural resource legislation affecting indigenous people's rights: Lessons from Peninsular Malaysia. *Biodiversity and Conservation* 22(3): 639–656.



Figure 1. Productive landscape: Whose vision of a landscape? Temiar man in Gua Musang.



Figure 2. A Concept of Nature: Musa explaining the significance of the Temiar headgear where the flowers hold sacred meaning to the ideal state of life are formed in a circle crowning the head. In Kampung Bering, Gua Musang.



Figure 3. The struggle for recognition: Temiar men holding up a customary map of Pos Gob outside the Bar council.


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

A blade of grass
A grain of rice
A wild flower...

Things that pulse
With life
Often move the Piper

But concrete steel
And glass...
What can they inspire?

Giant skyscrappers
Stand testimony
To hearts of mortar!

— Cecil Rajendra


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 679–685
doi: 10.62613/sonc2025.v3anc01

CHAPTER 1

State of the Malaysian rainforest 2025: Conversion outlook and emerging trends

ADAM FARHAN

Abstract: While Malaysia has committed to maintain at least 50% of its forest cover, there remains opacity regarding the actual extent of forests earmarked for conversion. This chapter, which focuses on predicting forest conversion ex-ante, refines and updates the findings of RimbaWatch's *State of Malaysian Rainforest* 2023 and 2024 studies, accounting for the most recently-available spatial forest cover dataset from the Joint Research Centre Tropical Moist Forest hub—an updated concession dataset accounting for recently-document threats, and re-calculation of threatened forests within concessions reflecting the updated forest cover dataset. Adopting FAO's definition of Naturally Regenerating Forest, the findings of this study estimates that about 3.65 million ha of undisturbed and degraded forest remain within known concession and are potentially at risk of conversion. Industrial timber plantation accounts for 2.59 million ha or 78% of all identified forest threats. The study further estimates that this forest conversion could release approximately 519.7 million MgC of carbon.

INTRODUCTION

At the Rio Earth Summit in 1992, Malaysia pledged to ensure that at least 50% of its land area would remain under forest cover. In the ensuing years, the Government and its representatives have made multiple verbal and written commitments reiterating this target, which has been enshrined in a number of policy and planning frameworks. This includes the 12th Malaysia Plan, the 4th National Physical Plan, and the 2021 Malaysia Forestry Policy (Endot *et al.* 2024).

While the Government of Malaysia publishes statistics on the remaining extent of forest cover, which in 2024 was 54.58%, these figures are not reinforced by publicly available geospatial data, or maps in general, illustrating which areas are counted as forest cover (Bernama 2024). Furthermore, while existing forest cover is reported, there is no transparent reporting on the extent of forest cover that has been earmarked, gazetted, or approved for conversion, which would impact the Government's alignment to the target. Interpretation of this target is further muddied by the absence of explicit guidance on which definition of forest applies to the 50% commitment, creating uncertainty on whether industrial plantations, cleared land and other land uses are counted.

The Government of Malaysia's performance on maintaining this target had not been independently verified until RimbaWatch published the *State of the Malaysian Rainforest 2023* study, which found that forest cover in Malaysia was estimated to decrease to 47% in the future. A second installment in the series, the *State of the Malaysian Rainforest 2024* study, adopted more accurate georeferencing methodologies, updated the extent of concessions to reflect state-published data and referred to three spatial forest cover baselines. The 2024 study found the extent of forests earmarked for conversion would cause Malaysia's forest cover to drop below 50% in the future in all three baselines, with the post-conversion forest cover ranging between 40% – 49% depending on the spatial dataset.

RimbaWatch, 35-10 Boulevard, Mid Valley City, 59200 Kuala Lumpur, Malaysia.
***Corresponding author: adam@rimbawatch.com**

The purpose of this chapter, which focuses on predicting conversion *ex-ante*, is to refine and update the findings of the *State of the Malaysian Rainforest 2024* study, taking into account:

- Most recently-available spatial forest cover datasets (Vancutsem *et al.* 2024);
- Addition of updated concession dataset, accounting for recently-documented threats;
- Re-calculation of threatened forests within concessions reflecting Vancutsem *et al.* (2024).

METHODOLOGY

This chapter is based on the following assumptions and definitions:

1. This chapter defines '**forests**' by adopting the FAO's FRA 2025 'Naturally Regenerating Forest' definition: "***Forest predominantly composed of trees established through natural regeneration***", including "i) forests for which it is not possible to distinguish whether planted or naturally regenerated; ii) forests with a mix of naturally regenerated tree species and planted/seeded trees, and where the naturally regenerated trees are expected to constitute the major part of the growing stock at stand maturity; iii) Includes coppice from trees originally established through natural regeneration and iv) Includes naturally regenerated trees of introduced species."
2. This chapter adopts the Vancutsem *et al*. (2024) forest cover dataset from the EU's Tropical Moist Forest (TMF) cover tool, developed to support the implementation of the EU Deforestation Regulation (EUDR). Sub-forest cover classifications, such as the extent of undisturbed, degraded and non-forest areas, are adopted from this dataset. The dataset, which identifies and classifies tree cover outside of non-natural forest uses, is adopted as it reflects 'Naturally Regenerating Forest' criteria (EU Science Hub 2025).
3. All areas within concession boundaries which meet the Vancutsem *et al.* (2024) criteria for undisturbed and degraded forest are assumed to be under threat from conversion, as data on areas set aside for conservation, and other non-conversion uses are not known.
4. Concessions are defined as "any areas which have been earmarked for conversion to non-forest uses, as demonstrated by spatially defined plans as published in state Forest Management plans, approved Environmental Impact Assessments (EIAs), and others".
5. It must be noted that due to continued limitations in data availability, the findings of this report must be taken as estimates produced within the confines of the methodology adopted.

The calculation methodologies from the *State of the Malaysian Rainforest 2024* report were adopted for this chapter. Where possible, concession boundaries were imported directly from existing datasets. If unavailable, maps were digitised to convert them from 2D images into shapefiles. To digitise maps of concessions, the maps were georeferenced on Google Earth Pro while referencing forest reserve boundaries, geographical features (i.e., rivers), or other other features (i.e., boundaries of monoculture plantations). Once digitised, concessions were then traced at less than a 100 km resolution for maps at State level, 50 km resolution for district level, and 20 km for individual concessions. The maps were traced following the outer boundary of the concession, as a .1 point line. It must be noted that the accuracy of concession boundaries are dependent on the resolution of the image used, and the data presented here is an estimate only.

The calculations for this chapter were conducted on ArcGIS Pro 2.9. This methodology may be applicable with other Geographic Information Systems (GIS) such as QGIS, however the details below are based solely on calculations performed with ArcGIS Pro.

Upon downloading the relevant data, the "Extract by Mask" raster tool and "Mosaic to New Raster" tool were applied to isolate and merge the data within Malaysia's administrative boundaries. This process generated a comprehensive layer representing the state of forests

within Malaysian territory, categorised as "Undisturbed", "Degraded", and "Other" (Vancutsem *et al.* 2024). To integrate the concession boundaries data obtained from RimbaWatch into the analysis, the Keyhole Markup Language (KML) format of the concession boundaries (see Appendix II) was converted into a layer file using the tool available in ArcGIS Pro. Further, classification of the polygons and lines in the concession dataset was conducted based on their respective attributes, such as timber plantations, palm oil areas, and settlements, utilising the reclassify tool. This step enabled the differentiation of different types of concessions within the dataset. Subsequently, the forest classification layer was overlaid onto the RimbaWatch dataset using the "Extract by Mask" tool. In this operation, the forest classification data served as the input data, and the RimbaWatch dataset functioned as the boundary, yielding forest classification information within the defined concession boundaries. The attribute tables from the new layers provide data for the number of cells for each type of forest cover.

The layer properties of the raster data, available for each layer, provide the necessary information for this calculation. Specifically, the Raster Spatial Reference and Extent provided the necessary values for cell length (x) and cell width, which were instrumental in calculating the size of each cell. The cell length was squared to determine the cell size in square meters (m^2), and this value was then converted to hectares (ha) by dividing it by 10,000. The formula for calculating the cell size (ha) is as follows:

$$\text{Cell size (ha)} = \frac{x^2}{10{,}000}$$

After obtaining the cell size, the attribute table of each layer was processed to extract pertinent information related to relevant values and the corresponding number of pixels for each row. The total area for each row in the attribute table was then determined by multiplying the number of cells by the previously calculated hectare value:

$$\text{Total area (ha)} = \text{Number of cells} \times \text{Cell size (ha)}$$

Finally, the total value in a given area is determined by multiplying the total area (ha) by the corresponding value specific to that region.

Considerations for the interpretation of data

The data presented in the following section must be interpreted with the following considerations in mind:

1. The concession data collected cannot be guaranteed to contain comprehensive coverage of all forest-risk activities, due to limited transparency of environmental and spatial data by the Department of Environment, State Forestry Departments, and other relevant agencies.
2. Due to this opacity, there is limited access to planting or forest management plans, and the data presented here is agnostic as to concession-level conservation exclusion zones.
3. The quality of georeferencing depends on the quality and granularity of original source maps, therefore some concession boundaries are indicative.
4. The Vancutsem *et al.* (2024) dataset is adopted due to its policy relevance; being used as a base layer for the Tropical Moist Forest Tool (TMF) developed by the EU Joint Research Centre (JRC) with the intention to support EUDR implementation (CIRAD, 2024). However, there is academic debate over its accuracy in classifying, for example, abandoned rubber plantations as natural forest cover, leading to either inflated or under-estimates of natural forest cover (Sheil *et al.* 2025).

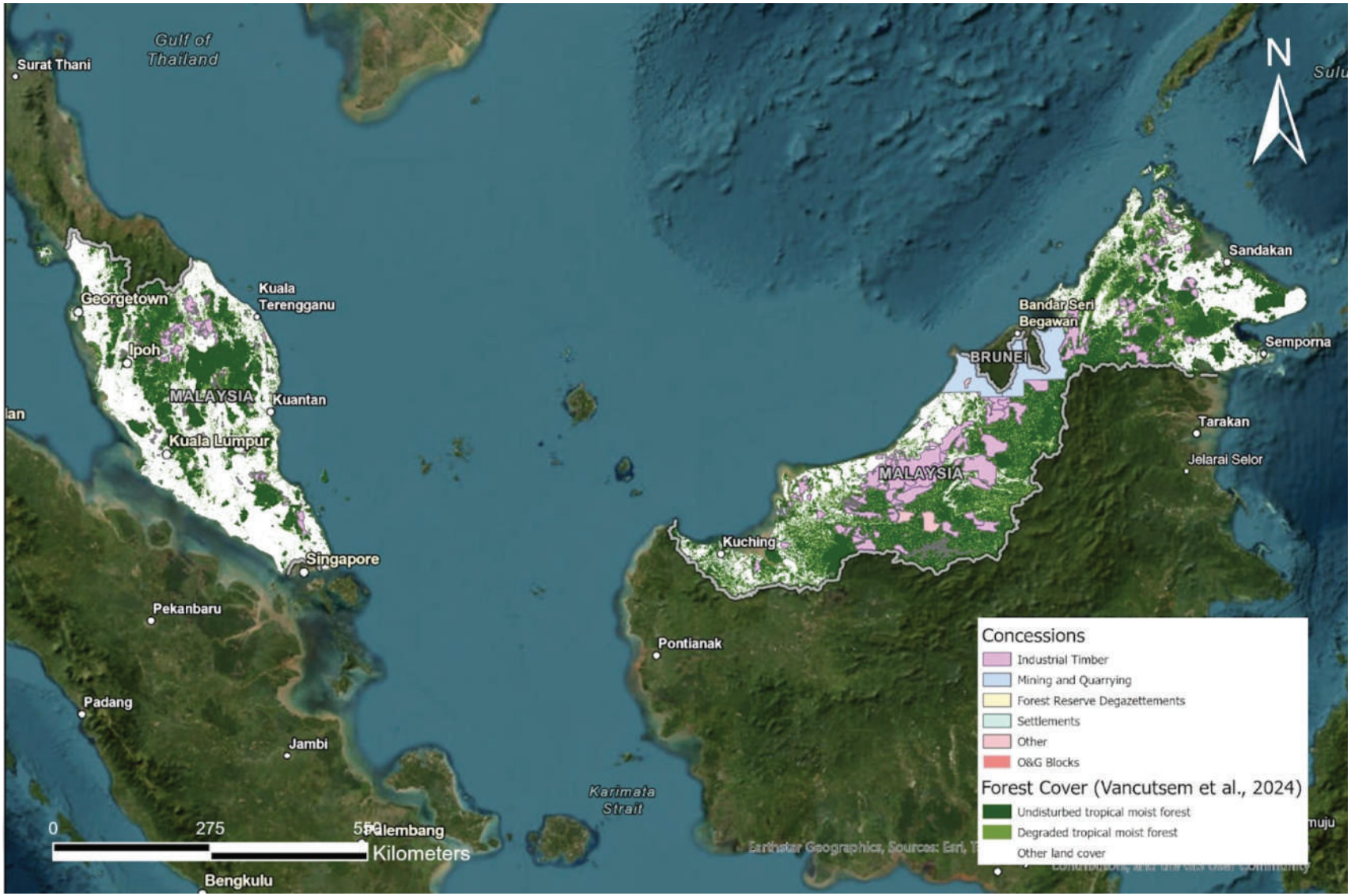


Figure I. Overview of concessions analysed in this chapter

RESULTS

The Vancutsem *et al*. (2024) dataset identifies 2,206,046 ha of remaining undisturbed forest and 1,444,752 ha of degraded forest within concessions, resulting in a combined 3,650,798 ha of forests earmarked for conversion in known concessions (Figure 1). There is a combined 2,588,964 ha of forests earmarked for conversion in industrial timber plantation (ITP) concessions. Within these concessions, 1,499,039 ha of threatened forests are classified as undisturbed, while 1,089,925 ha are classified as degraded. Therefore, 58% of remaining forests in known ITP concessions are undisturbed forests. ITPs consist of 78% of all threats to forests. The breakdown of forest areas for other economic activities is outlined in Table 1. The predicted forest conversion by State is presented in Table 2.

Table 1. Area of forest under threat based on economic activities.

Activity	Forest under threat (ha)
Industrial Timber Plantations	2,588,964
Oil Palm	28,644
Mining and Quarrying	14,731
Settlements (incl. Hydropower and other reservoirs)	181,415
Forest Reserve Degazettements	2,580
Other (incl. Verified real estate listings)	72,390

Table 2. Predicted forest conversion by State.

State	Forest under threat (ha)
Johor	28,644
Kedah	14,731
Kelantan	181,415
Negeri Sembilan	2,580
Pahang	72,390
Perak	33,393
Sabah	405,178
Sarawak	2,803,425
Selangor	6,935
Terengganu	17,126

Assuming that 100% aboveground biomass and 21.3% of soil carbon is vulnerable to release during conversion events (Noon *et al*. 2022), 519,691,344 Mg C is expected to be released from the conversion of known concessions, which is roughly equal to the annual emissions of Pakistan at current levels (EDGAR 2025). Proposals for the commercialisation of onshore oil and gas (O&G) resources have been revived in recent years. The two onshore O&G blocks with active exploration activities in Sarawak overlap with 765,016 ha of forests, posing significant emerging risks to communities and ecological integrity forests through conversion, soil, water and air pollution. However, this figure is not included in the final figure for threatened forest due to insufficient information on the extent of planned conversion within these O&G blocks.

DISCUSSION

These findings reflect those of the two previous *State of the Malaysian Rainforest* studies in 2023 and 2024, which is that ITPs will be the top future driver of forest conversion in Malaysia. The official position of the Peninsular Malaysia (FPD 2022), Sarawak (FDS 2022), and Sabah (Anjumin 2022) authorities are that ITPs, which are referred to officially as "*ladang hutan*", or other variations of the term, seems to be a method of rehabilitating degraded forests which reduces pressure on natural forests (Anjumin 2022). For example,

the Forest Plantation Development claims, "*The Programme supports rehabilitation of degraded forests, encroached forests, unproductive state lands, and poorly stocked forest areas*" (FPD 2022).

The findings above demonstrate that nearly 1.5 million ha of industrial plantation concessions are located in forests classified as undisturbed, which contradicts this official rationale. Further, ITPs are the primary threat to the conversion of natural forest, rather than a method of reducing pressure on them.

While the National Land Council placed a moratorium on new '*ladang hutan*' development in 2021, this moratorium: 1) only applies to new ITP zoning, and therefore has no impact on land already zoned, namely the 2.58 million hectares identified in this study; and 2) only applies to Peninsular Malaysia and does not cover Sabah and Sarawak, where the majority of the 2.58 million hectares are located.

Beyond ITPs, this data illustrates that threats to forests are varied and overlap. For example, there is 526,249.7 ha of overlap between ITPs and oil palm in Sarawak, which can be attributed to the fact that the Sarawak Forestry Department permits the planting of up to 20% of the timber plantation concessions with oil palm for one cycle. Further, oil palm concessions overlap with other emerging threats, such as coal, oil and gas production, and proposed settlements. Further, the extent that these overlapping contestations degrade habitat connectivity remains understudied and omitted from land planning decisions. While it is possible, for example, to model Tiger Habitat Quality using Sentinel-2 imagery and the InVEST model (Louis *et al.* 2023), there is a need to study how different concession types impact the distribution of a wider range of indicator species, and for this data to be incorporated into forest zoning and decision-making.

WAY FORWARD

These findings illustrate the urgent need to improve Malaysian forest governance, and underlying legislation and political attitudes towards the rainforest, the species which call it home, and their stewards.

1. An immediate moratorium on all forest degradation and conversion in ITP concessions across Malaysia.
2. Malaysia must adjust all forestry targets to reflect the definition of 'Naturally Regenerating Forest' from the FAO (FRA 2025).
3. In both policy documents and upcoming environmental legislation (i.e., the Climate Change Act), Malaysia must legislate the target to maintain natural forest cover above a certain minimum percentage of land cover, which should be set at Malaysia's current and existing natural forest cover.
4. All relevant development and planning frameworks, from State Structure Plans to the Environmental Quality Act 1974, should be amended to reflect the target in point 2 above.
5. The relevant agencies should spearhead constitutional amendments to reflect the right of Malaysians to a clean environment, and of its Indigenous communities to legal ownership of their Traditional Territories.

REFERENCES

Anjumin, E. 2022, July 7. Tree plantations way forward in forestry. *New Straits Times*. https://www.nst.com.my/news/nation/2022/07/811532/tree-plantations-way-forward-forestry

Bernama. 2024, May 11. Malaysia Reiterates Commitment to Maintain 50 pct Forest Cover. *Bernama*. https://bernama.com/en/news.php?id=2296618

CIRAD. 2024. A map of the world's forest to support the EU Regulation on deforestation-free supply chains. https://www.cirad.fr/en/cirad-news/news/2024/deforestation-reference-map-for-the-european-union

EDGAR - Emissions Database for Global Atmospheric Research. 2025. GHG emissions of all world countries. https://edgar.jrc.ec.europa.eu/report_2025

Endot, M.R., Nor, N.L., Rahim, M.K.A. 2024. Restoration, reclamation and rehabilitation of degraded forest areas in Peninsular Malaysia: Issues, challenges and way forward. *20th Malaysian Forestry Conference 2024* (MFC-20), 28th - 30th October 2024, Sabah International Convention Centre (SICC), Kota Kinabalu. Kota Kinabalu: Sabah Forestry Department.

EU Science Hub. 2025. Tropical Moist Forests product - Resources. https://forobs.jrc.ec.europa.eu/TMF

FAO. 2025. *Global Forest Resources Assessment - FRA 2025 - Terms and Definition*. Rome: Food and Agriculture Organization of the United Nations. https://openknowledge.fao.org/server/api/core/bitstreams/a6e225da-4a31-4e06-818d-ca3aeadfd635/content

Forest Plantation Development. 2022. Background/History. https://www.fpd.com.my/backgroundhistory

Forest Department Sarawak. 2022. Issues and Challenges https://forestry.sarawak.gov.my/page-0-245-1010-tid.html

JRC-TMF. 2024. Tropical Moist Forests product - Data Access. https://forobs.jrc.ec.europa.eu/TMF/data

Noon, M.L., Goldstein, A., Ledezma, J.C., Roehrdanz, P.R., Cook-Patton, S.C., Spawn-Lee. S.A., Wright, T.M. *et al.* 2021. Mapping the irrecoverable carbon in Earth's ecosystems. *Nature Sustainability* 5: 37–46.

RimbaWatch. 2023. State of the Malaysian Rainforest 2023. https://borneoproject.org/state-of-the-malaysian-rainforest-report/

RimbaWatch. 2024. State of the Malaysian Rainforest 2024. https://9b2d2d75-7adf-4ea5-8c47-1b96d3a7eaf6.filesusr.com/ugd/a4715a_ad144495d1fa46bf857166bda8e2e8a9.pdf

Sheil, D., Descals, A., Meijaard, E. and Gaveau, D. 2025. Rubber planting and deforestation. *Nature* 644: E20–E22.

APPENDIX

The list of concession datasets adopted for this chapter can be viewed and downloaded in the link below:

https://docs.google.com/spreadsheets/d/1OAjUDPJEshyzJ5P5QmIZ27i-lFILYp2Rg9qGJUj7-Wo/

The list of non-concession datasets adopted can be viewed and downloaded in the link below:

https://docs.google.com/spreadsheets/d/1AY-o1lka-2shgTwqszr2C6xH4ikRuIBjuDnYlD5bn9M/

This excludes linear infrastructure and environmental impact assessments (EIAs) for projects not approved by the Department of Environment as of 1 August 2025.


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 687–699
doi: 10.62613/sonc2025.v3anc02

CHAPTER 2

Connectivity science and the Central Forest Spine: Reconnecting a fragmented future

AGKILLAH MANIAM[1]*, SAMSUDIN MUSA[2]
and NOOR AZRIEN ZAINON[2]

Abstract: The Central Forest Spine (CFS) represents Malaysia's flagship initiative to restore ecological connectivity across fragmented tropical forests. Spanning 6.71 million hectares and 39 ecological linkages, the CFS aims to maintain biodiversity and ecosystem functions amid expanding infrastructure and land-use change. This paper reviews the scientific foundations of connectivity conservation and assesses progress under the CFS Master Plan for Ecological Linkages 2022–2040, with emphasis on lessons from the UNDP–GEF Improving Connectivity in the Central Forest Spine Landscape (IC-CFS) project (2015–2024). The findings show that while initiatives such as corridor restoration, biodiversity monitoring protocols, and SMART patrolling have strengthened conservation governance, persistent gaps remain in legal institutionalisation, long-term financing, and federal–state coordination. Embedding connectivity within spatial planning, infrastructure design, and fiscal mechanisms such as the Ecological Fiscal Transfer (EFT) is critical to sustaining outcomes. It further examines how wildlife drives the recovery of degraded habitats, and how forest connectivity supports water regulation and other ecosystem functions at the river-basin scale. The paper elaborates on challenges faced in the implementation of CFS Master Plan and concludes with policy directions to advance the CFS as Malaysia's central ecological network supporting biodiversity, climate resilience, and sustainable development.

INTRODUCTION

Connectivity science teaches us that survival is not about isolation but interaction, between forests and fields, rivers and roads, people and planet. In reconnecting our landscapes, we are also restoring balance between progress and protection, between the needs of today and the hopes of tomorrow. – Adapted from Hilty *et al.* (2019)

Landscape fragmentation remains one of the primary threats to biodiversity in tropical regions. Across Peninsular Malaysia, ancient forests form a living network of life, stretching from the montane peaks of the Titiwangsa Range to the lowland dipterocarp forests of Pahang and Johor (FDPM 2022). The total forest area in Peninsular Malaysia, which spans approximately 4.69 million hectares or about 43% of the region's total land area, is characterised by a patchwork of forested landscapes rather than a single, uninterrupted expanse. These forests are vital for maintaining biodiversity, regulating climate, protecting watersheds, and supporting local communities. This forest network is now under threat as expanding infrastructure, plantations, and urbanisation fragment once continuous landscapes. The resulting isolation of forest patches impedes wildlife movement, gene flow, and ecosystem functions, threatening the persistence of wide-ranging species such as the Malayan tiger (*Panthera tigris jacksoni*), Asian elephant (*Elephas maximus*), and Malayan tapir (*Tapirus indicus*).

Connectivity science offers both insight and solutions, helping us understand how ecosystems, species, and people remain linked across space and time, and how these vital relationships can be restored. In Peninsular Malaysia, this vision takes shape through the

[1] Green Spine Network.
[2] Forest Department of Peninsular Malaysia, Jalan Sultan Salahuddin, 50660 Kuala Lumpur, Malaysia.
***Corresponding author: agkillah@gmail.com**

CFS, a bold national effort to reconnect fragmented forests into a continuous ecological corridor. The CFS represents not only scientific determination, but also a lasting promise that Malaysia's forests will remain whole for generations to come.

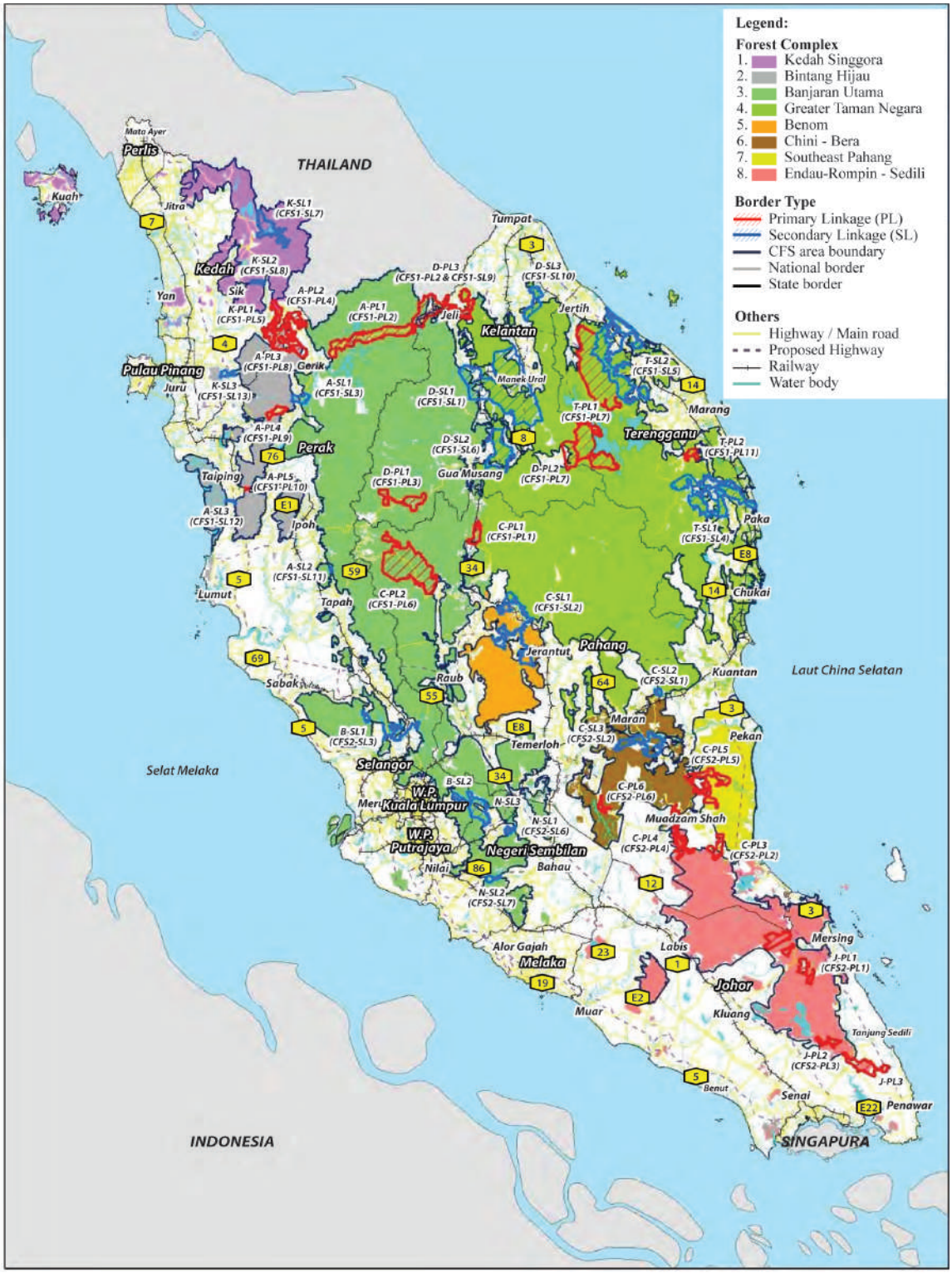


Figure 1. The CFS boundaries for the CFS Ecological Network Master Plan 2022, include coastal forest areas (PLANMalaysia 2022).

As the national blueprint to keep remaining forests connected across a mosaic of protected areas and national / state parks, Permanent Reserved Forests (PRF), state land forests, and other lands, the CFS totals 6.71 million hectares in area (PLANMalaysia 2022). It spans across eight states in Peninsular Malaysia: Kedah, Perak, Kelantan, Terengganu, Johor, Pahang, Selangor, and Negeri Sembilan and consists of eight major forest complexes, namely Titiwangsa Range-Bintang Range-Nakawan Range, National Park-Timur Range, Southeast Pahang, Chini and Bera Wetlands, and Endau Rompin National Park-Kluang Wildlife Reserve (Figure 1). The CFS has identified 39 ecological linkages comprising 20 Primary Linkages and 19 Secondary Linkages, and its implementation is guided by the Master Plan for Ecological Linkages Central Forest Spine 2022–2040 [a], which reinforces the vision, revised actions to be implemented, and stakeholder roles for restoring and maintaining these linkages (PLANMalaysia 2022). The plan outlines five main objectives, 14 strategies, and 38 specified actions.

THEORETICAL FOUNDATIONS OF CONNECTIVITY SCIENCE

Connectivity science provides a robust conceptual and empirical framework to understand and manage ecological flows of organisms, genes, water, and nutrients across complex landscapes. It integrates structural connectivity, referring to the physical configuration and spatial arrangement of habitat patches and corridors, and functional connectivity, which captures the realised movement of species and ecological processes (Taylor *et al.* 1993; Crooks and Sanjayan 2006; Meiklejohn *et al.* 2019). This dual perspective (structural connectivity and functional connectivity) is essential for assessing how landscapes support biodiversity and ecosystem function amid increasing habitat fragmentation.

Globally, research demonstrates that ecological networks and corridors enhance landscape resilience and biodiversity persistence when incorporated into spatial and development planning (Bennett and Mulongoy 2006; Hilty *et al.* 2020). Initiatives such as the Terai Arc Landscape (India-Nepal), the Yellowstone to Yukon (Y2Y) initiative (North America), and Europe's Natura 2000 network illustrate the power of connectivity science in driving effective landscape-scale conservation and cross-jurisdictional cooperation (Chester 2015; Jongman *et al.* 2021; Y2Y 2023). These examples show that durable connectivity outcomes require not only sound ecological design but also institutional frameworks that embed connectivity principles into planning, infrastructure, and finance.

In Malaysia, empirical research has confirmed the critical role of functional connectivity in sustaining viable populations of forest-dependent wildlife. For example, habitat rehabilitation and tree planting within CFS ecological linkages have restored degraded lands and enhanced wildlife movement through former barrier zones (FDPM 2024). At the same time, studies highlight persistent governance and land-use barriers that hinder effective implementation, including overlapping land tenure, inconsistent policy coordination, and competing development priorities (Maniam and Singaravelloo 2015; Aliman 2019).

These findings affirm that connectivity is measurable, mappable, and actionable. When integrated with spatial planning, infrastructure design, and governance systems, connectivity science becomes a practical guide for prioritising conservation investments, designing wildlife crossings, and restoring ecological linkages. Embedding connectivity science into Malaysia's national and state policies can therefore help safeguard biodiversity, sustain ecosystem services, and reduce human-wildlife conflicts, creating living landscapes that support both nature and society.

[a] In 2022, this new master plan replaced the original Central Forest Spine Master Plan 2010 after undergoing an evaluation for achievements and effectiveness.

Wildlife as agents of ecosystem recovery

Connectivity is usually framed as a means of allowing wildlife to move between habitat patches. The reverse relationship is equally important: wildlife moving through ecological linkages actively shapes how degraded habitats recover. In tropical forests, an estimated 70 – 90% of woody plant species depend on vertebrates to disperse their seeds (Howe and Smallwood 1982; Corlett 2017). Hornbills, pigeons, bulbuls, primates, civets and fruit bats carry seeds from intact forest into regenerating land, while the Asian elephant disperses large-seeded species that few other animals can move, a role that has earned it the description of a "megagardener" of the forest (Campos-Arceiz and Blake 2011). Not all large mammals perform this role equally; the Malayan tapir, for example, is a far less effective disperser of large seeds than the elephant (Campos-Arceiz *et al*. 2012). This underlines the value of retaining a diverse community of seed dispersers rather than relying on a single flagship species.

Wildlife therefore influences both the direction and the pace of succession. On degraded land, natural regeneration is frequently limited not only by soil conditions but by the failure of seeds to arrive, particularly the larger seeds of animal-dispersed, shade-tolerant trees (Wunderle 1997; Chazdon 2008). Sites that frugivores visit regularly tend to progress from pioneer-dominated vegetation towards a more diverse, mature forest composition, whereas sites cut off from dispersers can stall at a grass, fern or pioneer stage for decades. Other animal groups also shape this trajectory: pollinators such as bees and bats sustain the reproduction of planted and colonising trees; seed predators and browsers, including wild pig and deer, filter which species establish; dung beetles bury seeds and recycle nutrients; and elephants open gaps and trails that create new regeneration niches. Conversely, where hunting removes large frugivores, tree communities shift towards small-seeded and wind- or gravity-dispersed species, as demonstrated in defaunated forest in Sarawak (Harrison *et al.* 2013).

For the CFS, this has two practical implications. First, connectivity and restoration reinforce each other. Planting "framework" species that grow quickly and flower or fruit early attracts seed-dispersing animals, which in turn bring in seeds of many further species and accelerate recovery beyond what planting alone can achieve (Elliott *et al.* 2003); the Assisted Natural Regeneration approach applied under the IC-CFS project relies on this process. Second, a linkage that is structurally restored but emptied of its dispersers through poaching, snaring or disturbance will recover slowly, if at all. Monitoring of restored CFS linkages should therefore track not only tree survival and canopy cover, but also frugivore visitation, recruitment of non-planted species, and the shift from pioneer to mature-phase composition, as evidence that wildlife-mediated succession is under way.

STATUS OF THE CFS IMPLEMENTATION

Since its launch in 2010, CFS has progressed unevenly from policy conception to on-ground implementation. The Central Forest Spine Master Plan for Ecological Linkages 2022–2040 (*Pelan Induk Rangkaian Ekologi CFS 2022–2040*) replaced the original 2010 Master Plan, updating the vision, objectives, and institutional mechanisms for restoring and maintaining ecological connectivity across Peninsular Malaysia (PLANMalaysia 2022). This revision reflects a growing recognition that ecological linkages cannot be sustained through federal planning alone, but require continuous coordination between federal and state institutions, a challenge long noted by Maniam (2019) in her analysis of the federal-state dynamics shaping the CFS's implementation trajectory and Aliman's (2019) work on fiscal incentives.

Between 2015 and 2024, the UNDP-GEF-funded Improving Connectivity in the Central Forest Spine Landscape (IC-CFS) project provided significant technical and financial impetus to the initiative. With in-kind contributions from the Government of Malaysia, the

project operationalised selected ecological corridors [b] through habitat restoration, wildlife crossing structures, and community engagement in priority landscapes (UNDP 2023). These interventions have demonstrated the viability of collaborative models involving federal agencies, state forestry departments, and NGOs. However, Maniam (2019) underscores that such project-based mechanisms often operate within administrative silos, limiting their capacity to institutionalise cross-sectoral cooperation beyond the project's lifespan.

At state level, CFS Technical Committees were established and linked to the National Steering Committee, but their performance remains uneven. States such as Perak, Pahang, and Johor have advanced corridor restoration, while others face constraints from competing land-use pressures including plantation expansion, infrastructure development, and quarrying (Maniam and Singaravelloo 2015; Aliman 2019). To move the CFS from a master plan to a functioning landscape governance framework, Maniam's (2019) recommendation to institutionalise the CFS within statutory state planning documents (such as State Structure Plans and Local Plans) was pursued under the IC-CFS project, backed by enforceable guidelines and incentives for compliance. However, it still lacks legal force, coupled with sustainable financing for long-term monitoring, maintenance, and stakeholder coordination.

The IC-CFS project delivered substantial progress in strengthening the enabling environment for ecological connectivity within Peninsular Malaysia. By project completion, 664.26 hectares of degraded forests across Perak (489.16 ha), Pahang (152.00 ha), and Johor (23.10 ha) were rehabilitated using native species under the Assisted Natural Regeneration method. A total of 32,783 hectares of state land were gazetted as PRF, exceeding the initial project target. SMART patrolling systems were institutionalised across pilot states, enhancing enforcement capacity against illegal logging and wildlife crime. The project also developed the Biodiversity Monitoring Protocol and Ecosystem Services Assessment using InVEST, now integrated into Forestry Department of Peninsular Malaysia (FDPM)'s One Stop Centre for CFS data management. Moreover, four district local plans and three state structural plans incorporated CFS ecological corridors, ensuring long-term spatial protection. Through its community-based initiatives, including non-consumptive ecotourism and indigenous livelihood programmes, the IC-CFS demonstrated that restoring forest connectivity could be harmonised with local socio-economic resilience (UNDP 2023; FDPM 2024).

Despite progress, many priority linkages remain degraded or blocked by linear infrastructure and monoculture plantations. Monitoring and enforcement remain inconsistent, with ecological assessments varying across taxa and jurisdictions. Maniam (2019) noted that monitoring often depends on ad-hoc project funding, a situation still evident today. Recognising these fiscal constraints, Malaysia has introduced new financing instruments: the Ecological Fiscal Transfer (EFT) mechanism under the Twelfth Malaysia Plan (2021–2025). EFT provides performance-based state allocations for forest and biodiversity conservation. The Malaysian Forest Fund (MFF) was also established in 2021 to implement the national REDD+ Finance Framework and mobilises federal, state, and private-sector resources for forest-connectivity and conservation investments. Aligning the CFS with both the EFT and MFF could operationalise Maniam's (2019) call for stronger fiscal instruments that reconcile federal ecological goals with state development needs, ensuring sustained funding for

[b] The IC-CFS project was implemented across three priority ecological corridors identified under the CFS Master Plan: (1) CFS A-PL1 Temengor FR-Amanjaya FR-Belum FR, Perak, (2) CFS C-PL1 Sungai Yu FR-Tanum, Pahang, and (3) CFS J-PL2 Panti FR-Ulu Sedili FR, Johor. These corridors were selected for their ecological significance in maintaining connectivity between major forest complexes and tiger priority landscapes. The project involved multiple interventions, including the preparation of Special Management Plans, establishment of reforestation plots, installation of SMART patrol and intelligence systems, and integration of corridor boundaries into state and district spatial plans (UNDP 2023; FDPM 2024).

monitoring, maintenance, and connectivity restoration. However, key implementation gaps remain, including:

- Absence of legal recognition of ecological linkages within state-level spatial and land-use planning instruments;
- Limited long-term financing for maintenance and adaptive management; and,
- Weak institutional integration at the state-level between conservation planning and economic development decision-making.

Besides that, Malaysia's expanding road network, now nearing 290,000 kilometres [c] (JKR 2023), has become a major driver of forest fragmentation, disrupting wildlife movement and severing ecological linkages central to the CFS (Wadey *et al.* 2018; Hui *et al.* 2021). Roadkill and movement studies identify consistent hotspots along highways adjacent to forest reserves in Pahang, Kelantan and Johor (Norhafezah Kasmuri *et al.* 2021). Recent analyses demonstrate that engineered wildlife crossings and underpasses, when appropriately sited, are frequently used by elephants, tapirs and other vertebrates (Jasme *et al.* 2022). However, without nationwide road-ecology standards and mandatory connectivity assessments, these linear infrastructures will continue to undermine the ecological functionality of the CFS despite ongoing restoration efforts.

While the CFS 2022–2040 Master Plan and IC-CFS project have enhanced technical clarity and stakeholder engagement, enduring challenges in federal-state coordination, legal integration, and long-term financing continue to constrain the full realisation of the CFS vision of an ecologically connected Peninsular Malaysia (Maniam 2019; PLANMalaysia 2022; FDPM 2023).

CONNECTIVITY BEYOND WILDLIFE: WATER AND CATCHMENT FUNCTIONS

Connectivity in the CFS has largely been justified by the movement needs of wide-ranging mammals. Yet Peninsular Malaysia's forests are also the headwaters of its major rivers, and national policy has long recognised this link at the river-basin scale. The Malaysian National Conservation Strategy (EPU 1993) was among the first national documents to connect forest conservation with the protection of water catchments. The National Physical Plan, in which the CFS concept itself originated, classifies forests and water catchments as Environmentally Sensitive Areas (PLANMalaysia 2021). The National Water Resources Policy adopts Integrated River Basin Management (IRBM) as the basis for managing the nation's water (NRE 2012), and the National Policy on Biological Diversity 2022–2030 emphasises the conservation of ecosystems and the services they provide at the landscape level (KeTSA 2022). These river-basin perspectives are, however, not yet systematically reflected in how CFS linkages are prioritised, restored and monitored.

How much a forest contributes to water regulation depends on its size, ecological condition and position within the catchment. Large, intact blocks in headwater areas maintain high soil infiltration, sustain dry-season baseflow and keep sediment yields low; much of this benefit comes from undisturbed soils and litter layers rather than from tree cover alone (Bruijnzeel 2004). Small or degraded fragments have a higher proportion of edge exposed to drying and disturbance (Laurance et al. 2011), and often more compacted

[c] According to the Buku Statistik Jalan Malaysia Edisi 2023 published by Jabatan Kerja Raya Malaysia (JKR), the total length of Malaysia's federal and state roads as of 31 December 2022 stood at 289,996.655 kilometres, comprising 20,017.97 km of federal roads and 269,978.685 km of state roads (JKR. 2023. *Buku Statistik Jalan Malaysia Edisi 2023*. Kuala Lumpur: Jabatan Kerja Raya Malaysia).

and exposed soils, so their hydrological contribution per hectare is lower and less reliable. Riparian forest contributes disproportionately for its area by trapping sediment and nutrients, stabilising banks and shading streams (Luke *et al*. 2019). Reconnecting fragments, especially along watercourses, therefore does more than open a route for wildlife. It lengthens continuous riparian cover, reduces the edge-to-area ratio of the remaining forest, and links the hydrological functions of separate patches into a catchment-wide system (Mitchell *et al.* 2013).

Case study: CFS A-PL1 Temengor FR–Amanjaya FR–Belum FR, Perak

The A-PL1 linkage illustrates these wider functions. The Belum-Temengor forest complex forms the upper catchment of the Sungai Perak, the state's principal river, and drains into the Temengor reservoir, the uppermost of a cascade of hydroelectric dams along the river. The East–West Highway (Gerik–Jeli) divides this forest into northern and southern blocks, and the A-PL1 linkage through Amanjaya Forest Reserve is intended to reconnect them. Perak, where this linkage lies, accounted for 489.16 ha of the forest rehabilitated under the IC-CFS project.

Viewed through a catchment lens, the value of this linkage extends well beyond elephant and tiger movement. The large intact blocks of Royal Belum State Park and Temengor Forest Reserve would be expected to supply most of the baseflow and sediment retention; the logged-over and degraded forest along the highway corridor, together with land cleared for road works and settlements, presents a higher erosion risk close to the reservoir; and small riparian fragments along tributaries influence how much of that sediment reaches the water. Restoring forest across the linkage should therefore reduce sediment delivery to the reservoir, protecting storage capacity and hydropower generation, while sustaining water supply and flood regulation for downstream communities. An in-depth assessment would compare sub-catchments containing large, medium and small forest fragments of differing ecological quality, before and after restoration, using the InVEST sediment and water-yield models already applied under the IC-CFS project. Such an analysis would show whether, and at what thresholds of fragment size and condition, connectivity delivers measurable hydrological benefits, and would give state water, energy and planning agencies a direct stake in maintaining the linkage.

COMPARATIVE INSIGHTS: LESSONS FROM GLOBAL CORRIDORS

Global corridor initiatives offer transferable lessons for the CFS. The Terai Arc Landscape demonstrates how integrated protection, community stewardship, and targeted connectivity restoration can reverse fragmentation and contribute to tiger recovery (Harihar and Pandav 2012). The Yellowstone to Yukon initiative illustrates long horizon, cross jurisdictional collaboration that meshes scientific analyses, communications, and participatory governance to secure continent scale connectivity (Chester 2015). In Europe, Natura 2000 and the wider green infrastructure approach embed connectivity within legal and funding frameworks, creating deliverable pathways for transboundary ecological networks (Jongman *et al.* 2021).

From these models three practical lessons emerge: first, science must inform siting and design yet be coupled with durable institutions that can enforce outcomes across administrative boundaries; second, financing must be predictable and blended across public and private sources, and third, success depends on substantive involvement of local communities and rights holders so that connectivity delivers tangible livelihood and cultural benefits. These lessons are directly applicable to CFS implementation, where federal policy and state planning must be harmonised through statutory mechanisms and financing instruments.

CHALLENGES AND OPPORTUNITIES

Despite progress, implementation remains uneven. Monitoring systems are fragmented, corridor restoration funding is short-term, and federal-state coordination is often inconsistent. Poor inter-agency coordination between federal and state agencies obstructs consistent enforcement and can allow land use decisions to undercut corridor integrity (FDPM 2023). Data gaps persist for many species, particularly genetic and long-term movement datasets, limiting reliable assessments of functional connectivity. Funding for corridor maintenance is frequently short term, and community engagement is patchy, particularly with Indigenous and other forest-dependent people.

Yet opportunities are expanding. The rise of biodiversity finance instruments, including national biodiversity policy measures and exploratory biodiversity credit pilots, creates new revenue pathways to sustain restoration and long-term monitoring (BIOFIN Malaysia 2018; Carbon Pulse 2023). Natural capital accounting initiatives and open national data platforms provide mechanisms to value connectivity and incorporate those values into planning and investment decisions (Bank Negara Malaysia 2022; DOSM 2024). Advances in remote sensing, GPS telemetry, and circuit theory modelling also lower costs and increase precision in identifying priority interventions (de la Torre *et al.* 2019; Muhamad Nor *et al.* 2023).

Institutional innovation can capture these opportunities. For example, the Malaysian Space Agency (MySA) may be approached to integrate remote sensing, species tracking, road and land use layers and enable routine monitoring and provide a single source of data and information for planners and researchers. Blended finance mechanisms that combine federal and state budget contributions with private ESG capital and biodiversity credit revenues could provide predictable long-term funding. Integrating connectivity metrics into certification systems, such as the Malaysian Timber Certification Scheme (MTCS), Forest Stewardship Council (FSC), Malaysian Sustainable Palm Oil (MSPO), and Roundtable on Sustainable Palm Oil (RSPO), and into infrastructure procurement criteria, can align private actors with national conservation goals.

An integral component of the CFS Master Plan is the development of Special Area Management Plans (SAMPs). These plans enable site-specific strategies tailored to the ecological characteristics, biodiversity significance, and socio-economic contexts of each corridor segment. They ensure that management interventions are precise and effective, addressing the unique conservation needs of critical habitats within the CFS network. By integrating land-use planning and zoning into these sensitive areas, the SAMPs can help reconcile development pressures, such as infrastructure expansion, agriculture, and urbanisation, with ecological conservation priorities. This integrated approach allows economic growth to proceed without undermining the ecological integrity of the CFS. However, the development and implementation of SAMPs across all ecological corridors remain limited. This should be prioritised to ensure comprehensive and balanced management.

POLICY RECOMMENDATIONS

To ensure that CFS fulfils its vision of reconnecting Malaysia's fragmented landscapes, a series of institutional, regulatory, and financial reforms are urgently needed. Each of the recommendations below responds to a specific technical or institutional gap identified in the preceding sections. First, to address the federal–state coordination and legal recognition gaps, connectivity must carry statutory weight in state land-use decisions. Although the National Central Forest Spine Steering Committee and the National CFS Technical Committee were formed to facilitate coordination across federal and state levels, their effectiveness has been constrained by the constitutional reality that authority over land and

forest resources resides with the state governments. In parallel, stronger incentives should be introduced to encourage cooperation among multiple land users. Mechanisms such as conservation easements, biodiversity offsets, or co-investment frameworks could enable private landholders and state agencies to participate in maintaining ecological connectivity without forgoing economic benefits. Embedding such legal and economic instruments within the CFS governance structure would provide both the authority and the incentives necessary to sustain landscape-level conservation in the long term.

Second, responding to the fragmentation caused by Malaysia's expanding road network, all major infrastructure developments such as roads, railways, pipelines, and urban expansion projects, should be required to undergo ecological connectivity impact assessments. These assessments must be science-based, transparent, and mandatory before project approval, with mitigation and monitoring measures clearly stipulated. This measure will align infrastructure growth with biodiversity and climate commitments under the Twelfth Malaysia Plan and the National Policy on Biological Diversity. Complementing this, a National Road Ecology Framework should be developed to guide the integration of wildlife-friendly design standards across Malaysia's 290,000-kilometre road network. Standardising the use of wildlife crossings, fencing, signage, and roadkill monitoring can reduce mortality and restore safe movement for wide-ranging species (Hui *et al.* 2021; WWF 2024).

Third, consistent with the catchment-scale functions discussed above, connectivity must extend beyond forests. The CFS model should be adapted to encompass other critical ecosystems such as peatlands, mangroves, and riverine corridors, creating a more holistic landscape-scale network resilient to both biodiversity loss and climate impacts. Expanding the CFS into these ecosystems would advance the government's commitment to nature-based solutions and support Malaysia's adaptation goals under its Nationally Determined Contributions (NDCs).

Fourth, responding to the river-basin gap identified above, CFS linkages should be planned and prioritised at the catchment scale. Linkages that protect headwaters, riparian corridors or reservoir catchments should receive higher priority, and CFS planning should be integrated with IRBM plans and state water catchment protection, so that water, energy and planning agencies share both the responsibility for and the benefits of connectivity. Including hydrological indicators such as sediment load and dry-season flow in linkage assessments would make these benefits visible to decision-makers.

Fifth, building on the role of wildlife in forest recovery, restoration within CFS linkages should be designed to work with natural succession rather than rely on planting alone. This means favouring native framework species that fruit early and attract seed dispersers, protecting restoration sites from hunting and snaring so that dispersers remain present, and adopting natural recruitment as a core measure of restoration success.

Sixth, reforestation and tree-planting programmes should extend connectivity from forests into urban and peri-urban landscapes. River reserves, urban parks and green belts can serve as stepping stones and corridors linking urban green space to nearby forest reserves, benefiting pollinators, birds and smaller wildlife while also improving urban liveability. Species selection requires care. Planting should favour native species of local provenance and avoid exotic or potentially invasive species, particularly near rivers and water intakes. Some widely planted ornamentals, such as the African tulip tree (*Spathodea campanulata*), produce fluid-filled, mucilaginous flowers and can spread aggressively, and mass flower and fruit fall into streams adds organic matter that can degrade water quality. Clear native-species guidelines for public and corporate tree-planting campaigns would help ensure that planting serves both connectivity and catchment health.

Seventh, the fragmented monitoring and data gaps noted earlier call for a national CFS dashboard. While the establishment of a national dashboard to monitor the implementation progress of CFS has been proposed, its final form and operational use have yet to be realised. The dashboard was initially conceived as a dynamic, data-driven tool to consolidate and visualise progress on forest connectivity, restoration, and land-use planning across the CFS landscape. Recent initiatives show encouraging movement in this direction. Telekom Malaysia Research & Development, in partnership with the Forestry Department of Peninsular Malaysia and several State Forestry Departments, has piloted smart forest dashboards in eight states to enhance forest monitoring and management (TM R&D 2023; Business Today 2023). Anticipated to be launched next year, these platforms integrate remote sensing, IoT sensors, and AI analytics to detect forest cover changes and potential threats, offering a technological foundation for scaling up to a national-level system. Beyond forest cover and threats, the dashboard should also track the ecological functions discussed in this paper, including wildlife use of linkages, natural recruitment in restored sites, and catchment indicators such as sediment load and dry-season flow.

However, rather than a fully open-access model, the proposed CFS Dashboard should adopt a controlled-access framework to safeguard sensitive spatial and biodiversity data. This tiered-access approach would allow for different levels of data visibility for government agencies, researchers, and verified stakeholders, and address legitimate concerns regarding data misuse while maintaining transparency and accountability in decision-making. As a centralised repository integrating forest cover, species movement, genetic connectivity, and infrastructure data, the dashboard could still serve as a powerful tool for adaptive management and cross-sectoral collaboration. By institutionalising data governance protocols and access controls, Malaysia can ensure that the system remains both secure and credible, while transitioning from fragmented, project-based monitoring to continuous, evidence-based management of ecological connectivity (FDPM 2023; DOSM 2024).

Eighth, because monitoring and maintenance still depend largely on short-term project funds, securing long-term financing remains essential. Blended finance mechanisms that combine federal and state allocations with private sector environmental, social, and governance (ESG) investments, biodiversity credits, and international climate finance can sustain restoration and monitoring efforts over time (BIOFIN 2018; Bank Negara Malaysia 2022). The integration of connectivity indicators into green finance and certification frameworks such as the Malaysian Timber Certification Scheme (MTCS/PEFC) can further align market incentives with conservation outcomes. Within the EFT in particular, allocation criteria could reward states not only for forest area retained but also for the condition of CFS linkages and the protection of water catchments, directly linking fiscal transfers to the ecological functions described above.

Finally, as the global corridor experience shows, lasting success depends on people. Empowering Indigenous and local communities as co-stewards of ecological linkages can enhance both legitimacy and effectiveness. Integrating traditional ecological knowledge into restoration and monitoring, while ensuring tangible livelihood benefits, will strengthen local ownership of conservation goals. Equally important is cultivating a shared national narrative (e.g., “Connected Forests, Connected Future”) that positions ecological connectivity as a source of national pride and collective responsibility. Together, these measures can transform the CFS from a policy framework into a living, adaptive system that safeguards Malaysia’s natural heritage while supporting sustainable development.

CONCLUSION

Connectivity science demonstrates that biodiversity conservation cannot be decoupled from spatial planning, transport design, and social systems. The Central Forest Spine is Malaysia's defining effort to translate this science into policy and practice. The Master Plan 2022–2040 sets out a credible pathway, but achieving durable outcomes requires institutionalised governance, compulsory connectivity assessments for infrastructure, robust data systems, and predictable financing. It also requires recognising that connectivity is more than a wildlife issue: reconnected forests sustain the animals that drive forest recovery and the catchments that supply the nation's water, and these functions should shape how linkages are prioritised, restored and financed. If Malaysia can combine science, law, finance, and community stewardship, the CFS has the potential to be the nucleus of a national ecological network that maintains biodiversity, supports ecosystem services, and reduces conflict between people and wildlife. Reconnecting forests is therefore both a technical and a societal project: a commitment to keep development and ecological continuity aligned as the nation advances toward 2030 and beyond.

REFERENCES

Ahmad Ruzman, N.H., Shahfiz, M.A., Fauzi, N.F.M., Munian, K., Mahyudin, N.A.A., Azahar, M.A., Baharudin, M.S. *et al.* 2022. Small vertebrates in Central Forest Spine (CFS) landscape: CFS1 PL1 Tanum–Sungai Yu Forest Reserves, Pahang. *IOP Conference Series: Earth and Environmental Science* 1102(1): 012052.

Aliman, M. 2019. Konflik kepelbagaian guna tanah dalam pelaksanaan Pelan Koridor Ekologi Central Forest Spine di Negeri Perak. Master's thesis. Kuala Lumpur: Universiti Teknologi Malaysia.

Bank Negara Malaysia. 2022. An exploration of nature-related financial risks in Malaysia. https://www.bnm.gov.my/documents/20124/3770663/wb-bnm-2022-report.pdf

Beer, C., Reichstein, M., Tomelleri, E., Ciais, P., Jung, M., Carvalhais, N., Rödenbeck, C. *et al.* 2010. Terrestrial gross carbon dioxide uptake: Global distribution and covariation with climate. *Science* 329(5993): 834–838. https://doi.org/10.1126/science.1184984

Bennett, G. and Mulongoy, K.J. 2006. Review of experience with ecological networks, corridors and buffer zones. Montreal: Secretariat of the Convention on Biological Diversity. 100 pp.

BIOFIN Malaysia. 2018. Biodiversity finance plan for Malaysia. BIOFIN. https://www.biofin.org

Bruijnzeel, L.A. 2004. Hydrological functions of tropical forests: Not seeing the soil for the trees? *Agriculture, Ecosystems & Environment* 104(1): 185–228. https://doi.org/10.1016/j.agee.2004.01.015

Business Today. 2023, November 29. TM R&D Partners with JPNS to Install Smart Dashboards in Forests of Eight States. https://www.businesstoday.com.my/2023/11/29/tm-rd-partners-with-jpns-to-install-smart-dashboards-in-forests-of-eight-states

Campos-Arceiz, A. and Blake, S. 2011. Megagardeners of the forest – the role of elephants in seed dispersal. *Acta Oecologica* 37(6): 542–553. https://doi.org/10.1016/j.actao.2011.01.014

Campos-Arceiz, A., Traeholt, C., Jaffar, R., Santamaria, L. and Corlett, R.T. 2012. Asian tapirs are no elephants when it comes to seed dispersal. *Biotropica* 44(2): 220–227. https://doi.org/10.1111/j.1744-7429.2011.00784.x

Carbon Pulse. 2023, October 25. Malaysia to create biodiversity assets in carbon market through new finance instrument. *Carbon Pulse*. https://carbon-pulse.com/231575/

Chazdon, R.L. 2008. Beyond deforestation: Restoring forests and ecosystem services on degraded lands. *Science* 320(5882): 1458–1460. https://doi.org/10.1126/science.1155365

Chester, C.C. 2015. Yellowstone to Yukon: Transborder conservation across a vast international landscape. *Environmental Science & Policy* 49: 75–84. https://doi.org/10.1016/j.envsci.2014.12.006

Corlett, R.T. 2017. Frugivory and seed dispersal by vertebrates in tropical and subtropical Asia: An update. Global Ecology and Conservation 11: 1–22. https://doi.org/10.1016/j.gecco.2017.04.007

Crooks, K.R. and Sanjayan, M. 2006. *Connectivity Conservation*. Cambridge: Cambridge University Press.

de la Torre, J.A., Lechner, A.M., Wong, E.P., Magintan, D., Saaban, S. and Campos-Arceiz, A. 2019. Using elephant movements to assess landscape connectivity under Peninsular Malaysia's Central Forest Spine land use policy. *Conservation Science and Practice* 1(12): e133. https://doi.org/10.1111/csp2.133

Department of Statistics Malaysia. 2024. OpenDOSM and natural capital data platforms. https://open.dosm.gov.my

Economic Planning Unit (EPU). 1993. *Malaysian National Conservation Strategy: Towards Sustainable Development*. Kuala Lumpur: Economic Planning Unit, Prime Minister's Department.

Elliott, S., Navakitbumrung, P., Kuarak, C., Zangkum, S., Anusarnsunthorn, V. and Blakesley, D. 2003. Selecting framework tree species for restoring seasonally dry tropical forests in northern Thailand based on field performance. *Forest Ecology and Management* 184(1–3): 177–191.

Forestry Department Peninsular Malaysia. 2022. *Master Plan for Ecological Linkages Central Forest Spine (PIRECFS) 2022*. Putrajaya: PLANMalaysia.

Forestry Department of Peninsular Malaysia. 2023. *Annual report 2022: Improving connectivity in the Central Forest Spine landscapes*. Kuala Lumpur: Forestry Department of Peninsular Malaysia. https://www.forestry.gov.my

Harihar, A. and Pandav, B. 2012. Influence of connectivity, wild prey and disturbance on tiger occupancy in the Western Terai Arc Landscape. *PLoS ONE*7(11): e41045. https://doi.org/10.1371/journal.pone.0041045

Harrison, R.D., Tan, S., Plotkin, J.B., Slik, F., Detto, M., Brenes, T., Itoh, A. and Davies, S.J. 2013. Consequences of defaunation for a tropical tree community. *Ecology Letters* 16(5): 687–694. https://doi.org/10.1111/ele.12102

Hilty, J.A., Keeley, A.T.H., Lidicker Jr, W.Z. and Merenlender, A.M. 2019. *Corridor ecology: Linking landscapes for biodiversity conservation and climate adaptation* (2nd ed.). Washington, D.C.: Island Press.

Hilty, J.A., Worboys, G.L., Keeley, A., Woodley, S., Lausche, B., Locke, H., Carr, M. *et al.* 2020. *Guidelines for conserving connectivity through ecological networks and corridors*. Gland: International Union for Conservation of Nature and Natural Resources (IUCN).

Howe, H.F. and Smallwood, J. 1982. Ecology of seed dispersal. *Annual Review of Ecology and Systematics* 13: 201–228.

Hui, T.C.Y., Slade, E.M. and Chong, J.L. 2021. Roadkills in northern Peninsular Malaysia: Patterns, hotspots and mitigation implications. *Frontiers in Environmental Science* 9: 637462. https://doi.org/10.3389/fenvs.2021.637462

Jasme, A. A., Samsudin, M.S.A., Abu Bakar, S.Q. and Mat Nor, A.H. 2022. A study on the significance of wildlife crossings built in Malaysia. *Multidisciplinary Applied Research and Innovation* 3(1): 299–305.

Jongman, R.H.G. and van der Sluis, T. 2021. Green infrastructure and network coherence. In *Handbook B: Scientific support for successful implementation of the Natura 2000 network*. Brussels: European Commission.

Laurance, W.F., Camargo, J.L.C., Luizão, R.C.C., Laurance, S.G., Pimm, S.L., Bruna, E.M., Stouffer, P.C. *et al*. 2011. The fate of Amazonian forest fragments: A 32-year investigation. *Biological Conservation* 144(1): 56–67. https://doi.org/10.1016/j.biocon.2010.09.021

Luke, S.H., Slade, E.M., Gray, C.L., Annammala, K.V., Drewer, J., Williamson, J., Agama, A.L. *et al*. 2019. Riparian buffers in tropical agriculture: Scientific support, effectiveness and directions for policy. *Journal of Applied Ecology* 56(1): 85–92. https://doi.org/10.1111/1365-2664.13280

Maniam, A. 2019. Federalism and policy implementation: A case study of Malaysia's Central Forest Spine policy. Doctoral dissertation. Auckland: University of Auckland.

Maniam, A. and Singaravelloo, K. 2015. Impediments to linking forest islands to Central Forest Spine in Johor, Malaysia. *International Journal of Social Science and Humanity* 5(1): 22.

Meiklejohn, K., Ament, R. and Tabor, G. 2019. Habitat corridors and landscape connectivity: Clarifying the terminology. Bozeman: Center for Large Landscape Conservation. https://largelandscapes.org/wp-content/uploads/2019/06/Habitat-corridors-and-landscape-connectivity1.pdf

Ministry of Energy and Natural Resources (KeTSA). 2022. *National Policy on Biological Diversity 2022–2030*. Putrajaya: KeTSA.

Ministry of Natural Resources and Environment (NRE). 2012. *National Water Resources Policy*. Putrajaya: NRE.
Mitchell, M.G.E., Bennett, E.M. and Gonzalez, A. 2013. Linking landscape connectivity and ecosystem service provision: Current knowledge and research gaps. *Ecosystems* 16(5): 894–908. https://doi.org/10.1007/s10021-013-9647-2
Muhamad Nor, A.N., Rafaai, N.H. and Abdullah, S.A. 2023. Using circuit theory and least-cost path to model ecological corridors of Malayan tapir in Pahang. *Sains Malaysiana* 52(12): 3343–3355.
Norhafezah Kasmuri, N., Nazar, N. and Mohd Yazid, A.Z. 2021. Human and animal conflicts: A case study of wildlife roadkill in Malaysia. *Environment-Behaviour Proceedings Journal* 5(13): 315–322. https://doi.org/10.21834/e-bpj.v5i13.2093
PLANMalaysia. 2021. *Rancangan Fizikal Negara Ke-4 (RFN-4) / Fourth National Physical Plan*. Kuala Lumpur: PLANMalaysia.
PLANMalaysia. 2022. *Pelan Induk Rangkaian Ekologi Central Forest Spine (PIRECFS) 2022–2040: Master Plan for Ecological Linkages Central Forest Spine*. Putrajaya: PLANMalaysia. https://myplan.planmalaysia.gov.my/portal-main/publication-details?id=13
Public Works Department Malaysia (JKR). 2023. *Highway and road statistics report*. Kuala Lumpur: JKR Malaysia.
Taylor, P.D., Fahrig, L., Henein, K. and Merriam, G. 1993. Connectivity is a vital element of landscape structure. *Oikos* 68(3): 571–573.
TM Research & Development. 2023. TM R&D Collaborates with JPNS on the Central Forest Spine Programme. https://www.tmrnd.com.my/tm-rd-collaborates-with-jpns-on-the-central-forest-spine-programme
UNDP Malaysia. 2023. Partnerships to connect the Central Forest Spine in Peninsular Malaysia. UNDP Stories. https://www.undp.org/malaysia/stories/stronger-together-partnerships-connect-central-forest-spine-peninsular-malaysia
Wadey, J., Beyer, H.L., Saaban, S., Othman, N., Leimgruber, P. and Campos-Arceiz, A. 2018. Why did the elephant cross the road? The complex response of wild elephants to a major road in Peninsular Malaysia. *Biological Conservation* 218: 91–98. https://doi.org/10.1016/j.biocon.2017.11.036
WWF Asian Elephant Technical Working Group. 2024. *Handbook to mitigate the impacts of roads and railways on Asian elephants*. WWF. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/6p6mle7lmj_Asian_Elephant_Handbook_AsETWG_2024.pdf
Wunderle, J.M. 1997. The role of animal seed dispersal in accelerating native forest regeneration on degraded tropical lands. *Forest Ecology and Management* 99(1–2): 223–235.
Y2Y. 2023. Yellowstone to Yukon bibliography and research reports. *Yellowstone to Yukon Conservation Initiative*. https://y2y.net/research-reports/
Zainol, N., Taher, T.M., Razak, S., Nor, N.A.I., Nazir, N.A.M., Shukor, A., Ibrahim, A. and Md Nor, S. 2021. Wildlife crossings at Felda Aring–Tasik Kenyir Road, Malaysia. *Pertanika Journal of Tropical Agricultural Science* 44(2): 401–427.


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 701–715
doi: 10.62613/sonc2025.v3anc03

CHAPTER 3

Seventeen years of the Heart of Borneo: Research trends, progress, challenges, and pathways toward a connected conservation landscape

JAYASILAN MOHD-AZLAN[1]*, MUHD AMSYARI MORNI[1], SITI NURBAIDZURI RELI[2], NOR IZWAN HAKIMI NOR AZMI[1], MADELINE GEORGE PAU[3], JASON HON[4], ARTHUR Y.C. CHUNG[5] and JEDEDIAH F. BRODIE[1,6]

Abstract: Launched in 2007, the Heart of Borneo (HoB) represents one of Southeast Asia's most ambitious transboundary conservation collaborations, encompassing approximately 24 million hectares across Brunei Darussalam, Indonesia, and Malaysia. Seventeen years on, this paper examines the progress, challenges, and research trends within the HoB landscape through a systematic review of published studies and conservation activities. Research and conservation efforts remain unevenly distributed across taxa and localities, with limited integration between science, policy, and management. The analysis shows that the HoB has strengthened regional cooperation and elevated global recognition of Borneo's rich biodiversity. At the same time, it highlights important areas where continued, collaborative efforts can further enhance ecological integrity, particularly in managing land use, restoring habitats, and promoting long-term sustainability across the landscape. To achieve the Kunming –Montreal Global Biodiversity Framework's 30×30 target, there is a need to enhance ecological connectivity, establish other effective area-based conservation measures (OECMs), and strengthen governance across political boundaries. The HoB remains a globally significant yet fragile conservation experiment. Its success will depend on coordinated action, sustained political will, and equitable engagement with local communities.

INTRODUCTION

The Heart of Borneo (HoB) Initiative, launched in 2007, is a voluntary transboundary cooperation between Brunei Darussalam, Malaysia, and Indonesia, to enable conservation and environmental protection, while enhancing sustainable development that improve the welfare of those living on the island. The initiative covers approximately 24 million hectares of land encompassing diverse land uses, representing one of the most ambitious transboundary conservation collaborations in the region and perhaps the world. In 2018, Sarawak expanded the HoB area by 565,251 hectares to include additional regions, highlighting increasing recognition of its ecological significance and the need for stronger conservation efforts. The western expansion, incorporating areas up to Tanjung Datu National Park, underscores the importance of preserving biodiversity across diverse landscapes within Sarawak's jurisdiction. The HoB covers about 32% of Borneo's landmass, encompassing roughly 17 million ha (~70% of the HoB area) in Kalimantan, 4 million ha (~17%) in Sabah, 2.7 million ha (~12%)

[1] Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300, Kota Samarahan, Sarawak, Malaysia.
[2] Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300, Kota Samarahan, Sarawak, Malaysia.
[3] Forest Department Sarawak, Level 15, East Wing, Bangunan Baitul Makmur II, Medan Raya, Petra Jaya, 93050 Kuching, Sarawak, Malaysia.
[4] World Wide Fund for Nature, Malaysia; Petaling Jaya, Selangor, Malaysia.
[5] Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
[6] Division of Biological Sciences and Wildlife Biology Program, University of Montana, Missoula, MA, USA.
***Corresponding author: azlan@unimas.my**

in Sarawak, and 340,000 ha (~1.7%) in Brunei Darussalam (Keong and Onuma 2021) (Figure 1). In relation to each jurisdiction's total land area, approximately 59% of Brunei Darussalam, 54.1% of Sabah, 31.6% of Kalimantan, and 21.7% of Sarawak, fall within the HoB boundary.

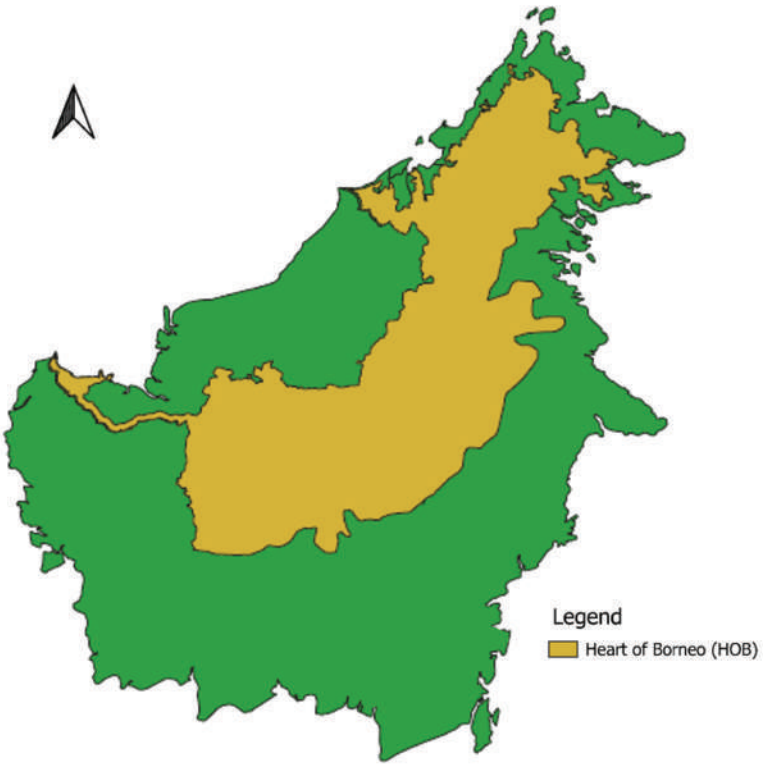


Figure 1. Map of the Heart of Borneo, including the 2018 extension by Sarawak that expands the boundary into western Sarawak.

The HoB initiative aligns closely with the Kunming-Montreal Global Biodiversity Framework (KMGBF) Global Target 3, which calls for at least 30% of terrestrial, inland water, marine, and coastal areas to be effectively conserved and managed by 2030, particularly those of high importance for biodiversity and ecosystem services. In Malaysia, the national commitment to this goal is articulated in the National Policy on Biological Diversity 2025 – 2030 (NPBD 2025 – 2030). Under Goal 3, Target 8, Malaysia aims to achieve the protection of 20% of its terrestrial areas by 2030, with a longer-term ambition to reach the 30% target within the subsequent five years. Furthermore, Goal 3, Target 10 of the NPBD 2025 – 2030 emphasises the establishment and management of key ecological corridors to strengthen landscape connectivity. Specifically, Target 10.2 seeks to enhance terrestrial ecological connectivity within Malaysian Borneo by securing, managing, and restoring key forest linkages within major forest complexes in Sabah and Sarawak. A key performance indicator for this target is a 10% increase in the protected area coverage within the HoB landscape. Similar commitments are expressed in the other two HoB countries. Indonesia has aligned its conservation agenda with global biodiversity goals, including the effective management of forest, as outlined in its Sixth National Report for the Convention on Biological Diversity (MoEF 2019) and the Forestry and Other Land Use (FOLU) Net Sink 2030 strategy (MoEF 2021). These frameworks have identified protection of forests, restoration of peatland and degraded land across major forest landscapes, including the Indonesian sector of HoB.

Brunei Darussalam showed a strong national conservation effort, aiming to increase its forest reserve from 41% to 55% of the total land area, heading towards a low carbon and climate-resilient nation and integrating biodiversity protection into national policy through the Brunei Darussalam National Climate Change Policy (BCCS 2020). Furthermore, Brunei's long-standing support for the HoB further confirms its stance in maintaining landscape connectivity and long-term ecosystem protection across Borneo. Together, these national frameworks highlight the alignment of HoB with the global "30×30" vision and shared responsibility for maintaining the ecological integrity of Borneo.

If the protected areas within the HoB can be effectively linked into a connected network, wildlife populations will be able to move between habitats and also along elevational gradients, reducing the risk of local extinctions that occur when species become confined to isolated parks surrounded by converted landscapes or are affected by climate change impacts. Effective management is equally crucial to ensure that both protected areas and wildlife corridors are safeguarded from overhunting, poaching, and illegal encroachment. A landscape or protected area network is well connected if organismal movement is sufficient to maintain the long-term persistence of species or ecological functions (including ecosystem services) relative to counterfactuals with the same amount of intact habitat and no barriers to movement (Brodie *et al.* 2025a).

Connectivity within the HoB should also be considered for aquatic and riparian organisms. Fourteen of Borneo's 20 major rivers originate from the HoB, and their watersheds extend well beyond the initiative's boundaries. Maintaining forest cover and riparian connectivity in these upper catchments therefore supports freshwater biodiversity by allowing dispersal and migration for fish and other aquatic animals, though these effects are considered far less often than in terrestrial systems. Riparian forest cover and connectivity also help regulate sedimentation, flooding, water quality, and downstream water supply. Coordinated management across entire river basins is especially important because ecological processes cross administrative and national boundaries (Witteveen+Bos 2011).

Thus, while the HoB encompasses several large and biologically significant protected areas, the long-term viability of large-bodied and wide-ranging species depends on maintaining ecological connectivity among these sites, including conserving lands outside of these protected areas. A well-connected HoB landscape will ensure that these species can persist and adapt in the face of ongoing habitat fragmentation and environmental change (Bennett 2003; Clements *et al.* 2014; Brodie *et al.* 2015). About 11 – 36% of Bornean mammal species are projected to lose 30% of their habitat based on climate projection, with increased economic cost of creating corridors estimated to be 65% higher in 2080 (Struebig *et al.* 2015, 2024).

Since its declaration, the three governments, along with NGOs, have conducted numerous scientific expeditions, conservation initiatives, and research projects to promote sustainable forest management and protect Borneo's natural heritage. Since 2007, Sabah has developed three Strategic Plans of Action (2009, 2015, and 2022) for HoB implementation, focusing on (1) protected area expansion and management, (2) sustainable resource use and biodiversity conservation, (3) ecotourism development, (4) transboundary management, and (5) capacity building, while Sarawak has reviewed its Project Implementation Framework (PIF) in 2019 to enhance its implementation. A remarkable milestone was reached in 2013 when the Sarawak Government set a goal for concession areas within the HoB to achieve sustainable forest management (FMC) certification by 2017 (Alek and Kader 2021). This initiative paved the way for the Government's subsequent commitment in 2022 to require all long-term Forest Timber Licences to obtain FMC certification, reinforcing Sarawak's dedication to sustainable forestry and responsible resource management.

Beyond Malaysia, the HoB member countries have taken parallel steps. In Indonesia, the national authorities together with NGOs, have promoted sustainable forest management, landscape-scale green economy planning, and community-based conservation within HoB zones (WWF 2017a, 2022; Firdaus *et al*. 2018). In April 2017, Indonesia established a National Task Force to advise on the development of a long-term roadmap for coordinated implementation, including opportunities for sustainable investment benefiting nature, communities, and the regional economy (WWF 2017a). Brunei Darussalam has likewise remained an active and committed partner. The country continues to play a key role in trilateral cooperation, including hosting several Trilateral Meetings and dynamically participating in the planning of transboundary initiatives such as the proposed HoB Corridor Project linking protected areas across the three countries (WWF 2017b; Keong and Onuma 2021).

Seventeen years after its inception, several positive developments have emerged, including increasing adoption of High Conservation Value (HCV) and sustainable forest management (SFM) standards. To ensure continued progress, a clearer picture of the knowledge gaps, issues, and challenges across the HoB landscape is needed. Accordingly, two central questions emerge: (1) What are the research trends and prevailing issues and challenges within the HoB, and; (2) How evenly are research and conservation efforts distributed across taxa and localities? To address these issues, a Systematic Literature Review (SLR) following a multi-step screening process was conducted. Studies were examined to assess publication trends, identify the taxa and regions that have received the most research attention, international collaborations, and funding sources. In total, 831 journal articles were initially identified, from which 438 publications met the selection criteria and were included in the analysis.

All spatial analyses were conducted in ArcGIS Pro version 3.5. Area calculations were performed using the Calculate Geometry tool. Village, river, and road features were buffered before calculating the areas to provide measurable polygon-based estimates (Village: 1km; River: 10 m; Road: 7.4 m). This assessment offers valuable insights into the threats, existing knowledge, and conservation challenges within the HoB landscape. It also highlights key research and management gaps, while providing guidance that may help shape future research directions and policy priorities.

Biodiversity research gaps

The understanding of research patterns within HoB is important as environmental and human pressures continue to influence the ecosystem resilience and research priorities. Biodiversity studies across the HoB exhibit a noticeable bias towards particular charismatic or readily accessible taxa. For flora, most publications are concentrated on a few prominent groups such as orchids, trees (including dipterocarps, mangroves, and other non-dipterocarps), gingers, and shrubs. In contrast, pitcher plants, palms, and many other groups have received comparatively less research attention (Figure 2a). For fauna, research shows a strong taxonomic bias toward mammals and herpetofauna, which together represent more than half of all studies conducted between 2007 and 2024 (Figure 2b). Although birds, fish, and invertebrates are critical for ecosystem processes such as pollination, seed dispersal, and nutrient cycling (Ng *et al.* 2020; Kamal *et al*. 2022; Nursyamin *et al.* 2023), they remain comparatively underrepresented in the HoB.

Flora studies were published predominantly in regionally oriented journals like *Reinwardtia*, *Gardens' Bulletin*, *Scientia Bruneiana* and the *Journal of Tropical Biology and Conservation*, accounting for a high share of flora studies (Figure 2e). For fauna, The *Raffles Bulletin of Zoology* and *Journal of Tropical Biology and Conservation* represent the largest number of publications followed by the few Malaysian-based journals such as *Borneo Journal of Resource Science and Technology*, *Malaysian Applied Biology*, *Malayan Nature Journal*, and a few international publishers such as *Zootaxa* and *Oryx* (Figure 2f).

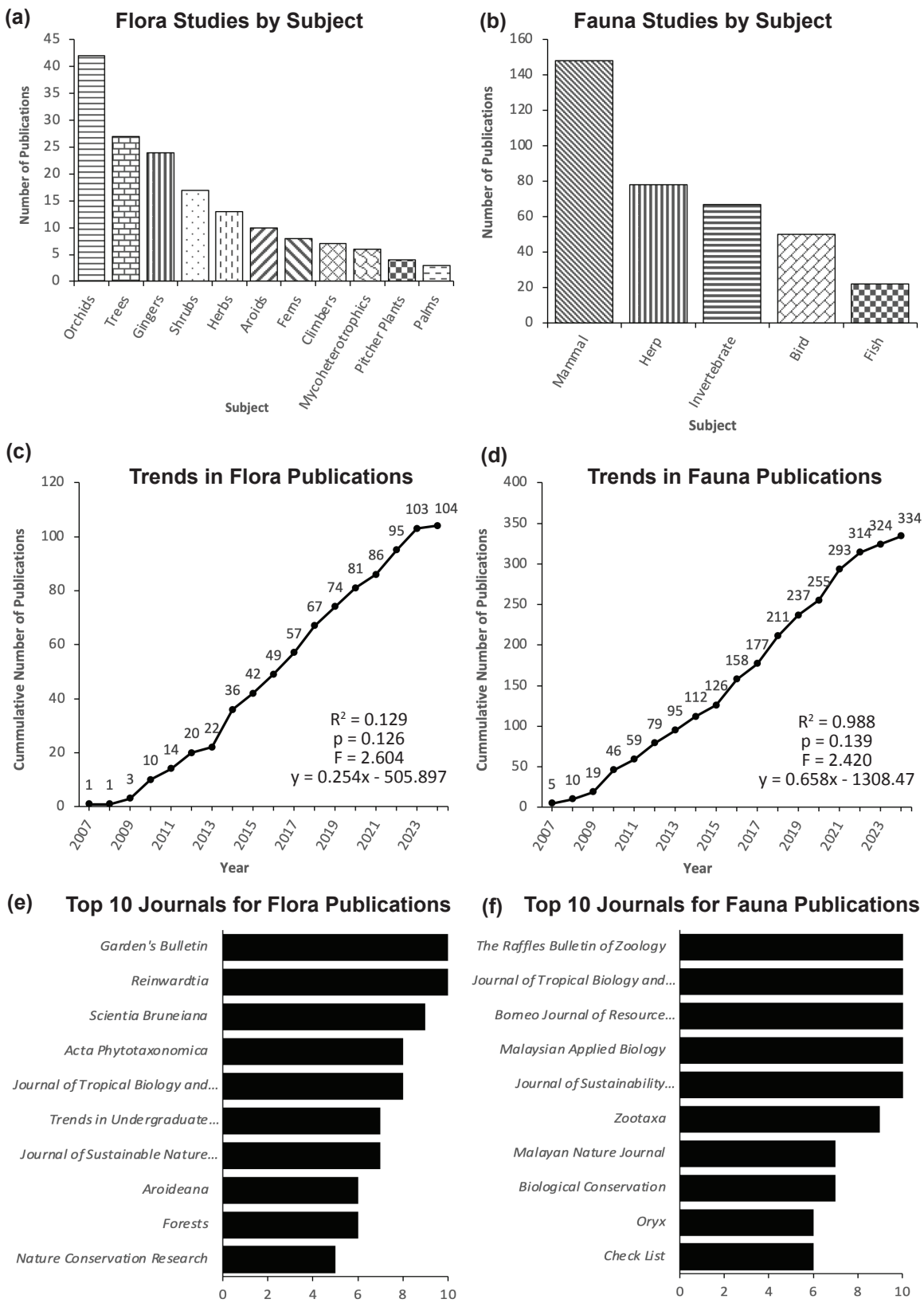


Figure 2. Distribution of flora and fauna research in HoB. Number of studies by subject/taxa categories for **(a)** flora, **(b)** fauna; annual trend in publications for **(c)** flora, **(d)** fauna; and, top 10 published journals for **(e)** flora, **(f)** fauna.

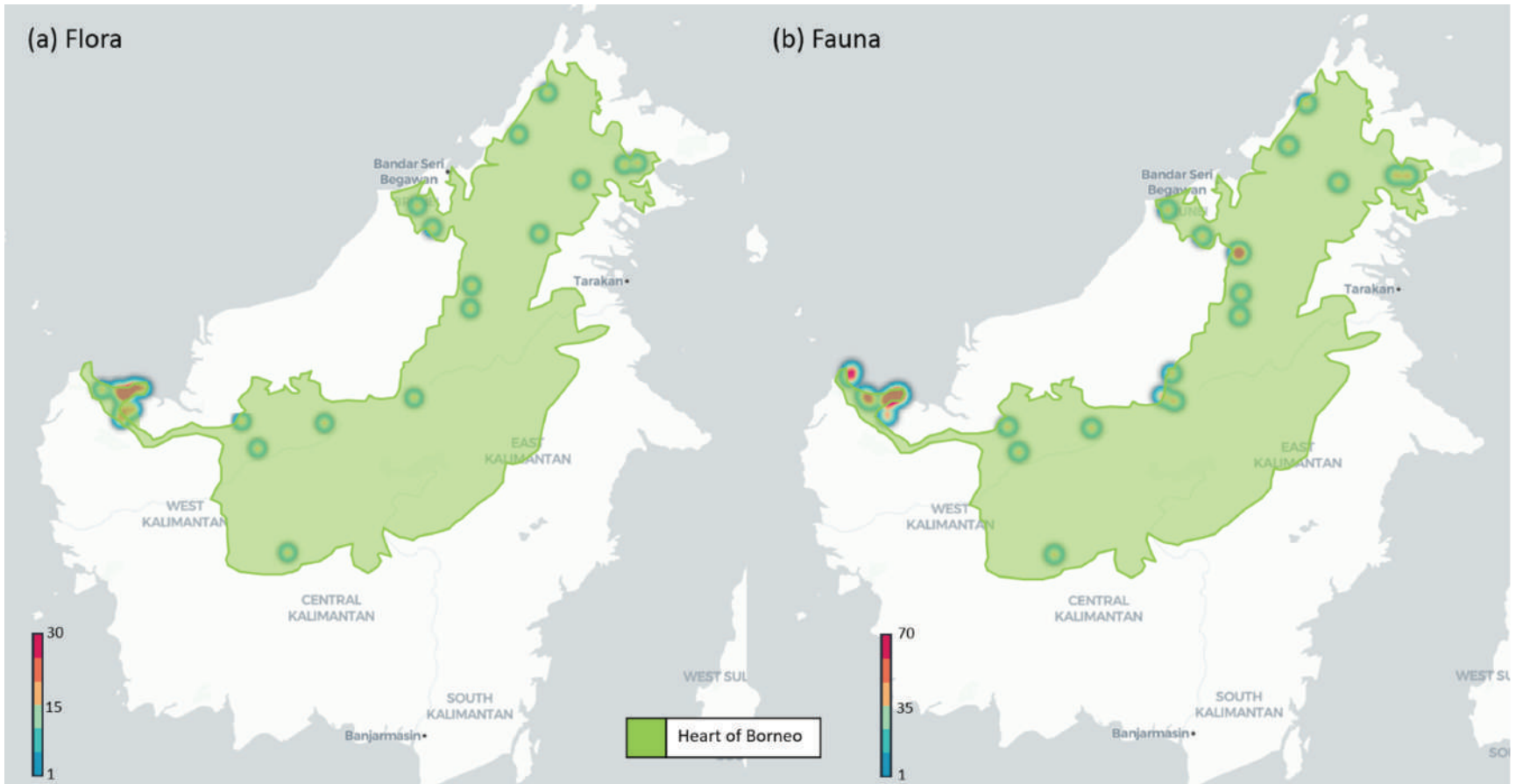


Figure 3. Research intensity heat maps for HoB of **(a)** flora and **(b)** fauna studies.

These findings indicate that the biodiversity research in HoB is largely driven by regional institutions and networks, with participation in international publication platforms still limited.

Studies of both plants and animals show that there are clear biases towards research areas in the HoB that are easy to access and well-known, such as Gunung Mulu, Kubah, and Pulong Tau National Parks (Figure 3). Much of the HoB's interior remains poorly documented scientifically. This geographic imbalance is caused by limited access and difficult logistics (Yang *et al.* 2019). Maps of research intensity (Figure 3) make these patterns even clearer and further highlight that biodiversity assessments covering the whole HoB would greatly contribute to management-relevant knowledge generation across the area.

Research in the HoB mainly consists of short-term and site-specific sampling. Over 17 years, 37 scientific expeditions were conducted across 47 forest reserves within Sabah's HoB area, generating biodiversity data that informed forest management plans and strengthened conservation efforts. Long-term monitoring with standardised survey designs is infrequent, limiting the detection of population trends, community turnover, and ecosystem responses to land-use and climate change. Several field facilities in the HoB do support long-term ecological research, including Danum Valley and Maliau Basin in Sabah, Kuala Belalong in Brunei, Lalut Birai in Kayan Mentarang, and the recently established Bako Research Station in Sarawak. But these facilities do not operate as a coordinated HoB-wide monitoring network. Linking research stations and other long-term study sites through common sampling protocols, shared data infrastructure and coordinated training would allow trends to be compared across jurisdictions, elevations, forest types and river basins. Such research should also incorporate interdisciplinary methodologies, and open-access data platforms that facilitate the comparison and analysis of results across taxa and regions.

Institutionally, funding patterns vary slightly between flora and fauna studies (Figure 4). For flora, the studies are supported mainly by national sources, showing strong domestic commitment to botanical work. In contrast, fauna studies show a near equal balance between local and international funding. This shows that both strong regional commitment and active global collaboration are taking place. Collaborations are further reflected in authorship patterns, with 49.4% (n = 254) of publications on the flora and fauna of the HoB involving co-authors from countries outside the island. The geographical distribution of all institutions (flora, n = 154; fauna, n = 71) and their publication output is illustrated in Figure 5. Together, these patterns highlight the importance of integrated local and international partnerships in biodiversity research and conservation in the HoB.

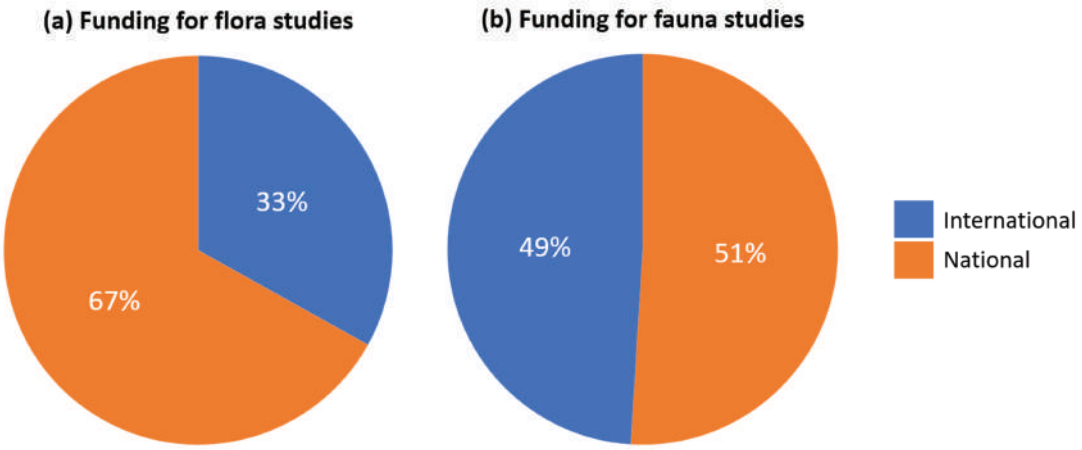


Figure 4. Scope of institutional funding for HoB research of **(a)** flora and **(b)** fauna.



Figure 5. Heatmap from geographical scope of the institutions that published flora and fauna studies on HoB from 2007 to 2024.

CHALLENGES WITHIN THE HEART OF BORNEO INITIATIVE

While the HoB faces emerging challenges, such as balancing conservation priorities with economic development, these present valuable opportunities to strengthen collaborative efforts, integrate sustainable resource management, and mobilise political and community support to safeguard the region's ecological integrity for the future. Indeed, Borneo shows the high rate of forest degradation and loss (Miettinen *et al.* 2011; Gaveau *et al*. 2016) and across much of the region, natural forests have been reduced to isolated fragments. Forest cover continues to decline, largely due to land conversion for agriculture, plantations, and infrastructure development (Gaveau *et al.* 2014). Between 2015 and 2019, there was a decrease of 2.8% in forest cover in Borneo, with lowland rainforest recording the highest loss of 2.8 million ha (WWF 2020). In the interior, logging activities intensified the construction of roads (Figure 6a), which led to further degradation of the forests.

Rural settlements (Figure 6b) form the social foundation of the HoB landscape, covering approximately 1.15% of the total HoB area (n = ~1300). Many local communities rely on forest resources for food and other needs, and many have created traditional systems of ownership that control who can use the resources and how (Wiersum 1997; Meijaard *et al.* 2013). Indigenous and local communities also play an essential role in sustaining biodiversity through traditional knowledge, customary land stewardship, and community-based conservation initiatives. Recognising and supporting these contributions is central to the long-term success of the HoB Initiative.

The hunting activities within the HoB appears under reported. Several publications reported hunting activities in these areas (Figure 6c). Local communities are generally permitted to hunt non-protected species for subsistence. Strengthening collaborative monitoring with communities can help integrate traditional knowledge with biodiversity management, supporting both sustainable livelihoods and conservation outcomes.

Within HoB, protected areas collectively cover approximately 35% of the landmass (Figure 6d), indicating that the size of protected areas remains limited relative to the region's biodiversity value. Although about 65% of the HoB remains unprotected and vulnerable to land-use change, its 35% protection exceeds global targets. The establishment of terrestrial protected areas in Sarawak appears progressing, currently covering close to 900,000 ha.

WAY FORWARD

The dynamic land-use changes within the HoB landscape strengthen the opportunity for Brunei Darussalam, Indonesia, and Malaysia to further strengthen coordinated and transboundary management. By enhancing forest connectivity, promoting sustainable land-use practices, and advancing ecological restoration, the HoB can continue to safeguard its ecological integrity. Strengthened governance and effective law enforcement, particularly in areas surrounding protected zones will support a resilient, well-connected landscape that sustains viable wildlife populations and delivers essential ecosystem services for generations to come.

A key strategy under the HoB framework involves strengthening ecological connectivity through the identification and protection of wildlife corridors linking existing protected areas and HCV areas. These efforts aim to reduce habitat fragmentation, enhance gene flow among wildlife populations, and improve ecosystem resilience (Coad *et al.* 2019). In Sarawak, the Batang Ai-Lanjak Entimau Wildlife Sanctuary, adjacent to Betung-Kerihun National Park in Kalimantan, is a good example of transboundary orang-utan conservation initiative that maintains ecological linkages and forest continuity for species movement.

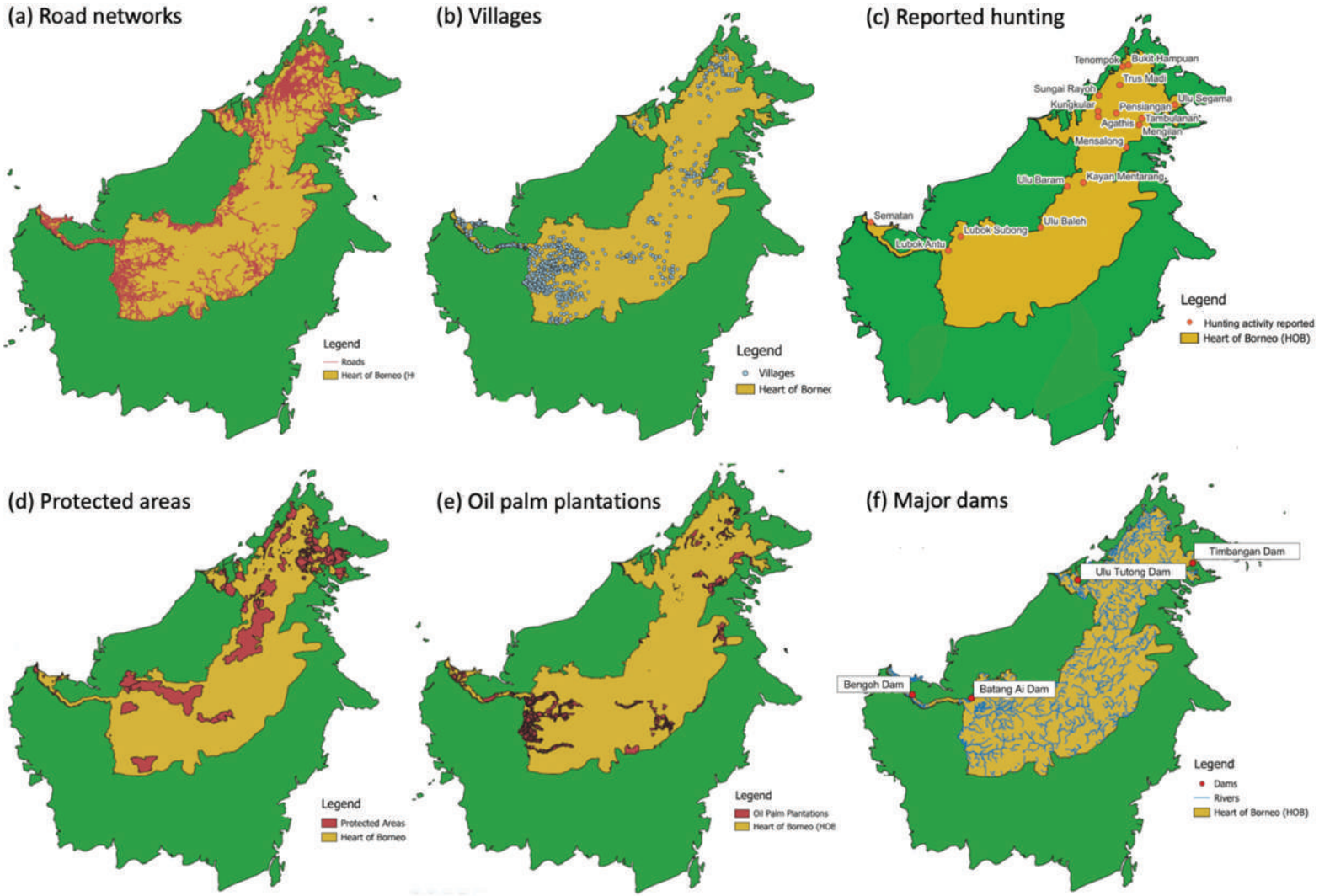


Figure 6. The land use in HoB area: **(a)** distribution of roads, **(b)** villages, **(c)** reported hunting activities, **(d)** protected areas, **(e)** distribution of oil palm areas, and **(f)** major dam projects across the HoB landscape.

Further north of this complex, Baleh National Park was gazetted after a successful expedition, indicating the role of the scientific community in extending this significant ecological connectivity. In Sabah, Ulu Segama-Malua, Northern Gunung Rara, and Maliau Basin forests are among the largest contiguous forests that serve as important wildlife corridors with HoB areas.

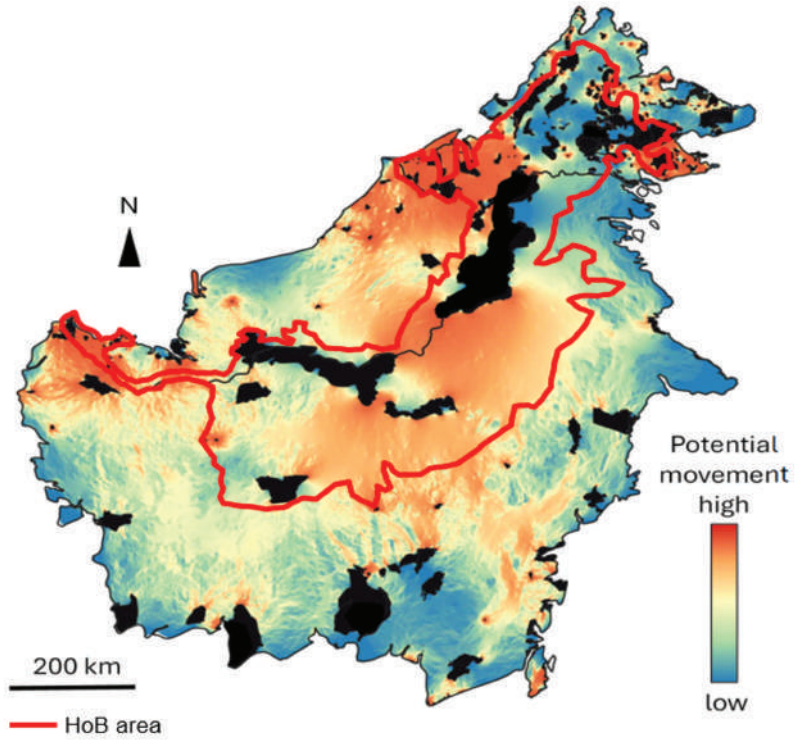


Figure 7. Landscape connectivity simulations performed using circuit theory algorithms (McRae *et al.* 2009). Landscape resistance was represented as the inverse of forest cover derived from spaceborne LiDAR measurements (Burns *et al.* 2025). The depicted potential movement values were log10-transformed (cf. Deith and Brodie 2020) and expressed without units.

Many of these national commitments are already reflected in SFM principles, implemented through various forestry frameworks and certification systems across Borneo. To build on these achievements, the HoB Initiative should continue to actively promote sustainable land-use practices through community-based forest management, HCV assessments, and credible certification schemes for both timber and palm oil. These mechanisms serve as an intervention measure to balancing conservation with economic development, especially in regions where communities depend heavily on forest resources (Azhar *et al.* 2017). The HCV approach is an effective tool for identifying not only key ecological and cultural values (Tuen *et al.* 2014), but for prescribing key management and conservation actions such as delineating conservation priority areas and reducing the uncontrolled extraction of natural resources (Areendran 2020).

Expanding OECMs within the HoB presents an opportunity to advance the 30×30 goal in a way that is inclusive, collaborative, and benefits both people and nature. OECM areas that benefit biodiversity even when conservation is not their primary objective can complement protected areas by safeguarding additional species, ecosystems, and ecosystem services, especially where formal protection is socioeconomically or politically unfeasible (Brodie *et al.* 2025b).

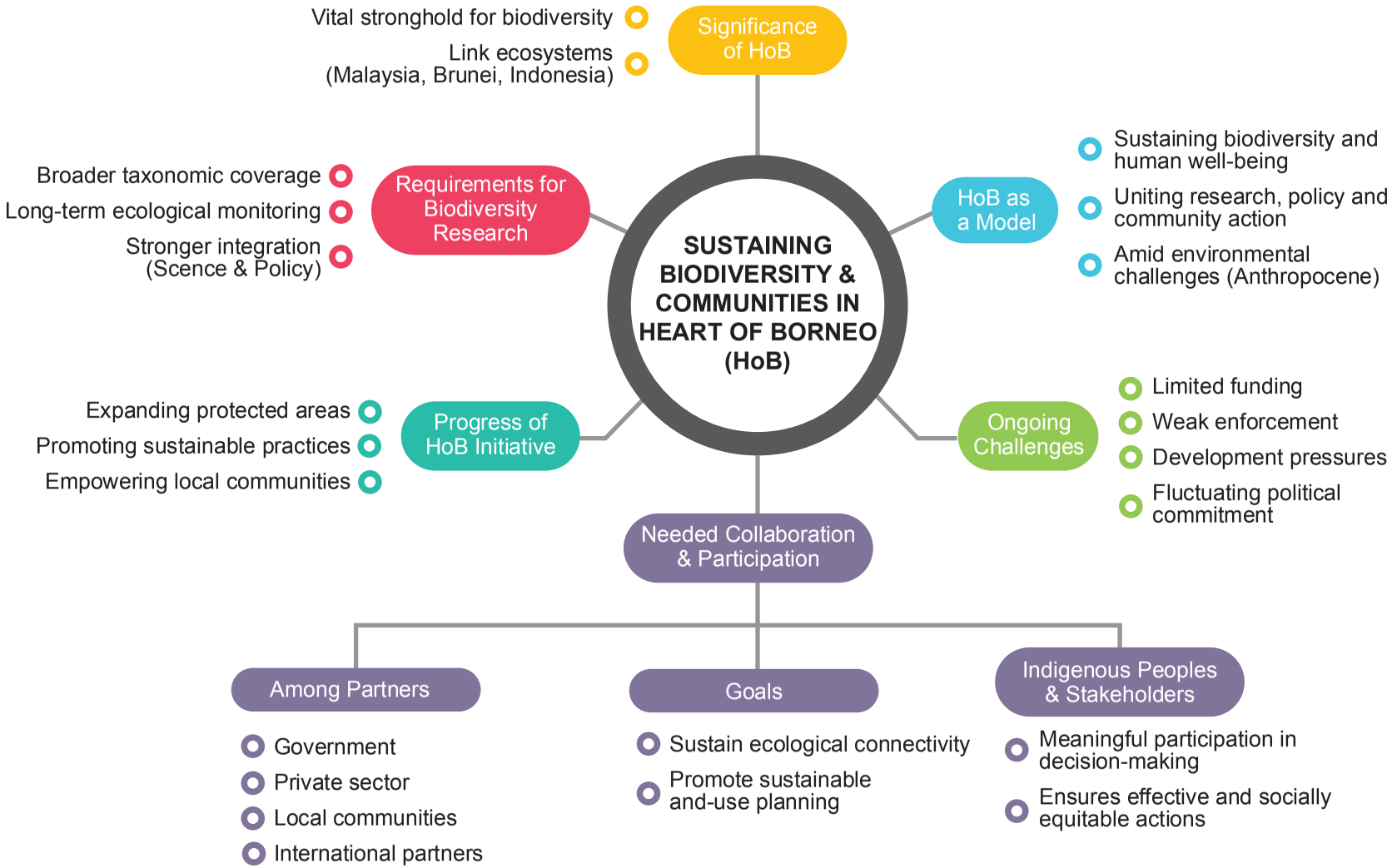


Figure 8. Summary of key elements needed to sustain biodiversity and community well-being in the Heart of Borneo (HoB), highlighting its ecological significance, research priorities, progress of current initiatives, stakeholder roles, collaboration needs, and ongoing conservation challenges.

The HoB represents a vital stronghold for biodiversity, linking ecosystems across Malaysia, Brunei, and Indonesia. Strengthening biodiversity research in this transboundary landscape requires broader taxonomic coverage, long-term standardised monitoring, and stronger integration between science and policy (Figure 8). Equally important is fostering collaborations among governments, the private sector, local communities, and international partners to sustain ecological connectivity and promote sustainable land-use planning. Meaningful participation of Indigenous Peoples and local stakeholders in decision-making can ensure that conservation actions are both effective and socially equitable. Collaboration among Malaysia, Indonesia, and Brunei has strengthened at different stages, most notably during the Brunei-hosted trilateral meeting in 2019. However, progress has been uneven in the past five years. Renewed commitment to joint monitoring, data sharing, and transboundary corridor planning could help to enhance the collective conservation efforts across the HoB landscape.

CONCLUSION

While the HoB Initiative has already made commendable progress in expanding protected areas, promoting sustainable practices, and empowering local communities, there remains ample opportunity to further strengthen its impact through enhanced funding, consistent enforcement, and sustained political support. With continued collaboration across research, policy, and community action, the HoB is well-positioned to become a global model for protecting biodiversity while uplifting human well-being. After 17 years, the HoB initiative has made steady and measurable progress toward its conservation goals. Protected area coverage has continued to expand, research collaboration has become more integrated, and transboundary partnerships have strengthened institutional capacity. Although challenges persist, they can be addressed through continued collaboration and collective commitment, strengthening the HoB role in supporting sustainable landscape management across the island.

REFERENCES

Alek, R.J. and Kader, W.A. 2021. We have not won yet, but we have not failed either – Forest Management Certification in Sarawak. In *Towards a Sustainable Forest Management for a Progressive Sarawak: Proceedings of Knowledge Sharing During Movement Control Order*, 20-24 April 2020, pp. 14–22. Kuching: Forest Department Sarawak.

Areendran, G., Sahana, M., Raj, K., Kumar, R., Sivadas, S., Kumar, A., Deb, S., and Gupta, V.D. 2020. A systematic review on high conservation value assessment (HCVs): challenges and framework for future research on conservation strategy. *Science Total Environment* 709: 135425. https://doi.org/10.1016/j.scitotenv.2019.135425

Azhar, B., Saadun, N., Prideaux, M., and Lindenmayer, D.B. 2017. The global palm oil sector must change to save biodiversity and improve food security in the tropics. *Journal of Environmental Management* 203: 457-466. https://doi.org/10.1016/j.jenvman.2017.08.021

Bennett, A.F. 2003. *Linkages in the landscape: The role of corridors and connectivity in wildlife conservation* (2nd ed.). Gland: IUCN.

Brodie, J.F., Deith, M.C.M., Burns, P., Goetz, S., Cunningham, C., Hill, J.K., Reynolds, G. and Mohd-Azlan, J. 2025a. The contribution of other effective area-based conservation measures (OECMs) to protecting global biodiversity. Nature Communications 16: 7886. https://doi.org/10.1038/s41467-025-63205-8

Brodie, J.F., Gonzalez, A., Mohd-Azlan, J., Nelson, C.R., Tabor, G., Vasudev, D., Zeller, K.A. and Fletcher Jr., R.J. 2025b. A well-connected Earth: The science and conservation of organismal movement. *Science* 388(6745): eadn2225. https://doi.org/10.1126/science.adn2225

Brodie, J.F., Giordano, A.J., Zipkin, E.F., Bernard, H., Mohd-Azlan, J. and Ambu, L. 2015. Correlates of mammal and bird declines in Bornean rainforests: logging, hunting, and forest edges. *Conservation Biology* 29(4): 1243–1253. https://doi.org/10.1111/cobi.12389

Brunei Climate Change Secretariat (BCCS). 2020. *Brunei Darussalam National Climate Change Policy (BNCCP)*. Brunei: Government of Brunei Darussalam. http://www.mod.gov.bn/Shared%20Documents/BCCS/Brunei%20National%20Climate%20Change%20Policy.pdf

Burns, P., Kaszta, Z., Cushman, S.A., Brodie, J.F., Hakkenberg, C.R., Jantz, P., Deith, M. *et al.* 2025. The utility of dynamic forest structure from GEDI lidar fusion in tropical mammal species distribution models. *Frontiers in Remote Sensing* 6: 1563430. https://doi.org/10.3389/frsen.2025.1563430

Clements, G.R., Lynam, A.J., Gaveau, D.L.A., Yap, W.L., Lhota, S., Goosem, M., Laurance, W.F. and Aziz, S.A. 2014. Where and how are roads endangering mammals in Southeast Asia's forests? *PLoS ONE* 9(12): e115376. https://doi.org/10.1371/journal.pone.0115376

Coad, L., Watson, J.E., Geldmann, J., Burgess, N.D., Leverington, F., Hockings, M., Knights, K. and Di Marco, M. 2019. Widespread shortfalls in protected area resourcing undermine efforts to conserve biodiversity. *Frontiers in Ecology and the Environment* 17(5): 259–264. https://doi.org/10.1002/fee.2042

Firdaus, R., Wibowo, P.M. and Rochmayanto, Y. 2018. Developing strategies for landscape sustainability: an Indonesian national strategic plan of action in the heart of Borneo. In *Landscape Ecology for Sustainable Society*, pp. 67–84. Cham: Springer International Publishing.

Deith, M.C., and Brodie, J.F. 2020. Predicting defaunation: Accurately mapping bushmeat hunting pressure over large areas. *Proceedings of the Royal Society B* 287: 20192677. https://doi.org/10.1098/rspb.2019.2677

Gaveau, D.L.A., Sheil, D., Husnayaen, Salim, M.A., Arjasakusuma, S., Ancrenaz, M., Pacheco, P., and Meijaard, E. 2016. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Scientific Reports* 6: 32017. https://doi.org/10.1038/srep32017

Gaveau, D.L.A., Sloan, S., Molidena, E., Yaen, H., Sheil, D., Abram, N. K., Ancrenaz, M. *et al.* 2014. Four decades of forest persistence, clearance and logging on Borneo. *PLoS ONE* 9(7): e101654. https://doi.org/10.1371/journal.pone.0101654

Kamal, A.H.M., Sinden, A., Idris, M.H., Hamli, H., Musa, N., Piah, R.M., Wahid, R.A.L. and Shahabuddin, A. 2022. Diversity of fisheries in Sarawak, Northwest Borneo: Present status and conservation issues. *Borneo Journal of Resource Science and Technology* 12(1): 32–51. https://doi.org/10.33736/bjrst.4651.2022

Keong, C.Y., and Onuma, A. 2021. Transboundary ecological conservation, environmental value, and environmental sustainability: lessons from the Heart of Borneo. *Sustainability* 13(17): 9727. https://doi.org/10.3390/su13179727

McRae, B.H., Shah, V.B., and Mohapatra, T. 2009. Circuitscape user's guide. Santa Barbara: University of California, Santa Barbara. http://www.circuitscape.org.

Meijaard, E., Abram, N.K., Wells, J.A., Pellier, A.S., Ancrenaz, M., Gaveau, D.L., Runting, R.K. and Mengersen, K. 2013. People's perceptions about the importance of forests on Borneo. *PloS ONE* 8(9): e73008. https://doi.org/10.1371/journal.pone.0073008

Miettinen, J., Shi, C. and Liew, S. C. 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. *Global Change Biology* 17(7): 2261–2270. https://doi.org/10.1111/j.1365-2486.2011.02398.x

Ministry of Environment and Forestry (MoEF) Indonesia. 2019. Sixth National Report for the Convention on Biological Diversity. Montreal: Convention on Biological Diversity. https://asean.chm-cbd.net/sites/acb/files/2020-04/6NR_IDN.pdf

Ministry of Environment and Forestry (MoEF). 2021. Indonesia Forestry and Other Land Use (FOLU) Net Sink 2030. Jakarta: Ministry of Environment and Forestry, Indonesia. https://planologi.kehutanan.go.id/assets/img/publication/BUKU_RENOPS_FOLU_NETSINK_2030_(English).pdf

Ng, W.S., Mohd-Azlan, J. and Wong, S.Y. 2020. Floral biology and pollination strategy of *Durio* (Malvaceae) in Sarawak, Malaysian Borneo. *Biodiversitas Journal of Biological Diversity* 21(12): 5687–5697. https://doi.org/10.13057/biodiv/d211203

Nursyamin, Z., Yahya, M.S., Atikah, S.N., Tohiran, K.A., Norhisham, A.R., Othman, N.W., Lechner, A.M. and Azhar, B. 2023. Identifying indicator bird species for sustainable oil palm plantation certification. *Journal of Cleaner Production* 415: 137852. https://doi.org/10.1016/j.jclepro.2023.137852

Struebig, M.J., Wilting, A., Gaveau, D.L.A., Meijaard, E. and Smith, R.J. 2015. Targeted conservation to safeguard a biodiversity hotspot from climate and land-cover change. *Current Biology* 25: 372–378. https://doi.org/10.1016/j.cub.2014.11.067

Struebig, M.J., Wenzler, M., Runting, R.K., Law, E., Budiharta, S., Seaman, D. and Kramer-Schadt, S. 2024. Connectivity conservation to mitigate climate and land-cover change impacts on Borneo. *Biological Conservation* 299: 110838. https://doi.org/10.1016/j.biocon.2024.110838

Tuen, A.A., Sayok, A., Das, I., Noweg, G., Laman, C. and Met, L. 2014. Applying the HCVF toolkit to assess the conservation value of Gunung Singai, Sarawak, East Malaysia. In *Sustaining Livelihood through Prudent Utilization and Management of Natural Resources*, pp. 52–62. Kota Samarahan: IBEC, UNIMAS.

Wiersum, K.F. 1997. Indigenous exploitation and management of tropical forest resources: an evolutionary continuum in forest-people interactions. *Agriculture, Ecosystems & Environment* 63(1): 1-16. https://doi.org/10.1016/S0167-8809(96)01124-3

Witteveen+Bos. 2011. *Quick scan watershed services: Heart of Borneo* (Report No. INA598-1-P/sumt2/006). Indonesia: WWF Indonesia, WWF Heart of Borneo Initiative.

WWF. 2017a. Visit the Heart of Borneo. *WWF-Indonesia*. http://www.wwf.id/en/blog/visit-heart-borneo

WWF. 2017b. HoB Week kicks off with Expert Dialogue in Celebration of the 10th Anniversary of the Heart of Borneo Initiative. *WWF-Indonesia and WWF-Malaysia*. https://wwf.panda.org/es/?314972/HoB-Week-kicks-off-with-Expert-Dialogue-in-Celebration-of-the-10th-Anniversary-of-the-Heart-of-Borneo-Initiative

WWF. 2020. Environmental Status of Borneo 2020: Balancing the Needs of People and Nature. WWF-Indonesia and WWF-Malaysia.

Yang, Y., Ren, G., Li, W., Huang, Z., Lin, A.K., Garber, P.A., Ma, C. *et al.* 2019. Identifying transboundary conservation priorities in a biodiversity hotspot of China and Myanmar: Implications for data poor mountainous regions. *Global Ecology and Conservation* 20: e00732. https://doi.org/10.1016/j.gecco.2019.e00732


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 717–727
doi: 10.62613/sonc2025.v3anc04

CHAPTER 4

Connectivity Science: Coral Triangle Initiative

CHOO POH LEEM*

Abstract: Malaysia lies within the Coral Triangle—the global center of marine life. Its waters are rich in coral reefs, fish, and other resources that provide food and jobs for many Malaysians. However, marine life and threats cross national borders and no single country can protect these assets alone. This is why Malaysia co-founded the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) with five other nations. Through this partnership, the nations plan and share responsibility for their shared ocean. As a founding member, Malaysia gains support, funding opportunities, and a stronger voice in regional ocean management. Malaysia also leads by example at home. Tun Mustapha Park in Sabah is the country's largest marine park, co-managed with local communities to restore fisheries and reefs. Sugud Islands Marine Conservation Area (SIMCA) is the first privately run marine reserve in Malaysia and has successfully protected turtle nesting beaches. On Omadal Island in Semporna, a local women's group patrols beaches to guard turtle nests and fund conservation by selling handicrafts. These efforts show how teamwork from the ground up delivers results. The best proof of collaboration is the green turtle's comeback. In 2024, this species moved from Endangered to Least Concern on the global list after years of joint protection across the region. Green turtles nest in Malaysia but feed in other countries, so only teamwork could save them. This success shows that when nations work together, nature recovers.

INTRODUCTION

Many Malaysians who grow up inland often view the ocean as distant, or as a place for family vacations. The truth is the ocean is much closer to us than we realise: it dictates our climate, regulates our weather and is responsible for over half of the oxygen we breathe (Hoegh-Guldberg *et al*. 2023). As Sylvia Earle, the celebrated marine biologist once said, "*Every drop of water you drink, every breath you take—that's how you are joined to the sea*" (DeLoughrey 2019). This connection is not merely symbolic; it is fundamental to our everyday lives and wellbeing.

The waters of Malaysia are a part of the Coral Triangle, a unique underwater world that spans six countries: Malaysia, Indonesia, the Philippines, Timor-Leste, Papua New Guinea and the Solomon Islands (Hoegh-Guldberg *et al.* 2009). Renowned as the "Amazon of the Sea," this area boasts 76% of all known coral species and supports the highest diversity of reef fishes worldwide (Hoegh-Guldberg *et al.* 2009). Coral reefs are more than just majestic landscapes, they are living systems that absorb carbon, protect coastlines, shelter marine life, and sustain fisheries that feed millions.

The ocean is not confined by political boundaries and jurisdictions; rather, it extends across national borders and forms part of a wider marine network (Treml and Halpin 2012). Fish, turtles, sharks—even marine debris—travel freely across national waters. The coral reefs, mangroves, and seagrass beds function as complementary habitats that nurture the diverse marine species throughout their different life stages, and enable crucial ecological processes such as larval dispersal, species migrations, and ocean currents (Mao *et al.* 2026).

WWF-Malaysia, Jln PJS 5/28 A, Pusat Dagangan Petaling Jaya Selatan, 46150 Petaling Jaya, Selangor, Malaysia.
***Corresponding author: plchoo@wwf.org.my**

The Coral Triangle represents a shared ecological, economic, and social landscape that links the countries within the region through common marine resources and ecosystems (Beger *et al*. 2015). This calls for a transition from isolated national conservation efforts towards integrated, multilateral initiatives that recognise the region's significance as an essential climate refuge (Fidelman *et al*. 2011). This requires governance approaches that extend beyond conventional maritime jurisdictions and account for ecological processes, including species movements across national boundaries (Telesetsky 2018).

Existing transboundary governance frameworks such as the Sulu-Sulawesi Marine Ecoregion Project allow ecological connectivity to be embraced through harmonising management strategies for migratory marine species across Indonesian, Malaysian, and Philippine borders (WWF-SSME 2004; Araújo *et al*. 2019). The Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF), established in 2009 with Malaysia as one of its founding members, was a landmark multilateral partnership aimed towards addressing systemic threats and sustainable resource management at this biodiversity hotspot (Foale *et al.* 2012).

WHY THE CORAL TRIANGLE IS IMPORTANT: CONNECTIVITY SCIENCE

Stretching across Malaysia, Indonesia, the Philippines, Timor-Leste, Papua New Guinea, and the Solomon Islands, Coral Triangle is recognised as the epicenter of marine biodiversity (Foale *et al*. 2012). Its ecological richness extends beyond its remarkable species diversity; it functions as an interconnected web, where the movement of larvae and adults sustain the ecological life along the vast transboundary marine corridors (Treml and Halpin 2012).

The green turtle (*Chelonia mydas*) is a classic example. Satellite tracking showed that these ancient mariners forage at transboundary feeding grounds, shared between Indonesia and the Philippines (Merwe *et al.* 2009; Chomchat *et al.* 2024). Genetic evidence has linked these turtles to nesting sites in Sabah (Joseph *et al.* 2023), thus emphasising the need for cross-border conservation efforts. Although individual countries may implement measures to protect nesting beaches and feeding grounds within their jurisdiction, the turtle populations remains at risk if critical habitats elsewhere along the turtles' migratory routes remain unprotected. Transboundary movements of this nature highlight the importance of a regional management approach that extends beyond individual national responsibility in maintaining the ecological integrity of the Coral Triangle marine corridors (Beger *et al.* 2015).

Green turtles are not the only species whose movements transcend national boundaries. Sharks, rays, and other endangered, threatened and protected species also travel the Borneo-Sulu-Celebes seascape, using habitats from ocean trenches to shallow coral reefs, across multiple national jurisdictions (Araújo *et al.* 2019). However, critical habitats for sharks and rays in Asia remain largely unprotected (González-Pestana *et al.* 2026).

Even microscopic and drifting coral larvae can travel far. Currents carry these coral larvae across the Indo-West Pacific, allowing them to settle and repopulate reefs miles away from their origin (Pata and Yñiguez 2019). Consequently, spawning events in one area may contribute to the reef recovery in another area (Treml and Halpin 2012). Consequently, the recovery of degraded coral reefs in Malaysian waters may depend, in part, on larval supply from reefs located hundreds of kilometres away, including those beyond our national jurisdictions (Schill *et al.* 2015).

Reefs in the Coral Triangle also act as important carbon sinks and storm buffers (Beck *et al.* 2018). They support the livelihood of more than 120 million people through fisheries, tourism, and other coastal activities (Green *et al.* 2011). Coral reefs closely interact with neighbouring habitats such as seagrass meadows and mangrove forests. These habitats function complementarily as nurseries and feeding grounds to various marine species. Disruptions to one ecosystem can caues ecological consequences to another ecosystem and triggers a ripple effect through national borders.

The movement of marine debris presents another dimension of this regional challenge. It is estimated that 80% of marine debris originated in land-based human activity (Cordova and Nurhati 2019), with plastic bottles, discarded fishing gears, and microplastics accumulating across the shared marine environments (Puspita *et al.* 2026). As marine debris can drift across national waters, pollution originating from one location may threaten marine species and their ecosystems elsewhere. In Malaysia, marine entanglement and ingestion of plastics have been observed in sea turtles and other marine fauna (Tan *et al.* 2022). This is a transboundary issue for international matters, not only in the local context (Puspita et al. 2026). Hence, maintaining the regional integrity of such seascapes requires coordinated management that extends beyond political boundaries, such as the establishment of marine protected area networks (Weeks *et al*. 2014), to protect the migratory pathways and larval exchange, both of which are critical for ecological resilience (Fidelman *et al.* 2011).

CTI-CFF IN THE PAST AND PRESENT

Malaysia's involvement in regional efforts to protect the Coral Triangle began well before the formal establishment of the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTS-CFF). In 2001, Malaysia joined the planning process of the Sulu-Sulawesi Marine Ecoregion (SSME; WWF 2004), working alongside Indonesia and the Philippines on a shared vision to conserve marine ecosystems across the region (WWF-SSME 2004; Fidelman *et al*. 2011). This early collaboration laid the foundation for subsequent multilateral conservation efforts.

In May 2009, the CTI-CFF was formally launched at the Leaders' Summit held at the Manado, Indonesia (Asaad *et al.* 2019). At this historic moment, representatives from Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste, signed the CTI Leaders' Declaration, founding the Coral Triangle Initiative. The declaration rightfully recognises that the transboundary nature of seascape conservation requires the cooperation and stewardship of the CTI countries.

The CTI-CFF's initial Regional Plan of Action (RPOA) had focused on ecosystem -based fisheries, community resilience, and recovery in threatened species. Since then, the six member nations have expanded this scope to include the systematic designation of priority seascapes and the establishment of robust, region-wide marine protected area networks (Asaad *et al.* 2019).

Today, the adoption of the RPOA 2 (2021–2030) marks a new era. It is shifting the paradigm from just biodiversity to climate resilience and sustainable finance, food security and recovery of threatened species. These priorities aligned with the broader international conservation commitments, including the global ambition to protect 30% of land and sea by 2030 (30×30) and commitments related to blue carbon. It emphasises resilient MPA networks, food security and threatened species recovery, under a connectivity framework.

MALAYSIA IN THE CORAL TRIANGLE INITIATIVE

Since the establishment of CTI-CFF, Malaysia has translated and implemented the Regional and National Plan of Actions domestically, whilst adhering to the principles of science-based participatory conservation, decisions made in consensus, alignment with international conventions and practices. The following examples illustrate how the regional objectives of CTI-CFF is being implemented locally in Sabah.

Tun Mustapha Park (TMP), Sabah

As Malaysia's largest multi-use marine protected area (MPA), TMP demonstrates how connecting ecosystems and managing them with local communities reduces destructive fishing, turtle poaching and helps reefs recover (Justine 2025). Its establishment was a 15-year journey of negotiation, community dialogue, and trust-building, beginning in 2003 and culminating in full gazettement in 2016 (Jumin *et al*. 2017). Through a zoning and co-management system, TMP is where fishing, tourism, and conservation all complement each other, allowing local communities to maintain their livelihoods while safeguarding the area's ecological functions (Teh *et al.* 2013). Today, TMP serves as a model where its various stakeholders collaborate equitably towards a shared vision—a large-scale MPA in Malaysia.

Sugud Islands Marine Conservation Area (SIMCA), Sabah

Established as the first private marine conservation area in Malaysia (Teh *et al.* 2007), SIMCA is also the first marine IUCN Green List site in Asia. This awards the country's first degree of legally protected, environmentally and operationally sustainable nature conservation in Malaysia. This certification recognises that SIMCA meets the world's highest standards of conservation effectiveness and governance. Through strict control of fishing activities, continuous protection of turtle nesting beaches, and sustained patrolling against illegal extraction, SIMCA demonstrates how sustained management and enforcement can contribute to actual biodiversity recovery (Chung 2026).

A recent study by Chung *et al*. (2026) reported a Coral Reef Fish Diversity Index (CFDI) of 647 species, including 36 species listed on the IUCN Red List. Of these. four are Critically Endangered elasmobranch species. The study also reported the first record of *Rhina ancylostoma* (Bowmouth Guitarfish) in SIMCA.

Community empowerment in Omadal Island, Semporna, Sabah

Wanita Pulau Omadal (WAPO)-Omadal Women in Conservation (Figure 1) conducted daily beach patrols that protect nesting sea turtles and document landings. Alongside conservation activities, they also produce weaved handmade items like bags and accessories using *Pandanus* and other locally-available natural materials (Figure 2), which attracted recognition beyond their local community. The income from these products helps sustain their conservation initiatives such as purchasing fuel for patrol vessels, allowance for patrollers and support community awareness (Musa 2026).

The importance of alternative and sustainable livelihoods in conservation initiatives cannot be understated, where local participants must be able to sustain themselves while being stewards of the environment, ensuring the long-term sustainability and success of conservation initiatives. The WAPO's story shows how community-led marine management can support community livelihoods while actively contributing to environmental stewardship.



Figure 1. A cultural *igal-igal* dance performance by Wanita Pulau Omadal (WAPO). Photo by WWF-Malaysia.



Figure 2. Weaved handicrafts made by WAPO. Photo by WWF-Malaysia.

CHALLENGES AND OPPORTUNITIES

Despite significant achievements, Malaysia still faces persistent challenges in conserving its marine ecosystems (Praveena *et al.* 2012). Fragmented marine governance, shortage of long-term financing, and enforcement gaps can undermine implementation (Ong 2020; Suherman *et al.* 2020). Many conservation efforts last only a year or two. While these short-term projects please donors, they often fail to deliver sustainable results for the local communities (Booth *et al*. 2022). Without long-term investment, efforts such as turtle monitoring, reef rehabilitation and community patrols remain difficult to scale or sustain.

This is where regional planning under the CTI-CFF becomes vital. It helps shift Malaysia from isolated, short-term projects toward long-term strategies, steady funding, and closer cooperation with neighbors (Foale *et al*. 2012). This is especially true for threats like illegal fishing, wildlife trafficking, and destructive practices as these issues span borders and require coordinated regional action (Widjaja *et al.* 2023).

Marine debris is another clear example of a shared environmental problem (Zambrano 2026). Plastic waste, ghost nets and other debris move across borders and continue to threaten biodiversity, fisheries and marine wildlife, including turtles, sharks, rays and marine mammals (Kühn *et al.* 2015). Transboundary environmental issues cannot be addressed in isolation by individual nations alone (Kamaruddin *et al.* 2022; Omeyer *et al.* 2022). Instead, through CTI-CFF, Malaysia can work with neighbours to align waste policies, track plastic sources, and move toward a circular economy.

Sustainable financing is another critical gap, but also an important opportunity to strengthen regional cooperation. Through the CTI-CFF and its regional partnerships, Malaysia has a unique opportunity to explore joint financial arrangements that bring together multilateral donors and regional counterparts. These multilateral funding sources such as the Green Climate Fund, the Global Environment Facility (GEF), SOMACORE and SEACONNECT may be utilised to support and expand future CTI-CFF initiatives. These mechanisms could help mobilise resources for cross-border initiatives, such as restoring ecosystems, managing coral reefs, and helping coastal communities adapt to climate change. Such collaborative financing arrangement would not only benefit Malaysia but also support shared solutions across borders. Such proposals can encourage blue carbon, coral restoration, coastal resilience, sustainable fisheries, and community-based adaptation, and allow for transitioning from short project cycles to long-term investments (Victurine *et al.* 2022).

Climate change challenges extend beyond mere lack of data. Even where data are available, they are often scattered across institutions, not fully accessible to the public, and not always translated into policy planning (Ooi *et al*. 2025). When ocean monitoring, biodiversity data, and climate vulnerability assessments are not available in a shared database, decision-makers are unable to use them to proactively address climate change issues. In this regard, the CTI-CFF provides an opportunity to improve regional knowledge sharing through tools such as the Coral Triangle Atlas (CT Atlas), while supporting marine spatial planning and better use of data for conservation, fisheries and climate adaptation (Cros *et al.* 2014). Data on MPAs, OECMs, coral reefs, seagrass, mangroves, threatened species, marine debris and climate vulnerability can be better integrated and made easier to use for planning. This would also contribute to a more robust evidence base for marine spatial planning, helping Malaysia decide exactly where to prioritise protection, restoration, and fisheries management (Wan Talaat *et al.* 2020).

Marine spatial planning enables the authorities to manage, conserve, and sustainably utilise the marine environment and the resources contained therein, *inter alia* fishery zones, protected areas, oil and gas development blocks, and community conserved areas (Wan Talaat *et al.* 2020; Lua and Aziz 2025). Through better spatial planning, Malaysia can then identify where protection, restoration, fisheries management and community use should take place (Jumin *et al*. 2017). This approach also provides an opportunity to establish an integrated network connecting marine protected areas (MPAs), other effective area-based conservation measures (OECMs), and locally managed marine areas, especially in Sabah. Peer learning can help MPAs move from designated but ineffective 'paper park' to an effectively-managed protected area. Under CTI-CFF, a regional MPA managers' network was established in May 2026, during the MPA Technical working group meeting in Kota Kinabalu (*pers. obs*.). This network enables practitioners to share insights with counterparts across the Coral Triangle on key management aspects from zoning and reef monitoring to financing and community engagement.

The various successful CTI-CFF initiatives in Malaysia should be highlighted in regional peer-to-peer sharing conferences and workshops, where CTI-CFF members can learn from and build on each other's successes. Examples such as the women-led turtle patrols in Omadal and the co-managed governance of Tun Mustapha Park show that conservation can be made more effective and sustainable when communities are part of the solution and long-term conservation achievement. Malaysia is also the first country to use climate adaptation tools such as the Local Early Action Planning (Christensen 2013) to bolster the resilience of vulnerable island communities in Mabul, Semporna (Semporna District Office 2024). By amplifying such experiences though regional platforms, combined with the strategic integration of such inclusive approaches into the current strategies, Malaysia has an opportunity to help chart the way forward for CTI-CFF, working collectively with our regional neighbours.

POLICY RECOMMENDATIONS

To build on the opportunities under the CTI-CFF, Malaysia can strengthen regional conservation planning and ensure closer alignment to national marine priorities. Conservation efforts should not depend only on short-term projects. Malaysia would benefit from the CTI-CFF's support for long-term seascape strategies, especially in Sabah (where marine protected areas, prospective OECMs, locally managed marine areas and community conservation sites are ecologically connected) (Lubchenco *et al*. 2023). Scaling these efforts would not only contribute to regional targets, but also accelerate Malaysia's progress towards the global 30×30 goal (Henneker *et al.* 2026). The CTI-CFF's framework provides guidance on scaling existing MPAs into more ecologically-linked networks to enhance resilience and meet international benchmarks (Walton *et al.* 2014).

To achieve this, Malaysia requires a stronger National Ocean Policy to provide strategic direction and improve coordination between federal and state authorities. Such policy would establish a more coherent framework, integrating sectoral priorities from fisheries and tourism to climate adaptation, under one clear plan (Hills *et al.* 2021). Harmonising cross-sectoral mandates can help countries better integrate national strategies with broader regional objectives established under the initiative (Putri *et al*. 2025).

Regional cooperation must also be strengthened to stop illegal fishing, destructive practices, and wildlife trafficking (Jiao *et al*. 2021) across the national borders (Witbooi *et al.* 2020). Through CTI-CFF, Malaysia can collaborate with neighbouring nations to improve information sharing, joint surveillance, enforcement coordination and response mechanisms for shared seascapes such as the Sulu-Sulawesi Seascape (Ellett 2021).

CONCLUSION

The Coral Triangle Initiative offers significant benefits for Malaysia. It gives credence to the marine parks and OECM sites, reinforces Malaysia's responsibility as a maritime nation to contribute to the conservation of shared marine species like turtles and sharks, provides access to international financing opportunities, and gives Malaysia a stronger voice in global ocean governance. The green turtle reminds us why this regional cooperation matters. Although green turtles nest in Malaysia, they also forage and migrate across waters shared with neighbouring countries. While Malaysia can protect our nesting beaches, the long-term recovery of the turtle population depends on effective management of their feeding grounds, migration routes, and fisheries interactions across their wider range. In 2024, some green turtle subpopulations were downlisted to Least Concern on the IUCN Red List, where interventions such as international cooperation, establishment of marine protected areas, and participatory conservation collectively contributed to the rebound of the green turtle. This case study exemplifies the multifaceted conservation initiatives combined with regional efforts, which alleviate existing anthropogenic pressures and allow marine ecosystems to recover. As Malaysia moves toward its 2030 aims, the path forward is clear: the ocean's future extends far beyond Malaysia's shores. Our prosperity depends on healthy reefs, safe migration corridors, sustainable fisheries, strong communities, and regional trust. Recognising these ecological and socio-economic interconnections, CTI-CFF gives us the platform to act on that science. Malaysia's success will depend on continued leadership, long-term collaboration, and our shared commitment to protect the sea that connects us all.

REFERENCES

Agamuthu, P., Mehran, S.B., Norkhairah, A. and Norkhairiyah, A. 2019. Marine debris: A review of impacts and global initiatives. *Waste Management & Research The Journal for a Sustainable Circular Economy* 37(10): 987–1002. https://doi.org/10.1177/0734242x19845041

Araújo, G., Agustines, A., Tracey, B., Snow, S., Labaja, J. and Ponzo, A. 2019. Photo-ID and telemetry highlight a global whale shark hotspot in Palawan, Philippines. *Scientific Reports* 9(1): 17209–17209. https://doi.org/10.1038/s41598-019-53718-w

Asaad, I., Lundquist, C.J., Erdmann, M.V. and Costello, M.J. 2019. An interactive atlas for marine biodiversity conservation in the Coral Triangle. *Earth System Science Data* 11(1): 163–174. https://doi.org/10.5194/essd-11-163-2019

Beck, M.W., Losada, Í.J., Menéndez, P., Reguero, B.G., Díaz-Simal, P. and Fernández, F. 2018. The global flood protection savings provided by coral reefs. *Nature Communications* 9(1): 2186–2186. https://doi.org/10.1038/s41467-018-04568-z

Beger, M., McGowan, J., Treml, E.A., Green, A.L., White, A.T., Wolff, N.H., Klein, C.J., Mumby, P.J. and Possingham, H.P. 2015. Integrating regional conservation priorities for multiple objectives into national policy. *Nature Communications* 6(1): 8208. https://doi.org/10.1038/ncomms9208

Booth, H., Ramdlan, M.S., Hafizh, A., Wongsopatty, K., Mourato, S., Pienkowski, T., Adrinato, L. and Milner-Gulland, E.J. 2022. Designing locally-appropriate conservation incentives for small-scale fishers. *London School of Economics and Political Science Research Online (London School of Economics and Political Science)* 277: 109821–109821. https://doi.org/10.1016/j.biocon.2022.109821

Chomchat, P., Klinsawat, W., Sirinarumitr, K., Inthong, N. and Sirinarumitr, T. 2024. Genetic structure and diversity of green turtle (*Chelonia mydas*) in the Gulf of Thailand. *Veterinary World* 17(1): 37–49. https://doi.org/10.14202/vetworld.2024.37-49

Christensen, J.D. 2013. *Climate change adaptation for Coral Triangle communities: a guide for vulnerability assessment and Local Early Action Planning (LEAP guide).*Washington, D.C.: United States Agency for International Development (USAID).

Chung, F.C. 2026, June 19. Effective Enforcement Strategy in the Sugud Islands Marine Conservation Area. *PANORAMA*. https://panorama.solutions/en/solution/effective-enforcement
-strategy-sugud-islands-marine-conservation-area
Chung, F.C., Sikim, L., Spiji, D.A. and Manjaji-Matsumoto, B.M. 2026. A catalogue of coral reef fishes from the Sugud Islands Marine Conservation Area, Sabah, Malaysia. *Zootaxa* 5741(1): 115–147. https://doi.org/10.11646/zootaxa.5741.1.4
Cordova, M.R. and Nurhati, I. S. 2019. Major sources and monthly variations in the release of land-derived marine debris from the Greater Jakarta area, Indonesia. *Scientific Reports* 9(1): 18730. https://doi.org/10.1038/s41598-019-55065-2
Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF). 2020. *Regional Plan of Action (RPOA) 2.0*. CTI-CFF Regional Secretariat. https://www.coraltriangleinitiative.org
Cros, A., Fatan, N.A., White, A.T., Teoh, S.J., Tan, S., Handayani, C.N.N., Huang, C. *et al.* 2014. The Coral Triangle Atlas: An integrated online spatial database system for improving coral reef management. *PLoS ONE* 9(6): e96332. https://doi.org/10.1371/journal.pone.0096332
Ellett, L.G. 2021. Transboundary Marine Management in the Sulu-Sulawesi Seascape. MSc thesis. Missoula: University of Montana.
Fidelman, P., Evans, L., Fabinyi, M., Foale, S., Cinner, J.E. and Rosen, F. 2011. Governing large-scale marine commons: Contextual challenges in the Coral Triangle. *Marine Policy* 36(1): 42–53. https://doi.org/10.1016/j.marpol.2011.03.007
Foale, S., Adhuri, D.S., Aliño, P.M., Allison, E.H., Andrew, N., Cohen, P.J., Evans, L. *et al.* 2012. Food security and the Coral Triangle Initiative. *Marine Policy* 38: 174–183. https://doi.org/10.1016/j.marpol.2012.05.033
González-Pestana, A., Kyne, P.M., García-Rodríguez, E., Charles, R., Brito, V.B., Armstrong, A.O., Batlle-Morera, A. *et al.* 2026. Critical habitats for sharks and rays in Asia remain largely unprotected. *Biodiversity and Conservation* 35(7): 179. https://doi.org/10.1007/s10531-026-03356-2
Green, S., White, A., Christie, P., Kilarski, S., Meneses, A., Samonte, G.P.B., Karrer, L. *et al.* 2011. Emerging marine protected area networks in the coral triangle: Lessons and way forward. *Conservation and Society* 9(3): 173–173. https://doi.org/10.4103/0972-4923.86986
Hays, G.C., Mortimer, J.A., Ierodiaconou, D. and Esteban, N. 2014. Use of long-distance migration patterns of an endangered species to inform conservation planning for the world's largest Marine Protected Area. *Conservation Biology* 28(6): 1636–1644. https://doi.org/10.1111/cobi.12325
Hays, G.C., Laloë, J. and Seminoff, J.A. 2025. Status, trends and conservation of global sea turtle populations. *Nature Reviews Biodiversity* 1(2): 119–133. https://doi.org/10.1038/s44358-024-00011-y
Henneker, C.R., Hinchliffe, G. and Jarvis, R.M. 2026. Achieving 30×30: How different nations report their contributions to international marine conservation targets. *Npj Ocean Sustainability* 5(1): 13. https://doi.org/10.1038/s44183-025-00177-8
Hills, J., Lajaunie, C., Maharaj, P.N. and Mazzéga, P. 2021. Orchestrating the ocean using a National Ocean Policy: The case of the Solomon Islands. *Frontiers in Marine Science* 8: 676944. https://doi.org/10.3389/fmars.2021.676944
Hoegh-Guldberg, O., Hoegh-Guldberg, H., Veron, J.E.N., Green, A., Gomez, E.D., Lough, J., King, M. *et al.* 2009. *The Coral Triangle and Climate Change: Ecosystems, Peoples and Societies At Risk*. Sydney: WWF-Australia.
Hoegh-Guldberg, O., Caldeira, K., Chopin, T., Gaines, S., Haugan, P., Hemer, M., Howard, J. *et al.* 2023. The ocean as a solution to climate change: Five opportunities for action. In *The Blue Compendium*, J. Lubchenco and P.M. Haugan (Eds.), pp. 619–680. https://doi.org/10.1007/978-3-031-16277-0_17
Jiao, Y., Yeophantong, P. and Lee, T.M. 2021. Strengthening international legal cooperation to combat the illegal wildlife trade between Southeast Asia and China. *Frontiers in Ecology and Evolution* 9: 645427. https://doi.org/10.3389/fevo.2021.645427
Joseph, J., Nishizawa, H., Jalimin, S.N., Othman, R., Jaaman, S.A., Bali, J. and Zhang, X. 2023. Health status and genetic compositions of green turtles (*Chelonia mydas*) foraging in Brunei Bay. *PLoS ONE* 18(11): 0293979. https://doi.org/10.1371/journal.pone.0293979

Jumin, R., Binson, A., McGowan, J., Magupin, S., Beger, M., Brown, C. J., Possingham, H.P. and Klein, C. J. 2017. From Marxan to management: ocean zoning with stakeholders for Tun Mustapha Park in Sabah, Malaysia. *Oryx* 52(4): 775–786. https://doi.org/10.1017/s0030605316001514

Justine, E.V. 2025, September 30. MARRS at Work: Restoring Coral Reefs in Tun Mustapha Park. *PANORAMA*. https://panorama.solutions/en/solution/marrs-work-restoring-coral-reefs-tun-mustapha-park

Kühn, S., Rebolledo, E.L.B. and van Franeker, J.A. 2015. Deleterious effects of litter on marine life. In *Marine Anthropogenic Litter*, M. Bergmann, L. Gutow and M. Klages (Eds.), pp. 75–116. https://doi.org/10.1007/978-3-319-16510-3_4

Lua, W.Y. and Aziz, N. 2025. Implementing marine spatial planning: Is Malaysia ready with the existing law and policy? In *Integrating Legal Compliance With Sustainable Development Goals*, F. Ghazali and S.F. Abdul Shukor (Eds.), pp. 73–94. https://doi.org/10.4018/979-8-3373-1792-2.ch003

Lubchenco, J., Dai, M., Douvere, F., Fernandes, L., Halpin, P., Hoel, A.H., Juinio-Meñez, M.A. *et al.* 2023. In *The Blue Compendium*, J. Lubchenco and P.M. Haugan (Eds.), pp. 523–552. https://doi.org/10.1007/978-3-031-16277-0_14

Mao, W., Geng, X., Huai, Z., Huang, W., Chen, G., Gonzalez, E.B., Strelnikov, I.I. and Ahmad, S. 2026. Synergistic effects of interconnectivity among coral reefs, seagrass beds, and mangroves under climate change. *The Innovation Geoscience* 4(1): 100189–100189. https://doi.org/10.59717/j.xinn-geo.2026.100189

Merwe, J.P. van de, Ibrahim, K., Lee, S.Y. and Whittier, J.M. 2009. Habitat use by green turtles (*Chelonia mydas*) nesting in Peninsular Malaysia: local and regional conservation implications. *Wildlife Research* 36(7): 637–645. https://doi.org/10.1071/wr09099

Musa, M.S. 2026, June 19. Empowering woman through enterprise for conservation. *PANORAMA*. https://panorama.solutions/en/solution/empowering-woman-through-enterprise-conservation

Novi, L. and Bracco, A. 2022. Machine learning prediction of connectivity, biodiversity and resilience in the Coral Triangle. *Communications Biology* 5(1): 1359–1359. https://doi.org/10.1038/s42003-022-04330-8

Omeyer, L.C.M., Duncan, E.M., Aiemsomboon, K., Beaumont, N., Bureekul, S., Cao, B., Carrasco, L.R. *et al.* 2022. Priorities to inform research on marine plastic pollution in Southeast Asia. *The Science of The Total Environment* 841: 156704–156704. https://doi.org/10.1016/j.scitotenv.2022.156704

Ong, D.M. 2020. Transboundary fisheries management. *The Korean Journal of International and Comparative Law* 8(2): 131–177. https://doi.org/10.1163/22134484-12340135

Ooi, M.C.G., Zaini, N., Wee, H.B., Hasan, N., Liew, J.N. and Said, M.N.M. 2025. MyIKLIM: Bridging the gap in public understanding and promoting climate change awareness through a centralized platform 1(1): 2. https://doi.org/10.17576/jccass.0101.2025.02

Pata, P.R. and Yñiguez, A.T. 2019. Larval connectivity patterns of the North Indo-West Pacific coral reefs. *PLoS ONE* 14(7): 0219913. https://doi.org/10.1371/journal.pone.0219913

Praveena, S.M., Siraj, S.S. and Aris, A.Z. 2012. Coral reefs studies and threats in Malaysia: a mini review [Review of Coral reefs studies and threats in Malaysia: a mini review]. *Reviews in Environmental Science and Bio/Technology* 11(1): 27–39. https://doi.org/10.1007/s11157-011-9261-8

Puspita, A.S., Budihardjo, M.A., Chegenizadeh, A., Nikraz, H., Sania, M.T. and Andini, A.M. 2026. Marine debris governance and regional dynamics in Southeast Asia. *Cleaner Water* 6: 100231–100231. https://doi.org/10.1016/j.clwat.2026.100231

Putri, D.A., Hidayat, T. and Ramadhan, M.F. 2025. Diplomasi lingkungan Indonesia melalui Coral Triangle Intiative: Peluang dan tantangan. *Jurnal Ilmu Kelautan Lesser Sunda* 5(1): 29–41. https://doi.org/10.29303/jikls.v5i1.128

Schill, S.R., Raber, G.T., Roberts, J.J., Treml, E.A., Brenner, J. and Halpin, P.N. 2015. No reef is an osland: Integrating coral reef connectivity data into the design of regional-scale Marine Protected Area networks. *PLoS ONE* 10(12): 0144199. https://doi.org/10.1371/journal.pone.0144199

Siry, H.Y., Rudianto, M.E. and Rukma, A. 2015. *Unlocking stories behind the initiative*. Jakarta: Interim Regional Secretariat CTI-CFF & Ministry of Marine Affairs.

Suherman, A.M., Yuliantiningsih, A., Indriati, N., Wismaningsih, W. and Rusli, H. 2020. Indonesian ocean policy: Paradigm shift in strengthening ocean governance. *Journal of East Asia and International Law* 13(2): 359–378. https://doi.org/10.14330/jeail.2020.13.2.06

Tan, E., Jaafar, N.F., Tan, S. and Zanuri, N.B.M. 2022. A review of plastic and microplastic pollution towards the Malaysian marine environment [Review of A review of plastic and microplastic pollution towards the Malaysian marine environment]. *IOP Conference Series Earth and Environmental Science* 1013(1): 12012–12012. https://doi.org/10.1088/1755-1315/1013/1/012012

Teh, L.C.L., Teh, L. and Chung, F.C. 2007. A private management approach to coral reef conservation in Sabah, Malaysia. *Biodiversity and Conservation* 17(13): 3061–3077. https://doi.org/10.1007/s10531-007-9266-3

Teh, L.C., Teh, L.S. and Jumin, R. 2013. Combining human preference and biodiversity priorities for marine protected area site selection in Sabah, Malaysia. *Biological Conservation* 167: 396–404. https://doi.org/10.1016/j.biocon.2013.09.002

Telesetsky, A. 2018. The role of boundaries and borders in ocean governance: Reflections on three promising transborder ocean governance models. *Indonesian Journal of International Law* 15(3): 1. https://doi.org/10.17304/ijil.vol15.3.728

Treml, E.A. and Halpin, P.N. 2012. Marine population connectivity identifies ecological neighbors for conservation planning in the Coral Triangle. *Conservation Letters* 5(6): 441–449. https://doi.org/10.1111/j.1755-263x.2012.00260.x

Victurine, R., Meyers, D., Bohorquez, J., Box, S., Blythe, J., Callow, M., Jupiter, S. *et al.* 2022. *Conservation finance for coral reefs: A vibrant oceans initiative whitepaper*. New York: Wildlife Conservation Society. pp. 1–19.

Walton, A., White, A.T., Tighe, S., Aliño, P.M., Laroya, L., Dermawan, A., Kasasiah, A. *et al.* 2014. Establishing a functional region-wide Coral Triangle Marine Protected Area system. *Coastal Management* 42(2): 107–127. https://doi.org/10.1080/08920753.2014.877765

Wan Talaat, W.I.A., Ghazali, F., Kaur, C.R., Abdul Rahman, M.A., Aziz, N. and Muhammad, Z. 2020. Conceptualising marine spatial planning for coastal development in Terengganu. In *South China Sea Scientific Studies in Malaysian Waters: Estuarine, Coastal, Offshore*, S. Suratman (Ed.), pp. 187–198. Terengganu: Universiti Terengganu Malaysia.

Weeks, R., Aliño, P.M., Atkinson, S., Beldia, P.D., Binson, A., Campos, W.L., Djohani, R. *et al.* 2014. Developing Marine Protected Area networks in the Coral Triangle: Good practices for expanding the Coral Triangle Marine Protected Area system. *Coastal Management* 42(2): 183–205. https://doi.org/10.1080/08920753.2014.877768

Widjaja, S., Long, T., Wirajuda, H., As, H.V., Bergh, P.E., Brett, A., Copeland, D. *et al.* 2023. Illegal, unreported and unregulated fishing and associated drivers. In *The Blue Compendium*, J. Lubchenco and P.M. Haugan (Eds.), pp. 553–591. https://doi.org/10.1007/978-3-031-16277-0_15

Witbooi, E., Ali, K.-D., Santosa, M.A., Hurley, G., Husein, Y., Maharaj, S., Okafor-Yarwood, I., Arroyo-Quiroz, I. and Salas, O. 2020. Organized crime in the fisheries sector threatens a sustainable ocean economy. *Nature* 588(7836): 48–56. https://doi.org/10.1038/s41586-020-2913-5

WWF Sulu-Sulawesi Marine Ecoregion Program (SSME). 2004. *Conservation Plan for the Sulu-Sulawesi Marine Ecoregion 2003*. Quezon City: Stakeholders of the SSME, Technical Working Groups of Indonesia, Malaysia, and the Philippines, and the WWF-SSME Conservation Program Team.

Zambrano, D.J.M. 2026. *Best practices on prevention and enforcement mechanisms against cross-border pollution and wildlife crime*. Zenodo. https://doi.org/10.5281/zenodo.18377603


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 729–735
doi: 10.62613/sonc2025.v3anc05

CHAPTER 5

Aligning Malaysia's protected area targets with global biodiversity goals: Directions, challenges, and initiatives

KHAIRUL NAIM ADHAM*

Abstract: Malaysia, as one of the 17 megadiverse countries, has made a global commitment to conserve its rich biodiversity for present and future generations. Area-based conservation, which includes all forms of protected areas and other effective area-based conservation measures (OECM), is a key strategy for protecting this precious biodiversity. The National Policy on Biological Diversity 2022-2030 (NPBD 2022-2030) has clearly outlined national protected area actions by aligning them with global commitments outlined in the Kunming -Montreal Global Biodiversity Framework, taking into account national circumstances. This paper presents the national directions pertaining to the management of protected areas, challenges, and strategic measures implemented by the Federal Government that are essential for Malaysia to meet its national targets and make a significant contribution toward global biodiversity goals by 2030.

INTRODUCTION

Malaysia became a Party to the Convention on Biological Diversity (CBD) in 1994 to strengthen its efforts in the conservation of biodiversity, sustainable use of its components, and equitable sharing of benefits arising from genetic resources. Area-based conservation, encompassing all forms of protected areas and other effective area-based conservation measures (OECM), continues to be the most effective approach to protect a wide range of species, their habitats and ecosystems (NRECC 2023a). Article 2 of the CBD defines protected areas as "geographically defined areas that are designated, regulated, and managed to achieve specific conservation objectives" (CBD 2010a), whereas OECM means "a geographically defined area other than a protected area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the *in situ* conservation of biodiversity, with associated ecosystem functions and services and, where applicable, cultural, spiritual, socio-economic, and other locally relevant values" (CBD 2018).

A protected area represents one of the most effective tools for conserving biodiversity and ensuring the long-term sustainability of ecosystem services (Gray *et al.* 2016). For protected areas to deliver their desired outcomes, they must be ecologically representative; large enough to support viable populations; optimally designed and managed; and provide benefits to Indigenous Peoples and Local Communities (IPLCs) (NRECC 2023a).

The CBD provides global frameworks on protected areas to complement national agendas. Article 8 of the CBD contains specific references to protected areas by encouraging Parties to establish a system of protected areas; develop guidelines for the selection, establishment, and management of protected areas; regulate or manage biological resources important for the conservation of biological diversity; promote environmentally sound and sustainable development in areas adjacent to protected areas; and cooperate in providing financial and other support for in-situ conservation (SCBD 2011).

[1] Deputy Undersecretary, Ministry of Natural Resources and Environmental Sustainability, Block F11, Complex F, Precinct 1, Pusat Pentadbiran Kerajaan Persekutuan, 62000 Putrajaya, Malaysia.
[2] Adjunct Professor, Universiti Teknologi MARA, Jalan Ilmu 1/1, 40450 Shah Alam, Selangor, Malaysia.
***Corresponding author: khairulnaim@nres.gov.my**

In general, the types of protected areas in Malaysia could be categorised based on the legal framework used in their establishment. The categories include protection forest reserves under the forestry laws; national parks, state parks, and nature reserves under the relevant park/forestry laws; wildlife reserves or sanctuaries under the wildlife laws; marine protected areas under the marine laws, and; areas reserved for a public purpose under the land laws (NRECC 2023b). These areas are managed under various Federal and State laws, and have long been established in Malaysia.

This paper acknowledges that multiple states have established state-level policies and action plans in line with the national directions aimed at the protection and conservation of natural resources. These include the Sarawak Biodiversity Masterplan 2023-2030, the Sabah Biodiversity Strategy 2024-2034, the Forestry Policy of Sabah, and the Forestry Policy of Sarawak. However, this paper focuses on the national policy that explicitly defines national objectives regarding protected areas and OECM, specifically the National Policy on Biological Diversity 2022-2030 (NPBD 2022-2030).

GLOBAL AND NATIONAL DIRECTIONS FOR PROTECTED AREAS

CBD Strategic Plan for Biodiversity 2011–2020 and achievements

The CBD Strategic Plan for Biodiversity 2011-2020 through Aichi Biodiversity Target 11 stated the need to achieve at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes by 2020 (CBD 2010b). Globally, this target, however, was only partially met, with approximately 15% of terrestrial and inland water, and 7.5% of coastal and marine areas protected by the established deadline (SCBD 2020).

Over the past decades, Malaysia has undertaken various measures to expand and strengthen its protected area system in line with global frameworks and national priorities. However, Malaysia, like many countries globally, faced challenges in achieving Aichi Biodiversity Target 11, which has been translated into Target 8 of the National Policy on Biological Diversity (NPBD) 2016-2025 to achieve at least 20% terrestrial areas and inland waters, and 10% of coastal and marine areas, are conserved through a representative system of protected areas and OECM by 2025 (NRE 2016a). By 2020, the nation had only conserved 13.3% of terrestrial and inland water areas and 5.3% of coastal and marine areas (NRE 2016b).

Kunming Montreal Global Biodiversity Framework

The Parties to the CBD adopted the Kunming-Montreal Global Biodiversity Framework (KMGBF) in 2022, setting more ambitious targets through its 23 global targets by 2030, including those related to protected areas. The overarching vision is to live in harmony with nature by 2050. In this context, Target 3 of the KMGBF stated that:

> "Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and OECM, recognising indigenous and

traditional territories, where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognising and respecting the rights of Indigenous Peoples and local communities, including over their traditional territories" (CBD 2022).

However, the KMGBF recognises that this target is global in nature, and each Party will contribute to attaining it in accordance with national circumstances, priorities, and capabilities.

National Policy on Biological Diversity 2022-2030

In response to the Kunming-Montreal Global Biodiversity Framework, Malaysia has strengthened its national framework through the National Policy on Biological Diversity 2022-2030, which outlines five overarching goals, 17 national targets, 61 actions, and 61 indicators. One of the targets is explicitly intended to promote the expansion and efficient management of protected areas, emphasising not only the area coverage, but also governance, management effectiveness, ecological representativeness, and connectivity. Target 8 explicitly stated that: "By 2030, at least 20 per cent of terrestrial areas and inland waters, and 10 per cent of coastal and marine areas are conserved through an effectively managed and ecologically representative system of protected areas and OECM". To achieve this target, NPBD 2022-2030 outlines five key actions: (1) strengthen and streamline the governance of protected areas; (2) enhance management effectiveness of protected areas; (3) expand the extent and ecological representativeness of the protected area network; (4) identify and recognise OECM; and (5) increase areas of global importance for biodiversity conservation (NRECC 2023a).

ISSUES AND CHALLENGES

Despite longstanding commitments, Malaysia faces several challenges in expanding and effectively managing its protected areas. The challenges include: fragmented management and legislation of protected areas; absence of national definitions and classifications of protected areas; inadequate resources for protected areas management; identifying and designating new sites; lengthy designation process, and; lack of stakeholder empowerment (NRECC 2023b).

Governance of protected areas

According to the Federal Constitution, land and natural resources are listed on the State List, whereas the wild animals and national parks are listed under the Concurrent List. This constitutional framework has resulted in fragmented management and legislation of protected areas, with over ten protected area authorities managing various categories of protected areas and about 19 pieces of legislation dealing with the gazettement of protected areas. Some of these are federal legislation enacted through the Parliament or state legislation enacted through the various State Legislative Assemblies to enable the designation and management of protected areas. Such fragmentation often leads to legal provisions varying from one to another, inconsistent standards, overlapping responsibilities, and challenges in coordinating conservation efforts at the national level.

Absence of national definitions and classifications for protected areas

Prior to 2022, Malaysia lacked a nationally agreed definition and classification for protected areas. This situation hinders the standardisation of action plans concerning protected areas and the associated reporting processes. As Malaysia is a signatory to the CBD and a member of the International Union for Conservation of Nature (IUCN), relevant protected area

authorities in Peninsular Malaysia, Sabah, and Sarawak have addressed this gap in 2022 by agreeing to adopt the CBD definition and IUCN Protected Areas Management Categories (IUCN 1994). The update of the PA Master List in 2022 reflects the adoption of national definitions and classifications for protected areas.

Inadequate resources for protected areas management
Protected area authorities are very dependent on either the Federal or State Government's operating and development funds to manage their areas. Insufficient financial allocations for protected areas have also resulted in inadequate human resources allocated to manage them. Based on a study commissioned in 2009, the findings showed that staffing for protected areas in Malaysia was far below the Southeast Asia regional standards and faced a major shortfall of more than 2,000 staff (EPU, 2009).

Identifying and designating new sites
As a developing nation, Malaysia continues to experience rapid land use change driven by infrastructure development, agriculture, and economic growth. With the socioeconomic development pressure, Malaysia has a challenging task in identifying and designating an additional 3.8 million hectares as protected areas, which includes 1.7 million hectares of terrestrial and 2.1 million hectares of coastal and marine, to achieve Target 8 of the NPBD by 2030 (NRECC 2023c). Furthermore, State Governments heavily rely on natural resource utilisation for revenue generation, thereby complicating the establishment of new protected areas.

Lengthy designation process
The current protected area designation in Malaysia under specific legislation is lengthy, from identification to gazettement. Among the reasons for this lengthy process are: survey and mapping to demarcate the protected area boundaries; conflicting land use by different interest groups; differences in priorities between the Federal and State authorities; concern over loss of revenue, funding constraints,and; lack of capacity (NRECC 2023b).

Lack of stakeholder empowerment
Besides the protected area authorities, there are also other important stakeholders, such as Indigenous Peoples and Local Communities (IPLC), academia, non-governmental organisations (NGO), civil society groups, and the private sector, who need to be engaged and empowered through legislative and administrative means to complement and enhance the Federal and State Governments' efforts to conserve and manage protected areas.

STRATEGIC MEASURES

Recognising various challenges in expanding and effectively managing its protected areas, the Federal Government has undertaken several strategic measures to strengthen protected areas' governance and effective management of protected areas. These include: the updating of the Protected Areas Master List of Malaysia (PA Master List); the development and operationalisation of the National Framework for Protected Areas (NFPA); the provision of the Ecological Fiscal Transfer for Biodiversity Conservation (EFT) incentive; the development of the OECM Framework, and; the implementation of marine conservation initiatives.

Update Protected Area Master List
The PA Master List was updated in 2022 using the standard dataset and spatial analysis for effective national planning and reporting processes of protected areas. This document is crucial for the preparation of reports at the national level, such as the Sustainable Development Goals Report, the Mid-Term Review of the Malaysia Plan, and reports by the Department

of Statistics Malaysia, as well as reports at the international level, such as the National Report to the CBD and the World Database on Protected Areas produced by the United Nations Environment Programme World Conservation Monitoring Centre. The PA Master List 2022 also provides data as a basis for allocating the EFT incentive to state governments. This document uses the CBD definition, and the IUCN Protected Areas Management Categories has identified, reviewed, and listed all protected areas gazetted in Malaysia between 1903 and 31 October 2022. The PA Master List 2022 reported that there are 723 protected areas for Malaysia, including protection forest reserves, national parks and state parks, wildlife reserves/sanctuaries, marine parks, turtle sanctuaries and fisheries prohibited areas, and areas reserved for a public purpose. These encompass 4,902,738.53 ha of terrestrial and 2,530,768.84 ha of coastal and marine areas. Based on these findings, the percentage of terrestrial and marine protected areas coverage for Malaysia is 14.83% and 5.34%, respectively (NRECC 2023c).

Develop and operationalise a National Framework for Protected Areas (NFPA)
The NFPA provides a strategic and coordinated framework designed to improve the governance, planning, and management of protected areas. It contains 20 strategies and 113 actions aimed at enhancing coordination among authorities, strengthening management effectiveness, and promoting sustainable financing (NRECC 2023b). The framework was approved by the National Steering Committee Meeting on 14 February 2019, and the National Biodiversity Council Meeting on 29 July 2024 agreed to operationalise the National and Regional Protected Area Working Group under the NFPA to strengthen and streamline governance and management of the country's protected areas.

Provide Ecological Fiscal Transfer (EFT) for biodiversity conservation
Recognising the need for alternative strategies and actions to ensure the existing protected areas and new protected areas have sufficient resources for their effective management, the Federal Government introduced the EFT in 2019 to incentivise state governments to conserve existing protected areas and gazette new ones. Until 2026, the Federal Government has allocated RM1.05 billion to states under the EFT incentive. As a result, more than 350,000 hectares of additional protected areas have been designated.

Develop an Other Effective Area-based Conservation Measure (OECM) framework
In addition to protected areas, Malaysia has taken efforts to develop a national framework for OECM since 2019. While the main objectives of these areas may not be biodiversity conservation, they are governed and managed in ways that achieve positive and sustained long-term outcomes for the in-situ conservation of biodiversity. OECM can therefore serve a complementary role to protected areas, contributing to the coherence and connectivity of protected area networks. This framework will recognise conservation initiatives outside protected areas, including conservation contributions from community-managed forests, indigenous territories, and other non-traditional conservation areas. The framework is expected to be launched by the end of 2026.

Implement marine conservation initiatives
During the Sixteenth Meeting of the Conference of the Parties to the CBD in 2024, Parties adopted new modalities for the modification of existing Ecologically or Biologically Significant Marine Areas (EBSA) descriptions and the identification of new areas. This evolution in the EBSA process paves the way for a more comprehensive, connected, and representative network of conserved areas, guided by science, enriched by traditional and local knowledge, and supported by strong institutions and governance mechanisms (CBD 2024). Subsequently, the Department of Fisheries has initiated the identification of EBSA in Malaysia to guide the establishment of marine protected areas and OECM. These efforts are crucial for expanding marine conservation coverage.

Implement science-based mapping and assessment

Malaysia has also established a robust and science-based foundation such as forest inventory, ecosystem mapping, biodiversity assessment and vulnerability analyses for supporting and monitoring its national targets. These include the implementation of the National Forest Inventory (NFI) in Peninsular Malaysia, ongoing since 1970, providing a vital information base for forest management decisions, national reporting, and long-term planning within the Permanent Reserved Forests (PRFs); the nationwide mapping of terrestrial and transitional ecosystems under the Red List of Ecosystems (RLE) assessment establishes a critical baseline for identifying threatened ecosystems; the implementation of the Continuous Monitoring and Surveillance (COMOS) initiative in Sarawak utilises satellite imagery, Geographic Information System (GIS) technology, aerial surveillance, hyperspectral remote sensing, and mobile platforms to enable early detection of forest changes; the systematic updates to the National Red Data List; and the implementation of the national seagrass mapping programme.

CONCLUSION

Area-based conservation, including protected areas, remains central to Malaysia's commitment to biodiversity conservation and recent initiatives by the Federal Government such as the PA Master List, NFPA, EFT, OECM, and EBSA demonstrate Malaysia's commitment to aligning national actions with global biodiversity goals. However, there is still much scope for protected area expansion across landscapes and seascapes, with room for improvement in management practices. For these reasons, future initiatives should prioritise several crucial areas, including: strengthening the governance of protected areas; facilitating collaboration between Federal and State authorities; streamlining gazettement procedures; increasing sustainable financial resources; enhancing the management effectiveness of protected areas; expanding the extent and ecological representativeness of the protected areas; identifying and recognising OECM, and; greater empowerment of stakeholders. Regarding resource mobilisation, several states have implemented sustainability-related levies associated with biodiversity conservation, including conservation and sustainability fees as well as heritage charges. However, there is a need for increased efforts to capitalise on the value of ecosystem services through mechanisms such as cesses, royalties, and carbon-related fees to expand the revenue base for conservation initiatives. Additionally, it is necessary especially for megadiverse countries to enhance the recognition and support for community conserved areas, increase reporting on privately protected areas, and systematically collect information on OECM (Bacon *et al.* 2019). Transformative changes are needed to meet Target 8 of the NPBD by 2030, which requires Malaysia to designate approximately 3.8 million additional hectares as protected areas. While this goal presents certain challenges, it is nonetheless attainable. Malaysia's existing forest cover, with approximately 54.4% under state government jurisdiction, presents significant opportunities for conservation activities. With coordinated efforts among Federal and State authorities, NGO, civil society, private sector, and IPLC, Malaysia is well positioned to strengthen its protected area network, thereby contributing significantly to global biodiversity goals.

Acknowledgement : The author expresses gratitude to the related Federal and State government agencies, and conservation partners including Malaysian Nature Society (MNS) whose collaborative efforts continue to advance biodiversity management in Malaysia.

REFERENCE

Bacon, E., Gannon P., Stephen, Seyoum-Edjigu, E., Schmidt, M., Lang, B., Sandwith, T. *et al.* 2019. Aichi Biodiversity Target 11 in the Like Minded Megadiverse Countries. *Journal for Nature Conservation* 51: 125723. https://www.sciencedirect.com/science/article/pii/S161713811830428X?via%3Dihub

Convention on Biological Diversity (CBD). 2010a. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting. Decision X/31. Protected areas. https://www.cbd.int/doc/decisions/cop-10/cop-10-dec-31-en.pdf.

Convention on Biological Diversity (CBD). 2010b. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting. Decision X/2. Strategic plan for biodiversity 2011–2020. https://www.cbd.int/doc/decisions/cop-10/cop-10-dec 02-en.pdf.

Convention on Biological Diversity (CBD). 2018. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its fourteenth meeting. Decision 14/8. Protected areas and other effective area-based conservation measures. https://www.cbd.int/doc/decisions/cop-14/cop-14-dec-08-en.pdf

Convention on Biological Diversity (CBD). 2022. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its fifteenth meeting. Decision 15/4. Kunming-Montreal Global Biodiversity Framework. https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

Convention on Biological Diversity (CBD). 2024. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its sixteenth meeting. Decision 16/6. Further work on ecologically or biologically significant marine areas. https://www.cbd.int/doc/decisions/cop-16/cop-16-dec-16-en.pdf.

Economic Planning Unit (EPU). 2009. *Sustainable Financing and Management of Protected Areas in Malaysia: Options for Decision Maker*. Putrajaya: EPU.

Gray, C.L., Hill, S.L.L., Newbold, T., Hudson, L.N., Börger, L., Contu, S. and Scharlemann, J.P.W. 2016. Local biodiversity is higher inside than outside terrestrial protected areas worldwide. *Nature Communications* 7: 12306. https://doi.org/10.1038/ ncomms12306.

International Union for Conservation of Nature (IUCN). 1994. *Guidelines for Protected Area Management Categories*. CNPPA with the assistance of WCMC. Gland: IUCN.

Ministry of Natural Resources and Environment (NRE). 2016a. *National Policy on Biological Diversity 2016-2025*. Putrajaya: NRE

Ministry of Natural Resources and Environment (NRE). 2016b. *Protected Areas Master List (PA Master List) in Malaysia*. Putrajaya: NRE (Embargo).

Ministry of Natural Resources, Environment and Climate Change (NRECC). 2023a. *National Policy on Biological Diversity 2022-2030*. Putrajaya: NRECC

Ministry of Natural Resources, Environment and Climate Change (NRECC). 2023b. *National Framework for Protected Areas Systems in Malaysia*. Putrajaya: NRECC (Embargo).

Ministry of Natural Resources, Environment and Climate Change (NRECC). 2023c. *Protected Areas Master List (PA Master List) in Malaysia*. Putrajaya: NRECC (Embargo).

Secretariat of the Convention on Biological Diversity (SCBD). 2011. *Convention on Biological Diversity: text and annexes*. Montreal: SCBD. https://www.cbd.int/doc/legal/cbd-en.pdf

Secretariat of the Convention on Biological Diversity (SCBD). 2020. *Global Biodiversity Outlook 5*. Montreal: SCBD. https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 737–745
doi: 10.62613/sonc2025.v3anc06

CHAPTER 6

Other Effective Area-based Conservation Measures (OECMs): A critical pathway to 30×30 for Malaysia

NADZIRAH HOSEN[1] and AMRAN HAMZAH[2]*

Abstract: Malaysia is committed to the global 30×30 target under the Kunming-Montreal Global Biodiversity Framework, which calls for effective conservation of 30% of terrestrial, inland water, coastal and marine areas by 2030. However, at present 14.83% of terrestrial and 5.34% of marine areas are currently under formal protection, and it is unlikely to achieve this target alone through expanding protected areas within Malaysia. Other Effective Area -based Conservation Measures (OECMs) therefore provide an important complementary pathway of recognising areas outside of the already formal protected areas, a framework that can be identified, measured, and ascertained on other effective areas or landscapes contributing to *in situ* biodiversity conservation. This paper examines the emerging role of OECMs in Malaysia following the completion of the National Framework for OECMs in 2026, which provides a voluntary and rights-based mechanism for identifying and recognising such sites. The endorsement of six pioneer OECMs, including community-managed forests, private sector conservation set-asides, and university research forests, marks an important step towards expanding Malaysia's conservation estate. However, this effective implementation remains constrained attributing to low awareness, the absence of statutory or legal recognition, and limited financing support. To operationalise this framework, Malaysia needs stronger national awareness efforts, clearer regulatory pathways, and the provision of incentives (including financial, such as a potential expansion of the Ecological Fiscal Transfer (EFT), amongst other forms of incentives) for the increased uptake and implementation of the National Framework for OECMs amongst the States. Strengthening these enabling conditions is essential for OECMs to contribute meaningfully to Malaysia's commitment to the Convention on Biodiversity.

INTRODUCTION

Malaysia is a megadiverse nation, home to an extraordinary range of terrestrial, freshwater, and marine ecosystems and species. Yet, despite decades of conservation efforts, the country's official protected areas cover only 14.83% of its terrestrial including inland water areas, and only 5.34% of its coastal and marine areas (NRES 2026). This significant gap remains a challenge for a country that operates in a federal system where land and natural resources are under the sub-national jurisdiction according to the constitution. This makes Malaysia one of the few countries regionally with multiple protected area laws and authorities. Seventeen of Malaysia's 61 Key Biodiversity Areas (KBAs) have no protected area coverage at all, while the average protected coverage across all KBAs stands at only 37.5% (NRES and UTM 2026). In 2022, Malaysia joined other Parties to the Convention on Biological Diversity in adopting the Kunming-Montreal Global Biodiversity Framework (KMGBF). Under Target 3, widely known as the '30×30' target, countries are expected to ensure that at least 30% of terrestrial, inland water, coastal, and marine areas are effectively conserved and equitably managed by 2030 through systems of protected areas and OECMs (CBD 2022). The National Policy on Biological Diversity 2022–2030 (NPBD 2022–2030) has

[1] Institut Alam Sekitar & Pembangunan (LESTARI), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.
[2] Faculty of Built Environment & Surveying, Lingkaran Ilmu, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia.
***Corresponding author: merang@utm.my**

aligned with this KMGBF target under Goal 3, Target 8 which states that: "By 2030, at least 20% of terrestrial areas and inland waters, and 10% of coastal and marine areas are conserved through an effectively managed and ecologically representative system of protected areas and OECMs". This target ca nnot be achieved through the expansion of formal protected areas alone and already includes OECMs. This requires recognition of other areas that are already delivering long-term biodiversity conservation outside the formal protected area system. This chapter explains the concept of OECMs, their relevance to Malaysia, and the practical mechanism now available to recognise and support conservation efforts beyond formal protected areas in alignment with the NPBD 2022–2030 and KMGBF.

WHAT ARE OECMs?

The term 'Other Effective Area-Based Conservation Measure' (OECM) was formally introduced by the Convention on Biological Diversity (CBD) under Aichi Target 11 in 2010. The CBD later provided a formal definition through Decision 14/8, which defines an OECM as: "A geographically defined area other than a Protected Area which is governed and managed in ways that achieve positive and sustained long-term outcomes for the *in situ* conservation of biodiversity with associated ecosystem functions and services, and where applicable cultural, spiritual, socio-economic and other locally relevant values" (CBD 2018).

In simpler terms, an OECM is an area outside the formal protected area system that is already contributing to the long-term conservation of biodiversity. It may not be gazetted as a national park, wildlife reserve, state park or other formal protected area, but it still delivers effective conservation outcomes through its existing governance and management arrangements.

The CBD identifies four high-level criteria for recognising OECMs, supported by eight sub-criteria. These criteria provide a simple way to understand what qualifies as an OECM. Criterion A requires that the area is not already recognised as a protected area. In other words, an OECM is not a national park, wildlife reserve, wildlife sanctuary, state park, or any other area gazetted primarily for conservation. Criterion B requires that the area is governed and managed by a legitimate authority, such as a village committee, Indigenous community, private company, university, state agency, or other entity with effective control over the area. Criterion C requires that governance and management achieve sustained and effective in-situ conservation of biodiversity, which may be demonstrated through evidence of species protection, habitat maintenance, ecosystem integrity, or ecosystem service provision. Criterion D recognises that OECMs may also support associated ecosystem functions, services, and cultural, spiritual, socio-economic or other locally relevant values, provided these are maintained or enhanced , alongside biodiversity conservation (CBD 2018; IUCN 2024). Importantly, OECM recognition does not change land ownership, land tenure, or governance rights. It does not turn the site into a protected area. Rather, it acknowledges and supports conservation outcomes that are already being delivered outside the formal protected area system (IUCN 2024; Jonas *et al*. 2024).

A key distinction between OECMs and protected areas lies in their management objectives. A protected area must have biodiversity conservation as its primary objective. An OECM, however, may have biodiversity conservation as a primary, secondary or ancillary objective, as long as the area delivers effective and sustained conservation outcomes. For example, a water catchment forest managed primarily for clean water supply, a community -managed river under a *Tagal* system that also protects freshwater fish, or a private nature reserve whose owner does not wish to seek protected area status may all qualify as OECMs if they meet the CBD criteria (IUCN 2024). This flexibility makes OECMs especially important

because they recognise conservation contributions that often remain invisible within formal protected area statistics. However, it also means that OECMs must be carefully assessed, documented, and monitored to ensure that recognition is based on real biodiversity outcomes rather than broad claims of environmental benefit. Alves-Pinto *et al*. (2021) note that while OECMs represent an important recognition of biodiversity conservation beyond formal protected area networks, their future social and ecological impacts will depend on robust guidelines for identification and effective monitoring. Similarly, a global scoping review by Petza *et al.* (2026), covering 99 studies and 694 case studies, found that potential OECMs are widespread, particularly in Asia, but that many assessments still rely heavily on qualitative expert knowledge, highlighting the need for more standardised methodologies.

THE IMPORTANCE OF OECMs FOR MALAYSIA

OECMs are not a substitute for protected areas. Instead, they are an essential complement to the existing protected and conserved area system. For Malaysia, OECMs are particularly important for three main reasons: they can help close the protected and conserved areas target gap, recognise existing conservation efforts outside formal protected areas and support more inclusive conservation governance beyond the public sector involving civil society, the private sector, Indigenous peoples, and local communities.

First, OECMs can help contribute towards Malaysia's target in the NPBD 2022–2030. As shown earlier, Malaysia's current formally protected area coverage remains well below the 30% target, particularly in the marine environment. This means that the country is unlikely to reach NPBD Target 8 or GBF Target 3 by 2030 through the gazettement of new protected areas alone. Gazettement is often slow, costly, and politically complex, especially where land ownership, development priorities, and jurisdictional issues are involved. OECMs offer a more flexible pathway because they do not require changes in land status, ownership, or governance arrangements. Instead, well-managed areas that already deliver biodiversity conservation outcomes can be assessed and recognised through a voluntary mechanism. In this sense, Malaysia's current shortfall in achieving this target is not only a protected area gap, but also an OECM recognition gap (NRES and UTM 2026). This potential is already visible globally. Jonas *et al.* (2024), in the first global assessment of OECMs, reported that between 2019 and 2023, 820 sites across nine countries and territories were submitted to the World Database on OECMs, covering approximately 1.9 million km^2 of the Earth's surface and contributing more than 1% towards the global 30% terrestrial coverage target. Nearly 30% of these reported OECMs overlap with identified KBAs, showing that OECMs can play a meaningful role in recognising areas of high conservation importance (Jonas *et al*. 2024).

Second, many areas in Malaysia are already delivering effective biodiversity conservation without formal recognition. These include Indigenous and community conserved areas (ICCAs), such as the kawasan rayau or foraging areas of Orang Asli communities, *Tagal* river management systems in Sabah and Sarawak, and community -managed marine areas documented by organisations such as PACOS Trust and Forever Sabah (SEARRP 2022). Other potential OECMs include private sector conservation set-asides, such as riparian reserves within oil palm estates, and biodiversity conservation areas within tree plantations. Sacred natural sites, water catchment forests managed by state water departments, university research forests, and some military training areas that function as *de facto* wildlife refuges may also be relevant, provided they meet the CBD criteria. Recognising these areas as OECMs would bring currently under-recognised conservation assets into national and global conservation accounting systems. More importantly, it would make visible the contribution of actors beyond conventional conservation agencies, including communities, universities, private land managers, water

authorities, and customary institutions. However, such recognition must be guided by clear criteria and credible assessment processes. Mgumia *et al.* (2025), in their study of sacred natural sites as potential OECMs in South Africa, highlighted several implementation challenges, including the absence of standard criteria at local or national levels and the lack of clear policy frameworks specifically designed for OECMs.

Third, OECMs can support more inclusive conservation governance by recognising the role of Indigenous Peoples and local communities (IPLCs). Malaysia's National Framework for OECMs is built on the principle of Free, Prior and Informed Consent (FPIC). This means that no community-governed site should be assessed or recognised as an OECM without the full consent of the community concerned. This is important because OECMs should not be used as a top-down conservation tool or as a way to impose external conservation labels on community lands and waters. Instead, they should provide a voluntary and rights-based mechanism for recognising conservation practices that communities have sustained over time. This makes OECMs especially relevant in contexts where biodiversity conservation is closely connected to customary governance, cultural values, traditional ecological knowledge, and local stewardship. Jonas *et al.* (2024) found that collaborative governance is the most common governance subtype among reported OECMs globally, accounting for 40.9% of reported sites, compared to only 2.5% for protected areas. This suggests that OECMs can create space for more diverse and inclusive conservation governance models. Fitzsimons *et al.* (2025) further clarify that OECMs are not simply "protected areas by another name" and do not automatically require changes in governance or land tenure. For Malaysia, this distinction is crucial. OECMs can help recognise conservation beyond the formal protected area system while respecting existing rights, responsibilities, and governance arrangements.

CUSTOMARY LANDSCAPES AND LOCALLY-EMBEDDED CONSERVATION

Some of Malaysia's less visible opportunities for OECM recognition may lie within landscapes where conservation outcomes coexist with long-established livelihood and resource-use practices. In Sarawak, customary farming has historically involved more than the cultivation of individual plots. Land may pass through different periods of use and regeneration, while forest resources, permanent crops and other livelihood activities remain part of the wider system. Studies of Iban and Kenyah communities have documented this complexity and the capacity of such systems to respond to changing environmental and socio-economic circumstances (Chin 1977, 1985; Padoch 1982; Cramb 1993). Their ecological significance is therefore difficult to judge from a cultivated site at a single point in time.

This becomes clearer when the wider landscape is considered. Padoch and Pinedo -Vasquez (2010) argue that some rotational farming systems retain substantial biodiversity because cultivated areas occur alongside fallows, agroforests and regenerating vegetation at different stages. Evidence from northern Borneo also shows that landscapes associated with forest-based rotational agriculture can provide greater tree diversity and multiple ecosystem services than simplified plantation systems, although natural and logged forests remain particularly important within these mosaics (Labrière *et al*. 2015). The implication is not that customary agriculture is inherently conservation-friendly. Management intensity, the length of regenerative periods and subsequent land-use change all affect the ecological outcome. Cramb's (1993) longitudinal study in Sarawak similarly shows why these systems need to be understood as part of a broader farming system and not solely through the temporary clearing of land.

Other productive landscapes may carry conservation value in less obvious ways. Traditional fruit gardens in Pahang, for example, supported higher mammal diversity and substantially greater mammal biomass than nearby comparison sites, including several species of conservation concern (Moore *et al*. 2016). Agroforestry orchards in Peninsular Malaysia have likewise been found to support richer and more abundant bird communities than oil palm and rubber monocultures (Yahya *et al*. 2022). Such findings are relevant to OECMs because biodiversity conservation does not have to be the primary purpose of management. A landscape used for food production or household livelihoods may still contribute to conservation if those outcomes are positive, sustained and demonstrable.

How these areas are governed matters just as much. Customary landscapes are rarely maintained by ecological processes alone. Shared responsibility, reciprocal labour and locally organised management can influence how resources are accessed, maintained and passed between generations. Experience from Sabah has shown that Indigenous and community-conserved areas can contribute to habitat connectivity and ecological services while operating through forms of governance that differ from conventional state-managed protected areas (Vaz and Agama 2013). For OECM purposes, however, the existence of a customary practice or strong community institution would not in itself be sufficient. The relevant question is what that governance achieves over time. Evidence of sustained biodiversity outcomes, a geographically defined area and a legitimate governing authority would still be required.

The ecological boundaries of these landscapes may also extend beyond what is immediately visible on land. Rivers, floodplains, wetlands and seasonally saturated areas are connected through movements of water, nutrients and organisms. Periodic changes in hydrological connectivity can alter habitat conditions and biological productivity across the land–water interface (Junk *et al.* 1989). Water levels and soil saturation also change oxygen conditions, affecting decomposition and nutrient transformations. At particular places and times, these interactions can produce disproportionately high rates of biogeochemical activity (McClain *et al*. 2003). For potential OECMs that encompass catchments, wetlands or connected terrestrial and freshwater environments, conservation effectiveness may therefore depend partly on retaining these functional connections, not only particular habitat patches or species.

Customary landscapes consequently present both an opportunity and a challenge for OECM recognition. Their conservation value may arise from combinations of livelihood use, ecological regeneration and locally embedded governance that do not fit neatly within conventional categories of protected land. At the same time, such landscapes should not be recognised simply because they are traditional or community-managed. OECM status depends on what is being conserved, how those outcomes are maintained and whether they can reasonably be expected to persist. This distinction is important if recognition is to make existing conservation contributions more visible without weakening the ecological standard on which OECMs depend.

MALAYSIA'S NATIONAL FRAMEWORK FOR OECMs

Recognising these varied forms of conservation requires an assessment process that can accommodate different management and governance arrangements while retaining a clear requirement for sustained biodiversity outcomes. Malaysia's National Framework provides the mechanism through which such areas can be considered for formal OECM recognition. In early 2026, Malaysia completed its National Framework for Other Effective Area-Based Conservation Measures (NF-OECMs). The framework was developed by the Ministry of Natural Resources and Environmental Sustainability (NRES), with technical support from

Universiti Teknologi Malaysia (UTM) and input from a wide range of stakeholders, including government, national and international organisations, Indigenous representatives, and civil society organisations spanning Peninsular Malaysia, Sabah and Sarawak. It provides Malaysia with an operational system for identifying, assessing, recognising, monitoring, and reporting OECMs across the country (NRES and UTM 2026). A significant milestone under the framework is the endorsement of six pioneer OECM sites. These sites were assessed using the CBD criteria and demonstrate that OECMs are no longer only a policy concept in Malaysia, but are already being operationalised through different governance and management contexts.

Table 1. Six pioneer OECM sites in Malaysia.

No.	Sites	Location
1.	Genting Tea Estate	Pahang
2.	Sungai Pin Conservation Area	Sabah
3.	Habitat Penang Hill	Penang
4.	Sekar Imej Wilmar	Sabah
5.	UiTM Kuala Pilah Campus	Negeri Sembilan
6.	Berungus Marine Management Area	Sabah

Source: NRES and UTM (2026).

To bring more sites into formal recognition, the framework establishes a four-stage recognition process that is voluntary, transparent, and low-cost. Stage 1 involves initial screening, where the site owner or manager submits a simple form confirming that the site is not a protected area and has reasonable biodiversity value. Stage 2 involves consent for full assessment. At this stage, relevant stakeholders receive a detailed briefing on OECMs and provide formal consent to proceed. For sites governed by IPLCs, this process must include FPIC. Stage 3 is the full assessment, conducted by a trained OECM Expert Assessment Group (EAG) using the eight CBD sub-criteria. Stage 4 is final approval and recognition, where the site receives formal recognition, is issued a certificate by the national authority and is added to the National OECM Registry before being reported to the global database (NRES and UTM 2026).

The governance structure supporting this process is also clearly defined. The National OECM Steering Committee (NSC OECM), chaired by NRES and involving representatives from Sabah, Sarawak, and relevant federal ministries, provides high-level policy direction. The National OECM Working Group (NWG OECM) oversees technical implementation, while the OECM Secretariat, based at NRES, manages day-to-day operations, applications, and reporting. Site assessments are carried out by the OECM Expert Assessment Group, which consists of trained independent assessors. Implementing partners, including NGOs such as the Malaysian Nature Society (MNS), WWF-Malaysia, SEARRP, PACOS Trust and Forever Sabah, support site identification, capacity building, and public outreach.

Recognition does not end with approval. Once a site is recognised as an OECM, it must continue to demonstrate that biodiversity conservation outcomes are being sustained. The framework therefore requires recognised sites to collect baseline data and carry out regular monitoring. However, it does not prescribe a single monitoring method. Instead, it allows different forms of evidence, including scientific surveys, citizen science, photo documentation, species checklists and, for sites governed by Indigenous peoples and local communities, traditional ecological knowledge systems. Where appropriate, the IUCN Green List of Protected and Conserved Areas may also provide a more rigorous framework for monitoring and strengthening site performance.

Reporting is coordinated through the OECM Secretariat. Recognised sites are first listed in the National OECM Registry and are then reported to the World Database on Protected and Conserved Areas via NRES, as Malaysia's national focal point to the Convention on Biological Diversity. This enables Malaysia's recognised OECMs to contribute to global reporting under Target 3 of the Kunming-Montreal Global Biodiversity Framework, as well as the relevant indicators for Sustainable Development Goals 14 and 15 (NRES and UTM 2026).

CHALLENGES AND THE WAY FORWARD

Despite the completion of a national framework, several challenges remain in operationalising OECMs in Malaysia. First, awareness of OECMs is still low among state governments, district offices, private landowners, and local communities. This is a significant gap because OECM recognition depends on voluntary participation by site owners, managers, and governing authorities. Without sufficient understanding of what OECMs are, how they differ from protected areas and what benefits recognition may bring, many potential sites may remain unidentified or unwilling to participate.

Second, legal recognition remains largely administrative rather than statutory. At present, OECMs do not have clear standing under Malaysia's land, forestry, wildlife, or marine governance systems. This does not prevent recognition from taking place, but it may limit the long-term security of recognised sites, especially where land-use pressure, development proposals, or changes in management priorities arise. A careful legal review is therefore needed to identify pathways for OECMs across Malaysia to be better supported without altering ownership, tenure, or existing governance rights.

Third, sustainable financing is not yet guaranteed. While the framework proposes expanding the Ecological Fiscal Transfer (EFT), which currently allocates RM250 million in 2026 for protected areas, to include OECMs, this has yet to be fully operationalised. Without dedicated financing, recognised sites may struggle to maintain monitoring, reporting, management, and community engagement activities over time. Other financing mechanisms, including conservation trust funds, ecotourism revenue, payment for ecosystem services, and corporate biodiversity contributions, may also be needed to support long-term implementation.

Fourth, Malaysia's federal structure requires careful state-level engagement. Conservation governance differs across Peninsular Malaysia, Sabah, and Sarawak, particularly in relation to land, forestry, water, wildlife, and Indigenous or customary governance systems. The national framework therefore needs to be applied flexibly, with room for state-level adaptation where necessary. This is especially important for community-governed sites and areas where biodiversity conservation is linked to customary practices, local livelihoods, and traditional ecological knowledge.

These challenges are consistent with wider global concerns about OECM implementation. Garcia *et al.* (2022), in their study of OECMs in marine capture fisheries, highlighted governance issues such as enabling frameworks, legitimate authorities, and cross-sectoral coordination as among the most critical challenges facing OECM recognition and implementation. For Malaysia, this means that the success of OECMs will depend not only on identifying suitable sites, but also on building the institutional capacity, legal and regulatory clarity, and financial support needed to sustain them.

Addressing these challenges requires a coordinated set of actions. The NF-OECM identifies five key strategies for strengthening implementation. The first is capacity building for government agencies, legal professionals, NGOs, private sector actors, and site managers

through training and awareness programmes. The second is strengthening governance quality using tools developed by the IUCN World Commission on Protected Areas. The third is improving management and monitoring through site-based teams and external technical support. The fourth is enhancing long-term recognition through a review of existing laws, policies, and other instruments for long-term security of the sites. The fifth is increasing financial support through mechanisms such as the EFT, conservation trust funds, ecotourism revenue, payment for ecosystem services, and corporate biodiversity offsets (NRES and UTM 2026).

The immediate way forward is therefore practical and achievable. A National OECM Roadshow should be carried out in every state to raise awareness, clarify misconceptions, and identify potential sites. The EFT guidelines should be amended to explicitly include recognised OECMs. A national legal review should identify minimal legislative or policy changes that can strengthen the recognition and long-term security of OECMs without changing or undermining existing rights and governance arrangements. At the same time, Malaysia should train and certify a pool of at least 20 to 30 OECM assessors to support the expected increase in applications. These steps would help move OECMs from framework development to active implementation.

CONCLUSION

Achieving Malaysia's commitment towards GBF Target 3 and NPBD Goal 3 will require more than the expansion of formal protected areas and should include OECMs by definition of the target. OECMs offer a pragmatic and inclusive pathway for recognising conservation efforts that are already taking place across different landscapes and seascapes, from community-managed fisheries and customary forests to corporate conservation set-asides and research forests. Their value lies not only in increasing Malaysia's conservation coverage, but also in making visible the contributions of communities, private land managers, public institutions, and other local stewards. Malaysia now has a National Framework for OECMS, but its real significance will depend on implementation. Success will require turning awareness into applications, administrative recognition into stronger legal and policy support, and short-term funding into sustainable financing. If these enabling conditions are strengthened, OECMs can contribute meaningfully to Malaysia's protected and conserved areas target while also supporting more inclusive governance, responsible land and seascape management, and the protection of the country's natural heritage for future generations.

REFERENCES

Alves-Pinto, H., Geldmann, J., Jonas, H., Maioli, V. and Strassburg, B. 2021. Opportunities and challenges of other effective area-based conservation measures (OECMs) for biodiversity conservation. *Perspectives in Ecology and Conservation* 19: 115–120.

CBD (Convention on Biological Diversity). 2018. *Decision 14/8: Protected areas and other effective area-based conservation measures*. Montreal: Secretariat of the Convention on Biological Diversity.

CBD (Convention on Biological Diversity). 2022. *Kunming-Montreal Global Biodiversity Framework*. Montreal: Secretariat of the Convention on Biological Diversity.

Chin, S.C. 1977. Shifting cultivation – A need for greater understanding. *Sarawak Museum Journal* 25(46): 107–128.

Chin, S.C. 1985. *Agriculture and Resource Utilization in a Lowland Rainforest Kenyah Community. Special Monograph No. 4*. Kuching: Sarawak Museum.

Cramb, R.A. 1993. Shifting cultivation and sustainable agriculture in East Malaysia: A longitudinal case study. *Agricultural Systems* 42(3): 209–226. https://doi.org/10.1016/0308-521X(93)90055-7

Fitzsimons, J.A., Hazin, C. and Smith, J.L. 2025. Common misconceptions of 'other effective area-based conservation measures' (OECMs) and implications for global conservation targets. *npj Biodiversity* 4: 8.

Garcia, S.M., Rice, J., Himes-Cornell, A., Friedman, K.J., Charles, A., Diz, D., Appiott, J. and Kaiser, M.J. 2022. OECMs in marine capture fisheries: Key implementation issues of governance, management and biodiversity. *Frontiers in Marine Science* 9: 920051.

IUCN (International Union for Conservation of Nature). 2024. *Guidance on other effective area-based conservation measures (OECMs)*. Gland: IUCN.

Jonas, H.D., Bingham, H.C., Bennett, N.J., Woodley, S., Zlatanova, R., Howland, E., Belle, E. *et al.* 2024. Global status and emerging contribution of other effective area-based conservation measures (OECMs) towards the '30x30' biodiversity Target 3. *Frontiers in Conservation Science* 5: 1456789.

Junk, W.J., Bayley, P.B. and Sparks, R.E. 1989. The flood pulse concept in river-floodplain systems. In *Proceedings of the International Large River Symposium*, D.P. Dodge (Ed.). *Canadian Special Publication of Fisheries and Aquatic Sciences* 106: 110–127.

Labrière, N., Laumonier, Y., Locatelli, B., Vieilledent, G. and Comptour, M. 2015. Ecosystem services and biodiversity in a rapidly transforming landscape in northern Borneo. *PLoS ONE* 10(10): e0140423. https://doi.org/10.1371/journal.pone.0140423

McClain, M.E., Boyer, E.W., Dent, C.L., Gergel, S.E., Grimm, N.B., Groffman, P.M., Hart, S.C., Harvey, J.W., Johnston, C.A., Mayorga, E., McDowell, W.H. and Pinay, G. 2003. Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems. *Ecosystems* 6(4): 301–312. https://doi.org/10.1007/s10021-003-0161-9

Mgumia, F.H., Jonas, H.D. and Woodley,, S. 2025. Sacred natural sites as other effective area-based conservation measures (OECMs) for biodiversity conservation in South Africa: Key opportunities and challenges for policy and practice. *Journal for Nature Conservation* 86: 126935.

Moore, J.H., Sittimongkol, S., Campos-Arceiz, A., Sumpah, T. and Eichhorn, M.P. 2016. Fruit gardens enhance mammal diversity and biomass in a Southeast Asian rainforest. *Biological Conservation* 194: 132–138. https://doi.org/10.1016/j.biocon.2015.12.015

NRES (Ministry of Natural Resources and Environmental Sustainability). 2026. *Malaysia - Seventh National Report*. Putrajaya: NRES.

NRES (Ministry of Natural Resources and Environmental Sustainability) and UTM (Universiti Teknologi Malaysia). 2026. *Developing a national framework for OECMs in Malaysia: Final report*. Putrajaya: NRES.

Padoch, C. 1982. Migration and its alternatives among the Iban of Sarawak. The Hague: Martinus Nijhoff. *Verhandelingen van het Koninklijk Instituut voor Taal-, Land- en Volkenkunde* 98.

Padoch, C. and Pinedo-Vasquez, M. 2010. Saving slash-and-burn to save biodiversity. *Biotropica* 42(5): 550–552. https://doi.org/10.1111/j.1744-7429.2010.00681.x

Petza, D., Amorim, E., Ben Lamine, E., Colloca, F., Dominguez Crisóstomo, E., Fabbrizzi, E., Fraschetti, S. *et al.* 2026. Unlocking the potential of other effective area-based conservation measures (OECMs) for achieving conservation targets: A global scoping review. *Ambio* 55: 210–228.

SEARRP (Southeast Asia Rainforest Research Partnership). 2022. *Recognising and reporting OECMs in Malaysia: Project report (October 2019 – September 2021)*. Kuala Lumpur: UNDP/GEF Small Grants Programme.

Vaz, J. and Agama, A.L. 2013. Seeking synergy between community and state-based governance for biodiversity conservation: The role of Indigenous and Community-Conserved Areas in Sabah, Malaysian Borneo. *Asia Pacific Viewpoint* 54(2): 141–157. https://doi.org/10.1111/apv.12015

Yahya, M.S., Atikah, S.N., Mukri, I., Sanusi, R., Norhisham, A.R. and Azhar, B. 2022. Agroforestry orchards support greater avian biodiversity than monoculture oil palm and rubber tree plantations. *Forest Ecology and Management* 513: 120177. https://doi.org/10.1016/j.foreco.2022.120177


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 747–769
doi: 10.62613/sonc2025.v3anc07

CHAPTER 7

High Conservation Value (HCV) approach in Malaysia

LISA LOK[1], DARSHANAA CHELLAIAH[1]*, SOPHIA CHONG[1], MELISSA CHIN[1] and SURIN SUKSUWAN[2]

Abstract: The High Conservation Value (HCV) approach has become an important tool for identifying, managing, and safeguarding areas of critical environmental and social importance within production landscapes. In Malaysia, HCV has been increasingly adopted across sectors such as forestry and oil palm, driven by certification schemes, corporate sustainability commitments, and evolving regulatory and market expectations. This chapter examines how the HCV approach has been applied in the Malaysian context, highlighting its role in conserving biodiversity, maintaining ecosystem services, and protecting areas of social and cultural significance. Drawing on a review of existing literature, policy and certification frameworks, and practical implementation experiences, the chapter assesses the conservation outcomes associated with HCV adoption in Malaysia, including contributions to ecosystem and biodiversity protection. It also reflects on persistent challenges faced, such as variability in implementation quality, limitations in monitoring and management effectiveness, and gaps in alignment with broader landscape-scale conservation objectives and national land-use planning. The analysis is informed by inputs from a range of relevant actors in Malaysia who apply the HCV approach in practice, including practitioners, companies, civil society organisations, and technical experts. These perspectives were consolidated to capture on-the-ground experiences, lessons learned, and emerging priorities. To ensure that the HCV approach continues to deliver meaningful and durable conservation outcomes in Malaysia, the chapter suggests some key pathways to strengthen HCV implementation in Malaysia, including improving governance and enforcement, enhancing technical capacity and data availability, fostering greater alignment with national conservation frameworks, and promoting landscape-level collaboration. Overall, the HCV approach has played a useful role in supporting conservation outcomes in Malaysia's rapidly changing landuse context, with scope for further strengthening to enhance long-term sustainability.

INTRODUCTION

Globally, only 17.6% of the world's land area is within recognised protected areas (UNEP-WCMC and IUCN 2024) leaving vast expanses vulnerable to conversion for commodity and agriculture production (Wilcove and Koh 2010; Giam 2017; Pacheco *et al*. 2021; Feurer *et al.* 2025). These landscapes often contain critical environmental and social conservation values that face significant risk from land-use change (Chellaiah and Yule 2018a; Koh and Wilcove 2008; Shukor *et al.* 2009; Dhandapani 2015; Pin and Tiong 2008). Safeguarding these values outside of legally recognised protected areas is essential to complement traditional conservation strategies, helping to protect crucial ecosystems, species, community livelihood and cultural in regions where production and conservation must coexist (Dudley *et al*. 2018; Styring *et al.* 2022; Jonas *et al*. 2024).

To address the challenge of identifying and managing critical environmental and social values in production landscapes—unprotected areas where economic activities, such as agriculture, livestock grazing, forestry or fishing, are conducted—the HCV approach was first developed in 1997 by the Forest Stewardship Council (FSC) and incorporated into its

[1] Proforest Southeast Asia, Unit 5-1, Tower B, The Vertical Business Suite, Avenue 3, Bangsar South, 59200 Kuala Lumpur, Federal Territory of Kuala Lumpur, Malaysia.
[2] c/o Sunda Shelves, No. 32 (1st floor, Jalan SS 20/10, Damansara Kim, 47400 Petaling Jaya, Selangor
***Corresponding author: darshanaa.chellaiah@proforest.net**

Principles & Criteria (P&Cs) in 1999 (FSC 2006). The HCV approach complements formal conservation mechanisms such as Protected Areas by identifying and safeguarding critical ecological and social values that may occur outside legally designated reserves. Unlike Environmental Impact Assessments (EIA) and Social Impact Assessments (SIA), which primarily evaluate potential impacts of specific projects, the HCV process focuses on proactively identifying areas of high environmental or social importance to guide responsible land-use decisions.

Over the past two decades, the HCV approach has been widely adopted by sustainability certification schemes in forestry, agriculture, and bioenergy sectors, reinforcing global efforts to embed conservation into commodity supply chains. However, implementation quality and consistency vary significantly across regions and sectors. Understanding how the HCV approach has been applied in Malaysia provides valuable insights into balancing economic development with biodiversity conservation and sustainable land management. This chapter explores Malaysia's experience with the HCV approach, highlighting observed outcomes, persistent challenges, and opportunities for scaling credible and effective implementation. The analysis draws on a literature review, the authors' own observations, and consultations with relevant stakeholders, allowing the chapter to reflect diverse perspectives and remain firmly grounded in practical experiences.

WHAT IS THE HCV APPROACH?

The HCV approach is a globally recognised framework designed to integrate biodiversity and social safeguards into land-use planning and production landscapes (Brown and Senior 2014; Areendran *et al.* 2020). Most HCV areas are located in relatively remote production landscapes such as plantations and forest reserves. It recognises six categories of HCVs, that encompass biodiversity, landscape-level ecosystems, rare or threatened habitats, ecosystem services, community livelihoods, and cultural values of outstanding significance.

These categories provide a common language to guide responsible land-use decisions across sectors and jurisdictions (Figure 1). By focusing on the values that are most critical to conserve, the HCV approach helps reconcile production and conservation objectives. It enables companies and land managers to avoid or minimise impacts, maintain essential ecosystem functions such as riparian protection and slope stability, and respect community livelihoods and cultural heritage. As a result, HCV has become an anchor for responsible land-use planning in the forestry, agriculture, and related sectors.

Core process

The HCV approach follows three connected steps (Figure 2):

1. Identification

Desktop review, field surveys, and stakeholder engagement are combined to locate HCVs, determine their attributes, and understand threats and dependencies.

2. Management

Measures are designed to maintain or enhance the identified values. This includes clear objectives, roles, timelines, and integration into operational planning and estate or FMU management systems.

3. Monitoring and Adaptive Management[a]

Indicators are used to track change in the values over time. Results inform iterative adjustments to management so that protection remains effective under evolving ecological and social conditions.

[a] HCV Management and Monitoring typically incorporates buffer zones and, where necessary, additional areas within the HCV Management Area to help maintain HCVs and reduce potential edge effects.

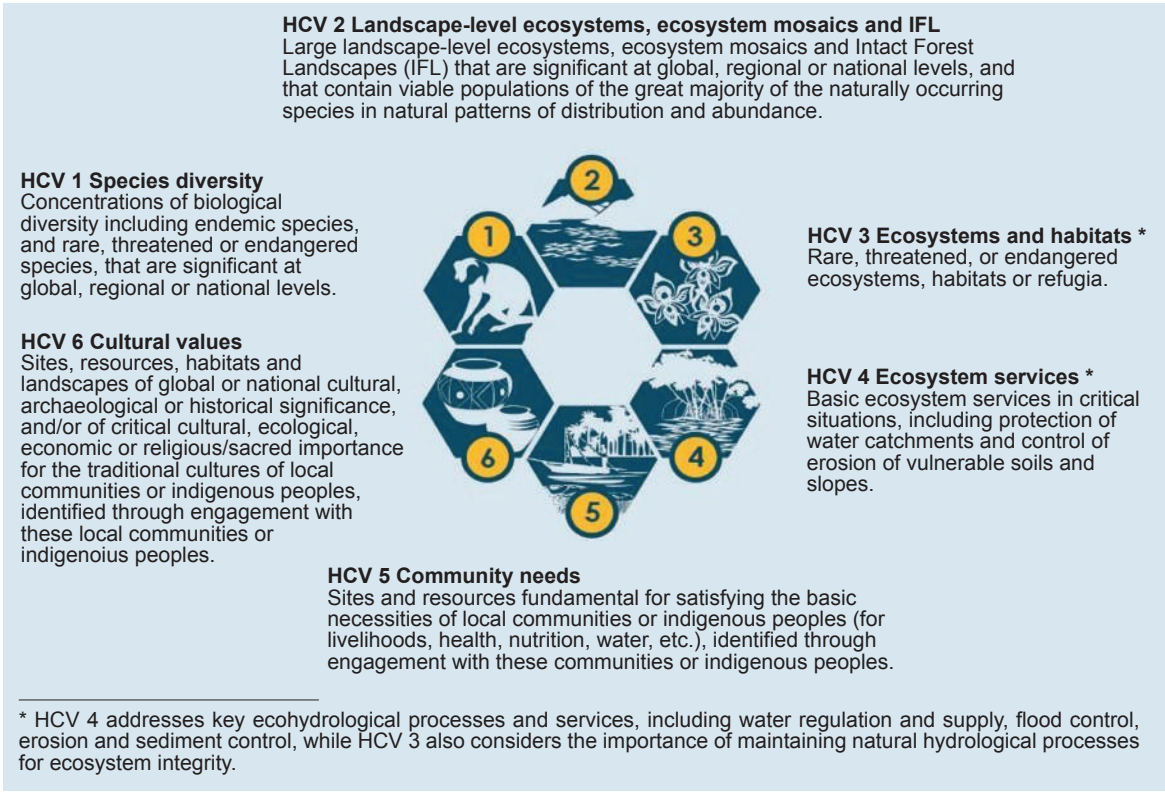


Figure 1. The six High Conservation Values.
(Source: Common guidance for identification of HCV, Brown *et al.* 2013)

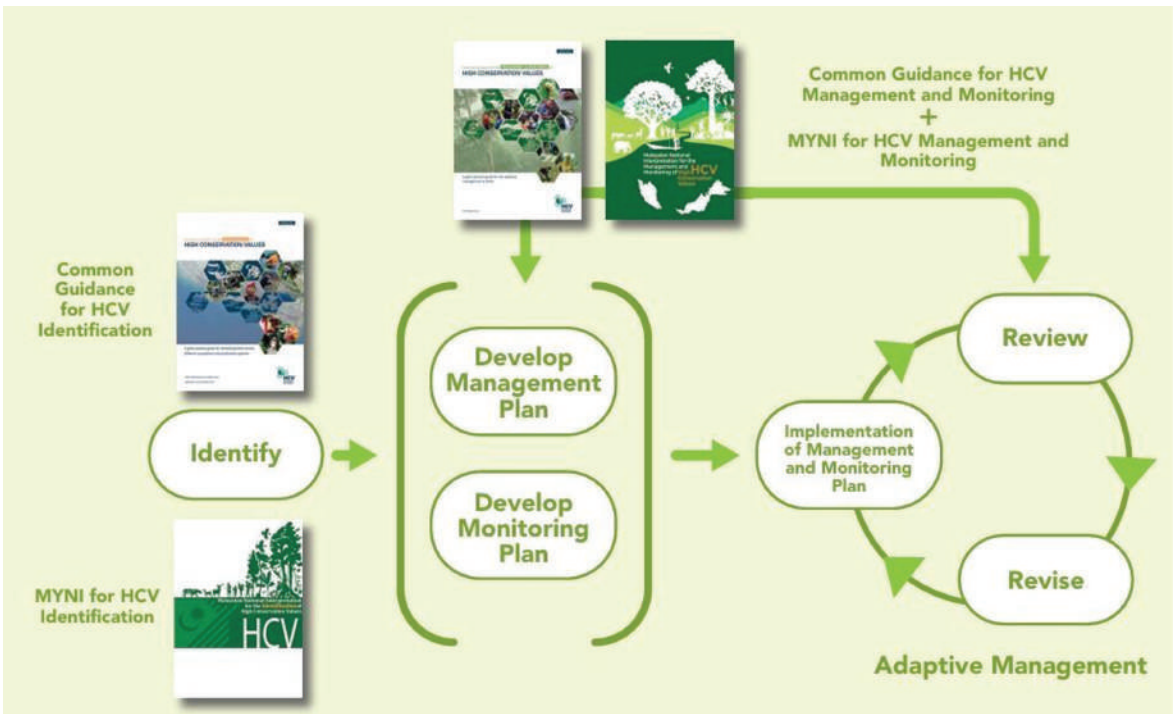


Figure 2. Key steps of the HCV Approach including the relevant guidance documents to be consulted at the various stages of the process. (Source: HCV Malaysia Toolkit Steering Committee 2021, as adapted from Brown and Senior 2014)

People and knowledge
Stakeholder participation is integral throughout the process. The approach brings together scientific data, expert judgement, and local knowledge, including traditional ecological knowledge, to ensure that management reflects real conditions and priorities. Where Indigenous Peoples and local communities are affected, Free, Prior, and Informed Consent (FPIC)[a] principles apply to uphold rights and support legitimate decision-making.

Origins and guidance
The HCV approach was incorporated into a certification for the first time when FSC adopted it as part of the first FSC standards in 1999, making the forestry sector a pioneer of the HCV uptake both globally and in Malaysia. To support consistent implementation, the *HCV Global Toolkit* was developed in 2003 (Jennings *et al.* 2003). In 2006, the HCV Resource Network (now HCV Network, HCVN) was established to promote and expand the adoption of the HCV Approach through a common set of tools, guidance and standards.

In Malaysia, the approach was first adapted for forestry through the High Conservation Value Forest (HCVF) Toolkit (WWF 2009) and later superseded by the Malaysian National Interpretation (MYNI) for HCV Identification (HCV Malaysia Toolkit Steering Committee 2018) and for HCV Management & Monitoring (HCV Malaysia Toolkit Steering Committee 2021). These tools provide guidance to ensure that HCV principles are applied effectively across diverse landscapes.

ADOPTION OF THE HCV APPROACH IN MALAYSIA

The adoption of the HCV approach in Malaysia has evolved over the past two decades through certification systems, national and state policy frameworks, and, more recently, financial sector requirements. These mechanisms have shaped how government agencies, private companies, and land managers integrate HCV identification, management, and monitoring into land-use planning.

Sustainability certification and frameworks
In Malaysia, the adoption of the HCV approach has been strongly influenced by the historical expansion and continued economic importance of the forestry and oil palm sectors (WWF-Malaysia 2009), driven primarily by the uptake of voluntary certification schemes (VCS) that incorporate HCV, particularly those linked to export-oriented commodity markets. Certification requirements incentivise private sector actors to identify, manage and monitor areas of high ecological, social and cultural-significance that are crucial for biodiversity conservation, ecosystem functioning, climate regulation and community wellbeing amid growing land-use pressures.

Pioneering with the early FSC standards, one of the most significant drivers of HCV adoption in Malaysia has been compliance with voluntary and international certification schemes. The Malaysian Timber Certification Scheme (MTCS) and the Roundtable on Sustainable Palm Oil (RSPO) both require companies to identify and manage HCVs before undertaking activities such as converting land for production or replanting and more recently the Malaysian Sustainable Palm Oil (MSPO) as well. In addition, other global voluntary certification schemes across various commodities, including the International Sustainability and Carbon Certification (ISCC), Roundtable for Responsible Soy (RTRS), Roundtable on Sustainable Biomaterials (RSB), Bonsucro, and Rainforest Alliance (RA), require their members to safeguard HCV areas as part of standard due diligence. Together, these certification systems have promoted the protection of HCV areas among private sector actors in Malaysia.

[a] FPIC is a crucial rights-based principle recognising Indigenous Peoples' right to self-determination, allowing them to give or withhold consent for activities affecting their lands, resources, and culture, as outlined in the UN Declaration on the Rights of Indigenous Peoples (UNDRIP).

Government initiatives & policy

The HCV approach has been increasingly adopted and implemented from state-wide and national levels (Table 1). It was first incorporated into Malaysia's Policy on Forestry in 1999, where HCV assessments were made as a requirement for forest management certification under the Malaysian Criteria and Indicators for Forest Management Certification (Natural Forests) (Ministry of Energy and Natural Resources 2021). Later, it was included as Principle 9 in the Malaysia Criteria and Indicators for Forest Management Certification (MC&I), developed by the Malaysian Timber Certification Council (MTCC). The Malaysian Timber Certification Scheme (MTCS) made MC&I standard compliance mandatory ensuring all MTCS-certified forests undergo HCV assessments at the Forest Management Unit (FMU) level.

Table 1. HCV adoption across governing policies across Malaysia.

Year	Action / Adoption	Level	Voluntary/Mandatory
1999	HCV was introduced as a requirement for forest management certification under the Malaysian Criteria and Indicators for Forest Management Certification (Natural Forests).	National	Voluntary requirement for certification under the Malaysian Criteria and Indicators for Forest Management
2002	MC&I 2002 developed by MTCC; Principle 9 includes HCV	National (forestry)	Voluntary (applies if seeking MTCS certification)
2021	MTCS applies MC&I standards across FMUs	National certification (forestry)	Mandatory for MTCS-certified forests
2025	MSPO includes HCV requirements as mandatory compliance	National certification (palm oil)	Mandatory nationwide
2022–2030	NPBD explicitly references HCV as a management tool (Targets 5 & 6)	National policy	Voluntary (policy guidance; not legally enforceable, but encourages adoption across sectors)
Recent / ongoing	Sabah Jurisdictional Certified Sustainable Palm Oil (Sabah JCSPO)[b] in Sabah promotes jurisdictional RSPO certification, HCV/HCS integration	State-level / sectoral implementation	Variable

Note: This table highlights some milestones in the adoption of High Conservation Value (HCV) approaches in Malaysia. It is not exhaustive, and other initiatives, regional programs, or sector-specific applications may exist beyond those listed.

[b] Sabah Jurisdictional Certified Sustainable Palm Oil (Sabah JCSPO) is a Sabah Government commitment with the vision of achieving 100% compliance of sustainability standards for oil palm across the entire state of Sabah to transform Sabah's palm oil production and supply chain, halt deforestation, restore ecosystems and secure livelihoods.

In the palm oil sector, MSPO's certification scheme has made HCV assessments a mandatory nationwide requirement (MSPO 2025) to align with global market expectations. These initiatives have raised local awareness and created a baseline expectation for responsible land management within the forestry and palm oil sector nation-wide including for small and medium-sized producers.

Certification schemes that require HCV assessments vary in their overall approaches, implementation practices, and system structures. Many are further adapted to local contexts, adding additional layers of complexity and variation. Nevertheless, these schemes remain united in their underlying intent for responsible production, all of which are anchored in internationally recognised HCV principles.

Federal-level policy frameworks have also begun to reference the HCV approach more explicitly. The National Policy on Biological Diversity (NPBD) 2022-2030 (Ministry of Natural Resources and Environmental Sustainability 2022) positions HCV as a tool to strengthen forest governance (Target 5) and support sustainable agro-commodities (Target 6). Its inclusion signals formal national recognition of the approach and opens opportunities for wider application across sectors that drive land-use change beyond forestry and palm oil.

At the state level, Sabah and Sarawak have taken the HCV approach further through a state-wide HCV mapping exercise with the intention to support state-wide land use planning (Ng *et al.* 2022). This would support consistent identification and protection of HCV areas across the state, including landscapes beyond the current certified operations. In addition, ongoing HCV-related initiatives in Sabah contribute to broader jurisdictional sustainability efforts under mechanisms such as Sabah JCSPO, helping to inform landscape-level planning and decision-making in a more systematic and coordinated manner.

Influence of financial sector standards

The financial sector is playing an increasingly important role in shaping how the HCV approach is implemented in Malaysia. Banks and investors are beginning to recognise that biodiversity loss and ecosystem degradation pose material risks to business operations, supply chains, and long-term financial stability. This shift is influenced by global frameworks such as the Taskforce on Nature-related Financial Disclosures (TNFD), the Equator Principles, the International Finance Corporation (IFC) Performance Standards, and the Kunming–Montreal Global Biodiversity Framework, all of which emphasise the need for financial institutions to address nature-related risks within their portfolios (UNEP Finance Initiative 2023).

In Malaysia, Bank Negara Malaysia (BNM) has been an early mover in this space. Its joint study with the World Bank (Bank Negara Malaysia and World Bank 2022) highlighted the financial sector's exposure to nature-related risks and positioned biodiversity loss as a factor that could affect national financial resilience. As Malaysia updates its National Biodiversity Strategy and Action Plan, financial regulators are expected to integrate biodiversity considerations more directly into supervisory expectations and guidance for the banking sector (Malaysian Building Society Berhad Bank, n.d.).

In response, several Malaysian banks have begun incorporating HCV safeguards into their lending and investment processes such as CIMB Bank Berhad and Malaysia Building Society Berhad (MBSB) Bank. For example, CIMB's sectoral guidelines for palm oil, forestry, mining and manufacturing explicitly integrate HCV considerations into lending requirement and sustainability due diligence (CIMB 2024). Similarly, MBSB Bank, applies an ESG exclusion framework in its corporate financing that prohibits financing for new estates or projects that convert or degrade of HCV / High Biodiversity (HBV) and High Carbon Stock (HCS) forests, primary forests, forest reserves and peatland.

Overall, the growing integration of nature-related risks within financial systems is strengthening the incentive for companies to adopt the HCV approach and improving the consistency with which HCV safeguards are applied across sectors.

CONSERVATION BENEFITS AND CASE STUDIES IN MALAYSIA

The HCV approach has been reported to be an effective tool for delineating conservation priority areas and help mitigate the extraction of natural resources (Areendran *et al.* 2020). The protection of high value areas such as riparian buffers, forests within oil palm estates, peat domes, and steep-slope forests form a mosaic of protected spaces that helps to maintain ecological connectivity, safeguard species and preserve key ecosystem services (Luke *et al.* 2017; Chellaiah and Yule 2018a, 2018b; Syahza *et al.* 2020). From the information gathered from HCVN, a total of 12,471.94 hectares of high-value areas in Malaysia have been identified and placed under conservation management through HCV Assessor Licensing Scheme (HCV ALS)[c] assessments.

Industrial stakeholders also agree that the adoption of HCV through the voluntary certification schemes (VCS) approach has been largely deemed as successful not only in safeguarding key areas within the production landscapes, in line with their sustainability commitments, but also to safeguard potential reputational risks. Similarly, non-governmental organisations report that through the HCV approach for VCS, companies as well as a growing number of smallholders have greater conservation awareness, promoting more sustainable and inclusive agricultural practices. For example, as of 2024, RSPO-linked HCV assessments have identified 22,087 ha HCV areas managed throughout Malaysia (RSPO 2025). Although these areas are primarily within oil palm landscapes that are often ecologically simplified and supports fewer species, they still harbour key high-value ecological areas that are crucial to ecosystem functioning, climate regulation and community well-being (Chellaiah and Yule 2018b; Styring *et al.* 2022). It provides a stepping stone that enhance connectivity across the wider landscape, further supporting biodiversity and ecosystem services. However, HCV service providers and NGOs have commented that relying mainly on voluntary mechanisms may limit the overall conservation impact and significant conservation efforts are still needed.

The HCV approach emphasises the identification and protection of key ecological, social and cultural values within the landscape, prioritising not only large or contiguous sites but also safeguards critical values that might otherwise be overlooked. Some sites may be relatively small, yet they can be a refugium hosting endemic as well as species or ecosystems features of significant conservation importance. A case in point is *Tomistoma schlegelii* (the false gharial), one of the largest yet least-known crocodilian species assessed to be at risk of extinction in Peninsular Malaysia (Stuebing *et al.* 2006). Unexpectedly, an HCV assessment in an existing (largely mature) oil palm estate in Terengganu, in northeastern Peninsular Malaysia, identified the presence of this crocodilian species within the plantation (PT Hijau Daun 2019). This underscores how HCV assessments can identify and protect values in small or fragmented areas that conventional biodiversity surveys would otherwise miss, perhaps due to difficulty in accessing production areas (which are mostly privately-owned or under long-term concessions) compared to legally constituted conservation areas.

[c] The HCV Assessor Licensing Scheme (HCV ALS) is the quality-assurance system managed by the High Conservation Value Network (HCVN) to ensure that HCV assessments are conducted by licensed assessors and reviewed against global standards. Only assessments recorded by HCVN submitted through the ALS are formally recorded by HCVN.

There is also emerging evidence from site-level documentation (Demies *et al.* 2015; HCV Malaysia Toolkit Steering Committee 2018; Mohd-Azlan *et al.* 2019; Mohd-Azlan and Ahmad Puad 2023) and highlighted case studies (see below), which indicate environmental and social benefits through the implementation of the HCV approach. These case studies from across Malaysia include the key values identified, conservation benefits, potential threats as well as management and monitoring efforts. They demonstrate how the HCV approach, when effectively implemented, offers a practical mechanism for balancing commodity production with biodiversity conservation and community well-being, ensuring also that threat is minimised, managed and monitored.

Additionally, stakeholders also emphasise how the HCV approach provides them with a systematic framework to integrate responsible forest management into larger landscape-level planning and protection efforts. It helps them to strengthen stakeholder trust and relationships, particularly with local communities and relevant stakeholders by demonstrating that ecological, social and cultural values are actively respected and protected. The process also provides valuable opportunities for capacity building and skill development among FMU holders and government officers, enhancing technical competence and supporting more effective implementation of conservation and management measures in production forests, which has strengthened the state's broader conservation objectives.

Case study: Wilmar - Sekar Imej Conservation Area (SICA)

Location: Paitan district, Sabah

Characteristics: Lowland mixed dipterocarp forest, hilly terrains with steep slopes.

Background: HCV areas were first identified as part of RSPO certification requirements. SICA is Wilmar's largest conservation area within its operations in Malaysia, spanning a total of 2,469 ha and approximately 68% of the Sekar Imej estate (Figure 3).

Importance: SICA holds a significant amount of biodiversity with a total of 82 species of fauna listed as protected under Sabah's Wildlife Conservation Enactment 1997, and 20 mammals on the IUCN Red List. SICA remains a sanctuary for many rare, threatened, and endangered (RTE) species including the Sunda pangolin (*Manis javanica*), Sunda clouded leopard (*Neofelis diardi*), North Borneo gibbon (*Hylobates funereus*), sun bear (*Helarctos malayanus*) and more, demonstrating its established role as a key refuge from external anthropogenic pressures. SICA also plays a vital role in controlling soil erosion and providing clean water supply to the surrounding region and local communities.

Identified HCVs:
- HCV 1: High concentrations of RTE species.
- HCV 2: Intact forest landscapes within the SICA area that support viable populations of species in their natural distributions.
- HCV 3: Freshwater swamp, flood plain and riverine ecosystem.
- HCV 4: Riparian buffers, steep slopes and existing dry lowland forest on steep hills.

Threats: Poaching, degazettement of surrounding forest reserves that reduces the overall connectivity to SICA, and expansion of community land use overlapping with HCV-designated areas.

Management & Monitoring: These HCV areas are actively managed and regularly monitored by Wilmar's HCV team, which also consists of honorary wildlife wardens from the local community. They use methods such as camera trapping and patrolling to safeguard and monitor the biodiversity present and maintain compliance with conservation policies. Other efforts include community engagements and programs such as the Wildlife Awareness Outreach Program (WAOP) to enhance conservation knowledge, foster a sense of ownership, and instil responsibility for protecting forests and the environment.

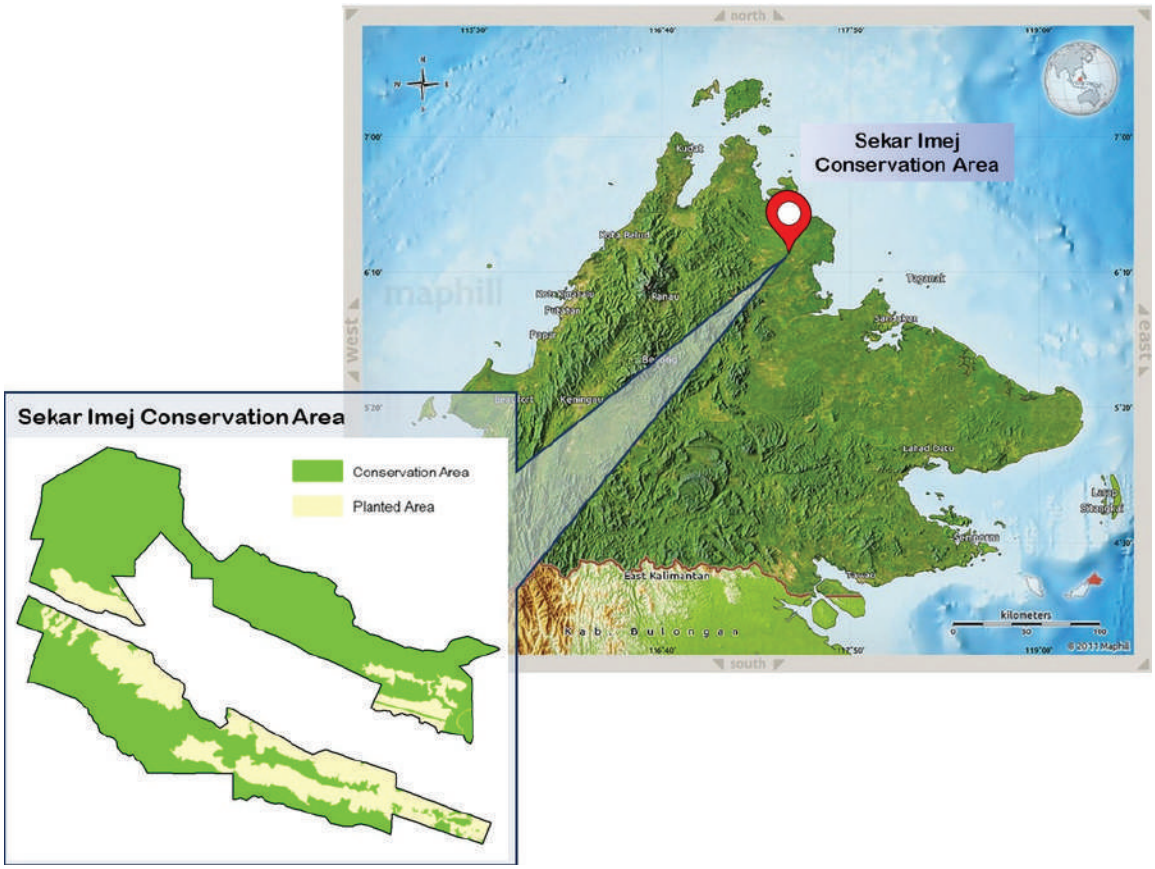


Figure 3. Location of Wilmar's Sekar Imej Conservation Area (Source: sica-vol-01-newsletter.pdf).



Figure 4. SICA rangers patrolling by foot.



Figure 5. Signboard indicating HCV area.



Figure 6. Conservation officer engaging with local communities and explaining the educational materials during the awareness session.

Contributors: Wilmar Plantations Sdn Bhd Management, James Wong and Chua Wan Ji

Case Study: SD Guthrie – Bukit Kiab, Kerdau Estate

Location: Temerloh district, Pahang

Characteristics: Isolated lowland dipterocarp forest; hilly terrains with steep slopes and ravines.

Background: The Kerdau Estate (formerly known as Jentar Estate) contains three main hills (Bukit Pasir, Bukit Angin, and Bukit Kiab) with 160 ha, consisting of >25º slopes and deep ravines. Bukit Kiab (226 m a.s.l.) has a total HCVA area of 59 ha of which 24 ha still contain natural vegetation (forest) that helps stabilise steep slopes and protect the surrounding landscape from erosion.

Importance: This area was financially sponsored by Yayasan Sime Darby (RM 4.1 million) for a tree planting project between 2013 and 2018 to support the restoration of these hills. A total of 126 tree species, mostly from the family Dipterocarpaceae such as *keruing* (*Dipterocarpus* spp.), *meranti* (*Shorea* spp.), *merawan* (*Hopea* spp.) and *resak* (*Vatica* spp.), have been planted and maintained within a 136 ha area, including 35 species that are classified as Critically Endangered (CR), 17 categorised as Endangered (EN), and eight listed as Vulnerable (VU), based on the IUCN Red List of threatened species. Its restoration has become a key focus for partnerships and funding support, strengthening the estate's overall environmental resilience.

Identified HCVs:
- HCV 4: Erosion control, stabilisation of steep slopes, reduction of soil loss across hilly terrain and other indirect ecosystem services.

Threats: Erosion or slope destabilisation (if vegetation cover is disturbed, particularly on steep gradients and ravines), accidental encroachment from estate operations, natural competition and pests impacting the survival and regeneration of planted RTE species, and illegal collection or unauthorised access.

Management & Monitoring: Management and monitoring actions include safeguarding vegetation cover, preventing encroachment, and maintaining the natural condition of the restored and regenerating hills. While earlier phases involved active planting and establishment, the area is now allowed to grow wild, enabling natural processes to

take over and strengthen long-term ecological resilience. The estate team continues to monitor boundaries and sensitive zones. Wildlife monitoring is supported through camera trap deployments. Periodic field inspections, slope observations, and reviews of wildlife data guide adaptive management and reinforce the protection of this hilly ecosystem.

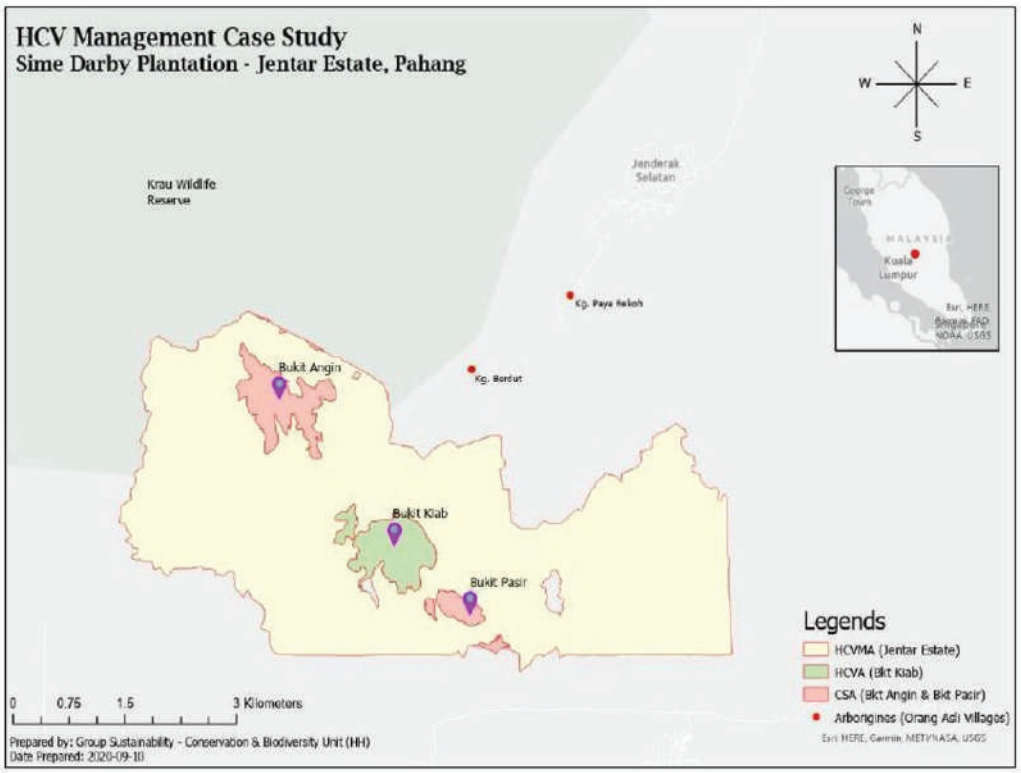


Figure 7. Map of SD Guthrie's Kerdau Estate and Bukit Kiab (HCVA) (Source: late Mohd Hafiz Hishammuddin).



Figure 8. The view of Bukit Kiab (Source: Nur Aida Ab Ghani).



Figure 9. *Merawan Siput Jantan* (*Hopea odorata*), one of the species planted at Bukit Kiab (Source: Nafiz Zainal Abidin).

Contributors: Nur Aida Ab Ghani, SD Guthrie

Case Study: Sabah Forestry Department – Deramakot Forest Reserve (DFR)

Location: Kinabatangan and Tongod districts, Sabah

Characteristics: Lowland dipterocarp forest (including extreme lowland dipterocarp forest), seasonal freshwater swamp, heath forest and ultramafic/ultrabasic forest.

Background: Deramakot Forest Reserve (DFR) is globally recognised as the first natural tropical forest to achieve the Forest Stewardship Council (FSC) Certification in 1997, with HCV areas first identified in 2014. It is a Class II commercial forest reserve that is managed by the Sabah Forestry Department with the whole of DFR (55,507 ha) categorised as HCV areas.

Importance: DFR is ecologically significant as it serves as an ecological corridor linking the Ulu Segama Malua (USM) Forest Reserve, Tangkulap Forest Reserve and surrounding Forest Management Units (FMUs). It is also located within the "Heart of Borneo" (HoB), which is a transboundary rainforest region spanning across Brunei, Indonesia and Malaysia. A total of 435 plant species and 430 faunal species have been recorded in DFR through HCV assessments and previous studies. DFR is home to many IUCN Threatened species and endemic species, e.g. Bornean orangutan (*Pongo pygmaeus*), banteng (*Bos javanicus*), *meranti* tree (*Shorea leptoderma*) and broad-stem pili nut tree (*Canarium latistipulatum*). Additionally, DFR plays a vital role in controlling soil erosion and providing clean water supply, especially to the local communities in the vicinity which utilise the rivers flowing from within DFR to Sg. Kinabatangan. These rivers also serve as essential fishing grounds for the local communities.

Identified HCVs:
- HCV 1: The entire Deramakot Sustainable Forest Management (SFM) Project area is categorised as HCV 1.
- HCV 2: The entire Deramakot SFM Project area is categorised as HCV 2.
- HCV 3: The entire Deramakot Forest Reserve (55,507 ha) is classified as High Conservation Value 3.
- HCV 4: Compartments 52, 108 and 109, as well as 30 m buffer areas on both sides of the permanent waterways within DFR.
- HCV 5: Durian orchard in Compartment 88 and the identified rivers directly feed into the major Kinabatangan River are categorised as HCV 5 in DFR.
- HCV 6: There is no HCV 6 within DFR.

Threats: Across all HCV categories, the main threats are forest fires, encroachment from land clearing, forest simplification, wildlife poaching, and the spread of invasive species.

Management & Monitoring:
i. Research and evidence-based action (establish R&D program to support HCV management, monitoring, enforcement and restoration);
ii. Conduct Landscape-scale Forest Monitoring (combine multi-source remote sensing; conduct systematic ground-truthing and field verifications; implement automated change-detection alerts to prioritise responses);
iii. Conduct RTE/ecosystem monitoring (establish network of plots stratified by ecosystem type and record species composition, DBH, canopy cover, recruitment, mortality to detect structural/floristic shifts; carry out Forest Integrity Assessment audits);

iv. Conduct RTE species monitoring (use appropriate monitoring methods such as camera traps, line-transect surveys, etc.; standardise sampling effort and analysis to estimate abundance, occupancy and habitat use; partner with universities, research institutions and NGOs for studies and capacity building);
v. Ecosystem services monitoring (regular monitoring of river health, above ground biomass (supported by remote sensing/LiDAR where feasible) and NTFP use (via social surveys/structured interviews documenting species use, harvest levels and community dependency));
vi. Undertake cross-cutting actions (adopt standard protocols and a centralised data management system; regular reporting cycles and predefined ecological/social thresholds that trigger management actions; integrate community engagement and staff training; prioritise short-term feasibility studies, then medium-term monitoring to inform adaptive management, enforcement targeting and restoration planning)

These HCV areas are actively managed and regularly monitored by the DFR management team through landscape-scale forest monitoring using satellite imagery, drones, and ground verification; permanent vegetation plots to track forest condition and biomass; and regular Forest Integrity Assessments. Monitoring of RTE species, including banteng and orangutan, is conducted using camera-trap grid systems, line-transect surveys, and standardised monitoring cycles. Ecosystem services are monitored through regular water-quality and sedimentation sampling, community engagement on NTFP use and river dependency, and periodic assessments to inform adaptive management, enforcement, restoration planning, and implementation of Reduced Impact Logging (RIL) v3 during harvesting.

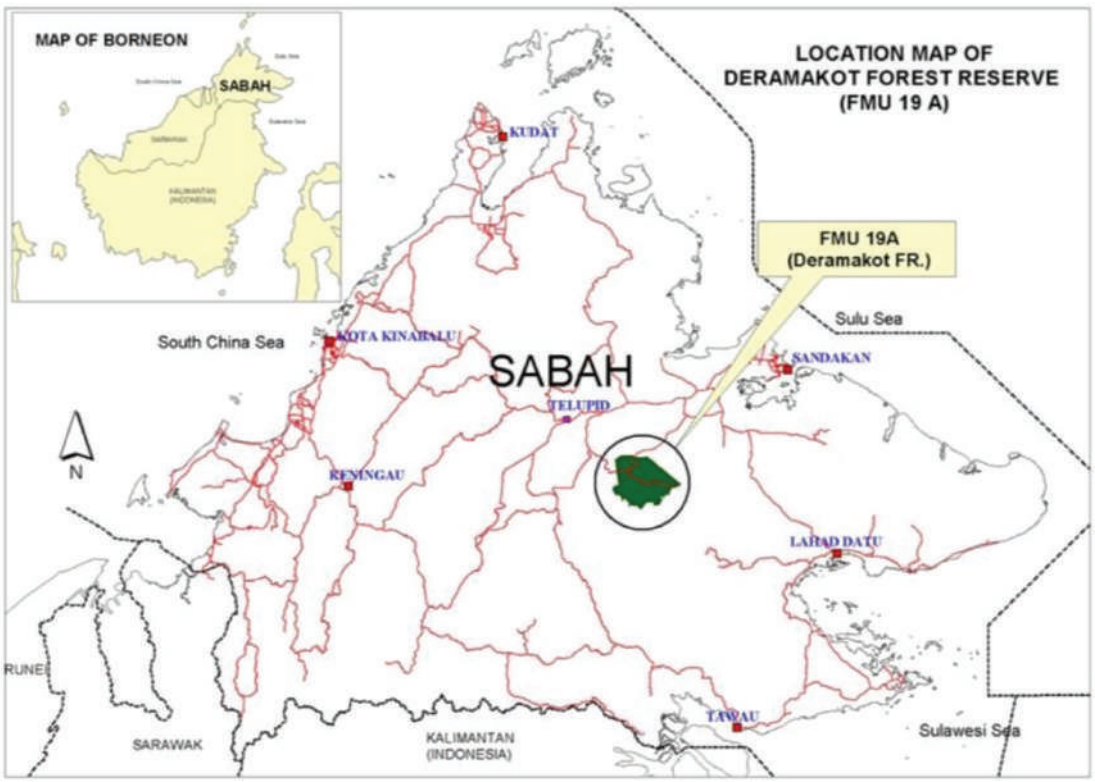


Figure 10. Location of Deramakot Forest Reserve
(Source: Sabah Forestry Department).

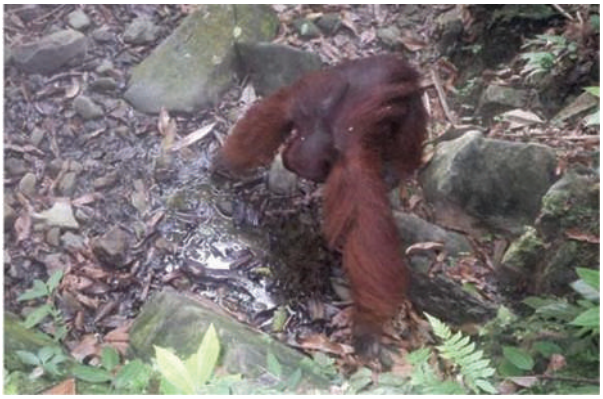


Figure 11. Camera trapped adult-male orangutan at a natural saltlick in DFR (Source: Matsubayashi *et al.* 2006).



Figure 12. NTFP collection (young rattan shoots) by local communities as a food source (Source: Proforest 2025).

Contributors: Sabah Forestry Department and Proforest

CHALLENGES OF THE HCV APPROACH IN MALAYSIA

While the HCV approach is widely recognised as a practical framework for integrating conservation into production landscapes, its implementation in Malaysia continues to face several systemic and operational challenges. These challenges span across governance limitations, uneven uptake across sectors, data and capacity gaps, and coordination barriers that collectively undermine the consistency, quality, and long-term effectiveness of HCV implementation.

Governance and legal mandate gaps

Despite policy signals through the NPBD 2022-2030, implementation remains the core challenge. The NPBD does not specify how HCV approach will be further operationalised, as there are no details of implementation guidelines, timelines, or assignment of statutory responsibilities including the legal recognition of HCV areas. In practice, and as echoed by many stakeholders, HCV uptake is still driven largely by voluntary mechanisms such as certification and industry-led No Deforestation, No Peat, and No Exploitation (NDPE) commitments, with MSPO standing out as the key exception that mandates HCV assessments in the palm oil sector.

In the absence of a formal legal mandate and a comprehensive policy framework to designate, manage, and monitor HCV areas across jurisdictions (including procedures for standardised implementation and remedies for non-compliance), long-term stewardship remains uncertain. This creates a critical protection gap whereby HCV areas are identified and safeguarded mainly where organisations voluntarily participate in sustainability initiatives, rather than through a uniform, nationwide system.

Barriers to sectoral scaling

Stakeholders highlighted that scaling HCV implementation across Malaysia's diverse commodities and land uses remains challenging. At present, uptake is heavily concentrated in the oil palm and timber sectors, largely driven by voluntary certification schemes. Extending the approach to other land-use sectors introduces additional complexity, as many lack established sustainability standards, technical guidance, or institutional familiarity with HCV requirements.

Stakeholders also noted that the HCV assessment and management process is resource-intensive, requiring significant time, technical expertise, and financial investment. These demands pose difficulties for small and medium enterprises (SMEs) and smallholders, who often operate with limited workforce capacity, technical knowledge, and access to external support. Without targeted assistance and practical tools, these constraints can discourage participation, lead to superficial compliance, and make it harder to maintain management and monitoring over time.

Data and information constraints

Stakeholders highlighted that data-related limitations hinder the quality, consistency, and long-term evaluation of HCV implementation in Malaysia. These challenges manifest in two distinct but interconnected ways.

Firstly, there is a lack of accessible, high-quality ecological and social data across Malaysia, which makes it challenging to conduct effective HCV assessments. Community -level data is often undocumented, making it difficult to integrate local perspectives systematically into assessments. These gaps require assessors and subject matter specialists to rely heavily on field surveys, expert judgement, and ad-hoc information sources, contributing to inconsistencies in assessment quality.

Secondly, Malaysia lacks a centralised database for HCV-related information, which significantly limits the ability to evaluate the overall effectiveness and long-term impacts of the HCV approach. At present, most data are held by individual organisations such as HCVN, RSPO, or private companies, with only fragments of information publicly available through certification systems or company disclosures. Stakeholder consultations also highlighted that HCVN maintains only a repository of HCV ALS reports (Table 2) leaving the majority of non-ALS assessments and other implementation data whether generated for certification or conservation initiative undocumented in any national system, resulting in the true extent of conserved HCV areas in Malaysia being under-reported, whether for certification purposes, or conservation initiatives. This fragmentation makes it difficult to determine where HCVs have been identified, how they are being managed, and what outcomes have been achieved. As a result, government agencies, researchers, and civil society are unable to gain a comprehensive picture of the status, performance, or cumulative conservation contributions of HCV implementation across Malaysia.

Table 2. HCV areas identified through HCV ALS assessments for oil palm plantations (Source: HCVN).

Location	Total Conservation area (ha)	HCVs Found	Required by	Year	Reference
Miri, Sarawak	4,717.82	1,4,6	RSPO NPP	2016	a
Tawau, Sabah	5,439.4	1,2,4,5	RSPO	2016	b
Pahang	0.6	4	RSPO NPP	2019	c
Kelantan, Pahang	67.4	1,4, potential 2	RSPO NPP	2018	d
Terengganu	2,246.72	1,2,3,4	MSPO	2019	e

[a] https://www.hcvnetwork.org/reports/felda-global-venture-miri-division-sarawak-state-malaysia
[b] https://www.hcvnetwork.org/reports/ben ta-wawasan-sabah-malaysia
[c] https://www.hcvnetwork.org/reports/hcv -chegar-perah-02-estate-bukit-sagu-08estate-tembangau-05 -estate-selendang03-estate-malaysia
[d] https://www.hcvnetwork.org/reports/hcv-kuala-gris-estate-and-kemasul-estatekuala-lumpur-kepong -berhad-malaysia-2
[e] https://www.hcvnetwork.org/reports/high-conservation-value-full-assessmentladang-rakyat-estate -terengganu-malaysia

The authors also observed that findings from company-commissioned HCV assessments are seldom integrated into scientific research, biodiversity databases, or policy planning exercises. As a result, valuable datasets such as species records, habitat assessments, and connectivity analyses remain under-utilised and largely invisible within broader conservation decision-making. This disconnect reinforces existing data gaps and reduces opportunities to generate landscape-level insights.

Competency and capacity considerations for HCV assessors

A key challenge observed by the authors is the difficulty in translating biodiversity data such as species richness, distribution, and population trends into practical conservation measures within the HCV Management and Monitoring Plan. This is due to limited awareness and technical competency among some HCV assessors and subject matter experts, resulting in inconsistent assessment quality and technical reports that do not adequately translate scientific findings into actionable strategies. Furthermore, stakeholders have also reported that operational teams often struggle to implement these plans due to the disconnect between conservation concepts and field-level practices. Within company conservation departments, limited technical capacity and frequent staff turnover further dampen consistency and the long-term effectiveness of HCV management and monitoring efforts.

Insufficient capacity and systems for long-term HCV monitoring

Stakeholders highlighted that long-term monitoring of HCV areas remains a significant challenge due to limited workforce capacity and the absence of structured monitoring systems. Companies often lack practical tools and clear guidance to establish measurable indicators, develop systematic monitoring procedures, and implement adaptive management strategies. Among smallholders, awareness of the HCV concept remains low, further hindering effective implementation.

In addition to these ecological and technical constraints, stakeholders also noted that limited capacity to manage social and community-related issues has contributed to weak or inconsistent implementation of social HCVs, particularly HCV 5 and HCV 6. These values require continuous engagement with local communities, participatory verification of land use, and management of culturally important sites. Many operators, especially small and medium-sized producers, struggle to maintain the skills, human resources, and systems needed to carry out these responsibilities. In some cases, unresolved community concerns or the inability to meet certification requirements for social safeguards have caused companies to withdraw from voluntary certification schemes rather than invest in building long-term social engagement capacity. These experiences reinforce the importance of strengthening institutional systems for community engagement, conflict resolution, and culturally sensitive monitoring as part of credible long-term HCV implementation.

Collectively, these challenges highlight structural, technical, and institutional gaps that must be addressed to ensure credible and scalable implementation of the HCV approach in Malaysia. The following section discusses potential pathways for strengthening adoption, effectiveness, and long-term impact.

DISCUSSION

The challenges outlined in the previous section show that while the HCV approach has gained traction in Malaysia, its implementation remains uneven and constrained by policy gaps, limited technical capacity, fragmented data, and inconsistent uptake across sectors. This section focuses on seven priority areas: policy integration, standards alignment, capacity building, data architecture and scientific integration, financial incentives and integrity safeguards, inclusive community participation, and landscape-level coordination. Together,

these pathways highlight what is needed to move the HCV approach toward a more coherent, well-supported system capable of safeguarding ecological and socio-cultural values across Malaysia's production landscapes and beyond.

Policy integration and mandate

Stakeholder feedback underscores the need for stronger government direction to shift the HCV approach from optional good practice to standard requirement in land-use decision -making. As land and forest governance falls under state authority, existing state legislation can be enhanced to incorporate HCV approach, including clear provisions for compliance monitoring and enforcement that reflects local contexts. In addition, to achieve broad and consistent uptake, the HCV approach must be formally recognised and embedded within national and state-level policies, legislation, and planning instruments. Importantly, policy integration should extend beyond the agricultural and commodity sectors. Other drivers of land-use change in Malaysia such as infrastructure development, extractive industries, and urban expansion also require safeguards capable of systematically identifying and protecting significant ecological and socio-cultural areas. Positioning the HCV approach as a complementary assessment tool within existing systems (e.g. applying it in environmentally sensitive areas (ESAs) or for any project involving land conversion) would help establish clear and consistent triggers for when HCV assessments are required.

While the NPBD 2022-2030 signals intent, operational detail implementation guidelines, timelines, institutional roles and legal recognition of HCV areas remain limited. Bridging the current gap between policy intent and implementation will require translating the NPBD's high-level commitments into binding regulatory mechanisms. These may include state and federal regulations, land-use planning and zoning rules, concession terms, and licensing or permitting conditions. Clear institutional roles for implementation, compliance monitoring, and enforcement must also be assigned, supported by incentives and/or penalties that make adherence to the HCV approach a standard expectation. Without such measures, the HCV approach will remain dependent on voluntary, sector-specific initiatives, limiting its potential to guide holistic, cross-sectoral land-use planning and long-term conservation outcomes.

HCV standards alignment and sectoral scaling

The recent integration of HCV requirements into the MSPO standard presents a significant opportunity to extend the HCV approach across all oil palm landscapes in Malaysia, including areas not previously covered under RSPO certification. This expansion has the potential to mainstream HCV identification, management, and monitoring across the national palm oil sector, provided the implementation challenges outlined in the previous section are adequately addressed. Stakeholders have noted concerns such as uneven technical capacity, variability in assessment quality, and limited data availability factors that, if unaddressed, could lead to inconsistent or superficial compliance.

The Malaysian National Interpretation (MYNI) can play a key role to ensure consistency in how HCVs are identified and managed across different certification systems: it provides nationally contextualised guidance for HCV identification, management, and monitoring across Malaysia's diverse ecosystems and is already harmonised with the HCV Network's Common Guidance. Ensuring that our local certifications reference and apply the MYNI consistently would improve comparability of assessments and help establish a shared baseline for quality.

Clear, harmonised expectations across certification schemes can reduce confusion among practitioners, prevent duplication of effort, and streamline training and capacity -building efforts across both industry and government. It can also improve the credibility of

HCV implementation by ensuring that assessment methodologies, management prescriptions, and monitoring requirements do not diverge between standards and meet international best practices.

There are recognised variations in implementation scope between certification systems. Even certification systems within a certain commodity, for example palm oil, such as RSPO and MSPO have differences in terms of assessment methodologies, scope, and governance structures. To help government agencies, practitioners, and certification bodies identify where alignment already exists and where greater coherence may be needed, a benchmarking exercise to map key similarities and differences across the schemes would be valuable. This can assist to clarify expectations, highlight opportunities for harmonisation, and support more consistent implementation nationwide.

Data architecture and scientific integration

Stakeholders emphasised that strengthening Malaysia's HCV system will require both a robust data architecture and deeper scientific integration. In order to enhance the quality of future HCV assessments and enable systematic evaluation of implementation effectiveness, stakeholders have proposed that a centralised HCV data-sharing platform should be established.

This platform would serve as a repository for core information on identified HCV areas, their management actions, and monitoring outcomes, and would integrate with existing biodiversity databases, spatial planning systems, and government open-data portals to support transparent and evidence-based decision-making. Regardless of whether the platform is led by a national, state, or delegated agency, it must operate across sectors and commodities, implement clear governance rules, and apply strict safeguards to ensure sensitive ecological or cultural data remain protected through controlled access protocols.

HCV findings are rarely incorporated into traditional scientific or policy decision -making, despite their relevance to land-use planning and biodiversity conservation. Many agencies, researchers, and practitioners remain unaware that substantial HCV datasets even exist. Moreover, the information is often fragmented across private companies, consultancies, state departments, and certification systems. This limited visibility results in valuable ecological and socio-cultural insights such as species occurrences, habitat condition, connectivity features, and community-derived knowledge being under-utilised in conservation science and planning. Stakeholders have suggested that integrating HCV outputs with national biodiversity inventories, habitat maps, and other environmental datasets could reveal landscape-scale patterns and risks that are otherwise overlooked, providing a more holistic basis for evidence-based decision-making.

Meaningful scientific integration will therefore require the adoption of consistent technical standards for HCV datasets, including harmonised indicators, spatial resolutions, taxonomic conventions, and metadata formats. Standardisation would allow HCV results to be compared across regions and over time and support the transition toward outcome -oriented monitoring that tracks measurable ecological and social changes such as species trends, habitat condition, landscape connectivity, and ecosystem-service indicators. Publishing non-sensitive HCV data on national biodiversity platforms and in academic repositories would further promote transparency, stimulate scientific use, and strengthen the relevance of HCV information to conservation policy.

Capacity and availability of tools

Stakeholders agree that building awareness and strengthening capacity are fundamental for effective HCV implementation across all stakeholder groups; government agencies, private sector actors, academia, technical experts, and local communities. Training must be tailored

to the different audiences e.g. for plantation workers and estate teams, guidance should be practical and field-oriented, supported by clear visuals and straightforward instructions; for government, private sector, and academic institutions, efforts should focus on deepening understanding of the HCV concept, its application, and its role in land-use decision-making. Beyond those responsible for day-to-day management and monitoring, stakeholders stressed the importance of building capacity among HCV assessors themselves. Given that the current number of qualified assessors in Malaysia is relatively small, targeted outreach, structured training, and clearer pathways for prospective assessors will be necessary to expand the assessor pool and meet future implementation needs.

Furthermore, stakeholders have highlighted that practical tools and simplified guidance are essential to bridge the gap between technical reports and on-the-ground implementation. This includes developing operational guides and visual checklists for estate managers and field teams, translating technical HCV terminology into actionable steps for day-to-day operations, and creating user-friendly monitoring and reporting tools to reduce complexity. Strengthened documentation processes will further support consistent, high-quality adoption of the HCV approach and enable more effective implementation across diverse landscapes. An example of this in practice is the effort by WWF Malaysia, the Forest Department Sarawak, Sarawak Forestry Corporation, and the Sarawak Timber Association, which, together with inputs from forest managers, have developed practical guides and training modules on HCV processes tailored for Forest Management Units in Sarawak. These materials demonstrate how clear, context-specific tools can help translate HCV guidance into operational practice.

Financial incentives and integrity safeguards

Stakeholders noted that, for the HCV approach to achieve wider uptake particularly among SMEs and smallholders, it must be economically viable and appealing. Financial and market -based mechanisms can help reframe HCV implementation from a compliance cost into a long-term value proposition. Expanding access to voluntary certification schemes (VCS), scaling payment for ecosystem services (PES), and mobilising biodiversity and carbon-related investments can reward land managers for maintaining ecological integrity and attract private capital into conservation efforts (Noza 2020). In addition, leveraging biodiversity conservation funds (e.g., Malaysian Palm Oil Green Climate Fund) and fostering public -private partnerships can help address resource gaps for SMEs and smallholders.

At the same time, the authors recognise that Malaysia's carbon market faces significant challenges, including a limited pipeline of projects, low credit supply on the domestic exchange, and persistent concerns around credit quality, integrity, and risks of greenwashing especially where projects lack strong verification frameworks. These gaps create an opportunity for the HCV approach to serve as a robust safeguard and validation tool. By embedding HCV principles into project screening, baseline design, and monitoring requirements, carbon- and nature-based initiatives can demonstrate stronger environmental and social integrity. In this way, HCV can enhance the credibility of nature-based claims, strengthen due-diligence processes, and support the development of higher quality ecosystem service verification protocols. This dual role making conservation economically attractive while reinforcing methodological rigour positions HCV as a practical mechanism for scaling credible, finance-aligned conservation outcomes in Malaysian landscapes.

Inclusive participation and community data

Stakeholders emphasised that community participation must extend beyond the one-off consultations undertaken during the HCV assessments. Ongoing involvement of Local Communities and Indigenous Peoples (IPLCs) helps build long-term ownership of HCV areas and ensures continuity in monitoring efforts. Participatory HCV monitoring provides a structured and meaningful role for communities to safeguard social and cultural values

while contributing to data collection. When designed as a form of community-based or citizen-science monitoring often in collaboration with NGOs and academic institutions, it can enhance data quality, strengthen local stewardship, and ensure that management decisions reflect on-the-ground realities. From a conflict-prevention perspective, participatory monitoring offers a practical pathway for embedding transparency and co-management into the HCV process. When communities play an ongoing role in documenting changes, identifying threats, or reporting boundary disputes, potential conflicts can be addressed early, rather than escalating due to miscommunication or lack of involvement. This aligns directly with the aforementioned stakeholder concerns regarding overlapping land-use claims and tensions arising when HCV areas are not well understood or locally accepted. Bottom-up approaches of this kind are essential for amplifying community voices and embedding local knowledge into long-term conservation outcomes.

Landscape-level governance and collaboration

As many HCV areas identified within production landscapes are often small and fragmented (e.g., riparian buffers, steep slopes and forest patches), stakeholders have emphasised that landscape-scale planning is essential to maintain connectivity and ecosystem function. These areas have the potential to function as ecological "stepping-stones" connecting larger protected areas and enhancing overall landscape connectivity. Disturbances in nearby conservation areas such as protected zones or other HCV sites can trigger cascading impacts on adjacent HCV areas. Events like fires or pest/disease outbreaks highlight the need for proactive measures; therefore, adaptive management and early mitigation are essential to prevent harm and maintain the integrity of interconnected conservation landscapes.

To operationalise these measures effectively, stakeholders recommend establishing a dedicated HCV Steering Committee to set landscape-level priorities, coordinate risk management, and guide the integration of HCV principles into broader land-use planning (taking into consideration protected areas and conserved areas within the landscape). This steering committee should be established at a landscape-level to allow coordination between companies and local authorities on HCV-related matters. Effective implementation will require robust data sharing and collaborating among the members, including governmental agencies across sectors, private companies, NGOs, academia and technical experts. This multistakeholder approach ensures that decisions are informed and inclusive.

CONCLUSION

Malaysia's experience with the High Conservation Value (HCV) approach demonstrates meaningful progress in integrating conservation within production landscapes, driven largely by voluntary certification schemes, private-sector commitments and lately state-level initiatives. These mechanisms have elevated awareness of ecological, social, and cultural values and contributed to the identification and management of HCV values across forestry and agricultural sectors. Case studies have also highlighted the practical benefits of the approach, including improved protection of rare and threatened species, maintenance of ecosystem functions, and strengthened engagement with local communities. However, despite these advances, implementation remains uneven due to structural and institutional limitations. The absence of a clear legal mandate, fragmented data systems, insufficient assessor capacity, and limited long-term monitoring continue to constrain the consistency and effectiveness of the HCV approach. While the National Policy on Biological Diversity 2022-2030 signals growing policy interest, further action is needed to translate high-level commitments into operational requirements supported by coordinated governance and enforcement mechanisms. Looking forward, several shifts will be essential to strengthen and scale the approach. Enhanced policy integration can provide the regulatory clarity needed for broad-based uptake, while harmonisation of national standards and improved

technical capacity can elevate the quality and credibility of assessments. Establishing a centralised data architecture, supported by scientific integration, will enable better transparency and landscape-level evaluation of conservation outcomes. Financial incentives will be needed to support broader uptake, particularly among SMEs and smallholders. At the same time, embedding HCV safeguards into carbon and biodiversity initiatives can strengthen the environmental and social integrity of nature-based solutions. Finally, sustained community participation and landscape-level collaboration are critical for ensuring long-term stewardship and ecological connectivity. Collectively, these actions will move Malaysia toward a more coherent, science-based, and accountable HCV system, one that supports national conservation goals while enabling responsible and sustainable development across diverse land-use sectors.

Acknowledgement: We would like to express our sincere gratitude to all individuals and organisations who contributed to this work. Special thanks to Sabah Forestry Department, Forest Department Sarawak, High Conservation Value Network, Roundtable on Sustainable Palm Oil (RSPO), FSC Malaysia, WWF-Malaysia, Earthworm Foundation, Malaysian Environmental Consultants, Wilmar Plantations Sdn Bhd – Sabah Operations, Wilmar Europe Trading and SD Guthrie for their valuable insights, guidance, and support throughout the process which improved the quality of this chapter. Thanks also to Zurfatiha Zulkarnain and Proforest team members for post-editing support.

REFERENCES

Areendran, G., Sahana, M., Raj, K., Kumar, R., Sivadas, A., Kumar, A., Deb, S., and Gupta, V. D. 2020. A systematic review on High Conservation Value assessment (HCVs): Challenges and framework for future research on conservation strategy. *Science of The Total Environment* 709: 135425. https://doi.org/10.1016/j.scitotenv.2019.135425

Bank Negara Malaysia and World Bank. 2022. *An exploration of nature-related financial risks in Malaysia*. Kuala Lumpur: World Bank. https://www.bnm.gov.my/documents/20124/3770663/wb-bnm-2022-report.pdf

Brown, E. and Senior, M.J.M. 2014. *Common guidance for the management and monitoring of High Conservation Values*. United Kingdom: HCV Resource Network.

Brown, E., Dudley, N., Lindhe, A., Muhtaman, D.R., Stewart, C. and Synnott, T. 2013. *Common guidance for the identification of High Conservation Values*. United Kingdom: HCV Resource Network.

Chellaiah, D. and Yule, C. M. 2018a. Litter decomposition is driven by microbes and is more influenced by litter quality than environmental conditions in oil palm streams with different riparian types. *Aquatic Sciences* 80(4): 43. https://doi.org/10.1007/s00027-018-0595-y

Chellaiah, D. and Yule, C.M. 2018b. Riparian buffers mitigate impacts of oil palm plantations on aquatic macroinvertebrate community structure in tropical streams of Borneo. *Ecological Indicators* 95: 53–62. https://doi.org/10.1016/j.ecolind.2018.07.025

CIMB. 2024. *Sustainable Finance Framework*. Kuala Lumpur, Malaysia: CIMB. https://www.cimb.com/content/dam/cimb/group/documents/sustainbility/sustainablefinance-framework.pdf

Dhandapani, S. 2015. Biodiversity loss associated with oil palm plantations in Malaysia: Serving the need versus serving the nature. *Journal of Ecosystem & Ecography* 4(3): 2–41.

Dudley, N., Jonas, H., Nelson, F., Parrish, J., Pyhälä, A., Stolton, S. and Watson, J.E.M. 2018. The essential role of other effective area-based conservation measures in achieving big bold conservation targets. *Global Ecology and Conservation* 15: e00424. https://doi.org/10.1016/j.gecco.2018.e00424

Feurer, M., Markovic, J., Starke, M., Wilkes-Allemann, J. and Wolf, O. 2025. Drivers of deforestation and forest degradation between 1990 and 2023 - A global meta-analysis. *Environmental Science & Policy* 173:104242. https://doi.org/10.1016/j.envsci.2025.104242

FSC. 2006. *FSC Principles and Criteria for Forest Stewardship*. Bonn: Forest Stewardship Council. https://connect.fsc.org/document-centre/documents/resource/392

Giam, X. 2017. Global biodiversity loss from tropical deforestation. *Proceedings of the National Academy of Sciences of the United States of America* 114(23): 5775–5777. https://doi.org/10.1073/pnas.1706264114

HCV Malaysia Toolkit Steering Committee. 2018. *Malaysian National Interpretation for the Identification of High Conservation Values*. Kuala Lumpur: HCV Malaysia Toolkit Steering Committee. https://www.my.fsc.org/sites/default/files/2022-06/Malaysian%20National%20Interpretation%20for%20the%20Identification%20of%20High%20Conservation%20Values%20%28HCVs%29.pdf

HCV Malaysia Toolkit Steering Committee. 2021. Malaysian National Interpretation for the Management and Monitoring of High Conservation Values. Kuala Lumpur: HCV Malaysia Toolkit Steering Committee. https://www.proforest.net/fileadmin/uploads/proforest/Documents/Publications/MYNI_Management_Monitoring_HCVs_Jan_2022.pdf

Jennings, S., Nussbaum, R., Judd, N. and Evans, T. 2003. *The High Conservation Value Forest Toolkit*. Oxford: ProForest. https://www.proforest.net/fileadmin/uploads/proforest/Documents/Publications/hcvftoolkit-part-1-final-updated.pdf

Jonas, H., Bingham, H., Bennett, N., Woodley, S., Zlatanova, R., Howland, E., Belle, E. *et al.* 2024. Global status and emerging contribution of other effective area-based conservation measures (OECMs) towards the '30x30' biodiversity Target 3. *Frontiers in Conservation Science* 5: 1447434.

Koh, L.P., and Wilcove, D.S. 2008. Is oil palm agriculture really destroying tropical biodiversity? *Conservation Letters* 1(2): 60–64. https://doi.org/10.1111/j.1755263X.2008.00011.x

Luke, S.H., Barclay, H., Bidin, K., Chey, V.K., Ewers, R.M., Foster, W.A., Nainar, A. *et al.* 2017. The effects of catchment and riparian forest quality on stream environmental conditions across a tropical rainforest and oil palm landscape in Malaysian Borneo. *Ecohydrology* 10(4): e1827. https://doi.org/10.1002/eco.1827

Malaysia Building Society Berhad (MBSB Bank). n.d. *MBSB Bank Sustainability Sukuk Framework*. Petaling Jaya: Malaysia Building Society Berhad Bank. https://www.mbsbbank.com/sites/default/files/inlinefiles/MBSBBank_Sustainability_Sukuk_Framework.pdf

Malaysian Sustainable Palm Oil (MSPO). 2025. *MSPO High Conservation Value (HCV) Assessment Procedure*. Shah Alam: Malaysian Sustainable Palm Oil. https://mspo.org.my/wp-content/uploads/2025/08/MSPO_HCVAssessment_Procedure.pdf

Demies, M., Ahmad, R., Ling, C.Y., Chong, L. and Chan, H. 2015. HCVF Assessment: A case study at Kubaan-Puak FMU, Sarawak. In *Proceedings of the 17th Malaysian Forestry Conference "A Century of Forest Management: Lessons Learnt & the Way Forward"*, pp. 142–149. Sandakan: Sabah Forestry Department.

Ministry of Energy and Natural Resources. 2021. *Malaysia Policy on Forestry* (Ver. 2.0). Putrajaya: Ministry of Energy and Natural Resources. https://www.nres.gov.my/ms-my/pustakamedia/Penerbitan/Malaysia%20Policy%20on%20Forestry%20(Ver%202.0).pdf

Ministry of Natural Resources and Environmental Sustainability (NRES). 2022. *National Policy on Biological Diversity 2022–2030*. Putrajaya: Ministry of Natural Resources and Environmental Sustainability.

Mohd-Azlan, J. and Ahmad Puad, A.S. 2023. *Bukit Durang, Hidden Jewel of Ulu Suai, Sarawak: Biodiversity at a Glance*. Kota Samarahan: UNIMAS Publisher. https://www.wilmar-international.com/docs/default-source/default-document-library/sustainability/wilmar-bukit-durang-coffee-table-book.pdf?sfvrsn=13d91e86_1

Mohd-Azlan, J., Soo, S. K., Lok, L. and Lawes, M. J. 2019. The role of forest fragments in small mammal conservation in an oil palm plantation in Northern Sarawak, Borneo. *Journal of Oil Palm Research* 31(3): 422–436. https://doi.org/10.21894/jopr.2019.0034

Ng, J.S.C., Chervier, C., Ancrenaz, M., Naito, D. and Karsenty, A. 2022. Recent forest and land-use policy changes in Sabah, Malaysian Borneo: Are they truly transformational? *Land Use Policy* 121: 106308. https://doi.org/10.1016/j.landusepol.2022.106308

Noza, Z.G. 2020, February 5. Payments for ecosystem services in the Philippines: A win-win approach for communities, businesses, and the environment. *World Agroforestry*. https://www.worldagroforestry.org/blog/2020/02/05/payments-ecosystem-services-philippines-win-win-approach-communities-businesses-and

Pacheco, P., Mo, K., Dudley, N., Shapiro, A., Aguilar-Amuchastegui, N., Ling, P.Y., Anderson, C., and Marx, A. 2021. Deforestation fronts: Drivers and responses in a changing world. Gland: WWF.

Pin, K.L. and Tiong, G.L. 2008. A study on the biodiversity of oil palm agriculture in KLK Estates in Sabah, Malaysia: a preliminary report. *Planter* 83: 81–92.

PT Hijau Daun. 2019. *High Conservation Value full assessment - public summary - Ladang Rakyat Estate, Terengganu: collaboration between Ladang Rakyat Trengganu Sdn Bhd, Bunge Loders Croklaan and Cargill*. United Kingdom: HCV Network. https://hcvrn.egnyte.com/dl/6MvH4PN2w0

Roundtable on Sustainable Palm Oil. 2025. *Impact Update 2025*. Kuala Lumpur: Roundtable on Sustainable Palm Oil. https://rspo.org/wp-content/uploads/ImpactUpdate2025_FA_181225.pdf

Shukor, A.R.A., Yusoff, A.M., Norowi, H.M. and Shukor, N.M. 2009. Contribution of biodiversity towards sustainable agriculture development. In *Biodiversity and National Development: Achievements, opportunities and challenges*. Proceedings of the Conference held in Kuala Lumpur, Malaysia from 28–30 May 2008, Y.H. Sen (Ed.), 20–31. Kuala Lumpur: Akademi Sains Malaysia.

Stuebing, R.B., Bezuijen, M.R., Auliya, M. and Voris, H. K. 2006. The current and historic distribution of *Tomistoma schlegelii* (the False Gharial) (Müller, 1838) (Crocodylia, Reptilia). *The Raffles Bulletin of Zoology* 54(1): 181–197.

Styring, A.R., Unggang, J., Ragai, R., Kueffner, K., Froehlich, D., Megom, N., Joseph, L. *et al.* 2022. Determining High Conservation Values in production landscapes: biodiversity and assessment approaches. *Frontiers in Environmental Science* 10: 783794. https://doi.org/10.3389/fenvs.2022.783794

Syahza, A., Suswondo, Bakce, D., Nasrul, B., Wawan and Irianti, M. 2020. Peatland policy and management strategy to support sustainable development in Indonesia. *Journal of Physics: Conference Series* 1655(1): 012151. https://doi.org/10.1088/1742-6596/1655/1/012151

UNEP Finance Initiative. 2023. Banking on nature: What the Kunming–Montreal Global Biodiversity Framework means for responsible banks. Geneva: United Nations Environment Programme Finance Initiative. https://www.unepfi.org/wordpress/wp-content/uploads/2023/01/21-Banking-on-nature.pdf

UNEP-WCMC and IUCN. 2024. *Protected Planet Report 2024*. Cambridge, UK and Gland, Switzerland: UNEP-WCMC and IUCN. https://digitalreport.protectedplanet.net/

Wilcove, D.S., and Koh, L.P. 2010. Addressing the threats to biodiversity from oil-palm agriculture. Biodiversity and Conservation 19(4): 999–1007. https://doi.org/10.1007/s10531-009-9760-x

WWF-Malaysia. 2009. *High Conservation Value Forest (HCVF) Toolkit for Malaysia*. Petaling Jaya: WWF-Malaysia. https://cdn.prod.website-files.com/624493bb51507d22cf218d50/644abf9741f3ae6d49bf736b_2009(HCVF-Toolkit-Malaysia)_english.pdf


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 771–780
doi: 10.62613/sonc2025.v3anc08

CHAPTER 8

Improving forest governance in Malaysia

TECKWYN LIM[1,2,3,4]*

Abstract: The Malaysian government has a long-stated commitment to keeping half of the nation's land under sustainable forest management. Over the years, increasing safeguards have been put in place to implement this commitment. However, two significant governance challenges remain: ensuring adequate scrutiny over decisions to change land status, and providing a legal basis for community forestry. This chapter reviews these issues as they apply in Malaysia, with a focus on the National Forestry Act 1984, which has been adopted by the states of Peninsular Malaysia and the federal territories. The requirement for states to hold public hearings prior to excision of forest reserves, as championed by the state of Selangor in 2011, is found to be inadequate. In addition, it is recommended that state legislative assemblies be given power to review executive decisions in this regard. We find that the Malaysian forestry policy is welcoming to community forestry; however, statutory provisions are inadequate, which leads to inconsistent application. The chapter reviews the legal basis for community forestry in the state of Selangor, looking at cases in Kota Damansara, Shah Alam, and North Selangor. The chapter concludes by highlighting medium- and long-term changes that are needed to allow the existing legislation.

INTRODUCTION

In the pursuit of global sustainable development goals, ensuring the resilience of life on land requires a robust forest governance framework, one that ensures that forest area increases and respects the views of local communities (Roka 2019). However, many countries lack an explicit legal basis for empowering communities to influence forest management decisions made by the government. Community influence is fundamental to forest governance. This is because a clear legal basis for communities to influence forest management would ensure that decisions are made transparently and accountably. Recognising this, there are efforts in several countries to strengthen the basis for community-based forest management (Roka 2019).

Malaysia is one country whose extensive forest estate has officially been managed almost exclusively by the executive arm of government (T. Lim 2011, 2022; J. Lim 2021). In 2016, Malaysia was still mostly forested (Figure 1). However, this forest is mostly in Sabah and Sarawak (Figure 2), with most of the forest in Peninsular Malaysia having been cleared (here only about 40% of the land is forested). Most forests are classified as "permanent reserved forest" (referred to as "forest reserves" in this paper), with the land having been officially placed within a network of forest reserves, under the jurisdiction of the state forestry departments. In the Peninsula, the legal basis for community forestry is being explored by both the forestry department and by civil society. In recent years, there have been several government projects to involve local communities in forestry activities and, likewise, the public has been seeking a bigger role in forest management.

[1] Resource Stewardship Consultants Sdn Bhd (RESCU), 38 Jln 12/15, 46200 Petaling Jaya, Malaysia.
[2] Shah Alam Community Forest Society, 17 Jalan U13/11D Setia Alam, 40170 Shah Alam, Malaysia.
[3] Center for Malaysian Indigenous Studies, University of Malaya, 11 Jln 16/4, 50603 Kuala Lumpur, Malaysia.
[4] School of Biological and Environmental Sciences, University of Nottingham, Malaysia, Jalan Broga, 43500 Semenyih, Selangor Darul Ehsan, Malaysia.
***Corresponding author: teckwyn@rescu.com.my**

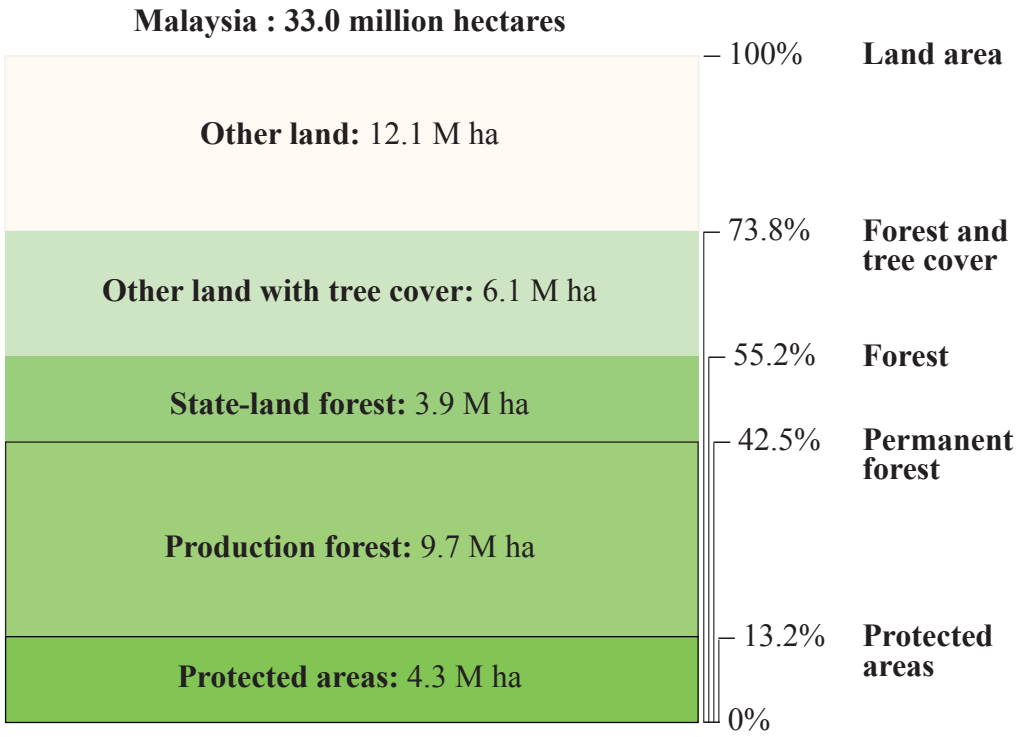


Figure 1. Forest land-use zoning in Malaysia (2016).

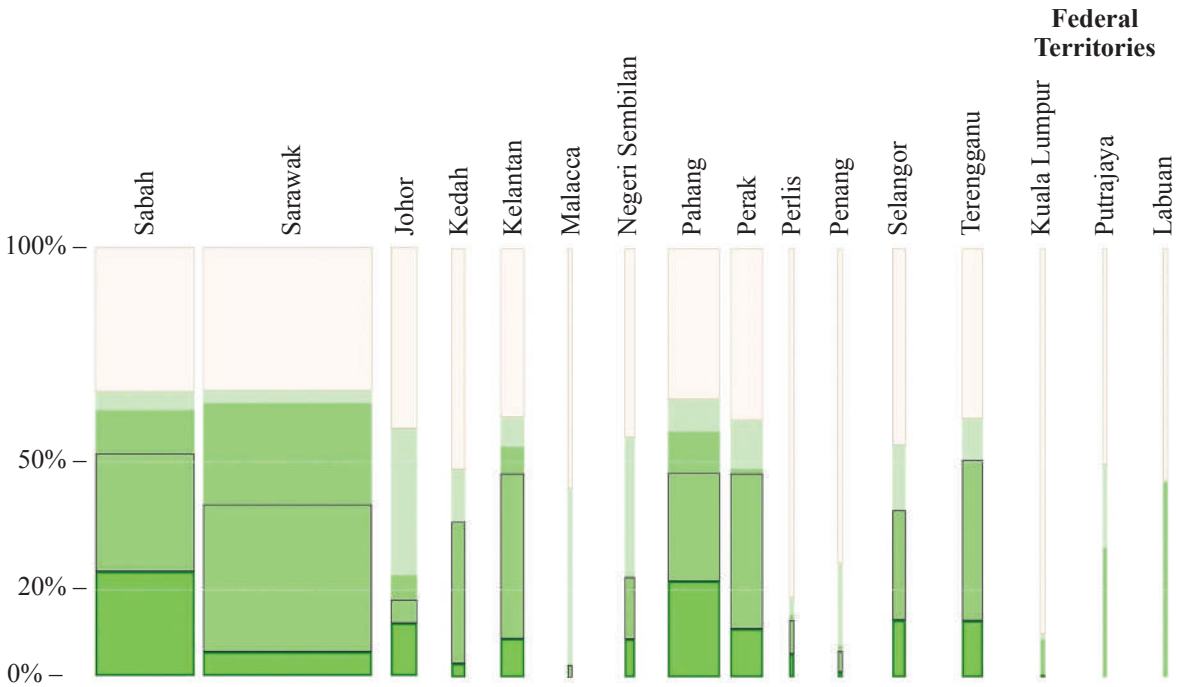


Figure 2. State land-use zoning in Malaysia (2016).

Both the government and the public have been working towards the establishment of community forests. Three cases in Selangor illustrate the challenges to implementing community forestry: two cases involving suburban forests in the outskirts of the Greater Kuala Lumpur conurbation (centred on the Klang Valley), while the other involves a rural community adjacent to a peat-swamp forest in the north of Selangor.

The first case involved a community that succeeded in convincing the government to protect a 322-ha area as the Kota Damansara Community Forest (Shaharuddin *et al.* 2012; Vaz and Lim 2012; Nath and Magendran 2020). In 2016, inspired by this success, a second group of residents of the neighbouring city of Shah Alam registered the Shah Alam Community Forest Society to conserve an area of 406 hectares within the Bukit Cherakah Forest Reserve. The third group was facilitated by Global Environment Centre (GEC), a non-governmental organisation that has worked with the Selangor Forestry Department since 2008, to rehabilitate the Raja Musa forest reserve (Alam *et al.* 2021).

Despite a somewhat sympathetic state government and active civil society, communities in Selangor still face uncertainties regarding the legal basis for them to manage their respective forest areas. In Kota Damansara, no institutional arrangements for co-management have been formalised between the state government and the CBOs (Nath and Magendran 2020). In Shah Alam, the government announced its decision to excise the community forest area for housing development (J. Lim 2021). While GEC has signed a memorandum of understanding with the state, the local community has no clear role in decision-making related to the forest (Alam *et al.* 2021). It is in this context that there is a need to review forest governance in Malaysia generally, and to discuss what options would be most suitable in the cases mentioned in Selangor specifically.

METHODOLOGY

Approach

The approach uses a broad definition of "community forestry" that has been adopted internationally: "any situation which intimately involves local people in a forestry activity" (FAO 1991). On this basis, a review was undertaken of the relevant provisions of (i) customary law; (ii) statutory law; (iii) judgements of the courts; and (iv) policy. The review of customary law focused on the traditions of the Orang Asli (aboriginal peoples). The review of statutory law looked at the Federal Constitution and at statutes enacted from 1984 to 2020. These included federal legislation, state legislation, and state subsidiary legislation (focusing on the state of Selangor). The review of court judgements included a review of cases that had been brought to court and subsequently settled out of court. Finally, the policy review focused on the provisions of the Malaysia Forest Policy (KeTSA 2021) that may guide future amendments to the law with regards to community-based forest management. The initial findings of the literature review were confirmed via informal interviews with key stakeholders.

Study area

Malaysia's forests span its 13 states and three federal territories, comprising over 8,800 plant species in 16 forest types (seven elevation-dependent and nine edaphic forest types). The dominant trees are dipterocarps, whose canopy rises 45 m above the forest floor, with emergents over 80 m. Forest management is controlled by the individual states. In Peninsular Malaysia, forest policy is coordinated by the Forestry Department Peninsular Malaysia (FDPM), which is headquartered in Kuala Lumpur. The implementation of forestry activities is carried out by the individual state forestry departments, which have operational autonomy under their respective state governments.

Selangor is a state on the west coast of Peninsular Malaysia. It is the most populous and developed state of Malaysia and is centred on Malaysia's primary urban conurbation (which includes the federal territories of Kuala Lumpur and Putrajaya as enclaves). Despite this development, Selangor has maintained about 30% of its land under forest cover, with 791,084 ha classified as forest reserves. Much of this forest is classified as protection forest and, since 2010, there has been a moratorium on commercial timber harvesting within these permanent forest reserves that are still classified as production forests (Alam *et al.* 2021).

RESULTS

Customary law

Customs and traditions of local communities (known as *adat* in Malay) related to forest management provide one aspect of the legal basis for community forestry in Malaysia (Lim 2011). This is because Malaysia's Federal Constitution has a broad definition of "Law" which in addition to written law, also includes "any custom or usage having the force of law in the Federation or any part thereof" [Article 160 (2)]. On this basis, it is important to examine the customs of the local and/or indigenous people as they relate to forest management.

For thousands of years, the indigenous communities of Malaysia have been involved in several forestry activities, including tree felling, harvesting non-timber forest produce, and facilitating the propagation of various species of beneficial plants. The specific customs vary somewhat according to the sub-ethnic group but one widespread and important agroforestry custom includes a swiddening system known as *selai*. This involves clearing a small patch of forest and planting it with rice for one harvest. The *selai* system was traditionally integrated with a *dusun* (orchard) system which involved planting a forest garden with fruit trees such as durian (*Durio* spp.). The *selai-dusun* system has recently been recognised to be a form of agroforestry, categorised as "forest-garden agroforestry", comprising 75% big trees, 20% starch crops, and 5% leaf vegetables and medicinal plants (Keat *et al.* 2018). The starch crops from customary agroforestry are not restricted to rice growing in clearings, but also include sago palms and root crops such as yams. The root crops are customarily managed through a form of "paracultivation" practised by foraging communities (Endicott and Endicott 2008). Indigenous Peoples also practise similar "sub-lethal" customs in the harvest of non-timber forest products such as agarwood (*Aquilaria* spp.) (Yamada 1995; Lim and Awang Anak 2010). The colonial and post-colonial authorities have criticised customary systems as being destructive, inefficient and uncontrolled "slashing and burning" (Subramaniam and Endicott 2020), but recent studies have shown that in fact, customary swiddening systems are "ecologically appropriate, culturally suitable, and under certain circumstances the best means for preserving biodiversity" (Fox 2000).

The extent to which of these customary forest management practices have "the force of law" varies from community to community. The customs have generally not been codified and there is variation in the extent to which they have been recognised by the courts. It is important to recognise that under customary law, the concept of land ownership as understood in English law does not exist (Subramaniam and Endicott 2020). Instead of land ownership, customary law recognises a community's ancestral territories ('*wilayah adat*' or '*tanah saka*') that are usually delimited on the basis of natural river catchment divides (Harper 1997). Thus, the paradigm for community-based forest management under customary law is quite different from that provided for by the statutes (which is the subject of the following section).

Statutory law

Since the 19th century, the colonial governments utilised land laws to create forest reserves and to control forestry activities. The first legislation specific to forestry was passed in 1907, when the Federated Malay States (including Selangor) passed state forestry enactments (e.g., the Selangor Forest Enactment 1907). In 1914, these state enactments were consolidated via the passing of the FMS Forest Enactment (Subramaniam and Endicott 2020). This legislation was subsequently revised in 1918 (F.M.S. En. 34/1918) and again in 1934 (F.M.S. Cap. 153/1934).

Today, the key statutory law governing forest management in Malaysia is the federal *National Forestry Act 1984* (Laws of Malaysia Act 313), an Act to promote uniformity of the laws of the States of Malaysia with respect to forest management. Under the Federal Constitution, forestry became a state matter, with the Act coming into force once it was adopted by the respective state governments. For example, in Selangor, the relevant enactment is the *National Forestry Act (Adoption) Enactment 1985* (Sel. En. 5/1985).

Since 1984, the federal law and the respective state enactments have been amended several times. In Selangor, the state enactment has been amended four times:

i. The first amendment (Sel. En. 2/1994) took into account amendments of the federal Act (*National Forestry (Amendment) Act 1993* (Act A864));
ii. The second amendment (Sel. En. 5/2005) was to include provisions related to State Parks;
iii. The third amendment (*National Forestry Act (Adoption) (Amendment) Enactment 2011*) added the requirement that a public inquiry be held prior to excision of forest reserves. The *National Forestry (Amendment) Act 2022* incorporated this requirement and it came into force in the federal territories in 2025. However, most states have yet to adopt this amendment.
iv. The fourth amendment (Sel. En. A55/2018) included provisions related to the *International Trade In Endangered Species Act 2008* (Act 686) and enhanced penalties.

The *National Forestry Act 1984* ('the 1984 Act') empowers the state to create subsidiary legislation in the form of state forestry rules. There have been several such rules formulated. Of particular importance to communities in Selangor are the rules that were drafted to facilitate the implementation of the 2011 amendment requiring public inquiries, the *National Forestry Act (Adoption) Enactment 1985, Public Inquiry (Selangor) Rules 2014* (Sel. P.U. 1/2014). This was amended via the *Public Inquiry (Selangor) (Amendment) Rules 2020* (Sel. P.U. 16/2020).

Provisions related to forest reserve excision

The law requires that decisions regarding the status of forest reserves be published in the respective government *Gazette* (the official channel of publication of government decisions). The *Gazette* is thus a key link between the government and the public. Unfortunately, for peninsular states, the *Gazette* is behind a steep paywall, requiring members of the public to purchase thousand-ringgit annual subscriptions. By the time the public is aware of *Gazette* notifications regarding forest reserve excisions, it is often too late to challenge the decision. This is because the courts require that applications for judicial review be filed within three months of the decision being made. The Federal Court recently held that it was too late to challenge a forest excision that took place in 2000, despite the *Gazette* notification only being published in 2022. [a]

[a] In the Federal Court of Malaysia, Civil Appeal No.: 01(i)-28-09/2024(B), between Damien Thaman Divean and Lim Teck Wyn and Majlis Eksekutif Negeri Selangor Darul Ehsan and four others. Coram: Abu Bakar Jais, PCA, Rhodzariah Bujang, FCJ, and Lee Swee Seng, FCJ.

Provisions related to community forestry

Under the colonial forest enactments, the authorities had the power to admit the rights of local people inside forest reserves (Harper 1997). Prior to 1984, the creation of new forest reserves required listing the rights of local communities inside these reserves. For example, in 1909, the Selangor government declared the creation of the Bukit Cherakah Forest Reserve (Notification No. 278 published in the Selangor Government Gazette dated May 21, 1909). This notification recognised the public right-of-way over a path through the forest and conceded several privileges to local "*Sakais*". The term "*Sakai*" referred to the Orang Asli sub-group living in and around the reserve and is now known as the "*Temuan*" (Shazlin Adila 2001). The specific rights and privileges listed in the notification were as follows:

i. Sakais living in or within three miles distance of the reserved forest may make clearings in that portion described in schedule II hereto [920 acres];
ii. Sakais living in or within three miles distance of the reserved forest may collect forest produce for their own use and hunt, shoot and fish within the reserve;
iii. Right of way over the path from Bukit Raja to Sungei Buloh.

However, the admitting of such special rights caused administrative difficulties for the forestry departments (Harper 1997; Subramaniam and Endicott 2020). These difficulties meant that the state governments became inclined to extinguish such rights and to cease conceding any special privileges to local communities inside forest reserves. With this aim in mind, the 1984 Act did not contain any clauses to allow the government to continue to admit special rights within forest reserves. On the contrary, the new legislation declared that such rights would cease after coming into force of the Act.

The 1984 Act criminalised entry into forest reserves without the permission of the forestry department. One exception is provided by Section 45 of Act, which states that: "The State Authority may, by notification in the *Gazette*, declare any permanent reserved forest or part thereof to be an open forest or a closed forest, and until a permanent reserved forest or part thereof has been so declared to be an open forest it shall be deemed to be a closed forest." Section 46 of the Enactment states that, in declaring a permanent reserved forest as "open forest", "the State Authority shall give due consideration to the necessity of protecting the forest and the environment and to the recreational and other needs of the public".

The 1984 Act also provided for the recreational and other needs of the public via a system that allows forest reserves or parts of forest reserves to be classified according to a particular functional class. The 1984 Act provided 11 such functional classes, including class (h) "amenity forest", for recreational purposes. In addition, some states (including Selangor) have added a 12th class to allow for forest reserves to be classified as State Parks.

In practice, a total of 74 areas inside forest reserves in Peninsular Malaysia have been designated as recreational areas that provide opportunities for the public to engage in outdoor recreation, including picnicking, camping, hiking, and swimming. The forestry department refers to such areas as *Taman Eko Rimba* (forest eco-parks). Incidentally, the formal designation of the Kota Damansara Community Forest is the Kota Damansara Permanent Reserved Forest (or "*Hutan Simpan Kekal Kota Damansara*"). The forestry department has taken the administrative decision to name the forest as "*Taman Eko Rimba Kota Damansara*". However this name has yet to be accepted by the community (Chan 2019).

In some states (including Selangor), eco-parks have been formally classified as amenity forest, while eco-parks in other states have no formal status or have alternatively been declared to be "open forest" (KATS 2019). Note that a forest reserve that has been

classified as amenity forest or state park forest still requires a permit to enter, unless it has also been declared to be an open forest. While the extent of eco-parks is small (2335 ha) (Kumari 1995), a much larger area has been declared as state park forest, such as the 93,002-hectare Selangor State Park (KATS 2019). No compilation of the total area declared as open forest is available.

Court Judgements

Judgements

The common law principle of the existence of *lex non scripta* (unwritten law) provides for the recognition of uncodified customs. In Peninsular Malaysia, there have been numerous court judgements that have upheld this principle with regard to adat rights to land. These judgements date back to the 19th-century case of *Sahrip v Mitchell* (Lim 2011). In particular, in the case of *Adong bin Kuwau*, the courts have held that Orang Asli have rights inside forests that are above and beyond the rights that have been explicitly recognised by the state; and in the case of *Mohamad Bin Nohing* the courts held that these rights can persist even in areas that the government has reserved for other purposes (Wook 2017).

Consent orders

Court judgements have also led to consent orders that have recognised the rights of local communities to continue to occupy and carry out activities within forest reserves. There are two particular examples, the cases of Pos Balar (*Hanan Anjang*) & Pos Belatim (*Mohamad Bin Nohing*) (SAM and JKOASM 2016; Vun ca. 2018; Kamal and Lim 2019). In the former case, the state of Kelantan and the Temiar Orang Asli of Pos Balar reached a consent agreement in 2017. This agreement effectively acknowledged the rights of the community to play an active role in the management of parts of the Sungai Betis and Sungai Perias forest reserves. The agreement explicitly admitted that the Temiar community of Pos Balar had the following rights:

i. the rights to hunting, fishing and foraging in the forest reserve surrounding their villages;
ii. for their cultivated lands to be recognised as 'aboriginal areas';
iii. that the state will issue no permits for outsiders to carry out logging in these areas;
iv. 28 key areas are to be protected, including 23 areas to be gazetted as water catchment areas (Vun ca. 2018).

Policy

The policy for forest management in Malaysia is set by the National Land Council, which has approved a *Malaysia Forestry Policy* (MFP) (KeTSA 2021). The MFP recognises the rights of local communities to own, use, and manage their areas and resources. The MFP, unlike Malaysia's earlier forest policies, recognises the potential to involve local communities in forest management, including social forestry and agroforestry (Lim and Harrison 2021). The MFP also spells out the importance of forests in providing resources for shelter, food, domestic use, firewood, and cultural and religious heritage. The MFP also includes an action plan to identify areas inside forest reserves that are of importance to rural communities, and to resolve any conflict arising from production forestry activities. The MFP also mentions the scope for urban forestry, including reforestation and tree planting programmes.

DISCUSSION

The most democratic avenue for forest management in Malaysia is found in the state of Sabah where the state legislative assembly is empowered to decide the fate of all forest reserves [*Forests (Constitution of Forest Reserves and Amendment) Enactment 1984* (En. No. 4 of 1984)]. It has been suggested that in addition to public hearings, all states in Malaysia should also empower their state legislative assemblies to control forest reserves

(T. Lim 2021). In particular, the state forestry enactments should provide that any decision to excise a forest reserve "shall be laid before the Dewan Undangan Negeri for approval". Then, forest excisions would not come into force unless and until the excision has been approved by the state assembly. This would enable the peoples' representatives to overrule the executive when necessary, such as in the face of significant public outcry.

In addition to empowering the public by this step, there is much scope for practising community forestry within Malaysia's existing forest governance framework. The legal basis for community-based forest management can, however, be strengthened by ensuring that the provisions of statutory law are brought on par with the more robust provisions of customary law, court judgements, and the Malaysia forest policy. Such legislative changes cannot be expected to take place overnight and thus, it would be most realistic to make recommendations for improving community forestry on three time horizons: short, medium, and long term. Short-term measures should include dialogue and full implementation of existing statutory provisions, while in the medium term the state can carry out minor legislative amendments. Long-term measures should include the approval of state forestry rules governing community forestry. These steps are best illustrated by reference to the three Selangor cases mentioned in the Background section: Shah Alam, Kota Damansara, and North Selangor Peat Swamp.

In the short term, the state should convene informal and regular discussions with the communities concerned. For example, in the case of the proposed Shah Alam Community Forest (Lim 2021), the state government (via the state forestry department) can convene informal discussions with the Shah Alam Community Forest Society and discuss the extent to which its proposals can be incorporated into the state forest management plan. In Shah Alam, Kota Damansara, and North Selangor, the state should consider declaring appropriate portions of the forest reserves to be "open forest", in accordance with the provisions of section 45 of the National Forestry Act 1984. In both Shah Alam and North Selangor, the state should also consider classifying portions of the forest according to one of the twelve existing functional classes, particularly as amenity forests. This step would empower the public to continue to use the land for public recreation and would not impose any administrative burden on the state government.

In the medium term, the state should consider developing rules for the co-management of amenity forests and community forests. The development of such rules should be carried out in consultation with relevant NGOs and community-based organisations. It is fortunate that extensive work to this effect has already been carried out by groups such as the Kota Damansara Community Forest Society (Vaz and Lim 2012). Proposals specifying the institutional arrangements for the appropriate management of the community forest have also been developed, suggesting that a multi-stakeholder co-management committee be established (Nath and Magendran 2020).

CONCLUSION

In conclusion, there is an extensive, multi-faceted, and long-standing basis for public participation and community forestry in Malaysia. However, due to deficiencies in statutory law in this regard, the implementation of community forestry is often applied in an *ad hoc* and inconsistent manner. This scenario means that the public receives mixed messages on whether they are welcome to play a role in forest management. The case of Selangor illustrates that political will to improve governance needs to be implemented via legislation. Such legislation is best developed in a phased approach, with broad provisions being put in place first, while details regarding management provisions being developed over the longer term via a consultative approach involving representatives of civil society and the communities concerned.

Acknowledgements: The author gratefully acknowledges the use of the library facilities of the Faculty of Law, University of Malaya; and those of the law firm, Syarikat Lek Yan, Peguambela & Peguamcara. Over the years, access to the Lawnet website has been paid for by several groups including Nature Based Solutions Sdn Bhd, Friends of Bukit Kiara, Shah Alam Community Forest Society, Kota Damansara Community Forest Society, and Friends of Bukit Dinding.

REFERENCES

Alam, M.J., Nath, T.K., Dahalan, M.P.B., Halim, S.A. and Rengasamy, N. 2021. Decentralization of forest governance in Peninsular Malaysia: The case of peatland swamp forest in North Selangor, Malaysia. In *Natural Resource Governance in Asia*, R. Ullah, S. Sharma, M. Inoue, S. Asghar and G. Shivakoti (Eds.), pp. 13–26. Amsterdam: Elsevier.

Chan, J. 2019, January 5. Metro News: Forest cleared for cemetery. *The Star*.

Endicott, K.M. and Endicott, K.L. 2008. *The Headman Was a Woman: The Gender Egalitarian Batek of Malaysia*. Illinois: Waveland Press.

FAO. 1991. *Community forestry: ten years in review*. Food and Agriculture Organization of the United Nations.

Fox, J.M. 2000. How blaming 'slash and burn' farmers is deforesting mainland Southeast Asia. *AsiaPacific Issues* 47: 1–8.

Harper, T.N. 1997. The Politics of the Forest in Colonial Malaya. *Modern Asian Studies* 31(1).

Kamal, S.F. and Lim, V.C. 2019. Forest reserve as an inclusive or exclusive space? Engaging Orang Asli as stakeholder in protected area management. *Journal of Tropical Forest Science* 31(3): 278–285.

KATS. 2019. *A Master List of Protected Areas in Malaysia – A Tool for National Biodiversity Conservation Management and Planning*. Putrajaya: Ministry of Water, Land and Natural Resources, Malaysia.

Keat, N.J., Nath, T.K. and Jose, S. 2018. Indigenous agroforestry practices by Orang Asli in Peninsular Malaysia: Management, sustainability and contribution to household economy. *Indian Journal of Traditional Knowledge* 17(3): 542–549.

KeTSA. 2021. *Dasar Perhutanan Malaysia*. Putrajaya: Kementerian Tenaga dan Sumber Asli, Malaysia.

Kumari, K. 1995. Is Malaysian forest policy and legislation conducive to multiple-use forest management? *Unasylva* 46: 51–56.

Lim, J. 2021, June 15. Metro News: Seeing the forest for the trees. *The Star.*

Lim, T. 2011. A critical review of forest regulatory frameworks and their implementation in Malaysia: The impact of recent reforms on forest-dependent people, with special reference to revisions of the Sarawak Land Code 1958. In *Critical Review of Selected Forest-Related Regulatory Initiatives: Applying a Rights Perspective*, H. Scheyvens (Ed), pp. 51–57. Japan: Institute for Global Environmental Strategies (IGES).

Lim, T. 2021, September 1. Empower the Dewan to safeguard forest reserves. *Macaranga*. https://www.macaranga.org/empower-the-dewan-to-safeguard-forest-reserves

Lim, T. 2022. The legal basis for community-based forest management within forest reserves in Peninsular Malaysia. *Proceedings of the Symposium on Multi-Stakeholders' Engagement in Forest/Protected Area Governance for Conservation and Livelihoods*, 23–26 August 2021, International Greentech & Eco Products Exhibition & Conference Malaysia (IGEM). Kuala Lumpur: Malaysian Nature Society. https://1drv.ms/b/s!AkmKWK4PIvd4wC_dOi4QspI1VNRk?e=5ijnlr

Lim, T. and N. Awang Anak. 2010. *Wood for the Trees: A review of the agarwood (gaharu) trade in Malaysia*. Petaling Jaya: TRAFFIC Southeast Asia. 108 pp.

Lim, T. and Harrison, R. 2021. Mainstreaming biodiversity conservation in forest management: Case study for Peninsular Malaysia. Center for International Forestry Research (CIFOR) for Food and Agriculture Organization of the United Nations (FAO).

Nath, T.K. and Magendran, M. 2020. Urban community forest in Kuala Lumpur, Malaysia: Current management, public uses and willingness toward conservation. *Journal of Sustainable Forestry* 40(8): 749–766.

Roka, K. 2019. Community-based natural resources management. In *Life on Land, Encyclopedia of the UN Sustainable Development Goals*, W. Leal Filho, A.M. Azul, L. Brandli, A.L. Salvia and T. Wall (Eds.). London: Springer.
SAM and JKOASM. 2016. *Encroachment on Orang Asli Customary Land in Peninsular Malaysia: Causes & Solutions*. Penang: Sahabat Alam Malaysia and Jaringan Kampung Orang Asli Semenanjung Malaysia. 335 pp.
Shaharuddin, M.I., Latiff, A. and Muda, Y. 2012. Forestry in the colonial Selangor and its implications to biodiversity conservation in peninsular Malaysia. In *Prosiding ekspedisi saintifik kepelbagaian biology- Hutan Simpan Kota Damansara, Selangor*, pp. 27–41. Shah Alam: Selangor State Forestry Department.
Shazlin Adila, M.S. 2001. Kesan modenisasi terhadap sosio-ekonomi di kalangan masyarakat Temuan di Kampung Air Kuning, Shah Alam Selangor Darul Ehsan [The impact of modernisation on the socio-economy among the Temuan community of Kampung Air Kuning, Shah Alam, Selangor Darul Ehsan]. PhD Thesis. Kuala Lumpur: Jabatan Antropologi dan Sosiologi, Fakulti Sastera dan Sains Sosial, Universiti Malaya.
Subramaniam, Y. and Endicott, K. 2020. Orang Asli Land and Resource Rights in the Malay States, 1874–1939. *Journal of the Malaysian Branch of the Royal Asiatic Society* 93(2): 87–118.
Vaz, J. and Lim, T.W. 2012. Realising our shared vision for the Kota Damansara Forest Reserve, Selangor. In *Prosiding ekspedisi saintifik kepelbagaian biology- Hutan Simpan Kota Damansara, Selangor*, pp. 176–183. Shah Alam: Selangor State Forestry Department.
Vun, J. ca. 2018. *Pos Balar: the Preservation of Native Ancestral Lands*. KH Koh, Jeremiah Vun and Tan Hooi Ping (Eds.) LHAG Celebrates 25th Anniversary [1993-2018]: Pro Bono Stories. Kuala Lumpur: Lee Hishammuddin Allen & Gledhill.
Wook, I. 2017. Acknowledging land rights of the Orang Asli: A historical perspective of laws in Peninsular Malaysia. *IIUM Law Journal* 25(1): 93–120.
Yamada, I. 1995. Aloeswood forest and the maritime world. *Southeast Asian Studies* 33: 181–186.

State of Nature Conservation in Malaysia 2025, 781–788
doi: 10.62613/sonc2025.v3anc09

CHAPTER 9

Wildlife trafficking in Malaysia: Current challenges and interventions

SERENE C.L. CHNG* and RAMACANDRA WONG

Abstract: Malaysia remains a critical source, transit and demand country for species trafficked across Asia and beyond. To address this, TRAFFIC employs a multi-pronged trade monitoring approach to build an evidence base that informs enforcement and policy. Through systematic seizure analysis, court monitoring, and online trade surveys, TRAFFIC identifies emerging trends, trafficking routes, and factors that facilitate trafficking. Recent findings highlight several pressing issues. Cross-border wildlife smuggling by air to India reflects sophisticated transnational networks. A surge in gibbon trafficking underscores the international demand for primates as pets. Meanwhile, shark and ray products continue to be openly traded online, and tiger parts persist in illicit markets. Together, these cases illustrate the scale and diversity of wildlife crime in Malaysia today. These data-driven insights help shape interventions and strengthen national responses. TRAFFIC's interventions target both supply and demand dimensions. The team delivers training and capacity-building for the transport sector, including airlines and postal and courier services, to detect and disrupt illegal shipments. In collaboration with government agencies and other partners, TRAFFIC supports law enforcement officers and prosecutors to strengthen investigations and secure convictions. Complementing enforcement, behaviour change initiatives within the Traditional Chinese Medicine community aim to reduce demand for products derived from threatened species. Multi-stakeholder partnerships bridge the private and public sectors, promoting shared responsibility in curbing illegal trade.

INTRODUCTION

Malaysia plays multiple roles in the global illegal wildlife trade: it is a source for wildlife taken locally, a transit point for shipments moving between other regions, and a consumer market for wildlife, whether for their parts and products in traditional medicines, or as exotic pets (TRAFFIC 2020). This section illustrates some of the most pertinent challenges posed by the illegal wildlife trade to Malaysia today, and showcases a range of interventions undertaken to tackle the problem. It is recognised that unregulated sourcing and poaching are important issues, and others are doing important work with local communities and site-based monitoring. This section instead focuses on the trade chain further downstream.

An unpublished analysis of data from TRAFFIC of seizures that occurred in Malaysia or involved Malaysia as a location on the trade routefrom January 2016 to December 2025 found at least 2,042 seizure incidents (TRAFFIC, unpublished data). These included approximately 150,000 live trafficked animals (individuals), 1.3 million live illegal fishery catches and about 205 tonnes of animal parts/products, 972 tonnes of illegal fishery catches alongside around 148,000 whole plants or parts, and about 6,845 tonnes of plant parts/products. Seizures occurred across both Peninsular and East Malaysia, with hotspots where smuggling attempts were intercepted focused around transport hubs like airports and sea port, and land borders (Figure 1). For seizures implicating Malaysia occurring outside the country, most occurred in neighbouring countries in Southeast Asia, but also included countries in South

TRAFFIC International Southeast Asia, Dataran Hamodal (Block B), No. 4, Jalan Bersatu 1/3, 46200 Petaling Jaya, Selangor, Malaysia.
***Corresponding author: serene.chng@traffic.org**

Asia and East Asia, and as far as Europe and Africa (Figure 2). The top seized taxa included live songbirds, primates, tortoises and freshwater turtles; pangolin scales and bodies; marine turtle eggs; elephant ivory; and tiger bodies and body parts (TRAFFIC, unpublished data). The sheer numbers illustrate the scale, diversity and transnational nature of wildlife trafficking involving Malaysia. It should be noted that seizure data represent an unknown proportion of total trafficking, and also reflect enforcement effort and reporting.

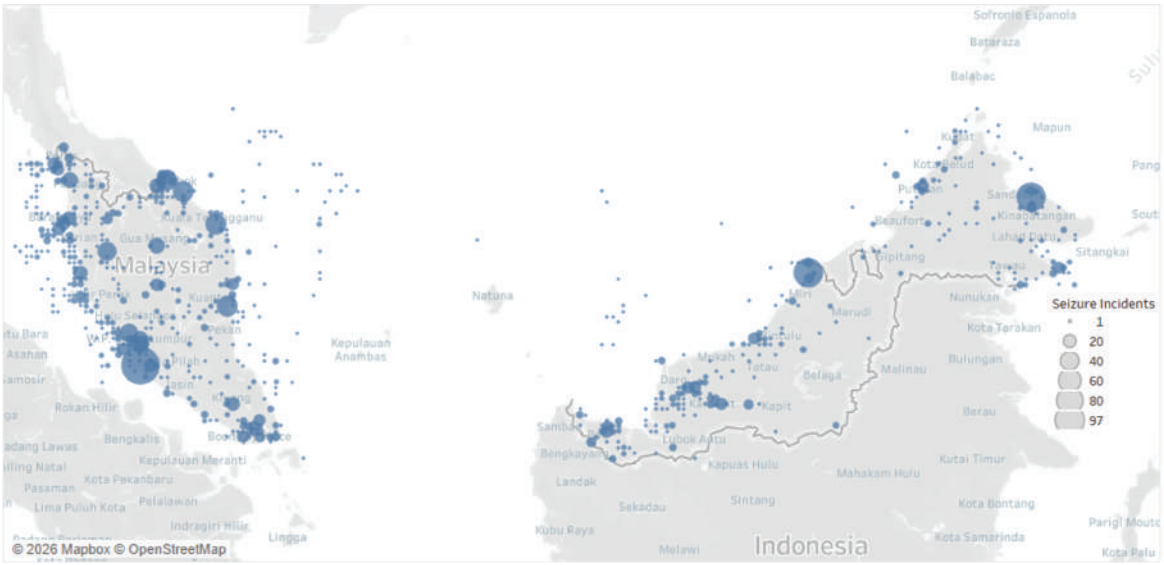


Figure 1. Location of 1,750 seizures that occurred in Malaysia (2016 – 2025). Source: TRAFFIC, unpublished data.

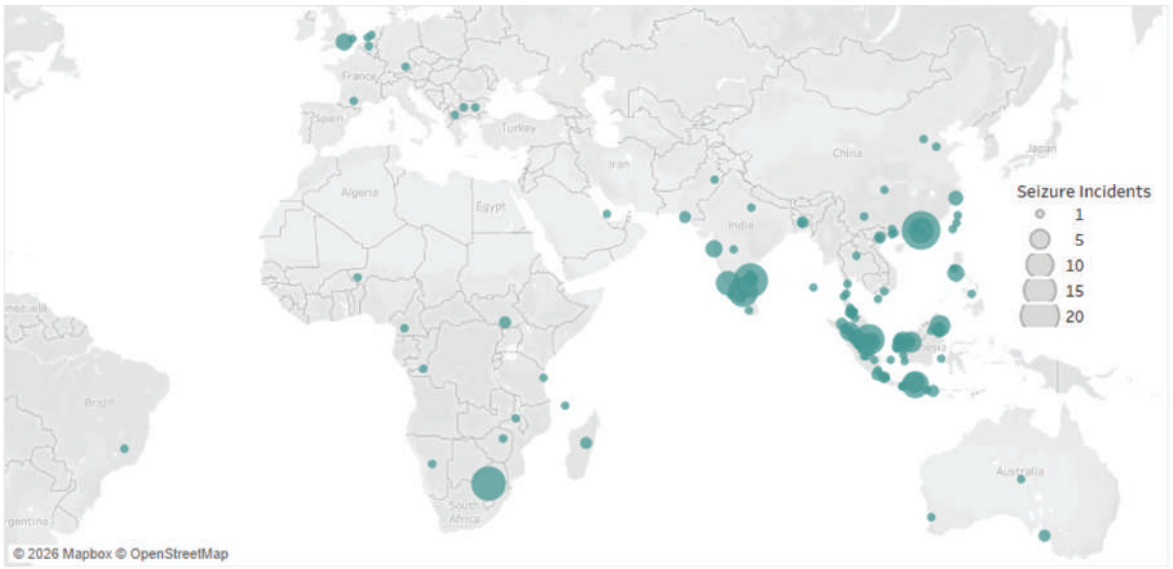


Figure 2. Location of 386 seizures that occurred outside Malaysia but involved Malaysia along the reported smuggling route (2016 – 2025). Source: TRAFFIC, unpublished data.

CURRENT CHALLENGES

Transnational organised crime networks and exploitation of the transport sector

Many wildlife smuggling networks involve transnational organised crime with multiple actors and strategies to evade detection, from the point of source to destination markets. As an example, smuggling cases between the emerging Malaysia-India route demonstrate how traffickers exploit commercial air travel routes to move live wildlife. Taxa such as freshwater turtles and tortoises, which can command high prices in the exotic pet trade, are regularly smuggled live from South Asia to Malaysia via these routes (Stoner 2018). In July 2024, Malaysian law enforcement agencies uncovered a smuggling ring referred to as the "Ninja Turtle Gang" and involved hundreds of tortoises and turtles smuggled from South Asia to meet lucrative demand in Malaysia and other countries in the region (Malay Mail 2024; The Star 2024).

In recent years, there has been a concerning surge in cases of primate smuggling, especially gibbons, from Malaysia to India; an analysis of gibbon seizures across South and Southeast Asia showed that detected trafficking reached an all-time high in 2025 (TRAFFIC 2025b). In one incident, two people flew from Malaysia to India with nine gibbons hidden in checked-in luggage; all but one were later found dead at a hotel in Mumbai, where Indian authorities nabbed the two suspects (Krishnasamy 2025; TRAFFIC 2025b).

These Malaysia–India examples sit within a broader pattern of wildlife trafficking facilitated by the aviation sector. At least 35 air-linked smuggling incidents were connected to Malaysia in 2025 alone, involving more than 22,000 individual animals, framing Malaysia's strong air connectivity as both an economic asset and a trafficking vulnerability (TRAFFIC 2026c).

Online wildlife trade: fast, large, and anonymous

Online trade is a growing enforcement challenge because of its rapidly-expanding markets and anonymous nature. The rising use of mail and courier services in the illegal wildlife trade is also closely linked to the expansion of online purchasing and growing parcel volumes, which increase opportunities to ship wildlife through routine delivery systems (TRAFFIC 2022). The large number of listings can overwhelm law enforcement as well. Only few cases reach arrest or prosecution, especially if listings and accounts can be removed quickly, or if evidence is hard to attribute to identifiable suspects with jurisdictionally usable evidence (UNODC 2024). Moreover, those offering or advertising wildlife for sale may not necessarily have the animals in their possession, making it even more challenging for authorities to conduct a successful bust.

Since around 2013 – 2014, a rising trend emerged where traders were documented using social media platforms in Malaysia to sell to local consumers (Krishnasamy and Stoner 2016). Just half an hour's daily monitoring over five months by TRAFFIC researchers of 14 Facebook Groups in Peninsular Malaysia found more than 300 live wild animals for sale as pets, ranging from sun bears and gibbons, to otters and even binturong. More than 60% of the 80 species recorded during the monitoring were native to Malaysia, indicating a demand for local wildlife as pets. Almost half of the species recorded were totally protected from hunting or trade and illegal to keep or sell under the country's Wildlife Conservation Act 2010 (Stoner and Krishnasamy 2016). This problem continues, with the Department of Wildlife and National Parks (PERHILITAN) reporting 654 cases involving illegal online sale of wildlife between 2020 and 2023 through various social media platforms (Morhan 2024). Between 2016 – 2025, at least over 4,700 individual animals were confiscated from at least 58 cases that reportedly involved social media (TRAFFIC, unpublished data).

Even marine species are not spared. An October–December 2022 online survey recorded more than 5 million kilograms of shark and ray products and parts sold across major e-commerce platforms including Facebook, Shopee, Lazada and business sites (Sidik *et al.* 2025). A vast majority of these were meat and bodies, indicating that the market for sharks and rays in Malaysia goes well beyond fins. Most concerningly, both threatened and CITES-listed species were recorded. In a separate study, an 11-day survey of sea cucumber and fish maw trade in Malaysia recorded almost 1500 kg of sea cucumber offered for sale, similarly including threatened and CITES-listed species (Ong and Chin 2022).

Traceability challenges

As illegally-sourced wildlife can be mixed into legal supply chains either deliberately or unknowingly, law enforcement face challenges in determining the provenance—and therefore legality—of traded wildlife. While captive breeding can potentially replace some of the pressure from wild populations, it unfortunately also presents a loophole where unscrupulous traders can launder wild-caught individuals as captive-bred ones to evade regulatory controls. Traceability along the supply chain is therefore required, where for instance individual animals are tagged with microchips or closed rings.

Traceability challenges are especially acute for processed commodities where the species identity and origin cannot be confirmed visually, most notably for commodities sourced from fisheries and the forestry industry. Origin information for online shark and ray sales posts was largely missing: only 18% of shark posts and 31% of ray posts included origin information (Sidik *et al*. 2025). Traceability, and therefore the ability to verify legality and sustainability, is essential; tools such as SharkTrace and rapid DNA tests have thus been recommended to strengthen oversight and to verify where and how shark and ray products were sourced from (Sidik *et al.* 2025). Similar traceability tools have been suggested to improve regulation of the sea cucumber and fish maw trade, noting that high trade volumes and the presence of protected and threatened species create compliance risks even where some trade is legal (Ong and Chin 2022).

INTERVENTIONS GLOBAL, LOCAL, AND ALONG THE TRADE CHAIN

Ensuring effective law enforcement

Malaysia's legal response addresses both international and domestic trade. Malaysia acceded to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1977 (CITES, n.d.). CITES is the main instrument regulating international wildlife trade globally. Species that are threatened by trade may be proposed by Parties for addition to CITES Appendix I (prohibiting all commercial international trade) or Appendix II (international trade requires permits). In 2022, Malaysia and Singapore successfully led two proposals to list the white-rumped shama on CITES Appendix II (CITES 2022a) and uplist the straw-headed bulbul from Appendix II to I (CITES 2022b). Both species face declining populations from demand for the caged bird trade; white-rumped shamas were especially being smuggled from Malaysia to neighbouring countries for bird singing competitions (Leupen *et al.* 2018; CITES 2022a). For the white-rumped shama, the Appendix II listing means that international trade requires export permits, allowing for better monitoring and protection.

Demonstrating proactive compliance with CITES, Malaysia has improved control over saiga antelope horn stockpiles by implementing inventory management, auditing, and enforcement oversight in line with CITES Decisions – the first country to do so for this species. This is crucial as Malaysia is a major consumer of these horns in use for traditional Chinese medicine (TCM), and the species is protected under CITES Appendix II.

Authorities conducted stockpile assessments, enhanced documentation and record-keeping systems, and increased monitoring of licensed premises handling saiga antelope horns. Efforts also included tighter regulation of domestic trade, awareness-raising among TCM stakeholders, and closer inter-agency coordination to prevent leakage of illegal saiga antelope products into legal markets (CITES 2025).

Looking at national level legislation, the *International Trade in Endangered Species Act 2008* (Act 686) was enacted to implement CITES. Domestic protection and offence provisions for wildlife in Peninsular Malaysia and the Federal Territory of Labuan are set out in the *Wildlife Conservation (Amendment) Act 2022* and likewise the *Wildlife Conservation Enactment 1997* for Sabah and the *Wildlife Protection Ordinance 1998* for Sarawak. A key recent intervention is stronger deterrence through heavier penalties. The *Wildlife Conservation (Amendment) Act 2022* now includes stronger provisions compared to the previous 2010 law with, among others, strengthened penalties for serious wildlife offences. Now, there are maximum penalties of up to RM1 million, and up to 15 years' imprisonment for certain offences involving totally protected wildlife.

Enforcement measures are most effective when they result in convictions and penalties that deter future offenders. NGOs such as Justice for Wildlife Malaysia and TRAFFIC have been working with law enforcement officers, prosecutors, and judiciary to organise training, which cover aspects from investigation processes, to crime scene and evidence handling, to running mock trials (JWM 2023; TRAFFIC 2024a). The establishment of Malaysia's National Wildlife Forensic Laboratory supports enforcement and prosecutions through forensic DNA testing and related analyses (Government of Malaysia 2021).

Recent cases indicate Malaysia can achieve high-impact prosecutorial outcomes in some instances. In February 2026, a Malaysian court issued landmark penalties totaling almost RM129 million and more than 70 years total jail time to three Vietnamese nationals convicted of illegally keeping over 1000 parts of wildlife from many protected and highly threatened species, including tigers, bears, pangolins, and others (Bernama 2026; TRAFFIC 2026b).

Another significant milestone is Malaysia's first rhino horn trafficking conviction. In October 2025, two men were convicted for illegal possession of multiple white rhino horn pieces and one black rhino horn piece without special permits and were sentenced to six months' jail (TRAFFIC 2025a). This demonstrates the possibility of follow-through from seizure to conviction for high-value, internationally trafficked products, consistent with the increasing emphasis on the importance of treating wildlife trafficking as a serious crime and strengthening criminal justice responses. While the conviction was welcomed, the low jail term for a serious offence emphasises the need to continue advocating for better understanding by the judiciary on the seriousness of wildlife crime, and the illicit profits that could have been gained from it.

Engaging the private sector to improve detection

Interventions at various points along the trafficking and transportation chain exploited by wildlife traffickers aim to raise the probability of detection in the systems traffickers rely on. The postal and courier sector is one such example. A TRAFFIC analysis found over 4,700 wildlife individuals, parts, and products seized via post and courier incidents implicating Malaysia from 2016 to 2025 (TRAFFIC, unpublished data). Recognising a need and an opportunity, TRAFFIC worked with Pos Malaysia to institutionalise training and tools to improve detection and interdiction by staff across Malaysia (TRAFFIC 2022). By the end of the project, Pos Malaysia data indicated that wildlife parcel detection rose over tenfold at the international mail hub, reflecting the value of a sustained partnership model that links awareness, tools, and escalation pathways for suspicious parcels (TRAFFIC 2023).

To address the surge in wildlife trafficking incidents implicating Kuala Lumpur International Airport, the "*Eyes at KUL*" initiative was developed with Malaysia Airports to strengthen frontline staff awareness (TRAFFIC 2026c). This is a continuation of years of engagement with airport and airline stakeholders that started as part of a global initiative bringing together transport and logistics companies, government agencies, development groups, law enforcement, conservation organisations, academia, and donors to disrupt wildlife trafficking activities (TRAFFIC 2026a).

Other vectors also need to be drawn into the fold. Online platforms are a crucial intervention point because they facilitate trader access to buyers. Financial-sector intervention ("following the money") can help identify broader criminal networks and disrupt profits by submitting Suspicious Transaction Reports and targeting financial flows and money laundering linked to wildlife (Financial Action Task Force 2020). Global efforts to engage both sectors are ongoing (WWF 2024; United for Wildlife 2026), and Malaysia-specific activities have been initiated.

Reducing the use and demand for protected wildlife

Demand-side and industry engagement can reduce incentives for illegal supply, particularly where wildlife ingredients are culturally embedded. In Malaysia, steps towards this were made with the traditional Chinese medicine (TCM) sector through the "*Ren Xin*" (Kind Heart) initiative, developed with Malaysian TCM industry associations to address the use of protected and threatened species by them (TRAFFIC 2024b). In addition to raising awareness about risks to the industry from the illegal wildlife trade, the initiative specifically targeted the industry's knowledge needs. A one-stop resource handbook was developed that includes relevant legislation, protection statuses of commonly used wildlife ingredients, and clinical trial studies showcasing alternative formulations that do not contain protected wildlife (Tsen *et al.* 2023). Recognising the gravity of the issue, stakeholders themselves have emphasised the role of shifting toward legal and sustainable alternatives, and reducing legal risk for practitioners and traders (Bernama 2025).

Bringing stakeholders together to find shared solutions

Illegal wildlife trade is difficult to control when agencies and sectors act in isolation, especially where responsibilities span multiple government agencies and private sectors. In September 2024, the "*UNITE: Combatting Wildlife Trafficking at Malaysian Borders*" roundtable was an example of a forum for both enforcers and the private sector to discuss strategies to collectively tackle trafficking across air, land, and sea entry and exit points (TRAFFIC 2024c). Public-private approaches are also crucial; a TCM conference connected key stakeholders in the industry with government health and wildlife regulators, fostering direct dialogue and greater clarity within the industry about compliance (TRAFFIC 2024b).

CONCLUSION

The illegal wildlife trade in Malaysia is large, complex, and covers a broad range of species and commodity types. Transnational organised networks exploit existing systems to advertise, transport and sell illegal wildlife. This problem therefore requires multi-faceted approaches. Successful interventions require deterrence and detection: stronger legal penalties, improved prosecution outcomes, and targeted partnerships with vectors such as postal/courier services and airports. Future effectiveness will likely depend on sustaining these measures while strengthening traceability and regulating online sales, deepening cooperation from the tech and finance sectors, and maintaining multi-stakeholder coordination so that intelligence, evidence, and action can move quickly across agencies and sectors. Working to shift demand away from illegal wildlife will also serve to remove an ultimate driver.

Acknowledgement: We would like to thank Ms. Aina Amyrah for providing an initial draft, and Kanitha Krishnasamy for reviewing the document. We would also like to thank TRAFFIC's zoo partners of the Zoo and Aquarium Association Australasia (ZAA) and the United States Department of State, Bureau of International Narcotics and Law Enforcement Affairs (INL) for supporting TRAFFIC's data work.

REFERENCES

Bernama. 2025, February 27. TCM transitioning to plant-based medicines to safeguard wildlife. *Bernama*. https://www.bernama.com/en/news.php?id=2397068

Bernama. 2026, February 19. Three Vietnamese nationals jailed, fined RM128.9 million for wildlife possession. Bernama. https://www.bernama.com/en/news.php/crime_courts/news.php?id=2525496&

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). n.d. *List of Contracting Parties*. Geneva: CITES.

CITES. 2022a. *Consideration of proposals for amendment of Appendices I and II: White-rumped Shama*. Geneva: CITES. https://cites.org/sites/default/files/documents/E-CoP19-Prop-08.pdf

CITES. 2022b. *Consideration of proposals for amendment of Appendices I and II: Straw-headed Bulbul*. Geneva: CITES. https://cites.org/sites/default/files/documents/E-CoP19-Prop-09-R1.pdf

CITES. 2025. *Malaysia's Saiga Horn Stockpile Inventory and Management. CoP20 Inf. 71*. Geneva: CITES. https://cites.org/sites/default/files/documents/E-CoP20-Inf-071.pdf

Financial Action Task Force. 2020. *Money laundering and the illegal wildlife trade*. Paris: Financial Action Task Force. https://www.fatf-gafi.org/en/publications/Environmentalcrime/Money-laundering-wildlife-trade.html

Government of Malaysia. 2021. *Sixth National Report to the Convention on Biological Diversity*. Montreal: Convention on Biodiversity.

Justice for Wildlife Malaysia (JWM). 2023. *Work - Justice for Wildlife Malaysia*. Petaling Jaya: Justice for Wildlife Malaysia. https://www.justicewildlifemy.com/our-work/

Krishnasamy, K. 2025, April 24. Securing Malaysian Skies Against Wildlife Traffickers. *Macaranga*. https://www.macaranga.org/securing-malaysian-skies-against-wildlife-traffickers

Krishnasamy, K. and Stoner, S. 2016. Trading Faces: *A Rapid Assessment on the use of Facebook to Trade Wildlife in Peninsular Malaysia*. Petaling Jaya: TRAFFIC. https://www.traffic.org/publications/reports/trading-faces/

Krishnasamy, K. and Zavagli, M. 2020. *Southeast Asia: At the heart of wildlife trade*. Petaling Jaya: TRAFFIC. https://www.traffic.org/publications/reports/renewed-game-plan-needed-to-tackle-southeast-asias-massive-wildlife-trafficking-problem/

Leupen, B.T., Krishnasamy, K., Shepherd, C.R., Chng, S.C.L., Bergin, D.A., Eaton, J.A.E., Yukin, D.A. *et al.* 2018. Trade in White-rumped Shamas Kittacincla malabarica demands strong national and international responses. *Forktail* 34: 1–8.

Malay Mail. 2024, July 4. Malaysia rescues hundreds of smuggled tortoises worth RM3.8m from 'Ninja Turtle Gang' crime ring. *Malay Mail*.https://www.malaymail.com/news/malaysia/2024/07/04/malaysia-rescues-hundreds-of-smuggled-tortoises-worth-rm38m-from-ninja-turtle-gang-crime-ring/142693?

Morhan, S. 2024, January 18. Combatting the illegal online wildlife trade in Malaysia: Minister reveals alarming statistics. *The Sun*. https://thesun.my/local_news/action-taken-on-illegal-online-wildlife-trade-LA11998298

Ong, E.J. and Chin, S.T. 2022. *A rapid assessment of online trade in sea cucumber and fish maw in Malaysia and Singapore*. Petaling Jaya: TRAFFIC. https://www.traffic.org/publications/reports/a-rapid-assessment-of-online-trade-in-sea-cucumber-and-fish-maw-in-malaysia-and-singapore/

Sidik, A., Chng, S.C., Yi, L.J., Adam, S. and Amer, A. 2025. *From Sea to Screen: Malaysia's Online Shark and Ray Trade*. Petaling Jaya: TRAFFIC. https://www.traffic.org/publications/reports/from-sea-to-screen-malaysias-online-shark-and-ray-trade/

Stoner, S. 2018. Operation Dragon: *Revealing new evidence of the scale of corruption and trafficking in the turtle and tortoise trade*. The Hague: The Wildlife Justice Commission. https://wildlifejustice.org/wp-content/uploads/2019/01/WJC-DragonReport-LR-DEF_update.pdf

The Star. 2024, July 4. Perhilitan rescues hundreds of tortoises from 'Ninja Turtle Gang'. *The Star*. https://www.thestar.com.my/news/nation/2024/07/04/perhilitan-rescues-hundreds-of-tortoises-from-039ninja-turtle-gang039?

TRAFFIC. 2022. February 22. Frontliners at Malaysia's international postal hub equipped with tools to detect wildlife in the mail. *TRAFFIC*. https://www.traffic.org/news/frontliners-at-malaysias-international-postal-hub-equipped-with-tools-to-detect-wildlife-in-mail/

TRAFFIC. 2023, October 31. Successful detection rises in effort to stamp out wildlife smuggled in the mail. *TRAFFIC*. https://www.traffic.org/news/successful-detection-rises-in-effort-to-stamp-out-wildlife-smuggled-in-the-mail/

TRAFFIC. 2024a. Specialised training for improved investigations of wildlife crime in Malaysia. *TRAFFIC*. https://www.traffic.org/news/specialised-training-for-improved-investigations-of-wildlife-crime-in-malaysia/

TRAFFIC. 2024b, June 28. Kind Hearts: New initiative with Traditional Chinese Medicine industry associations encourages wildlife protection. *TRAFFIC*. https://www.traffic.org/news/kind-hearts-new-initiative-with-traditional-chinese-medicine-industry/

TRAFFIC. 2024c, September 3. No entry: Malaysia's enforcers forge plans to prevent wildlife trafficking at borders. *TRAFFIC*. https://www.traffic.org/news/no-entry-malaysias-enforcers-forge-plans-to-prevent-wildlife-trafficking-at-borders/

TRAFFIC. 2025a, October 15. Two men sentenced to 6-months jail in Malaysia's first-ever rhino horn trafficking conviction. *TRAFFIC*. https://www.traffic.org/news/two-men-sentenced-to-6-months-jail-in-malaysias-first-ever-rhino-horn-trafficking-conviction/

TRAFFIC. 2025b, October 24. Gibbons in Peril as Trafficking Peaks. *TRAFFIC*. https://www.traffic.org/news/gibbons-in-peril-as-trafficking-peaks/

TRAFFIC. 2026a. *USAID ROUTES Partnership: Reducing Opportunities for Unlawful Transport of Endangered Species*. Petaling Jaya: TRAFFIC. https://www.traffic.org/what-we-do/thematic-issues/private-sector-guidance/routes/

TRAFFIC. 2026b, February 19. Malaysian court issues record penalties in case involving over 1,000 wildlife parts. *TRAFFIC*. https://www.traffic.org/news/malaysian-court-issues-record-penalties-in-case-involving-over-1-000-wildlife-parts/

TRAFFIC. 2026c, March 13. More eyes, less wildlife trafficking at Malaysia's main international airport. *TRAFFIC*. https://www.traffic.org/news/more-eyes-less-wildlife-trafficking-at-malaysias-main-international-airport/

Tsen, L., Teo, B. and Chng, S.C.L. 2023. *Handbook for TCM Practitioners & Traders in Malaysia*. Kuala Lumpur: Federation of Chinese Physicians and Medicine Dealers Association of Malaysia (FCPMDAM). https://healersforthewild.com/wp-content/uploads/2024/02/Handbook-for-TCM-Practitioners-Traders-in-Malaysia.pdf

United for Wildlife. 2026. Financial Taskforce. *United for Wildlife*. https://unitedforwildlife.org/taskforces/financial-taskforce/

United Nations Office on Drugs and Crime. 2024. World wildlife crime report 2024. Vienna: United Nations Office on Drugs and Crime. https://www.unodc.org/cofrb/uploads/documents/ECOS/World_Wildlife_Crime_Report_2024.pdf

World Wildlife Fund (WWF). 2024. The Coalition to End Wildlife Trafficking Online. *World Wildlife Fund*. https://www.endwildlifetraffickingonline.org/

State of Nature Conservation in Malaysia 2025, 789–801
doi: 10.62613/sonc2025.v3anc10

CHAPTER 10

Dimensions of human-wildlife conflict in Peninsular Malaysia

SHARMINI JULITA PARAMASIVAM[1,2]*, BENJAMIN GALEA[3,4], AINI HASANAH ABD MUTALIB[5,4], SUSAN LAPPAN[6,4] and NADINE RUPPERT[4,7,8,9]

Abstract: Human-wildlife conflict (HWC) is an increasing challenge globally, driven largely by habitat loss and degradation, human encroachment into animal habitats, and spatial and dietary overlap between humans and wildlife in shared spaces. Negative interactions affect both humans and animals through loss of resources, injuries and fatalities, and psychological stress, thereby threatening biodiversity conservation and human well-being. In this chapter, we review the major dimensions of HWC, including drivers of conflict and its negative impact in Peninsular Malaysia, and highlight the most reported interactions involving macaques, tigers, elephants, wild boars, snakes, and civets. These case studies demonstrate that conflicts are highly context-specific and are influenced by ecological factors, land-use change, resource availability, and human behaviour. We further examine the consequences of these interactions for rural livelihoods, public health, community perceptions, and conservation outcomes. Current and emerging mitigation approaches are discussed, including behaviour-based interventions, public awareness programmes, habitat connectivity measures, compensation schemes, and long-term monitoring and research. Effective management of HWC requires interdisciplinary and evidence-based approaches that address both ecological and socio-economic drivers, while promoting responsible human actions to maintain or enhance opportunities for coexistence. Strengthening species-specific conflict management, improving spatial planning, enhancing inter-agency collaboration, and empowering local communities will be essential to ensuring the long-term persistence of Malaysia's wildlife and the well-being of people living alongside it.

INTRODUCTION

Human–wildlife conflict (HWC) occurs when human needs and activities overlap with those of wild animals, leading to negative outcomes for one or both parties (Abrahms 2021). The IUCN Species Survival Commission Human-Wildlife Conflict and Coexistence Specialist Group further defined HWC as situations when the presence or behaviour of wildlife poses "actual or perceived direct and recurring threat" to human safety or livelihoods for some parties. Differences in perspective, interests, and proximity to conflict zones can lead to disagreements between different groups of people about the occurrence, importance, and intensity of conflict (IUCN SSC HWCTF 2020). Negative impact on people (including tangible and intangible costs) and wildlife (retaliation and persecution) can emerge if

[1] Animal Neighbours Project Society, Selangor, Malaysia.
[2] School of Veterinary Medicine, Faculty of Health and Medical Sciences, University of Surrey, Guildford, United Kingdom.
[3] School of Biological Sciences, Universiti Sains Malaysia, Gelugor, Pulau Pinang, Malaysia.
[4] Malaysian Primatological Society, Kulim, Kedah, Malaysia.
[5] Institute of Tropical Biodiversity and Sustainable Development, Universiti Malaysia Terengganu, Kuala Nerus, Terengganu, Malaysia.
[6] Department of Anthropology, Appalachian State University, Boone NC, USA.
[7] Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences, Yunnan, China.
[8] Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden - Chinese Academy of Sciences, Yunnan, China.
[9] Institute for Tropical Biology & Conservation, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia.
***Corresponding author: sharminijp@gmail.com**

reconciliation and conflict mitigation are not implemented. As human populations expand into natural habitats, and wildlife are displaced and have adapted to human settlements, conflict may become more frequent, severe, and widespread (IUCN SSC HWCTF 2020).

Conflict can happen when humans and wildlife use the same space or resources and when that overlap results in harm, loss, or stress for either or both species. In Malaysia, conflict involves various species and types of interactions, e.g., elephants feeding on crops, macaques and civets entering residential areas, tigers preying on livestock, snakes biting farm workers or hikers, or villagers feeling unsafe due to wildlife presence (Xin *et al.* 2024).

In this chapter, HWC refers to "any negative interaction between humans and wildlife". These interactions can involve tangible (i.e., crop loss, property damage, reduction in income) and intangible costs (i.e., negative emotions, avoidance of high-conflict spaces, social strain). For humans, conflict can range from mild discomfort to severe stress, which may be intermittent or persistent, depending on the situation on the ground (Zimmerman *et al.* 2020). Conflict may be experienced differently by local communities versus large corporations, or non-governmental organisations versus governmental agencies, due to differences in past experiences, objectives, beliefs, and values among stakeholders (Zimmerman *et al.* 2020). Sometimes it may be difficult to find common ground, especially regarding ethical and responsible actions for conflict-prone wildlife. As forests are cleared for farming, infrastructure, and settlements, surviving wildlife must remain in the area or move elsewhere, inevitably increasing their chances of contact with humans.

Peninsular Malaysia is one of the world's biodiversity hotspots, home to tropical rainforests that support diverse flora and fauna, including primates, megafauna, birds, and reptiles. The government of Malaysia has prepared a spatial planning policy known as the Central Forest Spine Masterplan (Kementerian Perumahan dan Kerjaan Tempatan 2022) to reconnect patches of forest across the main ranges of Peninsular Malaysia that constitute the country's ecological backbone and maintain water catchments, carbon storage, and wildlife corridors. However, rapid land-use changes over the past decades have significantly reduced and fragmented these natural habitats. Expansion of oil palm and rubber plantations, logging, infrastructure projects, and urbanisation have reduced natural habitat and led wildlife into closer contact with people (DWNP 2023). Wildlife may enter farmland and villages in search of food and space, leading to more frequent encounters with people. At the same time, rural communities living near forest edges may depend on agriculture for income and food security. Crop damage or livestock loss can harm smallholders and may affect the livelihoods of rural communities (Chung *et al*. 2000; Saaban *et al.* 2011, but see Holzner *et al.* 2019). In both rural and urban areas, negative interactions between humans and wildlife constitute a pressing conservation and community issue, with potential impacts for both people and wildlife including loss of resources, injury or even death. For example, between 2008–2019, 3,797 incidents of crop and property damage were reported by elephants and 33,198 by macaques in Malaysia (Xin *et al.* 2024). During that same period, there were 1,846 cases of human injuries caused by wildlife of which 62 were fatalities, largely from snakebites (Xin *et al*. 2024). Impacts of HWC on wildlife can range from individual-level, such as behavioural changes or individual mortality, to population-level effects such as local extinctions, range restrictions or changes in demography or disease epidemiology (Civitello *et al.* 2018). People affected by negative interactions may also escalate into retaliatory killings and deliberate persecution of wildlife, such as spray-painting macaques (Mohd Fadzli 2025). Direct interactions or fear and resentment of conflict-prone species can also reduce support for conservation and hinder sustainable long-term mitigation efforts. Overall, the needs of communities are often put in opposition to the conservation of wildlife and ecosystems, making it a complex socio-economic challenge to reconcile.

Efforts to address HWC must therefore consider both human and wildlife dimensions involving ecological, behavioural, psychological and political realities, which include human livelihoods, safety, and sentiments towards wildlife. This chapter provides case studies of some commonly reported species involved in HWC in Malaysia, and subsequently explores common drivers of conflict, their consequences, and potential mitigation measures.

CASE STUDIES

Macaques

In many areas bordering forests, large social groups of macaques are commonly encountered. Long-tailed macaques (*Macaca fascicularis*) and Southern pig-tailed macaque (*M. nemestrina*) are widely distributed across Southeast Asia (Hansen *et al.* 2025, Ruppert *et al.* 2023), but despite their increased visibility, their populations are declining, and both species are currently classified as Endangered on the IUCN Red List (Hansen *et al*. 2025; Ruppert *et al.* 2023). As highly synanthropic primates (Holzner *et al*. 2025), *M. fascicularis* readily adjust to human-modified landscapes, using remnant forest patches and carrying out daily activities in anthropogenic spaces, where behaviours such as foraging in rubbish bins, entering houses or orchards, and using human structures (Entezami *et al.* 2025). Additionally, habitat fragmentation and the loss of forest buffers increase the use of human-dominated landscapes by both *M. fascicularis* and *M. nemestrina*, which further increased the likelihood of aggressive behaviours that results in bites and scratches (Xin *et al.* 2024). Deliberate and indirect provisioning through unsecured garbage and other anthropogenic food sources can further reinforce associations between humans and food, creating a feedback loop that increases problematic interactions (Abdul-Nasir *et al*. 2021, Entezami *et al.* 2024; Hambali *et al.* 2012). Conflict management driven largely by complaints of *M. fascicularis* to The Department of Wildlife and National Parks (locally known as PERHILITAN) involves mainly culling (Xin *et al*. 2024).

Despite being perceived as pests, these animals also play an ecological role. Field studies in Peninsular Malaysia found *M. nemestrina* to be an important biological control by preying on rats in oil palm plantations and reduced rodent-related crop losses by approximately USD 100 per hectare per year (Holzner *et al.* 2019).

Tigers

The Malayan tiger (*Panthera tigris jacksoni*), a subspecies restricted to Peninsular Malaysia and southern Thailand (Luo *et al*. 2004), plays an important ecological role as an apex predator in tropical forests. Malayan tigers are Critically Endangered (CR), with current populations estimated as <100 individuals (Goodrich *et al*. 2022). Populations have declined due to agricultural expansion, urbanisation, road development, and depletion of prey populations (Kawanishi *et al.* 2013; Rayan and Linkie 2015; Ten *et al.* 2021; Goodrich *et al.* 2022). Poachers have also killed dozens of Malayan tigers in recent decades (Ten *et al*. 2021; Goodrich *et al*. 2022) while highways have increased the risk of both road mortality and poaching by providing access to key habitats (Clements *et al.* 2010; Ten *et al*. 2021; Goodrich *et al*. 2022).

Conflict by tigers involved attacks on humans or livestock, or the perceived risk of such encounters (Abas *et al.* 2026). Although conflict with tigers accounts for only 4% of reported HWC cases, Malaysians are less tolerant of tigers than elephants and tapirs (Tan *et al*. 2020) and incidents are often prioritised because of concerns for human safety (Abas *et al*. 2026). Livestock depredation represents about 24% of tiger conflict reports and has caused economic losses of RM 124,000 and above (DWNP 2008) between 2005 and 2006. Between 2008 and 2019, tigers injured three people, with no deaths (Ten *et al.* 2021), but since 2020, several fatal attacks have occurred (White 2022; Sharma 2023; Azmi 2024).

Conflict management commonly involves tiger removal or translocation, resulting in the loss of four individuals between 2008 and 2019 (Ten *et al.* 2021), with additional losses in subsequent years (White 2022; Azmi 2024). Consequently, despite low numbers of conflict reports, conflict has become a major threat to the persistence of Malaysia's remaining tigers (Ten *et al.* 2021).

Elephants

Asian elephants (*Elephas maximus*) favour palms, other monocots (i.e. grasses and bamboo), and pioneer plants, and will target young oil palms and occasionally push down older palms in plantations, resulting in crop damage. Modelling of elephant movement behaviour based on GPS satellite collar tracking data revealed that agricultural areas, particularly those near forests, are prime habitat for elephants (de la Torre *et al.* 2021, 2022). Habitat loss, fragmentation, and reduced connectivity have further increased elephant reliance on shared landscapes, where crops provide abundant and predictable food resources. Public attitudes towards large and conflict-prone wildlife such as elephants and tigers are often negative (Tan *et al.* 2020), raising concerns about people's willingness to coexist with elephants (de la Torre 2021). Greater efforts are therefore needed to overcome biases and promote coexistence between people and elephants.

Wild boars

Wild boars (*Sus scrofa*) are among the species most frequently associated with HWC in Peninsular Malaysia. Their rooting, trampling, and feeding behaviours damage crops, seedlings, and plantation infrastructure, resulting in economic losses for smallholders and commercial plantations (Muhammad Idrus and Cik Mohd Ridzuan 2019). Oil palm plantations provide abundant and predictable food resources that support high boar densities and encourage movement into surrounding forests and agricultural areas (Fujinuma and Harrison 2012; Luskin *et al.* 2017). Beyond direct crop damage, boar activities can alter soil properties, seedling recruitment, and forest regeneration, potentially changing habitat conditions and exacerbating conflict (Luskin *et al*. 2019; Brearley *et al.* 2024). They can also mediate large-scale edge effects in lowland tropical rainforest in Peninsular Malaysia (Fujinuma and Harrison 2012). Wild boars also occasionally injure people. Local attitudes towards boars are shaped by economic losses, safety concerns, and cultural or religious sensitivities, which influence the acceptability of lethal control and other management options (Xin *et al*. 2024).

Snakes

Human-snake conflict and bite risk in Peninsular Malaysia are driven largely by landscape change and increased contact at forest-agriculture interfaces. Agricultural expansion, deforestation, and expanding forest edges bring people and snakes into closer contact, with most bites occurring in rural and plantation settings during farming activities (Lee *et al.* 2025, Mhd Nizar *et al.* 2022). Risk is heightened by inadequate protective measures and attempts to capture or kill snakes, which account for many severe incidents (Renault *et al.* 2024). Forest-edge species such as cobras (*Naja* spp.), pit vipers, and kraits are frequently involved (Ismail *et al*. 2023). In human-dominated environments, snakes may also exploit drains and other sheltered microhabitats. Risks are further exacerbated by gaps in species-level surveillance, snake misidentification, inconsistent first-aid practices, and limited public awareness that trained emergency responders can safely remove snakes from residential areas (The Sun 2026). Many snakebite incidents are therefore preventable and strongly influenced by human behaviour.

Civets

Civets in Peninsular Malaysia, particularly the common palm civet (*Paradoxurus hermaphroditus*), increasingly exploit human-modified landscapes, resulting in crop losses, damage to buildings and poultry houses, and occasional public health concerns. Human-civet

conflict is driven primarily by habitat fragmentation, expanding agricultural and residential areas, and the availability of anthropogenic food, including fruit trees, unsecured waste, and poultry (Hasan and Csányi 2023b). Their behavioural flexibility enables civets to thrive in disturbed and semi-urban habitats, while poor waste management, inadequate poultry housing, and intentional feeding further promote habituation and increase the likelihood of conflict (Chong and Hashimi 2021; Hasan and Csányi 2023a). These factors contribute to frequent incursions into human spaces and heightened negative perceptions towards civets.

DISCUSSION

Drivers of HWC in Peninsular Malaysia

Human-wildlife conflicts in Peninsular Malaysia is shaped by interacting ecological and anthropogenic drivers that often operate simultaneously. Habitat loss and fragmentation, agricultural expansion, urbanisation, illegal wildlife exploitation, anthropogenic food resources, human behaviour during wildlife encounters, and climate change all contribute to increasing overlap between humans and wildlife (IUCN SSC HWCTF 2020; König *et al.* 2020; Gayo 2025). As natural habitats become fragmented and ecological connectivity is disrupted, wildlife is increasingly persisting within shared landscapes. Species with high ecological and behavioural flexibility, such as macaques, civets, wild boars, and some snakes, are particularly capable of adapting to anthropogenic environments when food and shelter are available (Holzner *et al.* 2025, Kulkarni and Radhakrishna 2026).

Changes in resource availability further intensify conflict. Human activities often reduce natural food availability while simultaneously providing attractive alternatives through crops, fruit trees, livestock, and unsecured waste. Wildlife may also access food from deliberate provisioning or feeding by residents or visitors (Hambali *et al.* 2012; Abdul-Nasir *et al.* 2021; Fehlmann *et al.* 2021; Entezami et al. 2024). As illustrated by macaques and civets, access to human food sources can promote habituation and increase the frequency of problematic interactions. Similarly, agricultural landscapes have taken over and modified natural habitats, and provide predictable resources that attract elephants and wild boars that could result in crop damage and economic losses if mitigations are not taken, and presence of livestock provides an alternative food source as abundance of wild tiger prey declines.

Human behaviour strongly influences the occurrence and severity of conflict. Feeding, approaching, photographing, harassing, or attempting to capture wildlife can increase risks to both humans and animals (Beisner *et al.* 2014; Weiler *et al.* 2021). Many snake bites occur when people attempt to capture or kill animals, suggesting that a considerable proportion of incidents are preventable (Renault *et al.* 2024). Once animals' associate humans with food, behavioural changes can create a positive feedback loop that further reinforces conflict (Entezami *et al.* 2024).

To manage HWC well, it is important to first understand the drivers contributing to a negative interaction which must be prioritised prior to developing a mitigation strategy. Additionally, it is important to consider the human dimension of the conflict and to explore mitigation approaches, positive interactions, and other ways to increase resilience of the community to tolerate or even thrive in the presence of the wildlife (IUCN 2023).

Mitigation strategies

Because conflict situations vary among species, landscapes, and stakeholders, mitigation measures should address underlying drivers rather than simply treating symptoms (Eklund *et al*. 2018). Effective strategies require a holistic understanding of ecological, social, cultural, and economic contexts and must be adapted for different species and landscapes.

Public awareness and behaviour change are therefore fundamental components of conflict mitigation (Basak *et al.* 2023). Over the years, PERHILITAN together with academic institutions and non-governmental organisations, has implemented numerous education and outreach programmes focusing on safe conduct around wildlife and the ecological importance of native species. For rural communities living near forests, these initiatives are particularly important in promoting coexistence and encouraging safe, non-lethal mitigation practices that minimise economic losses and improve safety without endangering wildlife (Esponisa and Jacobson 2011; Wong *et al.* 2021). Such programmes often emphasise community-based resource protection, non-lethal deterrence, and maintaining ecological balance for long-term livelihood security (Kansky *et al*. 2024). However, behavioural intentions are also influenced by personal values, social norms, and trust in institutions (IUCN 2023; Zahirudin 2025). Despite continuing efforts, understanding of wildlife behaviour and safe mitigation practices remains limited (Hasan and Csányi 2023a; Xin *et al.* 2024), highlighting the need for evidence-based approaches that promote tolerance and behavioural change (Baruch-Mordo *et al.* 2011; Tan *et al*. 2020).

In urban and peri-urban areas, awareness programmes are particularly relevant for adaptable species like macaques whose interactions with people are often shaped by daily experiences (Mohamad Muslim *et al.* 2018). Campaigns that discourage wildlife feeding and encourage proper waste management can reduce habituation and dependence on anthropogenic food sources, while coordinated measures such as "monkey guarding" have been successfully used to reduce macaque presence in both urban and rural settings (Hambali *et al.* 2019; Langur Project Penang 2022; Animal Neighbours Project 2025). Increased public awareness is also important for reducing snakebite incidents by encouraging people to seek assistance from trained emergency responders such as Bomba, Pertahanan Awam or PERHILITAN, rather than attempting to handle snakes themselves.

Maintaining habitat connectivity and identifying areas where interactions between people and wildlife are most likely to occur are important for conflict mitigation. Roads, highways, plantation access routes, agricultural frontiers, and forest edges frequently overlap with wildlife movement paths, creating hotspots of human-wildlife interactions (Clements 2014). Identifying these areas through conflict records, roadkill data, field surveys, spatial modelling, and community-based reporting allows management agencies and conservation groups to prioritise interventions and integrate wildlife considerations into land-use planning (Galea *et al.* 2024; Zanuari *et al.* 2024).

Once high-risk areas are identified, site-specific measures can reduce encounters while maintaining ecological connectivity. Buffer zones around forest edges, settlements, and protected areas can serve as transitional habitats, providing cover and directing animal movements away from roads, farms, and residential areas (Ahmad *et al.* 2018). Maintaining habitat corridors and safeguarding traditional movement routes are particularly important for wide-ranging species such as elephants, while also facilitating dispersal among smaller species.

Linear infrastructure can contribute to wildlife mortality and habitat fragmentation, particularly through wildlife-vehicle collisions. Measures such as fencing, warning signage, speed reduction zones, and, where necessary, wildlife crossings can reduce collisions and facilitate safe movement between fragmented habitats (Soanes *et al*. 2024; Balčiauskas *et al.* 2025). Public awareness campaigns promoting safe driving near wildlife crossing zones can provide additional benefits for both humans and wildlife (Wong *et al.* 2018a, 2018b; Borza *et al.* 2023). Long-term mitigation success depends on integrating wildlife movement and conflict data into transport and land-use planning, supported by regular monitoring and citizen-based reporting to enable adaptive management (Newell *et al*. 2025).

Several species-specific management interventions have been implemented in Peninsular Malaysia. For example, elephant conflict mitigation includes translocation programmes and the use of electric fencing systems in high-conflict areas (Ahmad Zafir and Magintan 2016; Hii *et al.* 2016; Ponnusamy *et al.* 2016). Similarly, macaques in high-conflict areas have been culled, translocated or sterilised, and tigers have been captured, translocated, or killed (Ten *et al.* 2021; Azmi 2024). However, the long-term effectiveness of such approaches depends on the ecological drivers of conflict and integrating mitigation into broader landscape planning.

Compensation mechanisms represent another important tool for maintaining local tolerance towards wildlife. The Wildlife Attack Aid Fund (*Tabung Bantuan Serangan Hidupan Liar*), launched in 2024 by the Ministry of Natural Resources and Environmental Sustainability (NRES), provides financial assistance to individuals and families affected by wildlife-related incidents, including crop losses, property damage, injuries, and fatalities (DWNP 2025). Similar schemes have been implemented elsewhere with varying success (Karanth *et al.* 2018, Wang *et al.* 2024, Dahal *et al.* 2025). Their effectiveness depends largely on accessibility, timeliness, and perceived fairness (Gloriose 2019). In Peninsular Malaysia, challenges remain, including limited awareness, delays in claim verification, and bureaucratic procedures that may discourage reporting of smaller but recurring losses.

Finally, long-term monitoring and research remain essential for adaptive HWC management. Continuous collection of ecological and social data allows managers to identify emerging conflict hotspots, evaluate mitigation measures, and respond to changing environmental and socio-economic conditions. Integrating scientific research with local knowledge and citizen-based reporting can further improve management effectiveness and support evidence-based decision-making (Newell *et al.* 2025). Ultimately, action to address both the ecological drivers of conflict and the human behaviours that influence its intensity is needed to promote long-term coexistence between people and wildlife.

BRIEF POLICY RECOMMENDATIONS

Species-specific management plans

- Develop evidence-based management strategies tailored to conflict-prone species.
- Incorporate species ecology (including food/prey species), movement behaviour, and local socio-economic contexts into mitigation planning.
- Incorporate an educational plan to increase stakeholder awareness and behaviour change.
- Prioritise non-lethal and coexistence-based approaches, with regular evaluation of management effectiveness.
- Establish long-term monitoring programmes to assess population trends and conflict hotspots.

Land use and habitat management

- Maintain and restore ecological connectivity through the establishment of evidence -based and realistic buffer zones around protected areas and forest edges.
- Identify and safeguard wildlife corridors and crossing hotspots during infrastructure and land-use planning.
- Incorporate wildlife-friendly infrastructure designs, including underpasses, overpasses, and road fencing where appropriate.
- Encourage sustainable agricultural practices that minimise habitat degradation and reduce opportunities for conflict.

Inter-agency collaboration

- Strengthen coordination among local authorities, plantation sectors, academic institutions, and non-governmental organisations.
- Develop standardised data-sharing platforms and joint response protocols for rapid conflict management.
- Integrate conflict considerations into broader land-use, transportation, and development policies.
- Promote cross-sector partnerships to support research, monitoring, and public outreach initiatives.

Community engagement and education

- Provide training and capacity building for local communities on safe coexistence strategies and non-lethal mitigation measures.
- Increase public awareness regarding wildlife ecology, responsible behaviour, and the importance of biodiversity conservation.
- Establish citizen reporting systems and community-based rapid response teams to improve early detection and incident management.
- Empower communities to participate in monitoring programmes and coexistence strategies including habitat restoration initiatives.
- Promote behavioural change campaigns aimed at reducing wildlife feeding and improving waste management practices.
- Funding and incentives:
- Expand and strengthen conservation-based funds and other financial mechanisms supporting conflict mitigation.
- Improve compensation and assistance schemes for affected farmers and communities to maintain tolerance towards wildlife.
- Provide incentives for wildlife-friendly agricultural practices and habitat conservation on private and plantation lands.
- Support community-based livelihood diversification and value-added products that reduce dependence on conflict-prone activities.
- Increase investment in long-term research, monitoring, and innovative technologies for conflict prevention and adaptive management.

CONCLUSION

Human-wildlife conflict in Peninsular Malaysia is a complex and multidimensional issue arising from overlap between human and wildlife in rapidly changing landscapes. Habitat fragmentation, agricultural expansion, anthropogenic food resources, and human behaviours have intensified interactions involving a wide range of species, with consequences that extend beyond immediate economic losses to include human injuries, psychological stress, and significant impacts on wildlife populations and ecosystem integrity. The examples of macaques, tigers, elephants, wild boars, snakes, and civets demonstrate that no single mitigation measure can effectively address all situations, as conflicts differ among species, landscapes, and stakeholders. Moving forward, management efforts should shift from reactive responses towards proactive coexistence strategies that address the underlying drivers of conflict. Such approaches require integrating ecological knowledge with social, cultural, and economic considerations, while recognising that sustainable solutions depend as much on changing human behaviour and perceptions as on modifying wildlife behaviour. Strengthening habitat connectivity, maintaining buffer zones, improving waste management, promoting biodiversity or wildlife-friendly agricultural practices, and reducing opportunities for conflict are essential components of long-term prevention. Equally important are public awareness, community participation, compensation mechanisms, and effective collaboration among government agencies, researchers, non-governmental organisations, industry, and

local communities. Continued monitoring and research are necessary to evaluate the effectiveness of mitigation measures and to enable adaptive management under changing environmental and socio-economic conditions. Ultimately, coexistence between people and wildlife will require balancing human safety and livelihoods with the conservation of biodiversity, ensuring that both communities and wildlife can persist within shared landscapes.

REFERENCES

Abas, A., Yusof, A.H.M., Rahman, A.H.A. and Fauzi, T.A.H.T.M. 2025. Investigating the dynamics of human–wildlife conflict in oil palm plantation: Cases from Johor and Sabah, Malaysia. *Society & Natural Resources* 39(5): 713–728. https://doi.org/10.1080/08941920.2025.2575461

Abdul-Nasir, N.S., Osman, N.A., Hashim, Z.F., Baharudin, Z., Abdullah, M.I., Isa, Z. and Md-Zain, B.M. 2021. Assessing perceptions and solutions to human-long tailed macaques (*Macaca fascicularis*) conflict in the Universiti Kebangsaan Malaysia campus, Bangi, Selangor, Malaysia. *Malayan Nature Journal* 73(2): 187–197.

Abrahms, B. 2021. Human-wildlife conflict under climate change. *Science* 373: 484–485. https://doi.org/10.1126/science.abj4216

Ahmad, C.B., Abdullah, J. and Jaafar, J. 2018. Buffer zone concept and its potential implementation in Tasek Bera. *Asian Journal of Environment-Behaviour Studies* 3(7): 11–18. https://doi.org/10.21834/aje-bs.v3i7.255

Ahmad Zafir, A.W. and Magintan, D. 2016. Historical review of human elephant conflict in Peninsular Malaysia. *Journal of Wildlife and Parks* 31: 1–19.

Animal Neighbours Project. 2025. Advocacy. *Animal Neighbours Project*. https://animalneighboursproject.org/advocacy

Azmi, H. 2024, October 21. Malaysia's capture of tiger blamed for 2 deaths highlights conservation dilemma. *South China Morning Post.* https://www.scmp.com/week-asia/health-environment/article/3283187/malaysias-capture-tiger-blamed-two-deaths-highlights-conservation-dilemma

Balčiauskas, L., Kučas, A. and Balčiauskienė, L. 2025. A review of wildlife–vehicle collisions: a multidisciplinary path to sustainable transportation and wildlife protection. *Sustainability* 17(10): 4644. https://doi.org/10.3390/su17104644

Baruch-Mordo, S., Breck, S.W., Wilson, K.R. and Broderick, J. 2011. The carrot or the stick? Evaluation of education and enforcement as management tools for human-wildlife conflicts. *PLoS ONE* 6(1): e15681. https://doi.org/10.1371/journal.pone.0015681

Basak, S.M., Rostovskaya, E., Birks, J. and Wierzbowska, I.A. 2023. Perceptions and attitudes to understand human-wildlife conflict in an urban landscape – a systematic review. *Ecological Indicators* 151: 110319. https://doi.org/10.1016/j.ecolind.2023.110319

Borza, S., Godó, L., Valkó, O., Végvári, Z. and Deák, B. 2023. Better safe than sorry – Understanding the attitude and habits of drivers can help mitigating animal-vehicle collisions. *Journal of Environmental Management* 339: 117917. https://doi.org/10.1016/j.jenvman.2023.117917

Brearley, F.Q., Song, H., Tripathi, B.N., Dong, K., Zin, N.M, Abdul Rachman, A.R., Ickes, K., Adams, J.M., and Luskin, M.S. 2024. Wild pigs influence tropical forest soil microbial communities in a forest-agriculture mosaic landscape. *Forest Ecology and Management* 572: 122320. https://doi.org/10.1016/j.foreco.2024.122320

Chong, J.L. and Mohd Amir Hashimi. 2021. A survey of civet cats in a semi-urban environment in Terengganu. *Universiti Malaysia Terengganu Journal of Undergraduate Research* 3: 87–92. https://doi.org/10.46754/umtjur.v3i3.221

Chung, G.F. 2000. Vertebrate pests of oil palm. In *Advances in Oil Palm Research Volume 1*, pp. 542–595. Kuala Lumpur: Malaysian Palm Oil Board.

Clements, G.R., Rayan, D.M., Ahmad Zafir, A.W., Venkataraman, A., Alfred, R., Payne, J., Ambu, L. and Sharma, D.S.K. 2010. Trio under threat: can we secure the future of rhinos, elephants and tigers in Malaysia? *Biodiversity and Conservation* 19(4): 1115–1136. https://doi.org/10.1007/s10531-009-9775-3

Clements, G.R., Lynam, A.J., Gaveau, D., Yap, W.L., Lhota, S., Goosem, M., Laurence, S. and Laurance, W.F. 2014. Where and how are roads endangering mammals in Southeast Asia's forests? *PloS ONE* 9(12): e115376. https://doi.org/10.1371/journal.pone.0115376

Civitello, D.J., Allman, B.E., Morozumi, C., Rohr, J.R. 2018. Assessing the direct and indirect effects of food provisioning and nutrient enrichment on wildlife infectious disease dynamics. *Philosophical Transactions of the Royal Society of London Series B: Biological Sciences* 373(1745): 20170101. https://doi.org/10.1098/rstb.2017.0101

Dahal, N.K., Harada, K., Adhikari, S. and Gurung, R. 2025. Enhancing human–wildlife coexistence: community perceptions of compensation policies in a protected area of Nepal. *GeoJournal* 90(2): 91. https://doi.org/10.1007/s10708-025-11341-5

de la Torre, J.A., Cheah, C., Lechner, A.M., Wong, E.P., Tuuga, A., Saaban, S., Goossens, B. and Campos-Arceiz, A. 2022. Sundaic elephants prefer habitats on the periphery of protected areas. *Journal of Applied Ecology* 59: 2947–2958. https://doi.org/10.1111/1365-2664.14286

de la Torre, J.A., Wong, E.P., Lechner, A.M., Zulaikha, N., Zawawi, A., Abdul Patah, P., Saaban, S., Goossens, B. and Campos-Arceiz, A. 2021. There will be conflict - agricultural landscapes are prime, rather than marginal, habitats for Asian elephants. *Animal Conservation* 24(5): 720–732. https://doi.org/10.1111/acv.12668

DWNP. 2008. National Tiger Action Plan for Malaysia 2008–2020. Kuala Lumpur: Department of Wildlife and National Parks Peninsular Malaysia.

DWNP. 2025. Prosedur operasi standard inisiatif bantuan kerugian harta benda dan tanaman akibat serangan hidupan liar Kementerian Sumber Asli dan Kelestarian Alam. Kuala Lumpur: Department of Wildlife and National Parks Peninsular Malaysia. https://files.wildlife.gov.my/wildlife-wp-media/2025/10/30063415/SOP_INISIATIF_BKHT_050924.pdf

Eklund, A., López-Bao, J. V., Tourani, M., Chapron, G. and Frank, J. 2018. Limited evidence on the effectiveness of interventions to reduce livestock predation by large carnivores. *Scientific Reports* 8: 5770. https://doi.org/10.1038/s41598-018-22471

Entezami, M., Mustaqqim, F., Morris, E., Lim, E.S.H., Prada, J.M. and Paramasivam, S.J. 2024. Effect of human activity and presence on the behavior of long-tailed macaques (*Macaca fascicularis*) in an urban tourism site in Kuala Selangor, Malaysia. *Animals* 14(8): 1173. https://doi.org/10.3390/ani140801173

Espinosa, S. and Jacobson, S.K. 2011. Human-wildlife conflict and environmental education: evaluating a community program to protect the Andean bear in Ecuador. *The Journal of Environmental Education* 43(1): 55–65. https://doi.org/10.1080/00958964.2011.579642

Fehlmann, G., O'riain, M.J., Fürtbauer, I. and King, A.J. 2021. Behavioral causes, ecological consequences, and management challenges associated with wildlife foraging in human-modified landscapes. *BioScience* 71(1): 40–54. https://doi.org/10.1093/biosci/biaa129

Fujinuma, J. and Harrison, R.D. 2012. Wild pigs (*Sus scrofa*) mediate large-scale edge effects in a lowland tropical rainforest in Peninsular Malaysia. *PLoS ONE* 7(5): e37321. https://doi.org/10.1371/journal.pone.0037321

Galea, B., Mobarak, I., Izzati, N. A., Fong, M.Y., Abdullah, M.F.D., Bukhari, A.M.M., Lim, C.K. and Ruppert, N. 2023. Recommendations for the establishment of a trans-island canopy bridge network to support primate movement across Langkawi Island, Malaysia. *Oryx* 58(2): 187–191. https://doi.org/10.1017/s0030605323001333

Gayo, L. 2025. A review of climate change, human population growth and poverty as potential drivers of human wildlife conflicts in Africa. *Discover Animals* 2: 49. https://doi.org/10.1007/s44338-025-00088-5

Gloriose, U. 2019. Community perceptions of human-wildlife conflicts and the compensation scheme around Nyungwe National Park (Rwanda). *International Journal of Natural Resource Ecology and Management* 4(6): 188. https://doi.org/10.11648/j.ijnrem.20190406.15

Goodrich, J., Wibisono, H., Miquelle, D., Lynam, A.J., Sanderson, E., Chapman, S., Gray, T.N.E., Chanchani, P. and Harihar, A. 2022. *Panthera tigris*. The IUCN Red List of Threatened Species 2022: e.T15955A214862019. https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T15955A214862019.en

Hambali, K., Ismael, A., Zulkifli, S.Z., Md-Zain, B.M., and Amir, A. 2012. Human-macaque conflict and pest behaviors of long-tailed macaques (*Macaca fascicularis*) in Kuala Selangor Nature Park. *Tropical Natural History* 12(2): 189–205. https://doi.org/10.58837/tnh.12.2.103050

Hansen, M.F., Ang, A., Fuentes, A. and Nijman, V. 2025. *Macaca fascicularis*. The IUCN Red List of Threatened Species 2025: e.T12551A273015436. https://dx.doi.org/10.2305/IUCN.UK.2025-2.RLTS.T12551A273015436.en

Hasan, S.M. and Csányi, S. 2023a. Attitude index of local communities toward wildlife and their management methods in Malaysia. *Diversity* 15(2): 202. https://doi.org/10.3390/d15020202
Hasan, S.M. and Csányi, S. 2023b. Human–asian palm civet conflict in Malaysia. *Sustainability* 15(15): 11570. https://doi.org/10.3390/su151511570
Hii, N., Wong E.P., Chackrapani P., Mena, A.S., Tan, A.S.L., Nagulendran, K., Wadey, J. *et al.* 2016. MEME-moving towards a science-based conservation of Malaysian elephants. *Malayan Nature Journal* 68: 191–197.
Holzner, A., Ruppert, N., Ilham, K., Kaburu, S.S.K., Koch Liston, A.L., Fuentes, A. and Hansen, M.F. 2025. Threatened synanthropes depend on intact forests: a critical evaluation of Moore *et al*. 2023. *Biological Reviews* 100: 1444–1451. https://doi.org/10.1111/brv.70007
Holzner, A., Ruppert, N., Swat, F., Schmidt, M., Weiss, B., Villa, G., Mansor, A., Sah, S., Engelhardt, A., Kühl, H. and Wittig, A. 2019. Macaques can contribute to greener practices in oil palm plantations as biological pest control. *Current Biology* 29(20): R1066–R1067. https://doi.org/R1066-R1067
Ismail, A.K., Abd Hamid, M.N.H., Ariff, N.A., and Frederic Ng, V.E.R., Goh, W.C., Abdul Samat, N.S., Osman, A.M.Z. *et al.* 2023. Frequency, clinical characteristics and outcomes of *Tropidolaemus* species bite envenomations in Malaysia. *PLoS Neglected Tropical Diseases* 17(1): e0010983. https://doi.org/10.1371/journal.pntd.0010983
IUCN. 2023. IUCN SSC Guidelines on human-wildlife conflict and coexistence. IUCN SSC Human-Wildlife Conflict & Coexistence Specialist Group. https://www.hwctf.org/guidelines
IUCN SSC HWCTF. 2020. What is Human-Wildlife Conflict? Briefing Paper by the IUCN Species Survival Commission Human-Wildlife Conflict Task Force. https://www.hwctf.org
Kansky, R., Maassarani, T. and Fischer, J. 2024. Participatory co-learning for human–wildlife coexistence: Reflections on a novel program applying systems thinking, nonviolent communication, and learning-based approaches. *AMBIO* 53(10): 1479–1491. https://doi.org/10.1007/s13280-024-02032-5
Karanth, K., Gupta, S. and Vanamamalai, A. 2018. Compensation payments, procedures and policies towards human-wildlife conflict management: Insights from India. *Biological Conservation* 227: 383–389. https://doi.org/10.1016/j.biocon.2018.07.006
Kawanishi, K., Clements, G.R., Gumal, M., Goldthorpe, G., Yasak, M.N., and Sharma, D.S.K. 2013. Using BAD for good: how best available data facilitated a precautionary policy change to improve protection of the prey of the tiger Panthera tigris in Malaysia. *Oryx* 47(3): 420–426.
Kementerian Perumahan dan Kerjaan Tempatan. 2022. *Central Forest Spine: A Master Plan for Ecological Linkages*. Kuala Lumpur: Kementerian Perumahan dan Kerajaan Tempatan. https://myplan.planmalaysia.gov.my/portal-main/publication-details?id=13
König, H.J., Kiffner, C., Kramer-Schadt, S., Fürst, C., Keuling, O. and Ford, A.T. 2020. Human–wildlife coexistence in a changing world. *Conservation Biology* 34(4): 786–794. https://doi.org/10.1111/cobi.13513
Kulkarni, V., Radhakrishna, S. 2026. Revisiting wildlife crop foraging: why don't all individuals forage on crops? *Acta Ethologica* 29: 14. https://doi.org/10.1007/s10211-026-00486-2
Langur Project Penang. 2022. Coexistence for all – for people & macaques. https://langurprojectpenang.com/coexistence-for-all-for-people-macaques/
Lee, S., Lee, J. and Min, K.-D. 2025. Association between deforestation and the incidence of snakebites in South Korea. *Animals* 15(2): 198. https://doi.org/10.3390/ani15020198
Luo, S.J., Kim, J.H., Johnson, W.E., Walt, J.V.D., Martenson, J., Yuhki, N., Miquelle, D.G. et al. 2004. Phylogeography and genetic ancestry of tigers (*Panthera tigris*). *PLoS Biology* 2(12): e442. https://doi.org/10.1371/journal.pbio.0020442
Luskin, M.S., Brashares, J.S., Ickes, K., Sun, I.F., Fletcher, C., Wright, S.J. and Potts, M.D. 2017. Cross-boundary subsidy cascades from oil palm degrade distant tropical forests. *Nature Communications* 8(1): 2231. https://doi.org/10.1038/s41467-017-01920-7
Luskin, M.S., Ickes, K., Yao, T.L. and Davies, S.J. 2019. Wildlife differentially affect tree and liana regeneration in a tropical forest: an 18-year study of experimental terrestrial defaunation versus artificially abundant herbivores. *Journal of Applied Ecology* 56: 1379–1388. https://doi.org/10.1111/1365-2664.13378
Mhd Nizar, M.N.F., Rahman, A., Baharuddin, K.A., Ahmad, M.Z. and Mohamed Ismail, M. 2022. Factors associated with severe evenomation of snakebite cases at emergency department, Hospital Sultan Abdul Halim, Kedah, Malaysia. *Medical Journal of Malaysia* 77(1): 20 –25. https://www.e-mjm.org/2022/v77n1/envenomation-of-snakebite.pdf

Mohamad Muslim, H.F., Tetsuro, H., Shinya, N., and Yahya, N.A. 2018. Nature experience promotes preference for and willingness to coexist with wild animals among urban and suburban residents in Malaysia. *Ecological Processes* 7: 18. https://doi.org/10.1186/s13717-018-0127-7

Muhammad Idrus, S. and Cik Mohd Ridzuan, Z.A. 2019. Survey and Study of Wild Boar Control Management on Oil Palm. *3rd International Conference on Veterinary and Animal Science* (Animalife 2019), Kuala Lumpur.

Newell, R., Lister, N., Dale, A. and Careri, S. 2025. Wildlife crossing database platform: A transdisciplinary approach to developing a tool for landscape connectivity planning and public engagement. *Wildlife Society Bulletin* 49(2). https://doi.org/10.1002/wsb.1593

Ponnusamy, V., Chackrapani, P., Lim, T.W., Saaban, S. and Campos-Arceiz, A. 2016. Farmers' perceptions and attitudes towards government-constructed electric fences in Peninsular Malaysia. *Gajah* 45: 4–11.

Rayan, D.M., and Linkie, M. 2015. Conserving tigers in Malaysia: A science-driven approach for eliciting conservation policy change. *Biological Conservation* 184: 18–26. https://doi.org/10.1016/j.biocon.2014.12.024

Renault, A., Ng, V.E.R.F., Goh, W.C., Hamid, M.N.H.A., Osman, A.M.Z., Safferi, R.S., Zainalabidin, M.A., and Ismail, A.K. 2024. Frequency, geographical distribution, clinical characteristics, antivenom utilisation and outcomes of King Cobra (*Ophiophagus hannah*) bites in Malaysia. *PLoS Neglected Tropical Diseases* 18(7): e0012359. https://doi.org/10.1371/journal.pntd.0012359

Ruppert, N., Holzner, A., Hansen, M.F., Ang, A. and Jones-Engel, L. 2022. *Macaca nemestrina* (errata version published in 2023). The IUCN Red List of Threatened Species 2022: e.T12555A223433999. https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T12555A223433999.en

Saaban, S., Nasharuddin, Nawayai, M., Mohd Nor, B., Zafir, A. and Campos-Arceiz, A. 2011. Current status of Asian elephants in Malaysia. *Gajah* 35: 67–75.

Sharma, S. 2023, November 17. 'Man-eating' tigers blamed for four deaths as Malaysia sounds alarm. *The Independent*. https://www.independent.co.uk/asia/southeast-asia/malaysia-tiger-deaths-killings-kelantan-b2449011.html

Soanes, K., Rytwinski, T., Fahrig, L., Huijser, M. P., Jaeger, J.A.G., Teixeira, F.Z., van der Ree, R. and van der Grift, E.A. 2024. Do wildlife crossing structures mitigate the barrier effect of roads on animal movement? A global assessment. *Journal of Applied Ecology* 61(3): 417–430. https://doi.org/10.1111/1365-2664.14582

Tan, A.S., de la Torre, J.A., Wong, E.P., Thuppil, V. and Campos-Arceiz, A. 2020. Factors affecting urban and rural tolerance towards conflict-prone endangered megafauna in Peninsular Malaysia. *Global Ecology and Conservation* 23: e01179. https://doi.org/10.1016/j.gecco.2020.e01179

Ten, D.C.Y., Jani, R., Hashim, N.H., Saaban, S., Abu Hashim, A.K. and Abdullah, M.T. 2021. *Panthera tigris jacksoni* population crash and impending extinction due to environmental perturbation and human-wildlife conflict. *Animals* 11(4): 1032. https://doi.org/10.3390/ani11041032

The Sun. 2026, April 8. Bomba personnel shares emergency tips on how to deal with snakes at homes during this Raya season. *The Sun*. https://thesun.my/going-viral/bomba-personnel-shares-emergency-tips-on-how-to-deal-with-snakes-at-homes-during-this-raya-season-jb12311697/

Wang, W., Wronski, T. and Yang, L. 2024. The status of wildlife damage compensation in China. *Animals* 14(2): 292. https://doi.org/10.3390/ani14020292

Weiler, B., Gstaettner, A. M. and Scherrer, P. 2021. Selfies to die for: A review of research on self-photography associated with injury/death in tourism and recreation. *Tourism Management Perspectives* 37: 100778.

White, R. 2022, January 11. Tiger Speared in Face and Shot Dead after Killing Man in Village. *Newsweek*. https://www.newsweek.com/tiger-speared-shot-dead-after-killing-man-malaysia-endangered-species-1667905

Wong E.P., Campos-Arceiz, A., Thuppil, V., Wadey, J., Solana-Mena, A., Saaban, S. and Othman, N. 2018a. Elephants, roads and drivers: Case study of Gerik-Jeli Highway. *Jurutera Bulletin* 9: 26–29.

Wong, E.P., Yon, L., Walker S.L., Mena, A.S., Wadey, J., Othman, N., Saaban, S. and Campos-Arceiz, A. 2018b. The elephant who finally crossed the road – Significant life events reflected in faecal hormone metabolites of a wild Asian elephant. *Gajah* 48: 4–11.

Wong, E.P., Campos-Arceiz, A., Zulaikha, N., Chackrapani, P., Quilter, A.G., de la Torre, A., Solana-Mena, A. *et al.* 2021. Living with elephants: evidence-based planning to conserve wild elephants in a megadiverse South East Asian country. *Frontiers in Conservation Science* 2. https://doi.org/10.3389/fcosc.2021.682590

Xin, L.Q., Ghani, S.N.A.M., Rasudin, N.S., Ghafar, N.A., Rashid, N.H.A., Ten, D.C.Y., Saaban, S., Edinur, H.A., and Abdullah, M.T. 2024. Characterisation of human-wildlife conflict and casualties caused by wildlife attacks in Peninsular Malaysia. *IIUM Medical Journal Malaysia* 23(01). https://doi.org/10.31436/imjm.v23i01.2283

Zahirudin, N.S. 2024. Human dimensions of coexistence with elephants in agricultural landscapes in Malaysia. PhD Thesis. Serdang: University of Nottingham in Malaysia.

Zanuari, A.H., Abidin, K.Z., Mansor, M S., Wan, H.Y., Abdullah, S.N.A.S., Abdul-Patah, P., and Nor, S.M. 2024. Identifying priority corridors and bottlenecks for three threatened large mammal species in the oil palm-dominated landscape of Peninsular Malaysia. *Global Ecology and Conservation* 54: e03092. https://doi.org/10.1016/j.gecco.2024.e03092

Zimmermann, A., Mcquinn, B. and Macdonald, D. 2020. Levels of conflict over wildlife: Understanding and addressing the right problem. *Conservation Science and Practice* 2(10): e259. https://doi.org/10.1111/csp2.259


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 803–807
doi: 10.62613/sonc2025.v3anc11

CHAPTER 11

Human-wildlife conflict: Perspectives from Sabah, Malaysian Borneo

JOHN PAYNE* and ZAINAL ZAHARI ZAINUDDIN

Abstract: Human-wildlife conflict happens when wild mammals with a large adult body mass enter lands cultivated by humans and feed on or damage human crop plants. There are only two options for solving human-wildlife conflict: either provide the problematic wildlife with alternative food sources forever, or keep the numbers of individuals at agreed, low numbers by culling or contraception. Other actions can be supplementary (notably electric fencing if located, built and maintained properly and consistently), but no other method will solve the problem. Two examples are offered: providing wild elephants with an alternative food to oil palms, with proven positive results in Sabah, and vasectomy of macaques, an option that is entirely feasible, but currently resisted.

INTRODUCTION

The concepts of 'weeds' or 'pests' or invasive species are used when referring to human conflict that occurs with plants, invertebrates, fish, amphibians, reptiles, birds or small mammals. These are generally addressed by extermination using chemical poisoning and other similarly fatal methods. Review of related literature and observation of social media content suggests that 'human-wildlife conflict' refers specifically to cases when wild mammals with an adult body mass exceeding about 5 kg enter lands cultivated by humans and feed on or damage human crop plants. Descriptions of human-wildlife conflict are not new, whether in Sabah (De Silva 1968), or Peninsular Malaysia (Foenander 1952, Guérin *et al.* 2018, Teckwyn and Campos-Arceiz 2021). Not many species are involved in human-wildlife conflict in Sabah. Obvious ones include elephants and macaques, to which porcupines, wild pigs and orangutans can be added in some agricultural contexts, along with some mustelids and viverrids in animal farming contexts. Those mammals come into conflict with humans because of a combination of three main factors: (a) mammals, like all life, strive to reproduce, (b) to reproduce, they need regular nutritious food, (c) the habitats in which residual clusters of these mammals exist are too small or of too low quality to supply sufficient year-round daily food to sustain reproduction, so they venture into farms, plantations and villages to obtain sufficient food for their health and reproduction. Once this is understood, the potential bases for managing the conflict becomes clear.

There are only two underlying approaches to solving human-wildlife conflict. One is to limit growth in numbers of the existing cluster of individuals. The other is to provide alternative food sources for the problem mammals, sources that are at least as good and productive as the cultivated or farmed foods managed by humans for human use. In either case, human society has to accept that there will be an upper limit to the number of individuals of the target wildlife species alive at any one time in any given cluster (although we do not need to know exactly what that number is). Any other form of purported method aimed at solving human-wildlife conflict will either fail, or make a small and unsustainable dent in the conflict, or be supplementary to the two fundamental approaches. Other solutions seem to be largely reactive (rather than proactive), aimed at specific clusters of animals (rather than population level), specific sites (rather than regional), and either emotion-based (rather than science-based) or academic (rather than pragmatic).

Borneo Rhino Alliance (BORA), c/o Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia.
***Corresponding author: sabahpayne@gmail.com**

In contrast to common practice in North America, Europe and African nations, there is an extremely strong sentiment in Malaysia amongst a vocal minority of predominantly urban citizens that condemns culling or contraception. Again, in the minds of those who oppose culling or contraception, there is a link to body mass, as they seem to have the same view in relation to problematic feral dogs and crocodiles, but not for rats, squirrels or bats. In other words, the objections are emotional and neither ethical nor rational. The minority objections over-ride the personal loss and anguish of tens of thousands of farmers whose crops are ruined annually, the dozens of nature tour guides who see macaques wiping out eggs and hatchlings from every wild bird nest, as well as orangutans under constant stress, and the thousands of cases annually of *Plasmodium knowlesi* malaria incurred by Malaysian human residents from the wild macaque zoonotic reservoir. A minority public opinion seems to have bullied the wildlife authorities into minimising or stopping culling, and ignoring contraception as a possible alternative approach (e.g., Mayberry 2013). As noted by Thomas Sowell, '*It is hard to imagine a more stupid or more dangerous way of making decisions than by putting those decisions in the hands of people who pay no price for being wrong.*'

Human conflict with Bornean elephant

Wild elephant clusters can grow at an annual rate of increase of 3% or more (Sukumar 1989), meaning that the cluster will double in size every 24 years in the absence of culling, poaching, poisoning, contraception or starvation. In Sabah, annual elephant mortality from human causes in recent years has been about 30 elephants (Sabah Wildlife Department, unpublished data), the majority from poisoning. This number is probably not much less than the number of elephant births annually, thereby accounting for the otherwise mysterious seeming stability in elephant population size in Sabah. In other words, elephant culling occurs, but unregulated by government and through a particularly horrible and painful means.

Elephants are bulk feeders. It is well-known that their preference and physiological need is for monocot plants (e.g., palms and grasses) to dominate in their diet (Terborg *et al.* 2025). Most palms in Malaysia now are commercially cultivated oil palms. At any one time, Sabah has about 240 million oil palms with perhaps 5 million cut down and replaced annually. In the Tabin area of Sabah, wild elephants spend about half their time outside the Tabin Wildlife Reserve, feeding predominantly on the meristems and leaf shoots of recently-felled old oil palms (unpublished WWF-Malaysia satellite tracking data over nine years). Presumably, about half their food intake is now oil palms. To fulfil their monocot requirements, they are now dependent on oil palm plantations. While palm replanting is ongoing within the home range of elephants, growers, managers, authorities and NGOs seem content with minimal interventions. However, this will change when there is no felling of old palms, and the monocot food that elephants seek consists of young living palms. Oil palm small-holders in Johor report (personal communication) that nowadays more than one elephant collaborate to push over mature palms in order to access the meristem to eat. The amount of biomass eaten by elephants from a felled palm is unknown, but assuming 120 kg and 140 palms per hectare (MPOB, pers. comm.) with a replanting cycle of 25 years, we can say that the productivity of oil palm biomass eaten by elephants after felling is 120 × 140 = 16,800 kg divided by 25 = 672 kg per hectare per year.

In contrast, annual biomass production of Napier grass in pastures created and managed by BORA for wild elephants starting from 2021 to present is about 60 tonnes per hectare per year, some 90 times greater than palm. This point is crucial, because elephants (like all mammals) will favour sites where the productivity of their food is highest. Also, palms do not grow back if eaten, but grasses do. Grasses seem common but at landscape scale, they are not. Grass species that grow tall are mostly confined to roadsides. The single best way to wean elephants from their oil palm dependency is to replace oil palms with grass, with total grassland areas of tens to a few hundreds of hectares being equivalent to many tens of thousands of oil palm as well as of thousands of hectares of forest, where non-monocot

plants needed in addition to monocots are super-abundant. BORA started development of elephant grasslands on the southern border of Tabin Wildlife Reserve in 2021. There are now about 22 hectares of managed grasslands in 12 sites on the forest edge. The grass has to be managed by frequent cutting, to ensure most growth is young (therefore nutritious) and grass height is suitable for both immature and mature elephants. Also they avoid grasses that are flowering or have flowered.

It has been suggested (e.g, Pelan Urus Service, n.d.) to use monocot crops other than grasses as a means to draw wild elephant attention away from feeding on oil palms. This idea is often referred to as 'elephant food banks'. We believe that this is unwise. Bamboo growth produces biomass at rates less than half that of grasses. The portion of biomass edible to elephants in bamboo is less than half that of biomass edible to elephants in grass, and nutritional quality of bamboo edible biomass is less than half that of grass. This implies that when comparing bamboo with grass as elephant food, grass is at least four times superior to bamboo in terms of production of quality elephant food. In addition, the energetic cost to an elephant of eating bamboo is much higher than eating the same quantity of grass, as the edible part is smaller in bamboo and the balance of the stems is lignified, hard and produces splinters in the mouth, and cannot be digested. This argumentation does not apply to bananas, but use of bananas to draw elephants away from oil palm has an even more serious drawback: elephants cannot distinguish between plots of bananas planted for them to eat and bananas planted by people to sell. As a result, planting bananas for elephants will draw elephants away from oil palm plantations into serious conflict with village banana farms.

Ample multi-mineral blocks are supplied at grassland sites, as Borneo vegetation is poor in many essential elements notably calcium, phosphorus, sodium, and trace elements needed for growth and reproduction. Elephant visits to and feeding on the managed grasslands have become progressively more frequent over the period of 2021 – 2025. Grasses most favoured by the elephants are *Tripidium arundineceum* and *Cenchrus purpureus* (formerly *Pennisetum purpureum*), and management is done by BORA to promote growth of both. The authors have long experience and are completely confident that neither grass species is invasive. In fact, the opposite is true: many other grasses, forbs, shrubs and woody plants (including trees) out-compete the favoured grasses, and so frequent weed removal is necessary. Unfortunately, the general response to this work has been disappointing. There has been no policy support through the government or the palm oil industry, while NGOs, such as WWF, Hutan, and Seratu Aatai, prefer to persist with satellite tracking (to date, an estimated 100 tracked elephants in Sabah since 2005; Benoit Goossens, pers. comm.) or even promote elephants to freely enter into oil palm plantations. The grassland programme needs to be large-scale and long-term, with grasslands concentrated on the forest-oil palm plantation interface, and supplementary minerals and clean water available at each site. There is no point to plant grasses just because a site happens to be available.

Finally, on management of elephants, the role of electric fencing seems to be widely misunderstood, from three angles. Firstly, electric fencing can work only if sufficient food is available where humans want elephants to be, to incentivise elephants not to try to break through fences. Secondly, electric fencing is a psychological barrier, not a physical barrier. The idea is that any elephant that touches any electric fence will incur a 9,000 – 10,000 volt shock, ensuring that they will never try to break through again. Thirdly, the authors of this paper have examined many hundreds of kilometres of 'electric fence' established with the aim of stopping elephants passing through, in Sabah, Johor, Pahang, and Perak. Our estimate is that well over 95% is not functioning, either because there is no or very low voltage to shock an elephant, or the design of the electric fence was not done correctly to also protect the posts (by 'looping'). Thus, many elephants in Malaysia probably know by now that 'electric fencing' is highly unlikely to give them a shock or that the posts can be

pushed over. Electric fencing erected to keep out elephants in Malaysia is currently a failure. A total re-set is needed, in tandem with the development of grasslands. The great majority of fences need to be reformulated, and a system is needed whereby there is constant maintenance of all. This requires a governmental policy decision and diversion of funds currently wasted on ineffective 'elephant projects' to grasslands and functional electric fencing. By 'functional fencing', we mean the following elements: decide the alignment of electric fences at State-level scale (and not just along human-generated titles or Reserve boundaries); ensure that the design, specifications and construction are optimum (most are currently sub-optimal); and full-time field teams whose sole job is to maintain the fencing with 10kV pulses, 24/7, irrespective of the ownership of the fencing. This concept and approach seems to be alien to the various stakeholders involved in solving human-elephant conflict, yet would be cheaper and much more effective than all the other approaches tried over the past decades.

Human conflict with macaques

A targeted look through social media reports on macaques and humans in Malaysia shows that many people in many situations experience chronic problems with wild macaques. Hilborn and Smith (2023) demonstrated that arguments for the IUCN-approved 'Endangered' status of long-tailed macaques are ludicrous, and that annual population growth of 7 – 10% is normal for this species, equivalent to a doubling in population size in 7 – 10 years in the absence of culling or contraception. Data for Sabah is not available, but from the fact that in Peninsular Malaysia about 70,000 macaques are culled legally annually based on public complaints (i.e. reactive) (PERHILITAN 2022), but macaque numbers remain high, it is apparent that this form of reactive culling is merely freeing up space and food resources for unculled macaques to reproduce and thrive. A programme of proactive culling seems to be socially unacceptable in Malaysia (e.g., Payne 2024). The idea of translocating problem macaques not only perpetuates the reactive, localised and ineffective approach, but it is actually the worst option because it either to transfers the same problem to another site or causes death by starvation of the translocated macaques as pure forest habitats have much lower productivity of macaque foods. There is no need to conduct a study to demonstrate that fact. It is obvious to experienced field zoologists.

A properly funded and supervised programme of vasectomy of male macaques appears to be the only way forward to significantly reduce macaque numbers in Malaysia. Capture, sedation, vasectomy, and release at site of capture is a well-established, humane way to render the males infertile. The programme must be a long-term commitment by the authorities, with annual funding, sensible leadership that focuses on the most problematic sites, done by experienced veterinarians, and supported by dedicated and compassionate staff. The target at every site must be that at least 70% of all adult males are vasectomised. Several years will be needed to show the results. Pushback will happen, with the arguments of cruelty and (from academic circles) human interference with dominance and breeding in macaque troops to be expected. Reactive 'solutions' will surface, such as tying down garbage bins and water tanks, and urging people to stop feeding macaques. It is to be hoped that negatively affected parties such as orchard and plantations managers, rural smallholders, nature tour guides, students on campuses with macaques, people concerned with wild orangutan conservation, human communities affected by zoonotic malaria, and medical specialists in malaria will be vocal in support for a programme to reduction in macaque numbers.

Acknowledgements : The authors thank Climate Governance Malaysia's The Hornbill Award (2021) and CIMB Foundation (2024) for funding development of the Tabin grasslands, and oil palm grower KLK for embracing the idea from the earliest stages. Oil palm growers Tradewinds and Sawit Kinabalu have subsequently provided in-kind support. NGO Responsible Elephant Conservation Trust has taken up the idea at Bilit village, Kinabatangan starting in 2024, with funding from Borneo Conservation Trust Japan and Intrepid Travel.

REFERENCES

de Silva, G.S. 1968. Elephants of Sabah. *Sabah Society Journal* 34: 169–181

Foenander, E.C. 1952. *Big Game of Malaya*. London: The Batchworth Press. 208 pp.

Hilborn, R. and Smith, D. 2023 Is the long-tailed macaque at risk of extinction? *American Journal of Primatology* 86(4): e23590. https://doi.org/10.1002/ajp.23590

Guérin, M., Teckwyn, L., Tan, A.S.L. and Campos-Arceiz, A. 2018. A favourable shift towards public acceptance of wildlife conservation in Peninsular Malaysia: comparing the findings of the Wild Life Commission of Malaya (1932) with a recent survey of attitudes in Kuala Lumpur and Taiping, Perak. *Malayan Nature Journal*, 2017 Special Edition: 21–31.

Mayberry, K. 2013, April 24. Massive Malaysia monkey cull spurs concerns. *Aljazeera*. https://www.aljazeera.com/features/2013/4/24/massive-malaysia-monkey-cull-spurs-concerns

Payne, J. 2024, February 12. The challenge of macaque management. *The Star*. https://www.thestar.com.my/news/nation/2024/02/12/the-challenge-of-macaque-management

Pelan Urus Service. n.d. *Bank Panduan Makanan Gajah di Johor*. Selangor: Universiti Teknologi Mara, Universiti Kebangsaan Malaysia & Jabatan Perlindungan Hidupan Liar Dan Taman Negara (PERHILITAN)

PERHILITAN. 2022. *PERHILITAN Annual Report 2022*. Kuala Lumpur: Department of Wildlife and National Parks Peninsular Malaysia.

Sukumar R. 1989. The Asian Elephant: Ecology and Management. Cambridge: Cambridge University Press.

Teckwyn, L. and Campos-Arceiz, A. 2021. A review of human-elephant ecological relations in the Malay Peninsula: Adaptations for coexistence. *Diversity* 14(36): 1–23. https://doi.org/10.3390/d14010036

Terborgh, T., Ong, L., Davenport, L., Tan W.H., Solana Mena, A., McConkey, K. and Campos-Arceiz, A. 2025. Release of tree species diversity follows loss of elephants from evergreen tropical forests. *Proceedings of the Royal Society B: Biological Sciences* 292: 20242026. https://doi.org/10.1098/rspb.2024.2026


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 809–835
doi: 10.62613/sonc2025.v3anc12

CHAPTER 12

Zoonotic wildlife pathogens in Malaysia and the effects of anthropogenic landscape alteration on transmission dynamics: Implications for One Health

REUBEN SHARMA

Abstract: Zoonotic diseases associated with wildlife represent an increasing public health concern, particularly in biodiversity-rich tropical regions experiencing rapid anthropogenic landscape modification. Malaysia harbours a diverse array of zoonotic wildlife pathogens, while deforestation, agricultural expansion, forest fragmentation and urbanisation are progressively altering ecological interactions among wildlife, domestic animals, vectors and humans. This review synthesises available evidence on the diversity, reservoir hosts and transmission pathways of wildlife-associated zoonotic pathogens in Malaysia, examines the influence of habitat degradation on disease spillover and highlights the importance of incorporating zoonotic disease risks into Environmental Impact Assessment (EIA) and Health Impact Assessment (HIA) frameworks. Anthropogenic habitat modification may amplify transmission risks by disrupting wildlife habitats, altering reservoir and vector dynamics, and creating ecological transition zones (ecotones) that increase opportunities for interspecific contact. The emergence and spread of zoonotic pathogens including the Nipah virus and malaria parasite (*Plasmodium knowlesi*) exemplify the complex relationships between land-use change and pathogen spillover in Malaysia. Despite these established ecological associations, wildlife-associated zoonotic spillover is not explicitly incorporated as a routine risk-assessment component within existing Malaysian EIA and HIA frameworks. This review advocates integrating wildlife reservoir and vector surveillance, ecological interface mapping, and pathogen exposure pathways into environmental assessment procedures, particularly for developments involving forest conversion, agricultural intensification and habitat disturbance. Adopting a multidisciplinary One Health approach involving environmental, veterinary, wildlife and public-health authorities would strengthen preventive surveillance, improve development-related risk mitigation and support more sustainable land-use planning while safeguarding ecosystem, animal and human health.

INTRODUCTION

Zoonotic diseases (caused by pathogens transmitted from animals to humans) present a significant threat to global public health and exert a substantial socio-economic burden, especially among developing nations (Budke *et al*. 2011; Torgerson and Macpherson 2011; Lv *et al.* 2024). The implementation of control and prevention strategies for zoonotic diseases are often challenging because their emergence is shaped by complex interactions among humans, domestic animals, wildlife, vectors, and rapidly changing environments. Wildlife populations constitute natural reservoirs for a diverse array of zoonotic pathogens including viruses, bacteria, protozoa and helminths; many of which can cross species barriers when ecological conditions facilitate contact with humans or domestic animals. Such spillover events are rarely determined by pathogen presence alone. Rather, they emerge from interacting ecological, environmental and socioeconomic processes that influence reservoir abundance, host behaviour, vector distribution and opportunities for interspecific transmission (Patz *et al*. 2004; Gibb *et al*. 2020; Plowright *et al*. 2021). Understanding zoonotic

Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
***Corresponding author: euben@upm.edu.my**

disease emergence therefore requires an integrated perspective that considers pathogen diversity together with host ecology, transmission pathways and anthropogenic modification of natural environments.

Malaysia provides a compelling setting in which to examine these dynamic interactions. The country supports a diverse array of wild flora and fauna while simultaneously experiencing extensive agricultural development, urbanisation, infrastructure expansion and modification of forested landscapes (Ma *et al.* 2024). Wild animals in Malaysian are known to be carriers of numerous zoonotic pathogens which may be transmitted through direct contact, aerosols, arthropod vectors, contaminated water and soil, and ingestion of infective stages (Nguyen *et al.* 2025). These sylvatic reservoir hosts include bats, non-human primates, rodents, wild pigs, birds, reptiles and other vertebrates, while mosquitoes, ticks, mites, fleas and other haematophagous arthropods may act as vectors connecting wildlife -associated transmission cycles with humans and domestic animals.

Several Malaysian examples demonstrate that the epidemiological significance of these pathogens is strongly influenced by ecological interfaces. The local Nipah virus outbreak (Chua *et al.* 2002a) and the emerging threat of zoonotic malaria (Johnson *et al.* 2024) illustrate clearly the detrimental effects of anthropogenic landscape alteration and habitat destruction on pathogen transmission dynamics. In addition, environmental modification can intensify these risks by restructuring the spatial relationships among the wildlife reservoirs, vectors, livestock and human populations. Deforestation, forest fragmentation, plantation expansion, mining, road construction, wetland modification and urban encroachment create ecotones between forests, farms, plantations and settlements. Such transition zones may increase opportunities for contact among species that previously interacted less frequently, thereby functioning as epidemiological interfaces for pathogen spillover (Shah *et al.* 2019; Gibb *et al.* 2020; Plowright *et al.* 2021).

Zoonotic disease spillover and transmission have important implications for environmental governance. Environmental Impact Assessment (EIA) is intended to anticipate the environmental consequences of development before implementation, while Health Impact Assessment (HIA) provides a framework for identifying potential effects on human health. In Malaysia, prescribed development activities are regulated under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015 (Department of Environment Malaysia 2015), and national guidance also recognises HIA within the EIA process. However, wildlife-associated pathogen spillover is not explicitly established as a routine risk pathway, despite the capacity of development projects to alter wildlife movement, vector ecology, livestock contact and human exposure.

Against this background, this review synthesises current knowledge on the diversity, wildlife hosts and transmission pathways of major zoonotic pathogens reported in Malaysia and examines how anthropogenic habitat degradation may modify their spillover risk. Data was gathered from published literature curated in public databases (PubMed, Scopus, Web of Science) as well as publications archived at the Faculty of Veterinary Medicine, Universiti Putra Malaysia. Particular attention was given to ecological interfaces created by land-use change, and to representative zoonoses illustrating wildlife–vector–domestic animal–human connectivity. Finally, the review evaluates the need to incorporate zoonotic spillover risk identification and assessment into Malaysian EIA and HIA processes within a One Health framework. Integrating wildlife ecology, veterinary health, environmental management and public-health surveillance into development planning may provide a more preventive approach to zoonotic disease emergence while simultaneously strengthening environmental, human and wildlife health protection.

DIVERSITY, TRANSMISSION PATHWAYS AND HOST OF ZOONOTIC WILDLIFE PATHOGENS IN MALAYSIA

Viruses

Transmission by direct contact/aerosols

Malaysia has experienced several zoonotic viral threats involving domestic animals, wildlife reservoirs, vectors, and human–animal interfaces. Documented examples include Nipah virus infection, mosquito-borne *Orthoflavivirus*, primate-associated *Simplexvirus* and *Alphavirus* infections, as well as bat-associated viruses such as *Paramyxovirus* and *Orthoreovirus*. The Nipah virus (*Henipavirus nipahense*) caused one of the most significant wildlife-related zoonotic disease spillovers in the country. The virus was first recognised during the 1998 – 1999 outbreak associated with pig-farming communities, where domestic pigs acted as amplifying hosts and facilitated transmission to humans. Evidence from Peninsular Malaysia indicate that frugivorous bats (*Pteropus vampyrus* and *P. hypomelanus*) are the natural sylvatic reservoir hosts (Chua *et al.* 2000, 2002b, 2010; Field *et al.* 2001; Rahman *et al.* 2010, 2013) that shed the virus in their saliva, urine, and partially eaten fruits, contaminating pig farms located near fruit orchards. Deforestation, slash-and-burn practices, and the severe 1997 – 1998 El Niño-driven drought significantly reduced fruit bats' forest habitats and the availability of food, resulting in the movement of these bats into cultivated fruit orchards (Chua *et al.* 2002a). Pigs likely became infected after consuming contaminated fruit or contacting contaminated surfaces, after which the virus spread efficiently through respiratory secretions and close contact (Chua *et al.* 2000). Epidemiological and virological investigations demonstrated that pigs acted as amplifying hosts, increasing viral transmission and facilitating subsequent infection of humans who had close contact with the infected swine (Parashar *et al.* 2000; Field 2009). This bat–pig–human transmission pathway is considered the primary mechanism responsible for the Malaysian Nipah virus outbreak and remains a classic example of zoonotic spillover involving wildlife, livestock, and humans.

Wildlife disease surveillance in Malaysia has identified several additional bat-associated viruses with zoonotic potential. The Tioman virus (*Tioman pararubulavirus*), a paramyxovirus, was isolated from fruit bats in Malaysia, specifically *P. hypomelanus* from Tioman Island (Chua *et al.* 2001; Yaiw *et al.* 2007). The Pulau virus (PRV2P, *Pteropine orthoreovirus* group) isolated from *P. hypomelanus* inhabiting Tioman Island is closely related to the Nelson Bay virus isolated in Australia (Chua 2003; Pritchard *et al.* 2006). The Melaka virus (PRV3M), Kampar Virus (PRV4K), and Sikamat virus (PRV7S) that belong to the *P. orthoreovirus* group have all been linked to acute respiratory disease in humans, although the exact bat reservoir host species and transmission route to humans remains undetermined (Chua*et al.* 2007, 2008, 2011). More recently, pathogen surveillance among bats detected alphacoronavirus and betacoronavirus in guano samples from the dusky fruit bats (*Penthetor lucasi*) in Sarawak (Habeebur-Rahman *et al.* 2023), and coronavirus in insectivorous bats (*Rhinolophus* spp.) from Pahang (Siew *et al.* 2023).

Non-human primates (hereinafter: primates) are also important reservoirs of zoonotic viruses which may be transmitted by direct contact or aerosols. These include the Herpes B virus [*Simplexvirus macacinealpha* or *Macacine alphaherpesvirus* 1 (MaHV1; B virus)] which has been detected in local populations of free-ranging long-tailed macaques (*Macaca fascicularis*) (Lee *et al.* 2015). The macaques exhibit substantial viral DNA shedding, highlighting occupational risk for personnel handling macaques during capture, transport, or conflict-management activities. Transmission risk is associated with bites, scratches, mucosal exposure, saliva, or direct contact with infected body fluids.

Transmission by arthropod vectors

The *Aedes*-borne Arboviruses of primates in Malaysia include Chikungunya (*Alphavirus chikungunya*) and Dengue (*Orthoflavivirus dengue*) viruses. In Sabah, serological titres of Arboviruses have been demonstrated in wild and semi-captive Orangutans (*Pongo pygmaeus morio*) as well as local human populations, strongly suggesting the existence of sylvatic transmission cycles (Wolfe *et al*. 2001). Chikungunya virus infection has been documented in local populations of *M. fascicularis*, supporting possible sylvatic primate–mosquito–human transmission (Marchette *et al*. 1978; Sam *et al*. 2015). While cases of this virus in Malaysia are currently sporadic, it is still considered an important emerging viral zoonosis (Lam *et al*. 2001). Sylvatic lineages have also been demonstrated for all four Dengue virus serotypes in Malaysia involving primates and forest-associated mosquitoes (Rudnick 1966; Cardosa *et al*. 2009; Wolfe *et al*. 2001; Teoh *et al*. 2010; Johari *et al*. 2019).

In Malaysian Borneo, *Aedes albopictus* and *Ae. niveus* mosquitoes have been identified as likely bridge vectors for sylvatic dengue spillover from canopy-dwelling primates. It was concluded that conversion of forests to agriculture will likely enhance the abundance of *Ae. albopictus* vectors which were found to thrive in agricultural areas (Young *et al.* 2017). Dengue is endemic in Malaysia with a total of 51,406 reported dengue cases and 43 fatalities in 2025 (World Health Organization 2026). As such, the sylvatic transmission cycle involving non-human primate hosts, and the effects of land conversion on mosquito vector abundance should not be ignored if comprehensive control and prevention measures for Dengue are to be instituted in the country.

The West Nile virus (*Orthoflavivirus nilense*) is a zoonotic *Culex* mosquito-borne flavivirus that circulates primarily through an enzootic cycle involving wild birds, with humans and other mammals serving as incidental or dead-end hosts (Rossi *et al.* 2010; Ain-Najwa *et al.* 2019). Migratory birds inhabiting the west coast of Peninsular Malaysia, namely Sand plovers (*Anarhynchus mongolus* and *A. leschenaultia*), Common Redshanks (*Tringa tetanus*), Common Sandpipers (*Actitis hypoleucos*), Black-capped kingfishers (*Halcyon pileata*), and residents including Little egrets (*Egretta garzetta*) have been shown to be important reservoirs of the virus (Ain-Najwa *et al.* 2020b). Further evidence of active transmission by *Culex* mosquitoes collected near migratory bird stopover sites along the west coast of Peninsular Malaysia further supports the role of migratory birds in virus maintenance and dispersal (Natasha *et al.* 2023). Antibody titres have also been demonstrated in long-tailed macaques and several bat species (*Cynopterus brachyotis*, *Emballonura monticola* and *Rhinolophus siamensis*) (Ain-Najwa *et al.* 2020a), indicating their role in local transmission cycles, albeit considered less significant than that of birds.

The Japanese encephalitis virus (*Orthoflavivirus japonicum*) is another *Culex* mosquito-borne zoonotic flavivirus maintained in enzootic cycles involving mosquitoes, pigs, and birds. In Malaysia, Japanese encephalitis has been reported for decades and has been described as endemic in several regions, particularly in rural and agricultural landscapes (Kreidl *et al.* 1999; Kumar *et al.* 2018a, 2018b). Serological evidence in domestic livestock, including pigs, bovids, and goats, support the role of pigs as amplifying hosts and wetland birds (including herons and egrets) as the main reservoir hosts that sustain viral circulation and contribute to geographic spread through migratory movement (Oliveira *et al.* 2017; Levesque *et al.* 2024; Kumar *et al.* 2018a). In addition to wild avian hosts, serological evidence indicate exposure among macaques, highlighting the potential involvement of a broader vertebrate host range for Japanese encephalitis transmission in Malaysia (Kumar *et al.* 2018b).

Bacteria

Transmission by arthropod vectors

A number of zoonotic bacteria have been isolated from wild animals and associated arthropod vectors in Malaysia, especially among rodents, non-human primates and birds. The major arthropod-borne zoonotic haemobacteria comprise species of the order Rickettsiales which include the genera *Orientia*, *Rickettsia* and *Anaplasma*. Pathogenic members of Rickettsiales cause a spectrum of acute febrile illnesses in humans that commonly manifest in fever, headache, myalgia, and may progress to vascular injury, neurological disease, respiratory failure, multiorgan dysfunction and death (Valbuena and Walker 2009; Robinson *et al.* 2019; Stewart *et al.* 2021). *Orientia tsutsugamushi*, the causative agent of scrub typhus, is the best-established wildlife-associated zoonotic Rickettsiales in Malaysia, where its transmission cycle between larval trombiculid mites (chiggers) and small-mammal hosts has been extensively studied (Nadchatram 1970; Walker *et al.* 1973; Muul *et al.* 1977; Muul and Chai 1978). A number of forest-dwelling and peridomestic rodents (*Rattus* spp.) and common treeshrews (*Tupaia glis*) are known to harbour the bacterium (Muul *et al.* 1977; Muul and Chai 1978; Ernieenor *et al.* 2021; Alkathiry *et al.* 2022; Mohd-Azami *et al.* 2023).

In addition, several spotted fever group *Rickettsia* with potential zoonotic significance and related to the human-infective species have been detected among wild rodents in the country (Tay *et al.* 2014). The bacterium closely related to *Rickettsia felis*, the causative agent of flea-borne spotted fever, has also been detected in long-tailed macaques, although their role as reservoirs is yet to be established (Tay *et al.* 2015). More recently, *R. felis* DNA was detected in *Laelaps* mites collected from forest rodents (*Maxomys whiteheadi* and *Bandicota indica*) in Selangor, indicating the possible role of these small mammals as sylvatic reservoirs (Mohamad Tahir *et al.* 2025). In addition, *Amblyomma varanense* and *A. helvolum* ticks from Indian pythons (*Python molurus*), and *A. helvolum* from Malayan spitting-cobras (*Naja sumatrana*) in Selangor, have also been shown to harbour spotted fever group Rickettsiae (Kho *et al.* 2015). *Rickettsia* was also detected in ticks collected from wild boars (*Sus scrofa*) in an Orang Asli community, indicating the importance of surveillance for tick borne-pathogen from wildlife at forest–human interfaces (Lim *et al.* 2020).

Wildlife-associated *Bartonella* in Malaysia has been detected mainly in rodents and their associated ectoparasites. Various species of wild rats including those in urban habitats are known to harbour this zoonotic bacterium (Tay *et al.* 2014, 2016; Blasdell *et al.* 2019b; Low *et al.* 2020). *Bartonella* has also been detected in ticks associated with rats, including *Dermacentor auratus* and *Haemaphysalis hystricis* collected from *Rattus tiomanicus* (Asyikha *et al.* 2020), and *Amblyomma cordiferum* infesting *Rattus rattus diardii* (Kazim *et al.* 2025). Bat-associated *Bartonella* has also been reported from bat flies from the families Nycteribiidae and Streblidae, but its zoonotic importance remains uncertain (Peng *et al.* 2024).

Coxiella, a gram-negative obligate intracellular bacterium, has been demonstrated in ticks (*Dermacentor steini* and *H. hystricis*) infecting *S. scrofa* from Selangor (Khoo *et al.* 2016). While the DNA of *Coxiella burnetii* (the agent for Q Fever in humans and animals) was amplified from these ticks, the role of ungulates as reservoirs of Q Fever in Malaysia remains to be elucidated. Tick-borne *Borrelia* spp. including relapsing-fever *Borrelia* (RFB) (*B. miyamotoi*) and Lyme disease *Borrelia* (LDB) (*B. yangtzensis*) genotypes have also been reported in ticks (*Ixodes granulatus*) infesting synanthropic rodents in Peninsular Malaysia (Khoo *et al.* 2018).

Transmission by ingestion (fecal-oral route)

Wild animals are known to harbour a number of zoonotic gastrointestinal bacteria, which are shed in their faeces. While most are normal inhabitants and commensals, pathogenic variants of *Escherichia coli* such as Shiga toxin-producing *E. coli* (STEC), enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC), enterotoxigenic *E. coli* (ETEC), and enterohaemorrhagic *E. coli* (EHEC) are capable of causing diarrhoea, haemorrhagic colitis, and haemolytic uraemic syndrome in humans (Shah *et al*. 2018). In Malaysia, pathogenic *E. coli* carriage has been demonstrated in birds, bats and rodents sampled from forest, oil palm plantations and human settlements (Bilung *et al.* 2014; Mohamed *et al.* 2022). In addition, Multiple Antibiotic Resistant (MAR) *E. coli* has been detected in bats and rodents for Sarawak (Apun *et al.* 2008).

Salmonella is another gastrointestinal bacterium of zoonotic concern, with birds and reptiles acting as important reservoirs. In Malaysia, *Salmonella* carriage has been reported in both wild and captive snakes (*Malayopython reticulatus*, *Python bivittatus*, *Coelognathus radiatus* and *N. sumatrana*) (Nur Mahiza *et al.* 2007; Abatcha *et al.* 2013), lizards (Noor Asyikin *et al.* 2006; Cheng *et al.* 2014), geckos (Fazhana *et al.* 2007) and chelonians (Noorazrena and Saleha, 2008). These studies revealed the presence of human-infective serovars including *S. typhimurium* with certain strains shown to be resistant to commonly used antibiotics. Reptile-associated salmonellosis is of concern as lizards and chelonians are common pets and transmission can occur if proper sanitisation is not practiced after handling. In addition, metagenomic surveillance revealed the presence of *Salmonella* among rodents (*Niviventer cremoriventer* and *Rattus* spp.) dwelling at forested areas close to human inhabitation in Sarawak (Azmi *et al.* 2025). Zoonotic species of *Campylobacter* with potential of causing acute bacterial gastroenteritis in humans have also been reported among peridomestic wild birds and poultry in the country (Ganapathy *et al.* 2007; Mohamed-Yousif *et al.* 2019), thus increasing the risk of human transmission in the urban environment.

Transmission by direct contact, ingestion, or aerosols

Leptospira is a widespread zoonotic bacterial pathogen associated with Malaysian wildlife. These motile spirochaetes are transmitted through direct contact with urine, tissues or fluids from infected animals, or indirectly through contaminated soil, mud, freshwater, floodwater or vegetation. In Malaysia, wildlife-associated leptospirosis is strongly linked to rodents and small mammals, including bats, squirrels, treeshrews, mongooses, porcupines, and primates (Thayaparan *et al.* 2013, 2014; Siti-Nurdyana *et al.* 2016; Suut *et al.* 2018; Philip and Ahmed 2023). Rodents are important reservoirs as they may carry *Leptospira* in the kidneys and shed them in urine. Over 40% of the rats (*Sundamys muelleri*, *R. rattus*, *R. exulans*) and squirrels (*Callosciurus notatus*) sampled in central Sarawak were positive for anti-*Leptospira* antibodies (Suut *et al.* 2018).

In Peninsular Malaysia, urban-dwelling rodents have also been confirmed as important zoonotic reservoirs. Benacer *et al.* (2013) isolated and molecularly characterised *Leptospira interrogans* and *L. borgpetersenii* from urban rats in Kuala Lumpur. These are pathogenic species associated with human leptospirosis, supporting the role of urban rodents as a major public health risk in Malaysian cities. The influence of urbanisation on rodent-associated *Leptospira* is further corroborated by a study in Sarawak whereby rodents sampled in urban sites had a higher molecular prevalence of the bacteria compared to those inhabiting rural areas (Blasdell *et al.* 2019a). Zoonotic species of *Leptospira* are also known to infect rodents collected from recreational forests and zoological parks in Peninsular Malaysia (Shafie *et al.* 2022), thus posing a risk to visitors and tourist who may come in contact with contaminated water bodies, mud and soil.

In addition to rodents, *Leptospira* exposure has also been demonstrated among a variety of primates (*M. nemestrina*, *M. fascicularis*, *Nasalis larvatus*, *Hylobates muelleri*, *Trachypithecus cristatus*, *P. pygmaeus*), bats (*C. brachyotis*, *P. lucasi*, *Nycteris tragata*, *Hipposideros cervinus*) and mongooses (*Herpestes brachyurus*) from recreational parks and wildlife tourism areas in Sarawak (Thayaparan *et al.* 2013, 2014), indicating that a broader taxon of wild mammals may be involved in the sylvatic transmission cycle and epidemiology of leptospirosis in the country.

Mycobacterium from wild mammals in Malaysia, including species of the *Mycobacterium tuberculosis* complex such as *M. bovis*, have been detected in wild boar (*S. scrofa*) from Selangor (Lekko *et al*. 2021a, 2021b) using both molecular and serological techniques. The detection of *M. bovis* DNA in the local wild boar population is of public health concern because it is a recognised zoonotic pathogen (Suraiya and Farakhin 2018). Since human infection can occur through ingestion, inhalation and direct contact through mucous membranes or broken skin, *Mycobacterium* is of concern for butchers handling wild boar meat, wildlife personnel, farmers at the wildlife–livestock interface, and consumers of inadequately cooked meat.

Protozoa

Transmission by arthropod vectors

Zoonotic malaria is widespread throughout Southeast Asia, and remains the most important arthropod-borne parasitic infection of in Malaysia (Singh *et al.* 2004, Cox-Singh *et al.* 2008; Vythilingam *et al.* 2014; Johnson *et al.* 2024) The disease is caused primarily by the haemoprotozoa *Plasmodium knowlesi* (Coatney *et al.* 1971; Singh *et al.* 2004) although human infections with other zoonotic simian malaria parasites such as *P. cynomolgi*, *P. inui*, *P. coatneyi*, and *P. simiovale* have been recently reported in the country (Ta *et al.* 2014; Grignard *et al.* 2019; Nada-Raja *et al.* 2020; Liew *et al.* 2021; Yap *et al.* 2021). Macaques (*M. fascicularis* and *M. nemestrina*) are the main reservoir hosts (Lee *et al.* 2011; Nada-Raja *et al.* 2022; Johnson *et al.* 2024) and transmission to humans is through the bites of infected forest-associated *Anopheles* mosquitoes (Vythilingam *et al.* 2006, 2008). Multilocus genotyping of *P. knowlesi* infections in humans have shown distinct divergent subpopulations associated with specific macaque hosts and geographical location (Divis *et al.* 2017), with no evidence of sustained human to human transmission (Fornace *et al.* 2023).

Malaysia remains a hotspot for zoonotic malaria with a significant disease burden. In 2024, there were 2164 global cases of *P. knowlesi*, of which Malaysia remains the principal contributor, accounting for 89.0% of these cases and all three deaths (World Health Organization 2025). The sustained sylvatic transmission cycle of zoonotic malaria in primate reservoirs presents a major obstacle for malaria elimination in the country (Chin *et al.* 2020; Mohammad *et al.* 2022). The risk of transmission is associated with environmental and land-use factors, including forest fragmentation, deforestation, and agricultural expansion, which decreases the transmission interface between macaque hosts, mosquito vectors, and humans (Fornace *et al.* 2016, 2019; Johnson *et al.* 2024).

Transmission by ingestion of infective stages – Gastrointestinal protozoa

Many genera of gastrointestinal (GI) protozoa are of zoonotic concern and cause disease in both animals and humans, particularly in rural and Indigenous communities in Malaysia where close contact between animals, humans, and contaminated water sources facilitates faecal-oral transmission. These GI protozoa may cause acute or chronic gastroenteritis, diarrhoea, malabsorption, and mucosal damage, which may be pronounced in immunocompromised individuals and children (Kelly 2013; Di Genova and Tonelli 2016).

Giardia duodenalis is a potentially zoonotic GI flagellate and is relatively common among livestock and companion animals in Malaysia (Farizawati *et al.* 2005; Lim *et al.* 2013; Ngui *et al.* 2014; Sai Gythri and Sharma 2020). *Giardia* infection has also been detected among wildlife in Malaysia suggesting that they may serve as reservoirs for spillover to domestic animals and zoonotic transmission. In Peninsular Malaysia, *Giardia* has been detected in wild macaques (*M. fascicularis*) (Goh and Sharma 2024) and siamangs (*Symphalangus syndactylus*) (Tan and Sharma 2017) housed in local zoos. In Sabah, the flagellate was detected in free-ranging Bornean orangutans (*P. p. morio*) (Tsen *et al.* 2019). *Giardia* is also known to infect synanthropic rodents (*R. rattus diardii*, *R. norvegicus*, *R. tiomanicus*) (Tan *et al*. 2019; Mohd-Qawiem *et al* 2022, 2024; Zainol and Sharma 2022) making them prime reservoir hosts for human transmission. Recent molecular studies in Sabah reported the first detection of zoonotic *Giardia* assemblages A and B in wild hornbills (*Rhinoplax vigil* and *Buceros rhinoceros*) from the Kinabatangan Wildlife Sanctuary, highlighting the potential role of free-ranging birds in maintaining environmental contamination and parasite transmission (Tan *et al.* 2025). In addition, environmental contamination of rivers and recreational waters with *Giardia* cysts supports the possibility of indirect transmission between peridomestic wildlife, domestic animals, and humans through shared water resources (Lim *et al.* 2009; Lee *et al*. 2014). Molecular detection also revealed the presence of zoonotic *Giardia* assemblages in surface water samples from a local zoo (Lim *et al*. 2009) indicating the potential of these captive wild animals to shed human-infective cysts in the peridomestic environment.

Balantidium coli is a ciliate which infects domestic pigs (Tan *et al*. 2014) and dogs (Ngui *et al*. 2014). Among wild mammals in Peninsular Malaysia, Balantidium has been demonstrated in captive Malayan tapirs (*Tapirus indicus*) (Mustapa *et al*. 2014), Sumatran orangutans (*P. abelii*), Bornean orangutans (*P. pygmaeus*), macaques (*M. arctoides*, *M. nemestrina*, *M. fascicularis*), white-handed gibbons (*H. lar*) and siamangs (*S. syndactylus*) (Lim *et al*. 2008, Tan and Sharma 2017). *Balantidium* has also been detected among captive and free-ranging orangutans in Sabah (Tsen *et al*. 2019). To date there are no records of *Balantidium* in birds, reptiles or amphibians from Malaysia.

Entamoeba has been detected in domestic dogs and cats (Ngui *et al*. 2014, 2020) and goats (Tan *et al*. 2017) in Malaysia. Wild animals commonly infected with *Entamoeba* include great apes (*P. abelii*, *P. p. morio*), small apes (*H. lar*, *S. syndactylus*) and macaques (*M. arctoides*) (Tan and Sharma 2017). *Entamoeba* infection has also been demonstrated among synanthropic rodents (*R. argentiventer*, *R. tiomanicus*, *R. exulans*) in Kuala Lumpur (Siti Shafiyyah *et al*. 2012; Lau *et al*. 2014).

Blastocystis, a common intestinal stramenopile reported in humans, is known to infect domestic animals such as dogs, cats, goats, sheep and cattle (Tan *et al*. 2013; Hemalatha *et al*. 2014; Lim *et al*. 2017; Rauff-Adedotun *et al*. 2020) in the country. Among captive primates, *Blastocystis* has been detected in orangutans (*P. abelii*, *P. p. morio*), small apes (*H. lar*, *S. syndactylus*) and macaques (*M. arctoides*, *M. nemestrina*) (Lim *et al*. 2008; Tan and Sharma, 2017). The protozoa have also been isolated from free-ranging Water monitors (*Varanus salvator*) and Mouse deer (*Tragulus* spp.) living in close proximity to human settlements on Tioman Island (Mohd Zain et al., 2017), as well as urban-dwelling rodents (*Rattus* spp.) (Premaalatha *et al*. 2017, 2018; Farah Haziqah *et al*. 2018).

Cryptosporidium is an important zoonotic enteric protozoan because infected hosts shed environmentally resistant oocysts that can contaminate water, soil, food, fomites, and animal-contact environments (Farizawati *et al*. 2005). It is known to infect various domestic animals including companion animals and ruminant livestock (Lee *et al*. 1989; Abdullah

et al. 1999; Ngui *et al*. 2014; Tan *et al*. 2017). *Cryptosporidium* has also been demonstrated in various taxa of animals in zoological facilities (including tigers, orangutans, macaques, langurs and birds), highlighting the risk of exposure and transmission to animal handlers and visitors (Lim *et al*. 2007, 2008; Quah *et al*. 2011; Tan and Sharma 2017).

Transmission by ingestion of infective stages – Tissue protozoa

Tissue-infecting coccidian protozoa including *Toxoplasma* and *Sarcocystis* are important zoonotic pathogens in Malaysia (Brandon-Mong *et al.* 2015; Latif and Muslim 2016). These protozoa have an obligatory two-host life cycle, in which sexual development occurs in the intestine of a definitive carnivorous or omnivorous host, and asexual development produces sarcocysts in the muscles or tissues of an intermediate host. Transmission occurs through ingestion of sporulated oocysts from contaminated soil, water, feed, or food; ingestion of tissue cysts in raw or undercooked meat; and congenital transmission from mother to foetus (Tenter *et al.* 2000; Hill and Dubey 2002).

Although *Toxoplasma* infection is usually asymptomatic or mild (fever, body aches, and swollen lymph nodes) in healthy adults, severe brain and eye damage have been reported in immunocompromised individuals. Transmission of *Toxoplasma* from infected pregnant mothers to their foetus (i.e., congenital toxoplasmosis) may result in significant pathology and birth defects. Domestic carnivores especially cats are the primary reservoirs of *T. gondii*, although the parasite has also been detected in local pigs, goats, cattle, dogs and poultry (Thomas 1979; Chandrawathani *et al.* 2008; Sabri *et al.* 2019; Tan *et al.* 2020; Sabrina *et al.* 2023b). Wild mammals (*N. coucang*, *T. cristatus*, *M. fascicularis*, *M. nemestrina*, *T. glis*, *Maxomys rajah*, *Rattus* spp.) have also been shown to either be actively infected or possess antibodies to the parasites indicating exposure (Zaman and Goh 1970; Lokman *et al.* 1989; Normaznah *et al.* 2015).

Sarcocystis is another important tissue protozoa with a number of focal outbreaks involving both locals and tourists (Latif and Muslim 2016). Humans can act as both intermediate hosts (infection by ingesting oocysts in contaminated water, food) and develop muscular-skeletal related symptoms, or definitive hosts (infection by ingesting mature sarcocysts in meat) and develop gastrointestinal related symptoms. Domestic carnivores (cats and dogs) are known definitive hosts in Malaysia, while cattle, water buffaloes, sheep, goats, pigs and poultry are proven intermediate hosts that develop infective stages (sarcocysts) in their muscles, organs and tissues (Latif *et al.* 2013; Kutty *et al.* 2015; Latif and Muslim 2016; Sabrina *et al.* 2023a). Among local wild animals, *Sarcocystis* has been reported in long-tailed macaque (Kan *et al.* 1979), Sunda slow loris (Zaman and Goh 1968), various species of rodents (Kan 1979; Ambu *et al.* 2011; Fong *et al.* 2014), snakes (*N. kaouthia*, *Ophiophagus hannah*, *M. reticulatus*, *Ovophis convictus*, *Ptyas carinata*, and *Boiga nigriceps*) (Fadil *et al.* 2019; Lau *et al.* 2013), and various captive animals including native species such as sun bear (*Helarctos malayanus*), hornbill (*Berenicornis comatus*), and fish owl (*Ketupa ketupu*) (Latif *et al.* 2010).

Helminths

Transmission by arthropod vectors

Brugia malayi and *B. pahangi* are mosquito-borne filarial nematodes of major veterinary and public-health importance in Malaysia, where the former is a recognised as the causative agent of human lymphatic filariasis, whereas *B. pahangi* is primarily an animal parasite with sporadic zoonotic infection in humans (Laing *et al*. 1960; Mak 1983, 1984; Naing *et al.* 2024). Domestic cats are among the most important animal hosts for both filarial species and act as principal reservoirs (Mak 1984; Muslim *et al*. 2013b). Dogs may also be infected (Vinnie-Siow *et al.* 2019, 2022) but their role in transmission is minimal due to the low prevalence reported. Among wild mammals, *B. pahangi* has been reported in clouded leopards (*Neofelis nebulosa*) (Zahedi *et al.* 1986) and Indochinese leopards (*Panthera pardus*

delacouri) (Strauss and Sivanandam 1966), indicating that wild felids can be naturally infected although their role as major maintenance reservoirs remains undetermined. Wild primates are potential sylvatic reservoirs of *B. malayi* with reports of infected *M. fascicularis*, *T. cristatus*, *T. obscurus* and *P. melalophos* (Buckley and Edeson 1956; Lim and Mak 1978; Mak 1983; Mak *et al.* 1988, 1990). Infection experiments have shown potential carriage of *B. malayi* among civets (*Paradoxurus hermaphroditus*) and Sunda slow loris (*N. coucang*) (Laing *et al*. 1960).

Transmission by ingestion of infective stages

A number of zoonotic helminths are transmitted to humans by ingestion of infective stages, which include the embryonated ova or immature stages (larvae) found in water, food, or contaminated environment. While there are numerous studies on the prevalence of these zoonotic helminths among domestic animals and livestock in Malaysia, data on their infection among wildlife is extremely limited and warrants further investigation. *Toxocara*, *Trichuris* and *Ancylostoma* are relatively common genera of zoonotic gastrointestinal nematodes that infect domestic cats and dogs in Malaysia (Amin-Babjee 1978; Abdullah *et al*. 1990; Ngui *et al*. 2014; Tun *et al*. 2015).

In humans, the migration of the larval stages of *Toxocara* causes pathology of the visceral organs (Visceral Larva Migrans) and eyes (Ocular Larva Migrans) especially in young children and immunocompromised individuals. Among wild mammals, *Toxocara* has been reported in native (*Panthers tigris jacksoni*, *Felis bengalensis*) and exotic felids housed in a local zoologic park (Lim *et al*. 2008), as well as wild civets (*Viverra tangalunga*) (Colón and Patton 2012).

Trichuris causes gastrointestinal related pathology in humans, and is known to infect a diversity if wild mammals including captive and free-ranging primates (*N. larvatus*, *P. p. morio*, *M. fascicularis*, *M. nemestrina*, *T. obscurus*, *T. cristatus*, *H. muelleri*) (Kilbourn *et al*. 2003; Lim *et al*. 2008; Kuze *et al*. 2010; Klaus *et al*. 2018; Teo *et al*. 2019; Tuan Said *et al*. 2022), carnivores (*H. malayanus*, *V. tangalunga*) (Colón and Patton 2012; Abdul -Mawah *et al*. 2023) and wild rodents (*Rattus* spp.) (Leong *et al*. 1979; Premaalatha *et al*. 2018; Tijjani *et al*. 2020).

The larval stage of *Ancylostoma* causes Cutaneous Larva Migrans in humans characterised by creeping eruptions of intensely rash, itching and inflammation. In the wild, this hookworm has been reported from civets (*V. tangalunga*) in Sabah (Colón and Patton 2012). Hookworms (genus not specified) have also been detected in captive primates (*P. pygmaeus*, *H. muelleri*, *M. nemestrina* and *M. arctoides*) (Lim *et al*. 2008).

Ascaris is a large nematode of the digestive tract of humans, with swine acting as principal domestic animal hosts. In Malaysia, both wild and domestic pigs are known to harbour this parasite (Lee *et al*. 1987; Vinnie-Siow *et al*. 2026). Among non-human primates, *Ascaris* has been detected in captive *T. cristatus* and *H. muelleri* (Lim *et al*. 2008), and free-ranging *P. pygmaeus* in Sabah (Kuze *et al*. 2010).

Angiostrongylus malaysiensis is a potentially zoonotic heteroxenous nematode with the larval stages in gastropods, and sexually mature adults and first-stage larvae in the pulmonary artery and lungs of rats, respectively. In Malaysia, various rodent species occupying forest fringe habitats (Lim and Ramachandran 1979) as well as recreational parks in within the city (Low *et al*. 2023) have been shown to be important reservoirs of the parasite.

The trematodes of major zoonotic concern in Malaysia include *Schistosoma* and *Paragonimus*; both genera use snails as intermediate hosts. Human infection with the blood fluke *Schistosoma* is through skin penetration of cercariae which are released from infected snails. The domestic animal hosts of *Schistosoma* in Malaysia include cattle, water buffalo and goats (Krishnasamy *et al.* 1991, 1998; Singh *et al.* 1997; Tan *et al.* 2015; Tookhy *et al.* 2024). Rodent species that act as principal sylvatic hosts for *Schistosoma* include *S. muelleri*, *R. tiomanicus*, *R. argentiventer*, *R. tanezumi*, and *B. indica* (Greer *et al.* 1988; Singh *et al.* 1992, 1997). Thus far, only one report from Sabah has identified free-ranging long-tailed macaque as a host for *Schistosoma* (Kuntz and Myers 1978).

Humans get infected with *Paragonimus* by ingesting metacercariae in infected freshwater crustaceans that are inadequately cooked or pickled. The parasite causes pathology to the lungs, central nervous system and visceral organs. While domestic cats and dogs may be experimentally infected (Kim 1978; Habe *et al.* 1996), the natural definitive hosts recorded from Malaysia include wild felids (*Panthera tigris jacksoni*, *Prionailurus planiceps*, *Catopuma temminckii*, *Panthera pardus*) as well as macaques (*M. fascicularis*) (Lee and Miyazaki 1965; Lim and Betterton 1977; Groves *et al*. 1967).

Cestodes, namely *Hymenolepis*, *Spirometra* and *Taenia* are noteworthy zoonotic pathogens in Malaysia. *Hymenolepis* primarily infects rodents while humans are accidental definitive hosts that acquire infection by inadvertently ingesting arthropods containing cysticercoids, which may be found in contaminated cereals, flour, dried foods or other stored products. The cestode has been detected in a number of synanthropic rodents including *R. tanezumi*, *R. tiomanicus*, *R. norvegicus*, *R. argentiventer* and *R. exulans* (Leong *et al*. 1979; Krishnasamy *et al*. 1980; Paramasvaran *et al*. 2009; Mohd Zain *et al*. 2012; Shafiyyah *et al*. 2012; Tijjani *et al*. 2020), highlighting the risk of rodent contamination of food-storage areas, kitchens, animal-feed stores, markets and eateries.

Spirometra has a complex aquatic life cycle involving copepods, vertebrate intermediate or paratenic hosts, and carnivorous definitive hosts. The adult tapeworms inhabit the small intestine of felids, canids and other carnivorous mammals, whereas their plerocercoid larvae (spargana), reside in the tissues of amphibians, reptiles, mammals and occasionally birds. Humans may acquire the infection by drinking untreated water containing infected copepods and eating raw or inadequately cooked tissues containing the plerocercoid larvae (Kuchta *et al*. 2024). The larvae may subsequently migrate into subcutaneous tissues, muscles, the eye, central nervous system or internal organs. In Malaysia, coproscopy revealed adult *Spirometra* infection among dogs and cats in rural areas (Ngui *et al*. 2014) as well as captive leopard cats (Lim *et al*. 2008), while the spargana stage as been detected in frogs (*Fejervarya cancrivora*) from Selangor (Kavana *et al*. 2015).

Humans are the normal definitive hosts of the adult *Taenia* tapeworms, whereas domestic pigs or cattle act as the principal intermediate hosts depending on the *Taenia* species. Humans develop intestinal taeniasis after consuming viable cysticerci in inadequately cooked pork, and human cysticercosis occurs when *Taenia* ova are ingested. The larvae migrate to the skeletal muscles, subcutaneous tissues, the eye or central nervous system, where neurocysticercosis may develop (Teoh 1976; Chua *et al*. 2017). Larval stages of *Taenia* have been recovered from various species of rats including *R. rattus*, *R. tanezumi* and *R. norvegicus* (Leong *et al*. 1979; Syed-Arnez and Mohd Zain 2006; Mohd Zain *et al*. 2012; Tijjani *et al*. 2020; Yamamoto *et al*. 2024). The prevalence of zoonotic cestodes among wild animals in Malaysia remains relatively under studied. Future surveillance should prioritise molecular identification because coproscopy alone may not be reliable to distinguish between species of zoonotic concern.

ANTHROPOGENIC LANDSCAPE ALTERATION AND ITS EFFECTS ON ZOONOTIC DISEASE TRANSMISSION

Human-mediated landscape alterations, including deforestation, forest fragmentation, agricultural expansion, mining, road construction, peatland drainage, and urban encroachment, can alter the dynamics of zoonotic disease transmission by changing the contact interface between wild animal reservoirs, feral and domestic animals, livestock, vectors, intermediate hosts, and humans (Patz *et al.* 2004; Shah *et al.* 2019; Gibb *et al.* 2020; Plowright *et al.* 2021, 2024; Johnson *et al.* 2024). Land-use change is a significant driver of zoonotic disease emergence because it disrupts the ecological balance, displaces many wildlife species, increases human access to forested areas, and establishes new wildlife–human interfaces (Rulli *et al.* 2025). Degraded and anthropogenically modified landscapes have also been shown to increase the population of peri-domestic wildlife and intensify zoonotic pathogen reservoirs and spillover (Gibb *et al.* 2020). These detrimental effects of land conversions are particularly apparent in Southeast Asia, a region with high wildlife biodiversity, dense human populations, expanding crop and livestock frontiers, and dependence on forest-edge livelihoods (Shah *et al.* 2019; Tobin *et al.* 2024).

The primary influence of habitat degradation on zoonotic disease transmission is by the creation and expansion of ecotones (ecological transition zones) between adjacent natural and disturbed habitats (e.g. forest–agriculture/plantations, forest–livestock farms, and forest–human settlement). These ecotones increase the contact between vectors, wildlife, domestic animals, and humans that would otherwise have minimal interaction (Despommier *et al.* 2006; Plowright *et al.* 2021). Transition habitats often contain high resource heterogeneity, altered microclimates, disturbed vegetation, poor drainage, livestock waste and feed, and human refuse; all of which can influence host and vector population dynamics. Ecotones are also frequently inhabited by synanthropic animal taxa with wide ecological plasticity, including rodents, bats, non-human primates, wild pigs, small carnivores, birds, reptiles, as well as feral dogs and cats. These taxa efficiently exploit food resources and shelter associated with human-modified landscapes, which often result in high population expansion rates. This is of major public health concern since many species of synanthropic wildlife serve as important pathogen reservoirs, amplifiers, and bridge hosts in zoonotic disease transmission systems (Gibb *et al.* 2020; Plowright *et al.* 2021, 2024).

Habitat degradation does not necessarily create new pathogens; rather, it changes ecological and social conditions that increase the probability of pathogen spillover (Plowright *et al.* 2021, 2024). Forest clearance and fragmentation can compress wildlife into smaller habitat patches, alter food availability, and push reservoir species into closer contact with farms, orchards, plantations, settlements, and peri-urban environments. These changes may increase exposure to infectious saliva, urine, faeces, blood, arthropod vectors, or contaminated water and soil. Agricultural land use has also been associated with elevated infectious disease risk in Southeast Asia, with one analysis reporting that people living or working in agricultural land-use settings in the region had higher odds of infection than those in non-agricultural settings (Shah *et al.* 2019).

The effects of human-modified landscapes and ecotonal interfaces on zoonotic disease transmission is exemplified in the local 1998/99 Nipah virus (NiV) outbreak which linked habitat disruption, agricultural intensification, wildlife reservoirs, and livestock amplification to the infection in humans (Looi and Chua 2007; Kulkarni *et al.* 2013). Fruit bats (*Pteropus hypomelanus* and *P. vampyrus*) were identified as the natural reservoir host of the virus, while pigs served as amplifiers. Evidence suggests that spillover occurred when fruit bats were drawn into orchard surrounding pig-farms, where bat-contaminated fruit or excretions likely exposed pigs to the virus. Haze-related flowering and fruiting failure of forest trees coupled with increasing deforestation probably drove the migration of the forest

fruit bats to cultivated orchards (Looi and Chua 2007). This example provides evidence for the complex interaction between diseases epidemiological risk factors including habitat alteration, climate change, wildlife reservoirs and domestic animal amplifiers which created a high-risk bat–pig–human transmission pathway (Looi and Chua 2007; Pulliam *et al.* 2012).

The widespread and potentially fatal zoonotic malaria in Southeast Asia caused by *Plasmodium knowlesi*, *P. cynomolgi* and *P. inui* provides another compelling example of deforestation and ecotone-mediated zoonotic disease transmission (Fornace *et al.* 2016; Johnson *et al.* 2024; Vythilingam and Jeyaprakasam 2024). These apicomplexan haemoparasites are naturally maintained in non-human primates (mainly macaques) and are transmitted to humans by the bite of forest-associated *Anopheles* mosquitoes (Warthon *et al.* 1962; Coatney *et al.* 1971; Vythilingam *et al.* 2008, 2014, 2021). In Southeast Asia, zoonotic malaria remains a major obstacle to malaria elimination certification as currently defined by the World Health Organization (WHO) because it is maintained in non-human primate reservoirs and cannot be removed through human case management alone (Fornace *et al.* 2023). This is of particular concern locally as Malaysia records the highest number of human zoonotic malaria cases and is a global hotspot of *P. knowlesi*, accounting for 89.0% of all reported infections and all three zoonotic malaria deaths in 2024 (World Health Organization 2025).

It has been demonstrated that agricultural expansion and forest fragmentation influence *P. knowlesi* exposure, supporting links between land-use change and zoonotic malaria transmission (Fornace *et al.* 2019). Vector studies in Sabah also show that human exposure to zoonotic malaria vectors occurs across village, farm, and forest habitats, while vector composition changes across forested to deforested ecotones in emerging areas of zoonotic malaria transmission (Wong *et al.* 2015; Hawkes *et al.* 2019; Brown *et al.* 2020). This is important because fragmented landscapes may create suitable vector habitats and increase outdoor biting exposure during farming, plantation work, forest visits, hunting, and evening peri-domestic activities.

Recent regional modelling indicates that *P. knowlesi* risk remains widespread across Southeast Asia and is shaped by environmental variables, forest cover, and land-use dynamics, including plantation development (Johnson *et al.* 2024; Tobin *et al.* 2024). Collectively, these studies have shown that anthropogenic habitat degradation functions primarily as a risk amplifier rather than as a single independent cause of zoonotic emergence. Ecotones are central to this process because they represent the spatial interfaces where wildlife reservoirs, domestic animals, vectors, contaminated environments, and humans most frequently intersect. These examples support a One Health interpretation in which land-use policy, biodiversity conservation, agricultural planning, vector ecology, wildlife surveillance, livestock biosecurity, water management, and public-health preparedness are treated as interconnected components of zoonotic disease prevention.

ZOONOTIC DISEASE SPILLOVER RISK: A VITAL COMPONENT FOR ENVIRONMENTAL IMPACT ASSESSMENTS (EIAs)

Environmental Impact Assessment (EIA) in Malaysia should explicitly include assessment of zoonotic disease spillover risk because anthropogenic landscape alterations and wildlife displacement can alter the wildlife–human disease transmission interface which has been shown to influence the spread of zoonotic diseases. Under Malaysia's EIA system, activities listed as "prescribed activities" under the *Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015* are subject to EIA requirements before implementation or approval (Department of Environment Malaysia 2015). Although the Order does not expressly require pathogen-specific zoonotic spillover assessment, several

prescribed activities listed in the First and Second Schedules are directly relevant to spillover risk because they involve forest conversion, wildlife-habitat disturbance, livestock intensification, wetland drainage, tourism development in protected areas, road construction near environmentally sensitive areas, waste treatment, housing, and township development. These activities can alter ecological interfaces among wildlife reservoirs, domestic animals, vectors, workers, and nearby communities; therefore, justifying zoonotic spillover risk evaluation as part of the environmental and health-risk assessment.

Health Impact Assessment (HIA) is also recognised within Malaysia's National Environmental Health Action Plan, 2021. The Malaysian HIA-in-EIA guidance describes HIA as a systematic process for identifying the likely adverse health consequences of proposed projects and provides requirements for conducting and reporting HIA within EIA (Ministry of Health Malaysia 2021). However, conventional EIA and HIA practice often emphasises pollution, water quality, air quality, occupational health, waste management, and vector breeding, while wildlife-associated pathogen spillover is neglected and not considered a formal risk pathway. In a biodiversity-rich country such as Malaysia, this is a critical gap because development projects can change wildlife movement, feeding behaviour, roosting patterns, vector ecology, livestock exposure, and human–wildlife contact.

The Nipah virus outbreak illustrates this clearly: deforestation, ecological stress, fruit cultivation near pig farms, and agricultural intensification created conditions for repeated bat-to-pig transmission of the virus (Chua 2002; Pulliam *et al.* 2012; Rahman *et al.* 2010, 2013). Similarly, sylvatic dengue studies in Malaysia show that forest conversion and urbanisation can alter *Aedes* mosquito communities, increasing bridge-vector exposure between wildlife, humans, and modified environments (Young *et al.* 2017; Johari *et al.* 2019). Wildlife displacement is also relevant because long-tailed macaques in Peninsular Malaysia have been shown to shed Macacine Herpesvirus 1, creating occupational risks during capture, translocation, rescue, or conflict-management activities (Lee *et al.* 2015). In Malaysian Borneo, Fornace *et al.* (2016) found that spatial patterns of human *P. knowlesi* malaria in Sabah were associated with landscape factors, including forest cover and fragmentation, supporting the hypothesis that deforestation and associated environmental change contribute to zoonotic malaria emergence.

Anthropogenic environmental changes including deforestation, reduced habitat complexity through monoculture of crops, creation of large ecotone areas, and ultimately biodiversity loss create ecological linkage mechanisms involving wildlife hosts and vectors that have negative impacts on human health (Young *et al.* 2017; Davison *et al.* 2019, Cooper *et al.* 2020). Recently, Johnson *et al.* (2024) further strengthened the reservoir-host component of this argument by showing that landscape characteristics drive zoonotic malaria prevalence in non-human primates, linking environmental change directly to infection patterns in macaque reservoirs. These examples show that EIA and HIA should move beyond general vector and waste considerations to explicitly assess how development may alter wildlife ecology, pathogen reservoirs, vector abundance, domestic animal contact, and human exposure pathways.

EIA should therefore incorporate zoonotic spillover risk as a formal component of project screening, scoping, baseline studies, impact prediction, mitigation, monitoring, and post-approval compliance. At the screening stage, projects involving forest clearance, plantation expansion, livestock development, dams, roads, quarrying, mining, tourism infrastructure, waste facilities, or development near protected areas should be flagged for zoonotic spillover assessment. At the scoping stage, the assessment should identify likely wildlife reservoirs, livestock or companion animal bridge hosts, vectors, nearby communities, roosting sites, migration corridors, and conflict-prone wildlife species. Baseline studies

should include wildlife presence, vector abundance and potential transmission routes/risk pathways, domestic animal density, land-cover mapping, waste and water management, and available human or animal disease records. Where risk is plausible, targeted pathogen surveillance, and consultation with veterinary, wildlife, environmental health, and public-health authorities should be incorporated.

The implications of human-mediated landscape alteration on One Health are substantial. One Health recognises that human health, animal health, and ecosystem health are interdependent. In the Malaysian EIA context, this means that zoonotic disease risk cannot be adequately assessed by environmental consultants, public-health authorities, veterinarians, or wildlife managers working separately. Applying zoonotic disease risk spillover in EIA's would require inter-agency involvement including the Department of Environment, Ministry of Health, Department of Veterinary Services, Department of Wildlife and National Parks, state wildlife agencies, local authorities, and project proponents. Such integration would allow development decisions to consider not only habitat loss and pollution, but also pathogen emergence pathways created by ecological disruption, and consequently safeguard the health of humans, animals and the environment through a concerted One Health framework.

REFERENCES

Abatcha, M.G., Zakaria, Z., Kaur, D.G. and Thong, K.L. 2013. Prevalence and antimicrobial susceptibility of *Salmonella* spp. isolated from snakes in Peninsular Malaysia. *Journal of Veterinary Advances* 3(12): 306–312.

Abdullah, D.A., Ola-Fadunsin, S.D., Ruviniyia, K., Gimba, F.I., Chandrawathani, P., Lim, Y.A.L., Jesse, F.F.A. and Sharma, R.S.K. 2019. Molecular detection and epidemiological risk factors associated with *Cryptosporidium* infection among cattle in Peninsular Malaysia. *Food and Waterborne Parasitology* 14: e00035.

Abdullah, W.O., Zahedi, M., Bakar, N.A. and Jeffery, J. 1990. Endo- and ectoparasites of stray cats from Kuala Lumpur, Malaysia. *Malaysian Journal of Medical Laboratory Sciences* 7(2): 38–44.

Abdul-Mawah, S.S., Norma-Rashid, Y. and Ramli, R. 2023. Survey on gastro-intestinal parasites of captive sun bears in Malaysia. *Ursus* 34(e8): 1–9.

Ain-Najwa, M.Y., Yasmin, A.R., Arshad, S.S., Omar, A.R., Abu, J., Kumar, K., Mohammed, H.O. *et al*. (2020a). Exposure to zoonotic West Nile Virus in Long-tailed Macaques and bats in Peninsular Malaysia. *Animals* 10(12): 2367.

Ain-Najwa, M.Y., Yasmin, A.R., Omar, A.R., Arshad, S.S., Abu, J. and Mohammed, H.O. 2019. West Nile Virus infection in human and animals: Potential risks in Malaysia. *Sains Malaysiana* 48: 2727–2735.

Ain-Najwa, M.Y., Yasmin, A.R., Omar, A.R., Arshad, S.S., Abu, J., Mohammed, H.O., Kumar, K. *et al.* 2020b. Evidence of West Nile virus infection in migratory and resident wild birds in west coast of Peninsular Malaysia. *One Health* 10: 100134.

Alkathiry, H., Al-Rofaai, A., Ya'cob, Z., Cutmore, T.S., Mohd-Azami, S.N.I., Husin, N.A., Lim, F.S. *et al*. 2022. Habitat and season drive chigger mite diversity and abundance on small mammals in Peninsular Malaysia. *Pathogens* 11(10): 1087.

Ambu, S., Yeoh, E.Y.S. and Mak, J.W. 2011. Prevalence of *Sarcocystis* spp. in rodents in Peninsular Malaysia. *International e-Journal of Science, Medicine and Education* 5(2): 29–38.

Amin-Babjee, S.M. 1978. Parasites of the domestic cat in Selangor, Malaysia. *Kajian Veterinar* 10: 107–114.

Apun, K., Chong, Y.L., Abdullah, M.T. and Micky, V. 2008. Antimicrobial susceptibilities of *Escherichia coli* isolates from food animals and wildlife animals in Sarawak, East Malaysia. *Asian Journal of Animal and Veterinary Advances* 3(6): 409–416.

Asyikha, R., Sulaiman, N. and Mohd-Taib, F.S. 2020. Detection of *Bartonella* sp. in ticks and their small mammal hosts in mangrove forests of Peninsular Malaysia. *Tropical Biomedicine* 37(4): 919–931.

Azmi, M.A.I., William-Dee, J., Morni, M.A., Azhar, N.A.A., Sabarudin, N.A., Jinggong, E.R., Zolkapley, S. *et al.* 2025. Metagenomic insights into host-specific gastroenteritis bacteria in forest rodents of Sarawak, Borneo: Implications for one health surveillance of rodent-borne pathogens. *BMC Microbiology* 25(1): 531.

Benacer, D., Mohd Zain, S.N., Amran, F., Galloway, R.L. and Thong, K.L. 2013. Isolation and molecular characterization of *Leptospira interrogans* and *Leptospira borgpetersenii* isolates from the urban rat populations of Kuala Lumpur, Malaysia. *American Journal of Tropical Medicine and Hygiene* 88(4): 704–709.

Bilung, L.M., Kho, K.L., Apun, K., Abdullah, M.T., Rahman, M.A., Ming, C.Y., Benjamen, A., *et al.* 2014. Occurrence of *Escherichia coli* in wildlife from different habitats of Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology*. 4(1): 19–27.

Blasdell, K.R., Morand, S., Perera, D. and Firth, C. 2019a. Association of rodent-borne *Leptospira* spp. with urban environments in Malaysian Borneo. *PLOS Neglected Tropical Diseases* 13(2): e0007141.

Blasdell, K.R., Perera, D. and Firth, C. 2019b. High prevalence of rodent-borne *Bartonella* spp. in urbanizing environments in Sarawak, Malaysian Borneo. *The American Journal of Tropical Medicine and Hygiene* 100(3): 506–509.

Brandon-Mong, G.J., Che Mat Seri, N.A., Sharma, R.S.K, Andiappan, H., Tan, T.C., Lim, Y.A., and Nissapatorn, V. 2015. Seroepidemiology of toxoplasmosis among people having close contact with animals. *Frontiers in Immunology* 6: 143.

Brown, R., Chua, T.H., Fornace, K., Drakeley, C., Vythilingam, I. and Ferguson, H.M. 2020. Human exposure to zoonotic malaria vectors in village, farm and forest habitats in Sabah, Malaysian Borneo. *PLOS Neglected Tropical Diseases* 14(9): e0008617.

Buckley, J.J.C. and Edeson, J.F.B. 1956. On the adult morphology of *Wuchereria* sp. (*malayi*?) from a monkey (*Macaca irus*) and from cats in Malaya, and on *Wuchereria pahangi* n. sp. from a dog and a cat. *Journal of Helminthology* 30: 1–20.

Budke, C.M., Carabin, H. and Torgerson, P.R. 2011. *Health impact assessment and burden of zoonotic diseases. Oxford Textbook of Zoonoses. 2nd Ed*. Oxford: Oxford University Press. pp. 30–37.

Cardosa, J., Ooi, M.H., Tio, P.H., Perera, D., Holmes, E.C., Bibi, K. and Abdul Manap, Z. 2009. Dengue virus serotype 2 from a sylvatic lineage isolated from a patient with dengue hemorrhagic fever. *PLOS Neglected Tropical Diseases* 3(4): e423.

Chandrawathani, P., Nurulaini, R., Zanin, C.M., Premaalatha, B., Adnan, M., Jamnah, O., Khor, S.K. *et al.* 2008. Seroprevalence of *Toxoplasma gondii* antibodies in pigs, goats, cattle, dogs and cats in Peninsular Malaysia. *Tropical Biomedicine* 25(3): 257–258.

Cheng, B.Y., Wong, S.P. and Dykes, G.A. 2014. *Salmonella* associated with captive and wild lizards in Malaysia. *Herpetology Notes* 7: 145–147.

Chin, A.Z., Maluda, M.C.M., Jelip, J., Jeffree, M.S.B., Culleton, R. and Ahmed, K. 2020. Malaria elimination in Malaysia and the rising threat of *Plasmodium knowlesi*. *Journal of Physiological Anthropology* 39(1): 36.

Chua K.B. 2003. A novel approach for collecting samples from fruit bats for isolation of infectious agents. *Microbes and Infection* 5(6): 487–490.

Chua, K.B. 2010. Epidemiology, surveillance and control of Nipah virus infections in Malaysia. *Malaysian Journal of Pathology* 32(2): 69–73.

Chua, K.B., Bellini, W.J., Rota, P.A., Harcourt, B.H., Tamin, A., Lam, S.K., Ksiazek, T.G. *et al.* 2000. Nipah virus: A recently emergent deadly paramyxovirus. *Science* 288(5470): 1432–1435.

Chua, K.B., Chua, B.H. and Wang, C.W. 2002a. Anthropogenic deforestation, El Niño and the emergence of Nipah virus in Malaysia. *The Malaysian Journal of Pathology* 24(1): 15–21.

Chua, K.B., Koh, C.L., Hooi, P.S., Wee, K.F., Khong, J.H., Chua, B.H., Chan, Y.P., Lim, M.E. and Lam, S.K. 2002b. Isolation of Nipah virus from Malaysian Island flying-foxes. *Microbes and Infection* 4(2): 145–151.

Chua, K.B., Crameri, G., Hyatt, A., Yu, M., Tompang, M.R., Rosli, J., McEachern, J. *et al.* 2007. A previously unknown reovirus of bat origin is associated with an acute respiratory disease in humans. *Proceedings of the National Academy of Sciences of the United States of America* 104(27): 11424–11429.

Chua, K.B., Voon, K., Crameri, G., Tan, H.S., Rosli, J., McEachern, J.A., Suluraju, S., Yu, M. and Wang, L.F. (2008). Identification and characterization of a new orthoreovirus from patients with acute respiratory infections. *PLoS ONE* 3(11): e3803.

Chua, K.B., Voon, K., Yu, M., Keniscope, C., Abdul Rasid, K. and Wang, L.F. 2011. Investigation of a potential zoonotic transmission of orthoreovirus associated with acute influenza-like illness in an adult patient. *PLoS ONE* 6(10): e25434.
Chua, K.B., Wang, L.F., Lam, S.K., Crameri, G., Yu, M., Wise, T., Boyle, D., Hyatt, A.D. and Eaton, B.T. 2001. Tioman virus, a novel paramyxovirus isolated from fruit bats in Malaysia. *Virology* 283(2): 215–229.
Chua, T.H., Emmanuel, J., Lee, K.T., Kan, F.K., Tee, K.S., Abidin, Z., Ganeswrie, R. *et al.* 2017. Taeniasis and neurocysticercosis among Malaysians. *Tropical Biomedicine*. 34(1): 7–13.
Coatney, G.R., Collins, W.E., Warren, M. and Contacos, P.G. 1971. *The Primate Malarias* Maryland: U.S. National Institute of Allergy and Infectious Diseases. 366 pp.
Colón, C.P. and Patton, S. 2012. Parasites of civets (Mammalia, Viverridae) in Sabah, Borneo: A coprological survey. *Malayan Nature Journal* 64(2): 87–94.
Cooper, D.J., Rajahram, G.S., William, T., Jelip, J., Mohammad, R., Benedict, J., Alaza, D.A. *et al.* 2020. *Plasmodium knowlesi* malaria in Sabah, Malaysia, 2015–2017. *Emerging Infectious Diseases* 26(7):1404–1411.
Cox-Singh, J., Davis, T.M., Lee, K.S., Shamsul, S.S., Matusop, A., Ratnam, S., Rahman, H.A. *et al.* 2008. *Plasmodium knowlesi* malaria in humans is widely distributed and potentially life threatening. *Clinical Infectious Diseases* 46(2): 165–171.
Davidson, G., Chua, T.H., Cook, A., Speldewinde, P. and Weinstein, P. 2019. The role of ecological linkage mechanisms in *Plasmodium knowlesi* transmission and spread. *EcoHealth* 16(4): 594–610.
Department of Environment Malaysia. 2015. *Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015*. Putrajaya: Ministry of Natural Resources and Environmental Sustainability, Malaysia.
Despommier, D., Ellis, B.R. and Wilcox, B.A. 2006. The role of ecotones in emerging infectious diseases. *EcoHealth* 3(4): 281–289.
Di Genova, B.M. and Tonelli, R.R. 2016. Infection strategies of intestinal parasite pathogens and host cell responses. *Frontiers in Microbiology* 7: 256.
Divis, P.C.S., Lee C.L., Rovie-Ryan, J.J., Khamisah, A.K., Anderios, F., Shamilah, H., Sharma, R.S.K. *et al.* 2017. Three divergent subpopulations of the malaria parasite *Plasmodium knowlesi*. *Emerging Infectious Diseases* 23(4): 616–624.
Ernieenor, F.C.L., NorJaiza, M.J., Fadillah, A., Canedy, J. and Mariana, A. 2021. Screening and genotyping of *Orientia tsutsugamushi* from field-collected on-host chiggers (Acari: Prostigmata) recovered from a positive scrub typhus locality in Kelantan, Malaysia. *Experimental and Applied Acarology* 84(1): 171–182.
Fadil, N.F.M., Cheong, F.W., Lau, Y.L., Mahmud, R. and Muslim, A. 2019. Molecular evidence of *Sarcocystis* species infecting reptiles in Peninsular Malaysia. *Iranian Journal of Parasitology* 14(4): 623–630.
Farah Haziqah, M.T., Chandrawathani, P., Douadi, B., Suresh, K., Wilson, J.J., Mohd Khalid, M.K.N., Rajamanikam, A. *et al.* 2018. Impact of pH on the viability and morphology of *Blastocystis* isolates. *Tropical Biomedicine* 35(2): 501–510.
Farizawati, S., Lim, Y.A.L., Ahmad, R.A., Fatimah, C.T.N.I. and Siti-Nor, Y. 2005. Contribution of cattle farms towards river contamination with *Giardia* cysts and *Cryptosporidium* oocysts in Sungai Langat Basin. *Tropical Biomedicine* 22(2): 89–98.
Fazhana, I., Salim, N. and Saleha, A.A. 2007. A study on the presence of *Salmonella* spp. in house geckos (Hemidactylus frenatus). In *2nd Proceeding of the Seminar on Veterinary Sciences*, *Faculty of Veterinary Medicine, Universiti Putra Malaysia*, pp. 24–26. Serdang: Universiti Putra Malaysia.
Field, H.E. 2009. Bats and emerging zoonoses: Henipaviruses and SARS. *Zoonoses and Public Health* 56(6–7): 278–284.
Field, H.E., Young, P.L., Yob, J.M., Mills, J., Hall, L. and Mackenzie, J.S. 2001. The natural history of Hendra and Nipah viruses. *Microbes and Infection* 3(4): 307–314.
Fong, J.H., Lau, Y.L., Mahmud, R. and Muslim, A. 2014. Phylogenetic analysis and identification of *Sarcocystis* spp. infecting rodents in Peninsular Malaysia. *International e-Journal of Science, Medicine and Education* 8(2): 12–17.
Fornace, K.M., Abidin, T.R., Alexander, N., Brock, P., Grigg, M.J., Murphy, A., William, T. *et al.* 2016. Association between landscape factors and spatial patterns of *Plasmodium knowlesi* infections in Sabah, Malaysia. *Emerging Infectious Diseases* 22(2): 201–208.

Fornace, K.M., Drakeley, C.J., Lindblade, K.A., Jelip, J. and Ahmed, K. 2023. Zoonotic malaria requires new policy approaches to malaria elimination. *Nature Communications* 14(1): 5750.
Fornace, K.M., Herman, L.S., Abidin, T.R., Chua, T.H., Daim, S., Lorenzo, P.J., Grignard, L. *et al.* 2019. Exposure and infection to *Plasmodium knowlesi* in case study communities in northern Sabah, Malaysia and Palawan, the Philippines. *The Lancet Planetary Health* 3(4): e179–e186.
Fornace, K.M., Topazian, H.M., Routledge, I., Asyraf, S., Jelip, J., Lindblade, K.A., Jeffree, M.S. *et al*. 2023). No evidence of sustained nonzoonotic *Plasmodium knowlesi* transmission in Malaysia from modelling malaria case data. *Nature Communications* 14: 2945.
Ganapathy, K., Saleha, A.A., Jaganathan, M., Tan, C.G., Chong, C.T., Tang, S.C., Ideris, A. *et al.* 2007. Survey of *Campylobacter*, *Salmonella* and mycoplasmas in house crows (*Corvus splendens*) in Malaysia. *The Veterinary Record* 160(18): 622–624.
Gibb, R., Redding, D.W., Chin, K.Q., Donnelly, C.A., Blackburn, T.M., Newbold, T. and Jones, K.E. 2020. Zoonotic host diversity increases in human-dominated ecosystems. *Nature* 584: 398–402.
Goh, K.S. and Sharma, R.S.K. 2024. Molecular detection and risk factors associated with potentially zoonotic enteric protozoa infecting synanthropic macaques (*Macaca fascicularis*) in the northern region of Peninsular Malaysia. In *21st Proceedings of the Seminar on Veterinary Sciences*, *Faculty of Veterinary Medicine, Universiti Putra Malaysia,* p. 179. Serdang: Universiti Putra Malaysia.
Greer, G.J., Ow-Yang, C.K. and Yong, H.S. 1988. *Schistosoma malayensis* n. sp.: A *Schistosoma japonicum*-complex schistosome from Peninsular Malaysia. *The Journal of Parasitology* 74(3): 471–480.
Grignard, L., Shah, S., Chua, T.H., William, T., Drakeley, C.J. and Fornace, K.M. 2019. Natural human infections with *Plasmodium cynomolgi* and other malaria species in an elimination setting in Sabah, Malaysia. *The Journal of Infectious Diseases* 220(12): 1946–1949.
Groves, M.G., Umathevy, T. and Lim, B.L. 1967. Helminth infections in a black panther (*Felis pardus* Linn.). *Medical Journal of Malaya* 21: 374.
Habe, S., Lai, K.P.F., Agatsuma, T., Ow-Yang, C.K. and Kawashima, K. 1996. Growth of Malaysian *Paragonimus westermani* in mammals and the mode of transmission of the fluke among mammals. *Japanese Journal of Tropical Medicine and Hygiene* 24(4): 225–232.
Habeebur-Rahman, S.P., Noni, V., Khan, F.A.A. and Tan, C.S. 2023. Detection of novel coronaviruses from dusky fruit bat (*Penthetor lucasi*) in Sarawak, Malaysian Borneo. *Veterinary Medicine and Science* 9(6): 2634–2641.
Hawkes, F.M., Manin, B.O., Cooper, A., Daim, S., Homathevi, R., Jelip, J., Husin, T. *et al*. 2019. Vector compositions change across forested to deforested ecotones in emerging areas of zoonotic malaria transmission in Malaysia. *Scientific Reports* 9: 13312.
Hemalatha, C., Chandrawathani, P., Suresh Kumar, G., Premaalatha, B., Geethamalar, S., Lily Rozita, M.H., Farah Haziqah, M.T. *et al.* 2014. The diagnosis of *Blastocystis* sp. from animals: An emerging zoonosis. *Malaysian Journal of Veterinary Research* 5(2): 15–21.
Hill, D. and Dubey, J.P. 2002. *Toxoplasma gondii*: Transmission, diagnosis and prevention. *Clinical Microbiology and Infection* 8(10): 634–640.
Johari, N.A., Voon, K., Toh, S.Y., Sulaiman, L.H., Yap, I.K.S. and Lim, P.K.C. 2019. Sylvatic dengue virus type 4 in *Aedes aegypti* and *Aedes albopictus* mosquitoes in an urban setting in Peninsular Malaysia. *PLOS Neglected Tropical Diseases* 13(11): e0007889.
Johnson, E., Sharma, R.S.K., Ruiz Cuenca, P., Byrne, I., Salgado-Lynn, M., Shahar, Z.S., Lin, L.C. *et al.* 2024. Landscape drives zoonotic malaria prevalence in non-human primates. *eLife* 12: RP88616.
Kan, S.P. 1979. Ultrastructure of the cyst wall of *Sarcocystis* spp. from some rodents in Malaysia. *International Journal for Parasitology* 9(5): 475–480.
Kan, S.P., Prathap, K. and Dissanaike, A.S. 1979. Light and electron microstructure of a *Sarcocystis* sp. from the Malaysian long-tailed monkey, *Macaca fascicularis*. *The American Journal of Tropical Medicine and Hygiene* 28(4): 634–642.
Kavana, N. J., Lim, L.H.S. and Ambu, S. 2015. The morphological characteristics of the sparganum stage of the Malaysian *Spirometra* species. *International e-Journal of Science, Medicine and Education* 9(2): 22–24.

Kazim, A.R., Nasir, D.M., Tan, T.K., Yin, V.W., Noh, A.A.M., Heo, C.C. and Low, V.L. 2025. New host record and redescription of *Amblyomma cordiferum* nymphs and larvae infesting Malaysian house rats (*Rattus rattus diardii*) in Peninsular Malaysia, with molecular evidence of *Rickettsia*, *Borrelia*, and *Bartonella*. *Acta Tropica* 261: 107496.
Kelly, P. 2013. Protozoal gastrointestinal infections. *Medicine* 41(12): 705–708.
Kho, K.L., Koh, F.X. and Tay, S.T. 2015. Molecular evidence of potential novel spotted fever group rickettsiae, *Anaplasma* and *Ehrlichia* species in *Amblyomma* ticks parasitizing wild snakes. *Parasites and Vectors* 8: 112.
Khoo, J.J., Ishak, S.N., Lim, F.S., Mohd-Taib, F.S., Khor, C.S., Loong, S.K. and AbuBakar, S. 2018. Detection of a *Borrelia* sp. from Ixodes granulatus ticks collected from rodents in Malaysia. *Journal of Medical Entomology* 55(6): 1642–1647.
Khoo, J.J., Lim, F.S., Chen, F., Phoon, W.H., Khor, C.S., Pike, B.L., Chang, L Y. and Abu Bakar, S. 2016. *Coxiella* detection in ticks from wildlife and livestock in Malaysia. *Vector-Borne and Zoonotic Diseases* 16: 744–751.
Kilbourn, A.M., Karesh, W.B., Wolfe, N.D., Bosi, E J., Cook, R.A. and Andau, M. 2003. Health evaluation of free-ranging and semi-captive orangutans (*Pongo pygmaeus pygmaeus*) in Sabah, Malaysia. *Journal of Wildlife Diseases* 39(1): 73–83.
Kim, J.-S. 1978. An ecological study of *Paragonimus* in Malaysia. *The Korean Journal of Parasitology* 16(1): 47–53.
Klaus, A., Strube, C., Röper, K.M., Radespiel, U., Schaarschmidt, F., Nathan, S., Goossens, B. and Zimmermann, E. 2018. Fecal parasite risk in the endangered proboscis monkey is higher in an anthropogenically managed forest environment compared to a riparian rain forest in Sabah, Borneo. *PLoS ONE* 13(4): e0195584.
Kreidl, P., De Mateo, S., Rasch, G., Desenclos, J.C., Hemmer, R., Thornton, L., Tielinen, M. and Tucker, R. 1999. Japanese encephalitis in Malaysia and vaccines. *Eurosurveillance Weekly* 3(13): 1430.
Krishnasamy, M., Singh, K.I., Ambu, S. and Ramachandran, P. 1980. Seasonal prevalence of the helminth fauna of the wood rat *Rattus tiomanicus* (Miller) in West Malaysia. *Folia Parasitologica* 27(3): 231–235.
Krishnasamy, M., Lee, C.C., Inder Singh, K., Amin-Babjee, S.M., Rehana, A.S. and Jeffery, J. 1991. Studies on animal schistosomes in Peninsular Malaysia: 1. Description of *Schistosoma spindale* (Montgomery, 1906) from goats and buffalo. *Tropical Biomedicine* 8: 161–165.
Krishnasamy, M., Ambu, S., Long, C. N., Inder Singh, K. and Jeffery, J. 1998. Prevalence of *Schistosoma nasale* ova in buffaloes (*Bubalus bubalis*). *Jurnal Veterinar Malaysia* 10(1): 27–29.
Kuchta, R., Kołodziej-Sobocińska, M., Brabec, J., Młocicki, D., Sałamatin, R. and Scholz, T. 2024. Diversity and biology of *Spirometra* tapeworms (Cestoda: Diphyllobothriidea), zoonotic parasites of wildlife: A review. *International Journal for Parasitology: Parasites and Wildlife* 24: 100936.
Kulkarni, D.D., Tosh, C., Venkatesh, G. and Senthil Kumar, D. 2013. Nipah virus infection: Current scenario. *Indian Journal of Virology* 24(3): 398–408.
Kumar, K., Arshad, S.S., Selvarajah, G.T., Abu, J., Toung, O.P., Abba, Y., Bande, F. *et al.* 2018a. Prevalence and risk factors of Japanese encephalitis virus (JEV) in livestock and companion animal in high-risk areas in Malaysia. *Tropical Animal Health and Production* 50(4): 741–752.
Kumar, K., Arshad, S.S., Selvarajah, G.T., Abu, J., Toung, O.P., Abba, Y., Yasmin, A.R. et al. 2018b. Japanese encephalitis in Malaysia: An overview and timeline. *Acta Tropica* 185: 219–229.
Kuntz, R.E. and Myers, B.J. 1978. North Borneo (Malaysia): A new locality for *Schistosoma japonicum*. *The American Journal of Tropical Medicine and Hygiene* 27: 438–440.
Kutty, M.K., Latif, B., Muslim, A., Hussaini, J., Daher, A.M., Heo, C.C. and Abdullah, S. 2015. Detection of sarcocystosis in goats in Malaysia by light microscopy, histology, and PCR. *Tropical Animal Health and Production* 47: 751–756.
Kuze, N., Kanamori, T., Malim, T.P., Bernard, H., Zamma, K., Kooriyama, T., Morimoto, A. and Hasegawa, H. 2010. Parasites found from the feces of Bornean orangutans in Danum Valley, Sabah, Malaysia, with a redescription of *Pongobius hugoti* and the description of a new species of *Pongobius* (Nematoda: Oxyuridae). *Journal of Parasitology* 96(5): 954–960.

Laing, A.B.G., Edeson, J.F.B. and Wharton, R.H. 1960. Studies on filariasis in Malaya: The vertebrate hosts of *Brugia malayi* and *B. pahangi*. *Annals of Tropical Medicine and Parasitology* 54(1): 92–99.

Lam, S.K., Chua, K.B, Hooi, P.S., Rahimah, M.A., Kumari, S., Tharmaratnam, M., Chuah, S K. *et al*. 2001. Chikungunya infection: An emerging disease in Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health* 32: 447–451.

Latif, B. and Muslim, A. 2016. Human and animal sarcocystosis in Malaysia: A review. *Asian Pacific Journal of Tropical Biomedicine* 6(11): 982–988.

Latif, B., Muslim, A., Daszak, P., Chomel, B.B. and Tappe, D. 2013. High prevalence of muscular sarcocystosis in cattle and water buffaloes from Selangor, Malaysia. *Tropical Biomedicine* 30(4): 699–705.

Latif, B., Vellayan, S., Omar, E., Abdullah, S. and Mat Desa, M.N. 2010. Sarcocystosis among wild captive and zoo animals in Malaysia. *The Korean Journal of Parasitology* 48(3): 213–217.

Lau, Y.L., Chang, P.Y., Subramaniam, V., Ng, Y.H., Mahmud, R., Ahmad, A.F. and Fong, M.Y. 2013. Genetic assemblage of *Sarcocystis* spp. in Malaysian snakes. *Parasites and Vectors* 6(1): 257.

Lau, Y.L., Jamaiah, I., Rohela, M., Fong, M.Y., Siti, C.O.S. and Siti, F.A. 2014. Molecular detection of *Entamoeba histolytica* and *Entamoeba dispar* infection among wild rats in Kuala Lumpur, Malaysia. *Tropical Biomedicine* 31(4): 721–727.

Lea, J.S.X., Reduan, M.F.H., Choong, S.S., Kamaruzaman, I.N.A., Ooi, P.T., Abu Bakar, S., Loong, S.K. and Abdul Rahman, M.S. 2025. Leptospirosis in humans and animals in Malaysia: A review from 1976 to 2023. *Veterinary World* 18(3): 673–685.

Lee, C.C., Chandrawathani, P., Sheikh-Omar, A.R. and Mohna, S.S. 1987. An abattoir survey of gastrointestinal parasites of pigs. *Kajian Veterinar* 19(1): 27–32.

Lee, C.C., Sheikh-Omar, A.R. and Rasool, N. 1989. Finding of *Cryptosporidium parvum* oocysts in diarrhoeic calves in Malaysia. *Tropical Biomedicine* 6: 145–146.

Lee, H.F. and Miyazaki, I. 1965. *Paragonimus westermani* infection in wild mammals and crustacean hosts in Malaysia. *The American Journal of Tropical Medicine and Hygiene* 14(4): 581–585.

Lee, K.S., Divis, P.C.S., Zakaria, S.K., Matusop, A., Julin, R.A., Conway, D.J., Cox-Singh, J. and Singh, B. 2011. *Plasmodium knowlesi*: Reservoir hosts and tracking the emergence in humans and macaques. *PLoS Pathogens* 7(4): e1002015.

Lee, M.H., Rostal, M.K., Hughes, T., Sitam, F., Lee, C.Y., Japning, J., Harden, M.E. *et al.* 2015. Macacine herpesvirus 1 in long-tailed macaques, Malaysia, 2009–2011. *Emerging Infectious Diseases* 21(7): 1107–1113.

Lee, S.C., Ngui, R., Tan, T.K., Roslan, M.A., Ithoi, I. and Lim, Y.A. 2014. Aquatic biomonitoring of *Giardia* cysts and *Cryptosporidium* oocysts in peninsular Malaysia. *Environmental Science and Pollution Research* 21(1): 445–453.

Lekko, Y.M., Che-Amat, A., Ooi, P.T., Omar, S., Mohd-Hamdan, D.T., Linazah, L.S., Zakaria, Z. *et al.* 2021a. Detection of *Mycobacterium tuberculosis* complex antibodies in free-ranged wild boar and wild macaques in selected districts in Selangor and reevaluation of tuberculosis serodetection in captive Asian elephants in Pahang, Peninsular Malaysia. *Journal of Veterinary Medical Science* 83(11): 1702–1707.

Lekko, Y.M., Che-Amat, A., Ooi, P.T., Omar, S., Ramanoon, S.Z., Mazlan, M., Jesse, F.F.A. *et al.* 2021b. *Mycobacterium tuberculosis* and avium complex investigation among Malaysian free-ranging wild boar and wild macaques at wildlife–livestock–human interface. *Animals* 11(11): 3252.

Leong, T.S., Lim, B.L. and Krishnasamy, M. 1979. Parasite fauna of the house rat, *Rattus rattus diardii*, in Kuala Lumpur and nearby villages. *Southeast Asian Journal of Tropical Medicine and Public Health* 10: 122–126.

Levesque, Z.A., Walsh, M.G., Webb, C.E., Zadoks, R.N. and Brookes, V.J. 2024. A scoping review of evidence of naturally occurring Japanese encephalitis infection in vertebrate animals other than humans, ardeid birds and pigs. *PLoS Neglected Tropical Diseases* 18(10): e0012510.

Liew, J.W.K., Bukhari, F.D.M., Jeyaprakasam, N. K., Phang, W.K., Vythilingam, I. and Lau, Y.L. 2021. Natural *Plasmodium inui* infections in humans and *Anopheles cracens* mosquito, Malaysia. *Emerging Infectious Diseases* 27(10): 2700–2703.
Lim, B.L. and Betterton, C. 1977. *Paragonimus westermani* in Malaysian Felidae and Viverridae: Probable modes of transmission in relation to host feeding habits. *Journal of Helminthology* 51(4): 295–299.
Lim, B.L. and Ramachandran, C.P. 1979. Ecological studies on *Angiostrongylus malaysiensis* (Nematoda: Metastrongylidae) in Malaysia. In: *Studies on angiostrongyliasis in Eastern Asia and Australia*, J.H. Cross (Ed.), pp. 26–48. Taipei: NAMRU-2-SP-44, US Naval Medical Research Unit No. 2.
Lim, B.L. and Mak, J.W. 1978. Non-human primates as reservoir of zoonotic diseases with special reference to *Brugian filariasis* in Peninsular Malaysia. In *Recent Advances in Primatology: Vol. 4. Medicine*, D.J. Chivers and E.H.R. Ford (Eds.),pp. 55–56. Cambridge: Academic Press.
Lim, F.S., Khoo, J.J., Tan, K.K., Zainal, N., Loong, S.K., Khor, C.S. and Abu Bakar, S. 2020. Bacterial communities in *Haemaphysalis*, *Dermacentor* and *Amblyomma* ticks collected from wild boar of an Orang Asli Community in Malaysia. *Ticks and Tick-Borne Diseases* 11(2): 101352.
Lim, M.Y., Sharma, R.S.K. and Selvarajah, G.T. 2017. Prevalence of zoonotic enteric protozoa (*Giardia*, *Blastocystis* and *Cryptosporidium*) in shelter cats in Selangor, Malaysia. In *12th Proceedings of the Seminar in Veterinary Sciences*, *Faculty of Veterinary Medicine, Universiti Putra Malaysia*. p.93. Serdang: Universiti Putra Malaysia.
Lim, Y.A.L., Rohela, M. and Shukri, J. 2007. Cryptosporidiosis among birds and bird handlers at Zoo Negara, Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health* 38(Suppl. 1): 19–26.
Lim, Y.A.L., Ngui, R., Shukri, J., Rohela, M. and Mat Naim, H.R. 2008. Intestinal parasites in various animals at a zoo in Malaysia. *Veterinary Parasitology* 157(1–2): 154–159.
Lim, Y.A.L., Ramasame, S.D., Mahdy, M.A.K., Sulaiman, W.Y.W. and Smith, H.V. 2009. Detection and molecular characterization of *Giardia* isolated from recreational lake water in Malaysia. *Parasitology Research* 106: 289–291.
Lokman, H.S., Mak, J.W. and Suresh, K. 1989. Prevalence of *Toxoplasma* antibodies in monkeys in Malaysia. *Tropical Biomedicine*. 6: 147.
Lim, Y.A.L., Mahdy, M.A.K., Tan, T.K., Goh, X.T., Jex, A.R., Nolan, M.J., Sharma, R.S.K. and Gasser, R.B. 2013. First molecular characterization of *Giardia duodenalis* from goats in Malaysia. *Molecular and Cellular Probes* 27(1): 28–31.
Looi, L.M. and Chua, K. B. 2007. Lessons from the Nipah virus outbreak in Malaysia. *Malaysian Journal of Pathology* 29(2): 63–67.
Low, V.J., Tan, T.K., Jamaiah, I., Abu Bakar, S. and Lim, Y.A.L. 2020. First evidence of *Bartonella phoceensis* and *Candidatus* Mycoplasma *haemomuris* subsp. *ratti* in synanthropic rodents in Malaysia. *Asian Pacific Journal of Tropical Medicine* 13(2): 94-96.
Low, S.Y., Lau, S.F., Ahmad, N.I., Sharma, R.S.K., Rosli, M.Z., Mohd-Taib, F.S., Ajat, M.M.M. *et al.* 2023. A cross-sectional study of *Angiostrongylus malaysiensis* in rats and gastropod hosts from recreational parks in Kuala Lumpur, Malaysia: Detection, risk factors and pathology. *Zoonoses and Public Health* 70(7):636–646.
Lv, C., Chen, Y., Cheng, Z., Zhu, Y., Chen, W., Zhou, N., Chen, Y. *et al*. 2024. Global burden of zoonotic infectious diseases of poverty, 1990–2021. *Infectious Diseases of Poverty* 13(1): 82.
Ma, T.Z., Teh, B.T. and Kho, M.Y. 2024. Land use change and Ecological Network in rapid urban growth region in Selangor region, Malaysia. *Scientific Reports* 14(1):16470.
Mak, J.W. 1983. Filariasis: clinical features. In *Bulletin No. 19*, J.W. Mak (Ed.), pp. 51–58. Kuala Lumpur: Institute for Medical Research Malaysia.
Mak, J.W. 1984. Zoonotic filariasis in Malaysia. *The Malaysian Veterinary Journal*. 8(1): 9–12.
Mak, J.W., Lam, P.L., Rain, A.N. and Suresh, K. 1988. Effect of ivermectin against subperiodic *Brugia malayi* infection in the leaf monkey, *Presbytis cristata*. *Parasitology Research* 74(4): 383–385.
Mak, J.W., Choong, M.F., Lam, P.L. and Suresh, K. 1990. Experimental infection of the leaf-mon keys, *Presbytis cristata* and *Presbytis melalophos*, with subperiodic *Brugia malayi*. *Acta Tropica* 47(4): 223–226.

Marchette, N.J., Rudnick, A., Garcia, R. and MacVean, D.W. 1978. Alphaviruses in Peninsular Malaysia: I. Virus isolations and animal serology. *The Southeast Asian Journal of Tropical Medicine and Public Health*. 9(3): 317–329.

Ministry of Health Malaysia. 2021. *National Environmental Health Action Plan. Health Requirements for Health Impact Assessment (HIA) in Environmental Impact Assessment (EIA).* Putrajaya: Ministry of Health Malaysia. 22pp.

Mohamad Tahir, H., Che Lah Ernieenor, F., Zainal Abidin, S., Narainasamy, V.V., and Ahamad, M. 2025. First report on the molecular detection and characterization of *Rickettsia felis* in Laelapidae (Acari: Mesostigmata) mites in Malaysia. *Veterinary Sciences* 12(5): 443.

Mohamed, M.I., Abu, J., Zakaria, Z., Khan, A.R., Abdul Aziz, S., Bitrus, A.A. and Habib, I. 2022. Multi-drug resistant pathogenic *Escherichia coli* isolated from wild birds, chicken, and the environment in Malaysia. *Antibiotics (Basel, Switzerland)* 11(10): 1275.

Mohamed-Yousif, M.Y.I., Aziz, S.A., Abu, J., Khairani-Bejo, S., Puan, C.P., Bitrus, A.A., Aliyu, A.B. and Awad, E.A. 2019. Occurrence of antibiotic resistant *Campylobacter* in wild birds and poultry. *Malaysian Journal of Microbiology* 15(2): 143–151.

Mohammad, A.H., Naserrudin, N.A., Syed Abdul Rahim, S.S., Jelip, J., Atil, A., Sazali, M.F., Muyou, A.J. *et al.* 2022. Narrative review of the control and prevention of *knowlesi* malaria. *Tropical Medicine and Infectious Disease* 7(8): 178.

Mohd Zain, S.N., Behnke, J.M. and Lewis, J.W. 2012. Helminth communities from two urban rat populations in Kuala Lumpur, Malaysia. *Parasites and Vectors* 5: 47.

Mohd Zain, S.N., Farah Haziqah, M.T., Woh, P.Y., Fazly Ann, Z., Vickneshwaran, M., Mohd Khalid, M.K.N., Arutchelvan, R. and Suresh, K. 2017. Morphological and molecular detection of *Blastocystis* in wildlife from Tioman Island, Malaysia. *Tropical Biomedicine* 34(1): 249–255.

Mohd-Azami, S.N.I., Loong, S.K., Khoo, J.J., Husin, N.A., Lim, F.S., Mahfodz, N.H., Ishak, S.N. *et al.* 2023. Molecular surveillance for vector-borne bacteria in rodents and tree shrews of Peninsular Malaysia oil palm plantations. *Tropical Medicine and Infectious Disease* 8(2): 74.

Mohd-Qawiem, F., Nur-Fazila, S.H., Ain-Fatin, R., Yong, Q.H., Nur-Mahiza, M.I. and Yasmin, A.R. 2022. Detection of zoonotic-borne parasites in *Rattus* spp. in Klang Valley, Malaysia. *Veterinary World* 15(4): 1006–1014.

Mohd-Qawiem, F., Md Isa, N.-M., Ahmad, N.I., Abd Rahaman, Y. and Saulol Hamid, N.-F. 2024. Zoonotic importance of ecto- and endoparasites in rodents in Malaysia: A review. *Journal of Veterinary Science* 25(6): e81.

Muslim, A., Fong, M.Y., Mahmud, R. and Sivanandam, S. 2013b. Vector and reservoir host of a case of human *Brugia pahangi* infection in Selangor, Peninsular Malaysia. *Tropical Biomedicine* 30(4): 727–730.

Mustapa, M.S., Ismail, A., Rahman, F. and Hj. Ramli, M.N. 2014. Preliminary study on the occurrence of intestinal parasites in Malayan tapir (*Tapirus indicus*) in Zoo Negara, Malaysia. *Journal of Tropical Biology and Conservation* (JTBC) 11: 97–101.

Muul, I., Lim, B.L. and Walker, J.S. 1977. Scrub typhus infection in rats in four habitats in Peninsular Malaysia. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 71(6): 493–497.

Muul, I. and Chai, K.S. 1978. Distribution of rats infected with *Rickettsia tsutsugamushi* (scrub typhus) in an edge habitat. *Southeast Asian Journal of Tropical Medicine and Public Health* 9(4): 489–493.

Nada-Raja, T., Hu, T.H., Kadir, K.A., Mohamad, D.S.A., Rosli, N., Wong, L.L., Hii, K.C. *et al.* 2020. Naturally acquired human *Plasmodium cynomolgi* and *P. knowlesi* infections, Malaysian Borneo. *Emerging Infectious Diseases* 26(8): 1801–1809.

Nada-Raja, T., Kadir, K.A., Divis, P.C.S., Mohamad, D.S.A., Matusop, A. and Singh, B. 2022. *Macaca fascicularis* and *Macaca nemestrina* infected with zoonotic malaria parasites are widely distributed in Sarawak, Malaysian Borneo. *Scientific Reports* 12(1): 10476.

Nadchatram, M. 1970. Correlation of habitat, environment and color of chiggers, and their potential significance in the epidemiology of scrub typhus in Malaya (Prostigmata: Trombiculidae). *Journal of Medical Entomology* 7(2):131–144.

Naing, C., Whittaker, M.A., and Reid, S.A. 2024. Prevalence of zoonotic brugian filariasis in Asia: A systematic review and meta-analysis. *Acta Tropica* 249: 107052.

Natasha, J.A., Yasmin, A.R., Sharma, R.S.K., Nur-Fazila, S.H., Nur-Mahiza, M.I., Arshad, S.S., Mohammed, H.O. *et al.* 2023). Circulation of West Nile virus in mosquitoes approximate to the migratory bird stopover in west coast Malaysia. *PLoS Neglected Tropical Diseases* 17(4): e0011255.

Ngui, R., Hassan, N.A., Nordin, N M.S., Mohd-Shaharuddin, N., Chang, L.Y., Teh, C.S.J., Chua, K.H. *et al.* 2020. Copro-molecular study of *Entamoeba* infection among the indigenous community in Malaysia: A first report on the species-specific prevalence of *Entamoeba* in dogs. *Acta Tropica* 204: 105334.

Ngui, R., Lee, S.C., Yap, N.J., Tan, T.K., Aidil, R.M., Chua, K.H., Aziz, S. *et al.* 2014. Gastrointestinal parasites in rural dogs and cats in Selangor and Pahang states in Peninsular Malaysia. *Acta Parasitologica* 59(4): 737–744.

Nguyen, H.T.T., Lindahl, J.F., Bett, B., Nguyen-Viet, H., Lâm, S., Nguyen-Tien, T., Unger, F. *et al.* 2025. Understanding zoonotic pathogens and risk factors from wildlife in Southeast Asia: a systematic literature review. *The Veterinary Quarterly* 45(1):1–17.

Noor Asyikin, A., Zunita, Z. and Saleha, A.A. 2006. Isolation and identification of *Salmonella* in green iguanas. In *1st Proceeding of the Seminar on Veterinary Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia*, pp. 70–72. Serdang: Universiti Putra Malaysia.

Noorazrena, A.A. and Saleha, A.A. 2008. Occurrence of antibiotic-resistant *Salmonella* spp. in tortoises and turtles. In *3rd Proceeding of the Seminar on Veterinary Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia*, p. 91. Serdang: Universiti Putra Malaysia.

Normaznah, Y., Azizah, M.A., Azuan, M.I., Latifah, I., Rahmat, S. and Nasir, M.A. 2015. Seroprevalence of *Toxoplasma gondii* in rodents from various locations in Peninsular Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health* 46(3): 388–395.

Nur Mahiza, M.I., Noordin, M.M. and Siti Khairani, B. 2007. A study of the prevalence of *Salmonella* spp. and antimicrobial resistance in pet snakes. In *2nd Proceeding of the Seminar on Veterinary Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia*, p. 231. Serdang: Universiti Putra Malaysia.

Oliveira, A.R.S., Cohnstaedt, L.W., Strathe, E., Etcheverry Hernández, L., McVey, D.S., Piaggio, J. and Cernicchiaro, N. 2017. Meta-analyses of the proportion of Japanese encephalitis virus infection in vectors and vertebrate hosts. *Parasites and Vectors* 10(418): 1–15.

Paramasvaran, S., Sani, R.A., Hassan, L., Hanjeet, K., Krishnasamy, M., Jeffery, J., Oothuman, P. and Salleh, I. 2009. Endo-parasite fauna of rodents caught in five wet markets in Kuala Lumpur and its potential zoonotic implications. *Tropical Biomedicine* 26(1): 67–72.

Parashar, U.D., Sunn, L.M., Ong, F., Mounts, A.W., Arif, M.T., Ksiazek, T.G., Kamaluddin, M.A. *et al.* 2000. Case-control study of risk factors for human infection with a new zoonotic paramyxovirus, Nipah virus, during a 1998–1999 outbreak in Malaysia. *Journal of Infectious Diseases* 181(5): 1755–1759.

Patz, J.A., Daszak, P., Tabor, G.M., Aguirre, A.A., Pearl, M., Epstein, J., Wolfe, N.D. *et al.* 2004. Unhealthy landscapes: Policy recommendations on land use change and infectious disease emergence. *Environmental Health Perspectives* 112(10): 1092–1098.

Peng, T.L., Kamar, A.H., Mohamed, M., Gilbert, B., Mohd Sani, N.I., Zalati, C.W.S., Hamdan, R.H. *et al.* 2024. Molecular prevalence of *Bartonella* spp. in bat flies in east coast Malaysia. *Heliyon* 10(9): e29785.

Philip, N. and Ahmed, K. 2023. Leptospirosis in Malaysia: Current status, insights, and future prospects. *Journal of Physiological Anthropology* 42: 30.

Plowright, R.K., Reaser, J.K., Locke, H., Woodley, S.J., Patz, J.A., Becker, D.J., Oppler, G. *et al.* 2021. Land use-induced spillover: A call to action to safeguard environmental, animal, and human health. *The Lancet Planetary Health* 5(4): e237–e245.

Plowright, R.K., Ahmed, A.N., Coulson, T., Crowther, T.W., Ejotre, I., Faust, C.L., Frick, W.F. *et al.* 2024. Ecological countermeasures to prevent pathogen spillover and subsequent pandemics. *Nature Communications* 15(1): 2577.

Premaalatha, B., Chandrawathani, P., Priscilla, F.X., Farah Haziqah, M.T., Jamnah, O., Zaini, C.M. *et al.* 2017. A survey of endoparasite and ectoparasite infections of wild rats caught in areas of Ipoh and Kuala Lumpur, Malaysia. *Malaysian Journal of Veterinary Research* 8(2): 29–34.

Premaalatha, B. Chandrawathani P., Jamnah O., Farah Haziqah M.T., Tan, P.S., Tharshini, J., Nor Ikhmal, S. *et al.* 2018. Survey of parasitic infections in wild rats from urban areas in Kuala Lumpur, Malaysia. *Malaysian Journal of Veterinary Research* 9(1): 31–38.

Pritchard, L.I., Chua, K.B., Cummins, D., Hyatt, A., Crameri, G., Eaton, B.T. and Wang, L.F. 2006. Pulau virus; a new member of the Nelson Bay orthoreovirus species isolated from fruit bats in Malaysia. *Archives of Virology* 151: 229–239.

Pulliam, J.R.C., Epstein, J.H., Dushoff, J., Rahman, S.A., Bunning, M., Jamaluddin, A.A., Hyatt, A.D. *et al.* 2012. Agricultural intensification, priming for persistence and the emergence of Nipah virus: A lethal bat-borne zoonosis. *Journal of the Royal Society Interface* 9(66): 89–101.

Quah, J.X., Ambu, S., Lim, Y.A.L., Mahdy, M.A.K. and Mak, J.W. 2011. Molecular identification of *Cryptosporidium parvum* from avian hosts. *Parasitology* 138(5): 573–577.

Rahman, S.A., Hassan, S.S., Olival, K.J., Mohamed, M., Chang, L.Y., Hassan, L., Saad, N.M. *et al.* 2010. Characterization of Nipah virus from naturally infected *Pteropus vampyrus* bats, Malaysia. *Emerging Infectious Diseases* 16(12): 1990–1993.

Rahman, S.A., Hassan, L., Epstein, J.H., Mamat, Z.C., Yatim, A.M., Hassan, S.S., Field, H.E. *et al.* 2013. Risk factors for Nipah virus infection among pteropid bats, Peninsular Malaysia. *Emerging Infectious Diseases* 19(1): 51–60.

Rauff-Adedotun, A.A., Mohd Zain, S.N. and Farah Haziqah, M.T. 2020. Current status of *Blastocystis* sp. in animals from Southeast Asia: A review. *Parasitology Research* 119: 3559–3570.

Robinson, M.T., Satjanadumrong, J., Hughes, T., Stenos, J. and Blacksell, S.D. 2019. Diagnosis of spotted fever group *Rickettsia* infections: The Asian perspective. *Epidemiology and Infection* 147: e286.

Rossi, S.L., Ross, T.M. and Evans, J.D. 2010. West Nile virus. *Clinics in Laboratory Medicine* 30(1): 47–65.

Rudnick, A. 1966. Studies of the ecology of dengue in Malaysia. *Bulletin of the World Health Organization* 35(1): 78.

Rulli, M.C., D'Odorico, P., Galli, N., John, R.S., Muylaert, R.L., Santini, M. and Hayman, D.T.S. 2025. Land use change and infectious disease emergence. *Reviews of Geophysics* 63(2): e2022.

Sabri, A.R., Hassan, L., Sharma, R.S.K. and Noordin, M.M. 2019. *Toxoplasma gondii* infection in native village chickens (*Gallus domesticus*) in Selangor and Melaka, Malaysia. *Tropical Biomedicine* 36(3): 604–609.

Sabrina, D.L, Hassan, L., Sharma, R.S.K. and Ooi, P.T. 2023a. Epidemiological risk factors and phylogenetic affinities of *Sarcocystis* infecting village chickens and pigs in Peninsular Malaysia. *Tropical Biomedicine* 40(3):281-289.

Sabrina, D.L., Hassan, L., Sharma, R.S.K., Ooi, P.T. and Musa, H.I. 2023b. Prevalence and haplotypes of *Toxoplasma gondii* in native village chickens and pigs in Peninsular Malaysia. *Veterinary Sciences* 10(5): 334.

Sai Gythri, N. and Sharma, R.S.K. 2020. Prevalence of enteric parasites in shelter dogs in Selangor, Malaysia. In *15th Proceedings of the Seminar on Veterinary Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia*, p. 179. Serdang: Universiti Putra Malaysia.

Sam, I.C., Chua, C.L., Rovie-Ryan, J.J., Fu, J.Y.L., Tong, C., Sitam, F.T. and Chan, Y.F. 2015. Chikungunya virus in macaques, Malaysia. *Emerging Infectious Diseases* 21(9): 1683–1685.

Shafie, N.J., Halim, N.S.A., Awoniyi, A.M., Zalipah, M.N., Md-Nor, S., Nazri, M.U.I.A. and Costa, F. 2022. Prevalence of pathogenic *Leptospira* spp. in non-volant small mammals of Hutan Lipur Sekayu, Terengganu, Malaysia. *Pathogens* 11(11): 1300.

Shafiyyah, C.O.S., Jamaiah, I., Rohela, M., Lau, Y.L., Aminah, F.S. and Siti Aminah, M.Y. 2012. Prevalence of intestinal and blood parasites among wild rats in Kuala Lumpur, Malaysia. *Tropical Biomedicine* 29(4): 544–550.

Shah, H.A., Huxley, P., Elmes, J. and Murray, K.A. 2019. Agricultural land-uses consistently exacerbate infectious disease risks in Southeast Asia. *Nature Communications* 10: 4299.

Shah, M.K., Abdul Aziz, S., Zakaria, Z., Lin, L.C. and Goni, M.D. 2018. A review on pathogenic *Escherichia coli* in Malaysia. *Advances in Animal and Veterinary Sciences* 6(2): 95–107.

Siew, Z.Y., Lai, Z.J., Ho, Q.Y., Ter, H.C., Ho, S.H., Wong, S.T. *et al.* 2023. Bat coronavirus was detected positive from insectivorous bats in Krau Wildlife Reserve Forest. *Tropical Biomedicine* 40(4): 462–470.

Singh, B., Kim Sung, L., Matusop, A., Radhakrishnan, A., Shamsul, S.S.G., Cox-Singh, J., Thomas, A. and Conway, D.J. 2004. A large focus of naturally acquired *Plasmodium knowlesi* infections in human beings. *The Lancet* 363(9414): 1017–1024.

Singh, K.I., Krishnasamy, M. and Ambu, S. 1992. The large bandicoot rat, *Bandicota indica*, a new host for *Schistosoma spindale* Montgomery, 1906, in Peninsular Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health* 23(3): 537–538.

Singh, K.I., Krishnasamy, M., Ambu, S., Rasul, R. and Long, C.N. 1997. Studies on animal schistosomes in Peninsular Malaysia: Record of naturally infected animals and additional hosts of *Schistosoma spindale*. *Southeast Asian Journal of Tropical Medicine and Public Health* 28(2): 303–307.
Siti Shafiyyah, C.O., Jamaiah, I., Rohela, M., Lau, Y.L. and Siti Aminah, F. 2012. Prevalence of intestinal and blood parasites among wild rats in Kuala Lumpur, Malaysia. *Tropical Biomedicine* 29(4): 544–550.
Siti-Nurdyana, A.K., Bahaman, A.R., Sharma, R.S.K., Azlan, C.M., Abdul Razak, M.F.A. 2016. Serological prevalence of leptospiral infection in captive Malayan porcupines (*Hystrix brachyura*). *Jurnal Veterinar Malaysia* 28(2): 1–3.
Stewart, A.G.A., Stewart, A.G. and Graves, S.R. 2021. An update on the laboratory diagnosis of *Rickettsia* spp. infection. *Pathogens* 10(10): 1319.
Strauss, J.M. and Sivanandam, S. 1966. A double infection of filariasis in a black panther (*Panthera pardus*) from Pahang. *Medical Journal of Malaya* 20(4): 336.
Suraiya, S. and Farakhin, N.I. 2018. *Mycobacterium bovis* infection in a human in Malaysia. *Clinical Microbiology Newsletter* 40(16): 136–137.
Suut, L., Mazlan, M.N.A., Arif, M.T., Katip, T., Nor Aliza, A.R. and Haironi, Y. 2018. Serovar diversity of *Leptospira* sp. infecting wild rodents in Sarawak, Malaysia. *Tropical Biomedicine* 35: 252–258.
Syed-Arnez, A.S. and Mohd Zain, S.N. 2006. A study on wild rats and their endoparasite fauna from the Endau Rompin National Park, Johor. *Malaysian Journal of Science* 25(2): 19–39.
Ta, T.H., Hisam, S., Lanza, M., Jiram, A.I., Ismail, N. and Rubio, J.M. 2014. First case of a naturally acquired human infection with *Plasmodium cynomolgi*. *Malaria Journal* 13: 68.
Tan, L.P., Megat Abd Rani, P.A., Sharma, R.S.K., Syed Hussain, S.S. and Watanabe, M. 2020. Prevalence of *Toxoplasma gondii* in pet and stray cats in Klang Valley, Malaysia. *Tropical Biomedicine* 37(3): 542–550.
Tan, T.C., Tan, P.C., Sharma, R., Sugnaseelan, S. and Suresh, K.G. 2013. Genetic diversity of caprine *Blastocystis* from Peninsular Malaysia. *Parasitology Research* 112(1): 85–89.
Tan, T.K., Low, V.L., Lee, S.C., Chandrawathani, P., Premaalatha, B. and Lim, Y.A.L. 2014. Gastro-intestinal parasitism among two swine populations in Malaysia: Highlighting the zoonotic transmissible protozoan *Balantidium coli* infections. *Malaysian Journal of Veterinary Research* 5(2): 63–68.
Tan, T.K., Low, V.L., Lee, S.C., Panchadcharam, C., Tay, S.T., Ngui, R., Bathmanaban, P. *et al.* 2015. Detection of *Schistosoma spindale* ova and associated risk factors among Malaysian cattle through coprological survey. *Japanese Journal of Veterinary Research* 63(2): 63–71.
Tan, T.K., Chandrawathani, P., Low, V.L., Premaalatha, B., Lee, S.C., Chua, K.H., Sharma, R.S.K., *et al.* 2017. Occurrence of gastro-intestinal parasites among small ruminants in Malaysia: highlighting *Dicrocoelium* infection in goats. *Tropical Biomedicine* 34(4): 963–969.
Tan, T.K., Low, V.L., Wern, H.N., Jamaiah, I., Daryi, W., Chun, H.T., Selvi, C. and Lim, Y.A.L. 2019. Occurrence of zoonotic *Cryptosporidium* and *Giardia duodenalis* species/genotypes in urban rodents. *Parasitology International* 69: 110–113.
Tan, T.K., Low, V.L., Lim, Y.A.L., Ser, H.L., Boyd, M., Sivapragasam, G. and Kaur, R. 2025. First report of *Giardia duodenalis* assemblages A and B in wild hornbills. *Tropical Biomedicine* 42(3): 356–360.
Tan, Y.K. and Sharma, R.S.K. 2017. Prevalence of zoonotic enteric protozoa among captive primates in Peninsular Malaysia. In *12th Proceedings of the Seminar in Veterinary Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia*, p. 127. Serdang: Universiti Putra Malaysia.
Tay, S.T., Mokhtar, A.S., Mohd Zain, S.N. and Low, K.C. 2014. Isolation and molecular identification of bartonellae from wild rats (*Rattus* species) in Malaysia. *American Journal of Tropical Medicine and Hygiene* 90(6): 1039–1042.
Tay, S.T., Koh, F.X., Kho, K.L. and Sitam, F.T. 2015. *Rickettsial* infections in monkeys, Malaysia. *Emerging Infectious Diseases* 21(3): 545–547.
Tay, S.T., Kho, K.L., Wee, W.Y. and Choo, S.W. 2016. Whole-genome sequence analysis and exploration of the zoonotic potential of a rat-borne *Bartonella elizabethae*. *Acta Tropica* 155: 25–33.
Tenter, A.M., Heckeroth, A.R. and Weiss, L.M. 2000. *Toxoplasma gondii*: From animals to humans. *International Journal for Parasitology* 30(12–13): 1217–1258.

Teo, S.Z., Tuen, A.A., Madinah, A., Aban, S. and Chong, Y.L. 2019. Occurrence of gastrointestinal nematodes in captive nonhuman primates at Matang Wildlife Centre, Sarawak. *Tropical Biomedicine* 36(3): 594–603.
Teoh, B.T., Sam, S.S., Abd-Jamil, J. and Abu Bakar, S. 2010. Isolation of ancestral sylvatic dengue virus type 1, Malaysia. *Emerging Infectious Diseases* 16(11): 1783–1785.
Teoh, S.K. 1976. Tapeworm infection in Perlis. *Medical Journal of Malaysia* 31(1): 57–58.
Thayaparan, S., Robertson, I.D. and Abdullah, M.T. 2014. Leptospiral agglutinins in captive and free-ranging non-human primates in Sarawak, Malaysia. *Veterinary World* 7(6): 428–431.
Thayaparan, S., Robertson, I.D., Fairuz, A., Suut, L. and Abdullah, M.T. 2013. Serological prevalence of leptospiral infection in wildlife in Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology* 2(2): 79–82.
Thomas, V. 1979. *Toxoplasmosis* with special reference to Peninsular Malaysia and Singapore. *Malaysian Journal of Pathology* 2: 23–31.
Tijjani, M., Abd Majid, R., Abdullahi, S.A. and Unyah, N.Z. 2020. Detection of rodent-borne parasitic pathogens of wild rats in Serdang, Selangor, Malaysia: A potential threat to human health. *International Journal for Parasitology: Parasites and Wildlife* 11: 174–182.
Tobin, R.J., Harrison, L.E., Tully, M.K., Lubis, I.N.D., Noviyanti, R., Anstey, N.M., Rajahram, G.S. *et al.* 2024. Updating estimates of *Plasmodium knowlesi* malaria risk in response to changing land use patterns across Southeast Asia. *PLoS Neglected Tropical Diseases* 18(1): e0011570.
Torgerson, P.R. and Macpherson, C.N. 2011. The socioeconomic burden of parasitic zoonoses: global trends. *Veterinary Parasitology* 182(1): 79–95.
Tookhy, A.N., Nur Mahiza, M.I., Yasmin, A.R., Nur Indah, A., Sharma, R.S.K., Lokman, H.I, Mansor, R. *et al.* 2024. Epidemiology of rumen fluke infection in selected buffalo farms in Perak, Malaysia: Prevalence, molecular species identification, and associated risk factors. *Parasitology Research* 123(5): 199.
Tsen, A., Sharma, R.S.K. and Norhadila Z. 2019. Molecular detection and risk factor analyses of enteric protozoa infection among Bornean orangutans (*Pongo pygmaeus*) in Sabah, Malaysia. In *14th Proceeding of the Seminar on Veterinary Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia*, p. 105. Serdang: Universiti Putra Malaysia.
Tuan Said, S.A., Vejayan, J., Mohd Zulkeffli, N.A. and Agustar, H.K. 2022. Gastrointestinal parasites in *Macaca fascicularis* living in two urban areas of Malaysia. *Malaysian Journal of Science* 41(3): 10–21.
Tun, S., Ithoi, I., Mahmud, R., Samsudin, N.I., Heng, C.K. and Ling, L.Y. 2015. Detection of helminth eggs and identification of hookworm species in stray cats, dogs and soil from Klang Valley, Malaysia. *PLoS ONE* 10(12): e0142231.
Valbuena, G. and Walker, D.H. 2009. Infection of the endothelium by members of the order Rickettsiales. *Thrombosis and Haemostasis* 102(6): 1071–1079.
Vinnie-Siow, W.Y., Low, V.L., Tan, T.K., Teoh, Y.B., Sivanandam, S., Vellayan, S. and Lim, Y.A.L. 2019. Observations of scrotal mass, liver mass, haemolytic jaundice and central vestibular disorder in *Brugia pahangi*-infected dogs. *Tropical Biomedicine* 36(1): 252–256.
Vinnie-Siow, W.Y., Tan, T.K., Low, V.L., Teoh, Y.B., Prakash, B.K., Sivanandam, S., Sharma, R.S.K. and Lim, Y.A. 2022. Integration of microscopic, serologic and molecular techniques for detection of filarial parasites in dogs in Malaysia. *Acta Parasitologica* 67(1):468–475.
Vinnie-Siow, W.Y., Tan, T.K., Low, V.L. and Ai, L.L.Y. 2026. Gastrointestinal parasites in wild boars from an indigenous community settlement in Sarikei, Sarawak. *Journal of Tropical One Health* 1: 6.
Vythilingam, I. and Jeyaprakasam, N.K. 2024. Deforestation and non-human primate malarias will be a threat to malaria elimination in the future: Insights from Southeast Asia. *Acta Tropica* 257: 107280.
Vythilingam, I., Tan, C.H., Asmad, M., Chan, S.T., Lee, K.S. and Singh, B. 2006. Natural transmission of *Plasmodium knowlesi* to humans by *Anopheles latens* in Sarawak, Malaysia. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 100(11): 1087–1088.
Vythilingam, I., Noorazian, Y.M., Huat, T.C., Jiram, A.I., Yusri, Y.M., Azahari, A.H., Norparina, I. *et al.* 2008. *Plasmodium knowlesi* in humans, macaques and mosquitoes in Peninsular Malaysia. *Parasites and Vectors* 1: 26.

Vythilingam, I., Lim, Y.A.L., Venugopalan, B., Ngui, R., Leong, C.S., Wong, M.L., Khaw, L.T. *et al.* 2014. *Plasmodium knowlesi* malaria an emerging public health problem in Hulu Selangor, Selangor, Malaysia (2009–2013): Epidemiologic and entomologic analysis. *Parasites and Vectors* 7: 436.

Vythilingam, I., Chua, T.H., Liew, J.W.K., Manin, B.O. and Ferguson, H.M. 2021. The vectors of *Plasmodium knowlesi* and other simian malarias Southeast Asia: challenges in malaria elimination. *Advances in Parasitology* 113: 131–189.

Walker, J.S., Gan, E., Chye, C.T. and Muul, I. 1973. Involvement of small mammals in the transmission of scrub typhus in Malaysia: Isolation and serological evidence. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 67(6): 838–845.

Wharton, R.H., Eyles, D.E., McWarren, W. and Moorhouse, D.E. 1962. *Anopheles leucosphyrus* identified as a vector of monkey malaria in Malaya. *Science* 137: 758.

Wolfe, N.D., Kilbourn, A.M., Karesh, W.B., Rahman, H.A., Bosi, E J., Cropp, B.C., Andau, M. *et al.* 2001. Sylvatic transmission of arboviruses among Bornean orangutans. *The American Journal of Tropical Medicine and Hygiene* 64(5-6): 310–316.

Wong, M.L., Chua, T.H., Leong, C.S., Khaw, L.T., Fornace, K.M., Wan-Sulaiman, W.Y., William, T. *et al.* 2015. Seasonal and spatial dynamics of the primary vector of *Plasmodium knowlesi* within a major transmission focus in Sabah, Malaysia. *PLoS Neglected Tropical Diseases* 9(10): e0004135.

World Health Organization. 2025. *World malaria report 2025: addressing the threat of antimalarial drug resistance*. Geneva: World Health Organization. License: CC BY-NC-SA 3.0 IGO.

World Health Organization. 2026. Update on the Dengue situation in the Western Pacific Region. *Dengue Situation Update 737*. pp. 1–18. Geneva: World Health Organization.

Yaiw, K.C., Crameri, G., Wang, L., Chong, H.T., Chua, K.B., Tan, C.T., Goh, K.J. *et al.* 2007. Serological evidence of possible human infection with Tioman virus, a newly described paramyxovirus of bat origin. *The Journal of Infectious Diseases* 196(6): 884–886.

Yamamoto, A., Perison, P.W.D., Ahmad, I.A., Awosolu, O., Hsieh, T.C., Nik Him, N.A.I.I. and Meor Termizi, F.H. 2024. Occurrence and morphological characteristics of *Cysticercus fasciolaris* in wild rodents from Penang, Malaysia. *Malaysian Journal of Microscopy* 20(1): 12–23.

Yap, N.J., Hossain, H., Nada-Raja, T., Ngui, R., Muslim, A., Hoh, B.P., Khaw, L.T. *et al.* 2021. Natural human infections with *Plasmodium cynomolgi*, *P. inui*, and 4 other simian malaria parasites, Malaysia. *Emerging Infectious Diseases* 27(8): 2187–2191.

Young, K.I., Mundis, S., Widen, S.G., Wood, T.G., Tesh, R.B., Cardosa, J., Vasilakis, N. and Perera, D. 2017. Abundance and distribution of sylvatic dengue virus vectors in three different land cover types in Sarawak, Malaysian Borneo. *Parasites and Vectors* 10: 406.

Zahedi, M., Vellayan, S., Jeffery, J. and Krishnasamy, M. 1986. A case of double infection with *Brugia pahangi* Buckley and Edeson, 1956 and *Dirofilaria immitis* Leidy, 1856 in a Malaysian clouded leopard, *Neofelis nebulosa*. *Veterinary Parasitology* 21(2): 135–137.

Zainol, I. and Sharma, R.S.K. 2023. Molecular detection of potentially zoonotic enteric protozoa infecting synanthropic rodents in Selangor and Kuala Lumpur, Malaysia. In *18th Proceedings of the Seminar on Veterinary Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia*, p. 113. Serdang: Universiti Putra Malaysia.

Zaman, V. and Goh, T.K. 1968. Isolation of *Toxoplasma gondii* from the slow loris, *Nycticebus coucang*. *Annals of Tropical Medicine and Parasitology* 62(1): 52–53.

Zaman, V. and Goh, T.K. 1970. Isolation of *Toxoplasma gondii* from Malayan tree shrew. *Transactions of The Royal Society of Tropical Medicine and Hygiene* 64(3): 462.


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 837–857
doi: 10.62613/sonc2025.v3anc13

CHAPTER 13

Soundscape research in Malaysia and its potential to support ecosystem conservation and planetary health

YEN YI LOO[1]*, NOORUL EZYAN NOR HASHIM[1],
ALAA' ZAIN AL-AABIDEEN[1] and SITHI V. MUNIANDY[2]

Abstract: The interconnected threats of environmental degradation, climate change, and biodiversity loss pose significant challenges to both human and ecosystem health. To address these challenges, it is critical to understand systemic processes that govern planetary health. Acoustic environments – comprising of sounds from biological (biophony), geophysical (geophony), and anthropogenic (anthropophony) sources – are perceived and interpreted through our hearing sensory system. Recent advancements in digital technologies and spatial data analytics accelerated ecosystems health monitoring, biodiversity assessment and evolutionary ecology studies, where both physiological and psychological aspects of human and non-human living organisms are explored. This chapter presents the status of bioacoustics and soundscape research in Malaysia, and discusses the relationships among soundscapes, biodiversity, and human health. Long-term monitoring of soundscapes is important to understand species occurrences and interactions, which may contribute to understanding ecosystem health. This understanding could be especially important in ecosystems vulnerable to climate change or habitat loss, such as tropical ecosystems in Southeast Asia. Future research should harness the potential of soundscapes as a cost -effective and less intrusive assessment tool for biodiversity conservation that complements other monitoring methods.

INTRODUCTION

The term "soundscape" is described as the relationship between a landscape and the composition of its sound (Southworth 1969). The Oxford dictionary gives a succinct definition of soundscape as 'the sounds heard in a particular location, considered as a whole'. A soundscape can be categorised into three parts: "biophony" (biological sounds produced by organisms, such as the songs, calls, and choruses of birds, frogs, insects, mammals, etc.), "geophony" (geophysical sounds from environmental process, such as wind, rain, thunder, waves, earthquakes, etc.), and "anthropophony" (human or manmade sounds, such as speech, traffic, music, construction, machinery, etc.). Figure 1 summarises the complex relationships between the three components of soundscape and the impact of human activities on natural soundscapes. The field of soundscape ecology concerns not only the study of these individual components but also how they interact with one another across time and space (Schafer 1977; Krause 1987). The human relationship with acoustic environment, or soundscape, is rooted deeply in the inter-connectedness among elements of natural sounds, be it from vocal or non-vocal sources. Thunder announces rain, and one may seek shelter. The perceived loudness of flowing water may indicate the how fast or wide a river is, and one may follow the direction of that sound to locate water source or identify suitable campsite. When arriving on an island, birdsong reveals the species present, from which one may infer the types of resources available to support a given composition of birds. Even a sudden silence or abrupt burst of sounds can be informative to indicate the presence of a predator or the break of dawn, and one may perceive or react accordingly to ensure survival.

[1] Sunway Centre for Planetary Health, Sunway University, Petaling Jaya, Selangor, Malaysia.
[2] Center for Theoretical & Computational Physics, Department of Physics, Faculty of Science, University Malaya, 50603 Kuala Lumpur, Malaysia.
***Corresponding author: looyenyi@gmail.com**



Figure 1. Soundscape is characterised by geophony, biophony and anthropophony sources and directly affected by the changes arising from natural and human-made causes. Illustrated by Nadia Radzif, Sunway Centre for Planetary Health.

Ancestral humans who were more capable of seeking out safe locations within a landscape were more likely to pass on their genes to subsequent generations (Smith and Pijanowski 2014). Consequently, modern humans are genetically hard-wired to prefer natural landscapes and soundscapes that minimise physical risks. Sight and hearing are often considered as primal senses that condition our perception of an environment. Actively listening to the soundscape provides valuable information from the surroundings, especially when visibility is limited by dense canopy, weather, distance, and/or darkness. The perception and evaluation of a soundscape's quality may be inherently subjective, with individual experiences shaping whether an acoustic environment is deemed appealing or aversive (Medvedev *et al.* 2015). With that said, investigations into the beneficial effects of natural soundscapes have revealed multiple underlying mechanisms that can improve health both physiologically and psychologically, suggesting a complex interplay between acoustic stimuli and human responses (Aletta *et al*. 2018; Song *et al.* 2023). Indeed, intact ecological relationships in the wild allowed for the evolution of the perception and use of soundscape by wildlife and people, not only to communicate and to survive (Marler 2004; Podos and Webster 2022). The human perception of and interaction with the soundscape contributes to the evolution of culture, where people are inspired to create music (Schafer 1977), to name something based on the sound it makes (onomatopoeia, see Lim *et al.* 2017), to pass on indigenous and traditional knowledge (Tidemann and Gosler 2011), and to incite imaginative and meaningful stories (Smalley *et al.* 2023).

Humans are intricately connected with the natural or built environment. By understanding these relationships through the soundscape, we can gain valuable insights into our health in relation to the health of ecosystems (Dumyahn and Pijanowski 2011; Farina 2018; Pillay *et al.* 2019; Sethi *et al.* 2022; Wang *et al.* 2024). As one of the three major tropical ecosystems in the world, Southeast Asia is understudied and disproportionately vulnerable to massive changes in climate and biosphere (Sodhi *et al.* 2004). However, Southeast Asia possesses high potential for positive change (Procheş *et al.* 2021). To address these challenges, there is a growing need to understand systemic processes that govern planetary health, a state where both people and the planet thrive together (Horton and Lo 2015; Whitmee et al. 2015; Gupta *et al*. 2024; Muniandy 2024), for which the soundscape

offers a unique and valuable perspective. To understand ecological relationships in large spatio-temporal scales that are timely for conservation action, scientists and practitioners are utilising the rapidly advancing technologies today. These approaches combine both automated collection of environmental data with automated detection systems, with the aim of reducing field labour and time taken to turn raw data to insightful information (Sugai *et al.* 2019), thereby enhancing the capacity to derive critical information on biodiversity and ecosystem health (Farina 2014; Pavan 2017; Johnson *et al.* 2023).

This chapter documents published research on bioacoustics and soundscape ecology in Malaysia, examines the inter-connectedness of people's health and wellbeing with soundscapes through the overlooked impacts of anthropogenic noise pollution, and finally provides an outlook of future directions and recommendations to protect our national acoustic heritage. The main takeaway of this chapter is that: More than being a voice for nature, we need to *listen* to the voices of those we often deem 'voiceless', only then can we learn how to live in harmony with the only planet that keeps us alive.

STATUS OF BIOACOUSTICS AND SOUNDSCAPE RESEARCH IN MALAYSIA

Malaysia is one of the 17 mega-biodiverse countries and possesses high potential for advancing the understanding and conservation of our natural soundscapes. To understand the breadth of research on the acoustic environment in Malaysia, a literature review of original research published up to 2025 was conducted using the keywords: (bioacoustic* OR ecoacoustic* OR soundscape* OR acoustic* OR sound* OR vocal* OR noise* OR call* OR song* OR record*) AND (Malaysia*). After excluding duplicates, reviews and perspectives, and studies conducted outside of Malaysia, the search were able to curate a collection of 69 relevant primary research articles (Figure 2).

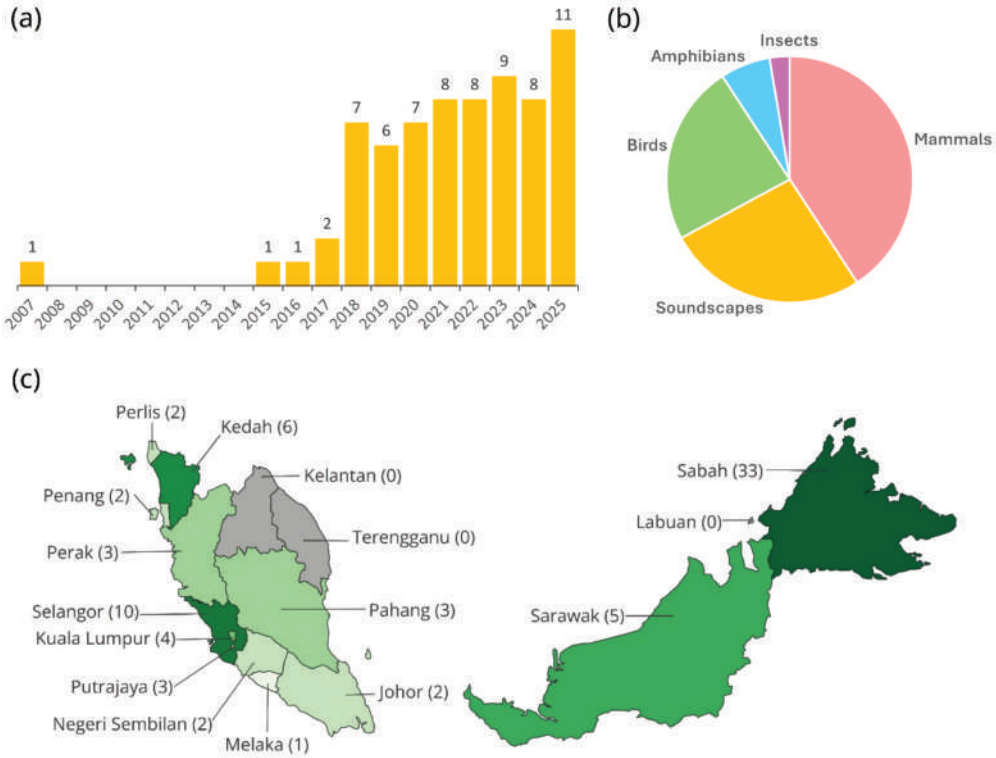


Figure 2. Number of published bioacoustics studies in Malaysia by (a) year, (b) taxonomic group or soundscape level, and (c) state.

Table 1. Reference table of primary research on soundscapes and bioacoustics in Malaysia by state, habitat type, and taxonomic group or soundscape level studies.

State	Habitat Type	Taxonomic group/ Soundscape	References
Sabah	Forest	Mammals	A.R. Lau *et al.* (2018, 2022); Cauzinille *et al.* (2024); Clink (2017); Clink *et al.* (2017, 2019, 2020a, 2020b, 2023, 2025); Clink and Klinck (2019a, 2019b, 2021); Clink and Lau (2020); Clink, Charif *et al.* (2018); Clink, Grote *et al.* (2018); Clink, Zafar *et al.* (2021); Lakdari *et al.* (2024); Tengström (2023)
		Birds	Clink and Ahmad (2025); Clink, Groves, *et al.* (2021); Gwee *et al.* (2019)*; Kennedy *et al.* (2023); Mitchell *et al.* (2020); Tengström (2023); Yusni (2023)
		Soundscapes	B.E. Heath *et al.* (2020, 2021); Mitchell *et al.* (2020); R. Heath (2022); Sethi *et al.* (2019, 2022); Sethi, Ewers *et al.* (2020); Sethi, Jones *et al.* (2020); Tengström (2023)
		Amphibians	Tengström (2023)
		Insects	Holmes *et al.* (2025)
	Plantation	Mammals	A.R. Lau *et al.* (2018); B.E. Heath *et al.* (2021); Clink *et al.* (2019); Tengström (2023)
		Birds	Tengström (2023)
		Soundscapes	B.E. Heath *et al.* (2021)
		Amphibians	Tengström (2023)
Selangor	Forest	Birds	Chang *et al.* (2018); K.K.S. Lau (2018); Mah *et al.* (2023); Nawi *et al.* (2021); Yee *et al.* (2016, 2018)
	Plantation	Birds	Chang *et al.* (2018); Yee *et al.* (2016, 2018)
	Mangrove	Birds	Rahim *et al.* (2025)
		Soundscapes	Rahim *et al.* (2024)
	Built environment	Birds	Hanafi *et al.* (2019)
		Soundscapes	Muniandy (2024)
Kedah	Forest	Amphibians	Ong and Shahrudin (2021, 2022a, 2022b)
		Mammals	Pang *et al.* (2022)
		Soundscapes	Razali *et al.* (2015)
	Marine	Mammals	Bono *et al.* (2022)
Sarawak	Forest	Birds	Gwee et al. (2019)*; Kueffner (2023)
		Amphibians	Arch *et al.* (2007)
		Soundscapes	Yi *et al.* (2021); Harmon and Wahid (2024)

Kuala Lumpur	Urban green space Built environment	Soundscapes Birds	J.S.L. Lee *et al.* (2023a, 2023b) Hanafi *et al.* (2019); Othman *et al.* (2024)
Pahang	Forest	Mammals Soundscapes	Kamaruzaman *et al.* (2023) Muniandy *et al.* (2025); Miza (2025)
Perak	Forest	Mammals Soundscapes	Avicena *et al.* (2025) Loo *et al.* (2024) Nurika *et al.* (2025)
Putrajaya	Urban green space Built environment	Soundscapes Birds	J.S.L. Lee *et al.* (2023a, 2023b) Hanafi *et al.* (2019)
Johor	Forest Lab	Mammals Insects	Loo, Avicena *et al.* (2025) Tan *et al.* (2024)
Negeri Sembilan	Forest Built environment	Mammals Birds	Okuda *et al.* (2022) Hanafi *et al.* (2019)
Penang	Forest Urban green space	Soundscapes Mammals Soundscapes	Loo, Lee, *et al.* (2025) Miard *et al.* (2019) Loo, Lee *et al.* (2025)
Perlis	Forest Marine	Soundscapes Mammals	Razali *et al.* (2015) Bono *et al.* (2021)
Melaka	Marine	Mammals	Bono *et al.* (2021)
Others (with secondary data sources)		Birds	Gwee *et al.* (2019)*; Hing *et al.* (2025)*

Note: Published papers with studies involving multiple sites, habitats and taxonomic groups, are reflected in each relevant category. 'Forest' includes primary, secondary, lowland, and highland forests; Plantation includes any type of cultivated land including oil palm, rubber, etc.; 'Built environment' refers to urban, suburban and rural areas; 'Urban green spaces' refers specifically to urban parks, botanical gardens, recreational parks, and other green spaces that do not qualify as forests. *denotes studies that included xeno-canto recordings from various sites in Malaysia (xeno-canto.org).

The study of soundscapes in Malaysia is advancing in the recent decade, with increased accessibility to equipment and software for analysing sounds, as well as collaborations with international institutions (see Box 1). The two main approaches for studying biological sounds are through passive acoustic monitoring and focal recordings of target species or individuals. Passive acoustic monitoring allows researchers to collect acoustic data at large spatio-temporal scales using pre-scheduled recording units deployed strategically at study sites, while focal recording allows the researcher to follow vocalising individuals and provide behavioural contexts of the sounds recorded. Social studies about the perception of soundscapes were also included in this review.

According to the literature review, bioacoustics and soundscape research from Malaysia covers various habitats, including forests (n = 57), plantations (n = 7), urban green spaces (n = 4), built environments and laboratory studies (n = 4), marine environments (n = 2), and mangroves (n = 2), as well as various states in Malaysia, including Sabah (n = 33), Selangor (n = 10), Kedah (n = 6), Sarawak (n = 5), Kuala Lumpur (n = 4), Pahang (n = 3), Perak (n = 3), Putrajaya (n = 3), Johor (n = 2), Negeri Sembilan (n = 2), Penang (n = 2), Perlis (n = 2), and Melaka (n = 1).

Bioacoustic studies documented the presence, vocal features and behaviours, as well as ecological interactions of animals, such as mammals (n = 31), including both land and marine mammals (see Box 2), birds (n = 17), amphibians (n = 5), and even insects (n = 2) in both wild and urban environments. For example, some notable studies described

novel vocalisations of amphibians (Ong and Shahrudin 2021, 2022b), marine mammals (Bono *et al.* 2021, 2022), and Sunda colugos (Miard *et al.* 2019), and investigated vocal signature patterns and linguistic theories in primates (Clink *et al.* 2017; Clink, Ahmad *et al.* 2020; Clink *et al*. 2021; Clink and Lau 2020). These studies provide new insights and deeper understanding into these vocalising animals and thus aid in identifying potential new species and examining their conservation status. For instance, population densities of wildlife can also be revealed using acoustic methods, such as through acoustic triangulation (Pang *et al.* 2022). The increase of labelled data from passive acoustic monitoring studies enables the training of machine learning models to automate data analysis and provide timely insights for early warning systems that benefit the safety of people in areas where human -wildlife conflicts may occur (Avicena *et al.* 2025; Clink and Klinck 2021; Loo *et al.* 2024).

Box 1.

The Locally-led East Asian Flyway (LEAFA) program is a transboundary collaborative effort that leverages local researchers and practitioners to co-design standardised methods for passive acoustic monitoring projects at key migratory bird sites along the East Asian-Australasian Flyway (EAAF). The EAAF is one of the most diverse flyways in the world with the highest overlap with human population (~2 million), which exacerbates anthropogenic threats such as poaching and habitat degradation. LEAFA is currently led by 17 teams spread across five countries (Philippines, Indonesia, Taiwan, Cambodia, and Malaysia) and has collected sound data for at least one year at the time of writing. To gain insights from the immense amount of data collected, the teams will utilise deep learning technologies for automated detection of bird calls to accelerate the process from research to conservation action. This initiative provides a framework to create partnerships for the transboundary protection of migratory birds that can be adapted to global flyways.

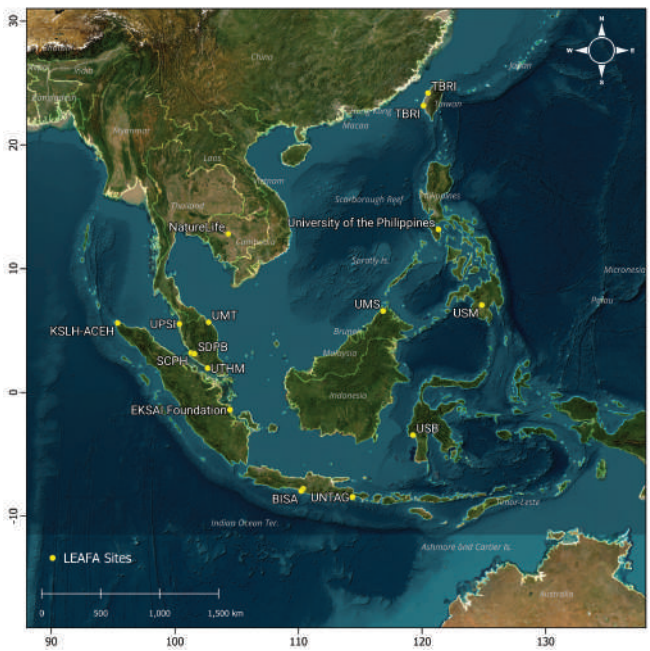






Photo credits: LEAFA

Research on the changes and anthropogenic impacts and perception towards soundscapes (n = 20) were also increasing in recent years, where ecoacoustic indices are used for rapid ecosystem health assessments (Loo, Avicena *et al.* 2025; Mammides *et al.* 2021; Mitchell *et al.* 2020). Ecoacoustic indices, also known as soundscape metrics, features or indices, are mathematically derived numerical representations of the soundscape (Farina

2018; Sueur and Farina 2015). In other words, the diversity of species found in an area can be interpreted through the soundscape, and this relationship has been studied using traditional biodiversity surveys and over 60 types of soundscape indices, such as Acoustic Complexity Index (ACI), Bioacoustic Index (BI), Soundscape Evenness Index (SEI), Normalised Difference Soundscape Index (NDSI), Soundscape Richness Index (SRI), and many others (Stowell and Sueur 2020; Xiang *et al*. 2023; Zhao *et al*. 2022).

Soundscapes offer a holistic approach to enhance conservation efforts in Malaysia. For instance, acoustic monitoring is an effective complementary tool for biodiversity assessment, particularly for vocal taxonomic groups that rely heavily on vocal communication. For instance, Miza (2025) found that rich biophony of birds and insects coincide with high acoustic complexity and diversity with diurnal cycle pattern in key soundscape indices, typical of a healthy tropical highland forest. Monitoring remote habitats such as highlands or deep forests benefits from passive acoustic monitoring approach, which can reduce fieldwork costs while allowing prolonged deployment of recording units. Abd Mutalib and colleagues explore the movement ecology of primates in Kenyir, Terengganu (https://primatesmalaysia.org/home/project-soundskape/). This study, among others (Abd Mutalib *et al.* 2025), demonstrates the scalability of studying home range dynamics of vocally active species using passive acoustic approaches, enabling conservation efforts to align with the needs of vulnerable species.

Box 2.
The MareCet Research Organization has been collaborating with bioacoustics researchers since 2014 to study dugong acoustics in Johor, porpoise echolocations in Langkawi, and Irrawaddy dolphin and Indo-Pacific humpback dolphins in Langkawi and Matang. However, more comprehensive bioacoustics work on the marine mammals in Peninsular Malaysia only began in 2019. MareCet now covers acoustics on cetaceans such as Indo-Pacific humpback dolphins, Irrawaddy dolphins, Indo-Pacific finless porpoises and Bryde's whales, including sirenians such as the dugongs. Other opportunistic studies cover spinner dolphins and bottlenose dolphins that are seen when studying the Bryde's whales offshore. Beyond the species level, research also covers the soundscape of the marine mammal habitat, which include understanding the boat noise impacts to their acoustic behaviour and the absence or presence of these animals for long-term monitoring purposes.



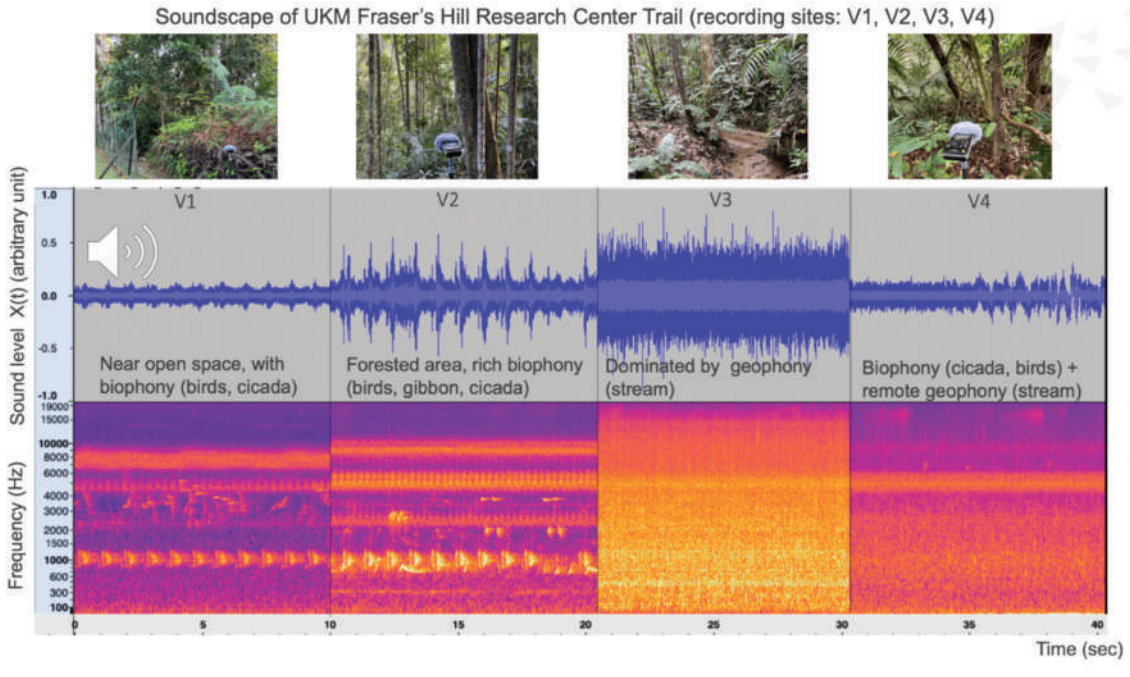
Photo credits: The MareCet Research Organization.

The typical picture of habitat loss is usually visualised through satellite images of fragmenting or displaced landscapes. However, the real impacts are sometimes felt through the silencing of natural soundscapes. Factors like topography, vegetation, and species distribution influence the production and propagation of sounds, making soundscape patterns valuable for understanding ecological integrity across various spatial and temporal scales (Müller *et al*. 2023; Pillay *et al*. 2019; Sethi *et al*. 2022; Wang *et al*. 2024). Soundscapes

vary spatially across habitat, ecosystem, and landscape scales (Mammides *et al.* 2025). They also vary temporally across seconds, days, seasons, years, and aeons (Loo, Lee *et al.* 2025). Taken together, soundscape indices can explain ecosystem integrity indices (Sánchez-Giraldo *et al.* 2021), such as the factors influencing the ability to maintain biodiversity and ecosystem processes in any given habitat (W.H. Lee and Abdullah 2019; McGarigal *et al.* 2018). By analysing the acoustic environment, we can infer the presence, diversity, and interactions of species, as well as their responses to external stressors like climate change, habitat degradation, or anthropogenic noise (Krause and Farina 2016; Sethi *et al.* 2024). For example, the Natural Soundscape Quality (NSQ) indices have been used to quantify the soundscape ecosystem services with deep socio-psychological wellbeing values (Chen *et al.* 2024). NSQ indices are widely used to indicate significant heritage values, especially for planning and management of green spaces with landscape aesthetic quality. Several studies in Malaysia monitored the soundscape characteristics in different habitat types revealed that soundscapes in functioning ecosystems are more diverse than disturbed ones, and are more desirable to urban dwellers (see Box 3) (Loo, Lee *et al*. 2025; Muniandy 2024; Muniandy *et al.* 2025; Othman *et al.* 2024).

Box 3.

Soundscape is a powerful medium to promote action research and ecological empathy given the re-emergence of planetary awareness under the field of environmental humanities. Muniandy (2024) created a sympathetic theme using soundscapes of water bodies originating from the same hill with different paths, one passing through a rewilded urban forest (Rimba Ilmu Botanic Garden, Universiti Malaya) and another stream endured a challenging build environment. This study adopted an Artscience approach by combining robust soundscape signal analysis and eco-philosophy (or ecosophy) to raise awareness for ecological empathy and promote the protection of soundscape heritage, especially that of natural waterbodies and landscape. The figure below shows the time domain representation of the sounds signal sampled for 10 seconds (for illustration) at four different locations along the UKM Fraser's Hill Research Station Trail (N 3.7261, E 101.7165, 1023 m asl) along with the time-frequency spectrogram (Muniandy *et al.* 2025).



HIDDEN COSTS OF ANTHROPOGENIC NOISE POLLUTION

One of the biggest threats to the preservation of natural soundscape is anthropogenic noise pollution, thereafter 'noise pollution'. Noise pollution occurs when sounds are excessively loud and continue for an extended period (United Nation Environmental Programme 2022), while positive soundscapes encompass acoustic environments that individuals perceive as aesthetically pleasing or beneficial to their auditory experience (Aletta *et al.* 2018; Zhu *et al.* 2023). Anthropogenic noise generated from human activities, such as transportation, urbanisation and industrial revolution, is recognised as a significant global pollutant that affects both terrestrial and aquatic ecosystems (Kok *et al*. 2023; Kunc and Schmidt 2019; Shannon *et al.* 2016). It transforms natural acoustic environments by increasing high -intensity noise events and creating consistently high and homogenised background sound levels (Senzaki *et al.* 2020; Shannon *et al.* 2016). This section will explore how changes in the soundscape impact the health and wellbeing of both wildlife and people.

Noise pollution is an underestimated public health risk as the impacts are not always immediately visible or easily quantifiable. Noise pollution is associated with broad spectrum of acute and chronic health issues, manifesting as both auditory and non-auditory health effects (Mohamed *et al*. 2021; The Lancet Regional Health – Europe 2023). These harmful health impacts of noise pollution can be measured by Years Lived with Disability (YLDs) from hearing loss. The safe noise level according to the WHO for humans is less than 70 dB(A) for 24-h exposure (World Health Organization 2010, 2021). Fifteen percent of the global population experiences hearing reduction due to exposure to loud noise from various sources, including occupational, recreational, and mobile phone use (Taneja 2014), as seen from the 73.6% increase in YLDs from hearing loss between 1999 and 2019. By 2050, the burden is anticipated to escalate globally, including Southeast Asia regions (Haile *et al*. 2021).

As cities continue to expand, the increasing intensity and extent of noise pollution from urban activities have construction, transportation, and industrialisation increases the prevalence of stress, anxiety, cardiovascular problems, and impaired cognitive function (Basner *et al.* 2014). For instance, in Kuala Lumpur and Klang Valley, noise from traffic frequently exceeded 70dB due to rapid urbanisation (Halim *et al.* 2017; Halim 2019; Chieng and Chan 2021; Faisal *et al.* 2023; Y.L. Lee *et al.* 2023), surpassing the threshold for safe exposure and putting people's livelihood at risk (Ali Najah Ahmed *et al.* 2019; Ismail *et al.* 2020; Mamat *et al.* 2022).

Beyond hearing loss, chronic exposure to noise pollution can also trigger tinnitus (ringing or buzzing sound in ears), cause stress and anxiety, disrupt sleep and impair cognitive function (Fritschi *et al.* 2011; Thompson *et al.* 2022), all of which can undermine performances in both school and work settings (Basner *et al.* 2014; Di Gennaro *et al.* 2023). When the nervous system is exposed to chronic stress, it can lead to serious cardiovascular issues such as hypertension, ischemic heart disease, and stroke (Fritschi *et al.* 2011; Basner *et al.* 2014). Vulnerability to noise-related health impacts varies by age, gender, income and comorbidities. Unlike air, water, and soil pollution, noise pollution is often overlooked in Asian cities, as 11% of the global cost of hearing loss or US$108 billion (RM 456.46 billion) is attributed to Southeast Asian countries (World Health Organization 2021). This systemic environmental challenge extends beyond mere acoustic measurements, presenting significant implications for public health and urban liveability.

While noise pollution affects people's health, livelihoods and quality of life, its negative impact on wildlife often goes unnoticed. Recently, this field of study has gained traction in the scientific literature. It has been shown that noise pollution interferes with sensory systems and masks the animal's ability to interpret environmental information required for habitat selection, foraging, species recognition, and risk assessment (Dominoni

et al. 2020), altering wildlife behaviour and physiology, with cascading effects on community dynamics (Shannon *et al.* 2016; Kunc and Schmidt 2019; Dominoni *et al.* 2020). Noise can significantly influence community composition through various mechanisms such as masking, misleading and distraction – directly and indirectly, altering interactions among individuals to species within the ecosystem. For instance, direct impacts of noise exposure can result in habitat avoidance, reduced recruitment, and increased mortality (Kok *et al.* 2023), impacting not only acoustics-oriented animals with auditory receptors, such as birds, but also indirectly affect non-acoustic species such as grasshoppers, dragonflies and damselflies (Senzaki *et al.* 2020; Shannon *et al.* 2016). Bird species that rely on songs for territorial defence and mate attraction are especially vulnerable to the masking effects of anthropogenic noise (Hu and Cardoso 2010; Slabbekoorn 2013; Hao *et al.* 2024).

Moreover, noise pollution can disrupt interactions among different species in a community by increasing mortality through predation and reducing foraging success (Phillips *et al.* 2021; Cho *et al.* 2025). In addition, birds may avoid noisy areas more readily than less mobile species such as ground-dwelling insects (Senzaki *et al.* 2016). Species that adjust the frequency, amplitude or timing of vocalisations, or switching to alternative sensory modes to survive can incur high energetic cost (Hu and Cardoso, 2010; Slabbekoorn 2013; Tolentino *et al.* 2018; Hao *et al.* 2024). However, not all species have the behavioural plasticity to adapt to noisy environments. These impacts can cause long-term harm, such as poorer body condition, reproductive success and offspring development (Dominoni *et al.* 2020), albeit their being difficult to attribute directly to noise pollution. Ecosystem services may be disrupted due to noise pollution. By examining the interactions between wildlife and their acoustic environment, we may begin to understand the integrity of ecosystems on a deeper level beyond biodiversity metrices.

Call to Action: Harnessing an "invisible" resource

Establish the linkages between healthy soundscapes and human health

The global imperative to monitor and protect biodiversity and the advancements of passive acoustic monitoring tools provided increasingly rapid assessments beyond single target species, but also broader soundscape patterns such as community integrity and ecosystem functioning (Sugai *et al.* 2019; Bradfer-Lawrence *et al.* 2023; Sethi *et al.* 2024). Strategies informed by local ecological knowledge, including education and community outreach, can help accelerate these efforts (Doran-Sherlock *et al.* 2025). The preservation and therapeutic use of pristine soundscapes in Malaysia offers significant potential for enhancing human wellbeing through non-invasive, nature-based interventions (Jeon *et al.* 2012). Exposure to natural sounds or aesthetically pleasing auditory stimuli has been found to correlate with accelerated recovery rates following stress-inducing events (Alvarsson *et al.* 2010; Medvedev *et al.* 2015) and increased positive mood states, such as comfort and relaxation (Song *et al.* 2023). Growing evidence highlights the effectiveness of healthy soundscapes in healthcare settings, such as improving comfort and physiological responses in dementia care (Sabran *et al.* 2018), reducing pain and agitation in surgical intensive care patients during endotracheal suctioning (Ruan *et al.* 2024), and aiding recovery in patients with myocardial infarction (Fatehimoghadam *et al.* 2023). Practices like Japan's '*Shinrin-yoku*' (forest bathing) further illustrate how immersive natural soundscapes can stabilise mood, boost immunity, and aid stress recovery (Han 2003; Li 2022).

In rapidly urbanising cities in Malaysia, architects, engineers, and township designers can work together to build nature sounds into city landscape and green space design. In green spaces dominated by natural sounds, soundscape diversity can be enhanced by increasing vegetation richness and water features. Diverse tree species in dense vegetation increase the number of sound types, reflecting the multi-layered or closed vegetation structures of tropical ecosystems that can enhance both species diversity and preserve natural soundscapes (Zhao *et al.* 2022; Hao *et al.* 2024). Connectivity within landscapes can

be enhanced by increasing vegetation richness and water features. Diverse tree species in dense vegetation increase the number of sound types, reflecting the multi-layered or closed vegetation structures of tropical ecosystems that can enhance both species diversity and preserve natural be modelled by considering the impact of landscape features on the efficiency of sound propagation for animal communication and the spatial distribution of anthropogenic noise sources (Sánchez-Giraldo *et al.* 2021).

The distribution of acoustically rich zones across a landscape may also have the potential to indicate key connectivity elements such as least-cost corridors, defined as the pathway of preferred movement from one point to another that requires the least amount of energy, or resistance (Balbi *et al.* 2019), especially if these are indicated by habitat structures that can be readily reflected by the properties of the soundscape. Natural soundscape has been incorporated in the design of many well-known parks around the world (e.g., Beijing Olympic Forest Park, Paris Bamboo Garden in Le Parc de la Villette, Shiru-ku Road pocket park in Japan) using diverse plants, water and other landscape elements (Song *et al.* 2023). Sound-borrowing, adapted from "scenery-borrowing" techniques in traditional gardens is used to stimulate more senses by combining the visual and aural experiences associated with associations with water, wind, rain, plants and landscaping. For instance, sounds of plants, water, insects and birds are usually used to mask noises (sound-masking). Future research can utilise sound measurement tools to monitor the impacts of a nature-based soundscape design on human health and wellbeing in cities and rural areas, to explore the connection between human wellbeing and positive conservation outcomes.

Long-term, evidence-based monitoring to enhance and protect soundscape health

Longitudinal research to track how changes in soundscapes over extended periods impact both ecosystems and human health is needed to understand the long-term consequences of soundscape alterations. Additionally, understanding how the soundscape is influenced by climate change or habitat fragmentation may provide a comprehensive view of fundamental ecological questions that are relevant to achieving planetary health. These objectives could be achieved by designing studies that monitor the changes to the different components of soundscapes across seasons, years, and geographic regions including different habitat types and biomes (Zwerts *et al.* 2022; Loo, Lee *et al.* 2025; Mammides *et al.* 2025). Such studies must involve interdisciplinary parties to ensure that the outcomes of the studies are beneficial to all stakeholders. Some examples of existing networks and datasets include the Locally-led East Asian Flyway Acoustics (LEAFA) Program (Abd Mutalib *et al.* 2025), Stability of Altered Forest Ecosystem (SAFE) Project (Ewers *et al.* 2011; Sethi, Ewers *et al.* 2020), and landscape-scale sensor network in Japan (Ross *et al.* 2018).

Well-designed research and monitoring programs will accelerate conservation action through policies to protect pristine natural soundscapes and promote low-noise city soundscapes. At the 16th Conference of the Parties to the Convention on Biological Diversity (CBD COP16 2024), the Global Action Plan on Biodiversity and Health was adopted, with a recommended action to '*promote strategies to reduce light and noise pollution, especially in urban environments, that is harmful to human health and the health of other organisms*' as a strategy for '*mainstreaming biodiversity and health interlinkages into the implementation of the Kunming-Montreal Global Biodiversity Framework.*' Thus, we call on nations to propose and implement policies to preserve natural soundscapes and promote the lowering of anthropogenic noise by developing soundscape status using criteria that reflect ecological function and human health. These categories can include "Pristine Soundscape" for a completely natural and intact soundscape with no detectable anthropogenic noise, "Near Pristine Soundscape" for a mostly intact soundscape with low levels of anthropogenic noise that does not affect wildlife or people in any measurable ways, "Vulnerable Soundscape" for a soundscape suffering from moderate anthropogenic noise which impacts the presence of wildlife and psychological health of people, "Critically Damaged Soundscape" suffering from severe anthropogenic noise which impacts the ecosystem function and physical health of people.

Invest in technological advancements to reduce noise pollution

Human innovation and the growing accessibility of advanced tools to mitigate noise pollution is essential for preserving and restoring natural soundscapes, enhancing public health and conserving wildlife. Existing innovations for quieter technologies, including electric vehicles, noise-reducing road surfaces, and low-noise industrial machinery, have proven effective in reducing urban and transportation-related noise. Urban planners, landscape designers, and architects can integrate noise-reduction measures into city infrastructure, such as green buffers and sound-absorbing materials in building designs. In tourism and park management, adopting sustainable practices such as limiting motorised vehicles in sensitive areas and using low-noise operational equipment, can help protect natural soundscapes while enhancing visitor experiences and wildlife conservation. These efforts collectively improve urban liveability and ecosystem health, ensuring benefits for both people and the planet.

Community involvement is also vital to drive demand for quieter, eco-friendly innovations and ensure the success of noise mitigation efforts. For example, integrating mobile applications and web-based tools (Estrella *et al.* 2024), can enable citizens to monitor and report noise pollution in real time, contributing to localised data collection and awareness. Public campaigns and education initiatives can empower individuals about the importance of mitigating noise pollution and preserving natural soundscapes, encourage them to make environmentally conscious choices such as supporting businesses offering quieter options, and adopt low-noise appliances. Engaging the public in citizen science projects and involving them as testers of noise-reducing interventions fosters a sense of ownership and responsibility while addressing local concerns. These efforts help bridge the gap between technological solutions and practical, community-driven implementation. Collaborative efforts between local authorities, community organisations, and the public could give demand to urban planners and policymakers to prioritise creating quieter and healthier cities. By aligning technological advancements, community action, and sustainable practices, we can preserve the natural soundscapes essential to human wellbeing and ecological resilience.

CONCLUSION

The acoustic environment or soundscape represents the full collection of acoustic activities arising from biological, geophysical, and anthropogenic sources at a particular place and time, thus providing a unique perspective through which we can examine our relationship with the environment (Kong and Han 2024; Aletta *et al.* 2025). Soundscapes enable rapid assessment of biodiversity, as well as monitoring of ecosystem changes and responses to ecological threats. The potential of soundscapes as health indicators is particularly salient in rapidly urbanising regions such as Southeast Asia, where economic growth is reshaping urban ecosystems. However, addressing the acoustic environment in these dynamic settings presents complex challenges. Safeguarding the healing qualities of soundscapes is more than just reducing anthropogenic noise pollution but also making sure we maintain the ecosystems for species that rely on them. Therefore, we call for scientists, policymakers, planetary health actors, and the public to identify the connections between ecosystem and human health, and provide innovative ways to preserve rapidly disappearing natural soundscapes to safeguard people and the planet so that both can thrive.

Acknowledgements : We are grateful to the Malaysian Nature Society for entrusting us with this chapter. We give our sincere thanks to the anonymous reviewer for providing feedback to this chapter. We also acknowledge Nadia Radzif from Sunway Centre for Planetary Health for illustrating Figure 1, Saliza Bono from The MareCet Research Organization for providing the content for Box 2, and Ana Gabrielle C. Alcantara for her

assistance with producing Figure 2. SVM acknowledges funds provided by Malaysian Ministry of Higher Education under the Fundamental Research Grant Scheme (FRGS/1/2023/WAB11/MMU/02/1) for data collection of soundscapes used to produce the figure in Box 3.

REFERENCES

Abd Mutalib, A.H. binti, Abdul Rahman, N.A., Alcantara, A.G.C., Azman, N.M., Clink, D.J., Gangko, D.G., Handono, C.D. *et al.* 2025. Launching of the Locally led East Asian Flyway Acoustics Program. *Oryx* 58(6): 693–694. https://doi.org/DOI: 10.1017/S0030605324001121

Aletta, F., Oberman, T. and Kang, J. 2018. Associations between positive health-related effects and soundscapes perceptual constructs: A systematic review. *International Journal of Environmental Research and Public Health* 15(11): 2392. https://doi.org/10.3390/ijerph15112392

Aletta, F., Zhou, K., Mitchell, A., Oberman, T., Pluchinotta, I., Torresin, S., Cerwén, G. *et al.* 2025. Exploring the relationships between soundscape quality and public health using a systems thinking approach. *Npj Acoustics* 1(1): 3. https://doi.org/10.1038/s44384-025-00003-y

Ali Najah Ahmed, A.-M., Ismail, M., Wan Mansor, W.N., Zulkifli, M. Fakhratul R. and Abdullah, S. 2019. Spatio-temporal analysis of environmental noise in institutional area. https://doi.org/10.35940/ijrte.B3306.078219

Alvarsson, J.J., Wiens, S. and Nilsson, M.E. 2010. Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health* 7(3): 1036–1046. https://doi.org/10.3390/ijerph7031036

Arch, V.S., Grafe, T.U. and Narins, P.M. 2007. Ultrasonic signalling by a Bornean frog. *Biology Letters* 4(1): 19–22. https://doi.org/10.1098/rsbl.2007.0494

Avicena, N.R., Loo, Y.Y., Maul, T., Thong, N., Wong, C.C.T., de Silva, S., Saaban, S. and Wong, E.P. 2025. Living with elephants: Deep learning models performance in examining Asian elephant (*Elephas maximus*) sounds from Sri Lanka and Malaysia with considerations for application. *Biological Conservation* 309: 111272. https://doi.org/10.1016/J.BIOCON.2025.111272

Balbi, M., Petit, E.J., Croci, S., Nabucet, J., Georges, R., Madec, L. and Ernoult, A. 2019. Ecological relevance of least cost path analysis: An easy implementation method for landscape urban planning. *Journal of Environmental Management* 244: 61–68. https://doi.org/https://doi.org/10.1016/j.jenvman.2019.04.124

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S. and Stansfeld, S. 2014. Auditory and non-auditory effects of noise on health. *Lancet* 383(9925): 1325–1332. https://doi.org/10.1016/S0140-6736(13)61613-X

Bono, S., Kimura, S.S., Kuit, S.H., Ng, J.E., Tanaka, K., Ichikawa, K. and Ponnampalam, L.S. 2021. Description of the first acoustic recording of spinner dolphins (*Stenella longirostris*) from the northern straits of Malacca, Malaysia (L). *The Journal of the Acoustical Society of America* 150(3): 2189–2192. https://doi.org/10.1121/10.0006377

Bono, S., Kimura, S.S., Teoh, Z.Y., Ng, jol E., Ichikawa, K. and Ponnampalam, L.S. 2022. Whistle variation in Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in relation to behavioural and environmental parameters in Northwestern Peninsular Malaysia. *Acoustics Australia* 50(3): 315–329. https://doi.org/10.1007/s40857-022-00273-6

Bradfer-Lawrence, T., Desjonqueres, C., Eldridge, A., Johnston, A. and Metcalf, O. 2023. Using acoustic indices in ecology: Guidance on study design, analyses and interpretation. *Methods in Ecology and Evolution* 14(9): 2192–2204. https://doi.org/https://doi.org/10.1111/2041-210X.14194

Buxton, R.T., Pearson, A.L., Allou, C., Fristrup, K. and Wittemyer, G. 2021. A synthesis of health benefits of natural sounds and their distribution in national parks. *Proceedings of the National Academy of Sciences* 118(14): e2013097118. https://doi.org/10.1073/pnas.2013097118

Cauzinille, J., Favre, B., Marxer, R., Clink, D., Ahmad, A.H. and Rey, A. 2024. Investigating self-supervised speech models' ability to classify animal vocalizations: The case of gibbon's vocal signatures. *Interspeech* 2024: 132–136. https://doi.org/10.21437/INTERSPEECH.2024-1096

Chang, P.K., Puan, C.L., Yee, S.A. and Abu, J. 2018. Vocal individuality of large-tailed nightjar (*Caprimulgus macrurus*) in Peninsular Malaysia. *Bioacoustics* 27(2): 131–144. https://doi.org/10.1080/09524622.2017.1292408;REQUESTEDJOURNAL:JOURNAL:TBIO20

Chen, Z., Hermes, J. and von Haaren, C. 2024. Mapping and assessing natural soundscape quality: An indicator-based model for landscape planning. *Journal of Environmental Management* 354: 120422. https://doi.org/https://doi.org/10.1016/j.jenvman.2024.120422

Chieng, J. and Chan, C.J. 2021. Narrative review of soundscape studies. *International Journal of Academic Research in Business and Social Sciences* 11(11): 1652–1672. https://doi.org/10.6007/ijarbss/v11-i11/11652

Cho, D.-H., Lee, J.-H., Jang, J.-U., Son, J.-J. and Sung, H.-C. 2025. The adaptation and fitness costs to urban noise in the calls of the tree sparrow (*Passer montanus*). *Scientific Reports* 15(1): 5359. https://doi.org/10.1038/s41598-025-88287-8

Clink, D.J. 2017. *The Evolutionary and Ecological Implications of Variation in Bornean Gibbon (*Hylobates muelleri*) Female Calls*. Davis: University of California Davis.

Clink, D.J., Bernard, H., Crofoot, M.C. and Marshall, A.J. 2017. Investigating individual vocal signatures and small-scale patterns of geographic variation in female Bornean Gibbon (*Hylobates muelleri*) great calls. *International Journal of Primatology* 38(4): 656–671. https://doi.org/10.1007/S10764-017-9972-Y

Clink, D.J., Charif, R.A., Crofoot, M.C. and Marshall, A.J. 2018. Evidence for vocal performance constraints in a female nonhuman primate. *Animal Behaviour* 141: 85–94. https://doi.org/10.1016/J.ANBEHAV.2018.05.002

Clink, D.J., Grote, M.N., Crofoot, M.C. and Marshall, A.J. 2018. Understanding sources of variance and correlation among features of Bornean gibbon (*Hylobates muelleri*) female calls. *The Journal of the Acoustical Society of America* 144(2): 698–708. https://doi.org/10.1121/1.5049578

Clink, D.J., Crofoot, M.C. and Marshall, A.J. 2019. Application of a semi-automated vocal fingerprinting approach to monitor Bornean gibbon females in an experimentally fragmented landscape in Sabah, Malaysia. *Bioacoustics* 28(3): 193–209. https://doi.org/10.1080/09524622.2018.1426042

Clink, D.J. and Klinck, H. 2019a. A case study on Bornean gibbons highlights the challenges for incorporating individual identity into passive acoustic monitoring surveys. *The Journal of the Acoustical Society of America* 146(4, Supplement): 2855–2855. https://doi.org/10.1121/1.5136908

Clink, D.J. and Klinck, H. 2019b. GIBBONFINDR: An R package for the detection and classification of acoustic signals. *ArXiv: Audio and Speech Processing*. https://arxiv.org/pdf/1906.02572

Clink, D.J., Ahmad, A.H. and Klinck, H. 2020a. Brevity is not a universal in animal communication: Evidence for compression depends on the unit of analysis in small ape vocalizations. *Royal Society Open Science* 7(4): 200151. https://doi.org/10.1098/rsos.200151

Clink, D.J., Ahmad, A.H. and Klinck, H. 2020b. Gibbons aren't singing in the rain: presence and amount of rainfall influences ape calling behavior in Sabah, Malaysia. *Scientific Reports* 10(1): 1282. https://doi.org/10.1038/s41598-020-57976-x

Clink, D.J. and Lau, A.R. 2020. Adherence to Menzerath's Law is the exception (not the rule) in three duetting primate species: Linguistic rules in duetting primates. *Royal Society Open Science* 7(11): 201557. https://doi.org/10.1098/RSOS.201557

Clink, D.J., Groves, T., Ahmad, A.H. and Klinck, H. 2021. Not by the light of the moon: Investigating circadian rhythms and environmental predictors of calling in Bornean great argus. *PLOS ONE* 16(2): e0246564. https://doi.org/10.1371/JOURNAL.PONE.0246564

Clink, D.J. and Klinck, H. 2021. Unsupervised acoustic classification of individual gibbon females and the implications for passive acoustic monitoring. *Methods in Ecology and Evolution* 12(2), 328–341. https://doi.org/10.1111/2041-210X.13520

Clink, D.J., Zafar, M., Ahmad, A.H. and Lau, A.R. 2021. Limited evidence for individual signatures or site-level patterns of variation in male Northern Gray Gibbon (*Hylobates funereus*) duet codas. *International Journal of Primatology* 42(6): 896–914. https://doi.org/10.1007/S10764-021-00250-2

Clink, D.J., Kier, I., Ahmad, A.H. and Klinck, H. 2023. A workflow for the automated detection and classification of female gibbon calls from long-term acoustic recordings. *Frontiers in Ecology and Evolution* 11: 1071640. https://doi.org/10.3389/fevo.2023.1071640

Clink, D.J. and Ahmad, A.H. 2025. gibbonNetR: an R package for the use of convolutional neural networks for automated detection of acoustic data. *Journal of Open Source Software* 10(110): 7250. https://doi.org/10.21105/JOSS.07250

Clink, D.J., Kim, J., Cross-Jaya, H., Ahmad, A.H., Hong, M., Sala, R., Birot, H. *et al*. 2025. Automated detection of gibbon calls from passive acoustic monitoring data using convolutional neural networks in the "Torch for R" ecosystem. *Ecology and Evolution* 15(7): e71678. https://doi.org/10.1002/ece3.71678

Convention on Biological Diversity (CBD). 2024. Global Action Plan on Biodiversity and Health. https://www.cbd.int/health/GAP.shtml

Di Gennaro, G., Papadopoli, R., Licata, F. and Nobile, C. 2023. The environmental pollution's influence on public health: general principles and case studies. In *Current Trends and Future Developments on (Bio-) Membranes*, A. Basile, M. Gensini, I. Allegrini and A. Figoli (eds.), pp. 77–100. Amsterdam: Elsevier. https://doi.org/10.1016/B978-0-12-824103-5.00008-5

Dominoni, D.M., Halfwerk, W., Baird, E., Buxton, R.T., Fernández-Juricic, E., Fristrup, K.M., McKenna, M.F. *et al.* 2020. Why conservation biology can benefit from sensory ecology. *Nature Ecology and Evolution* 4(4): 502–511. https://doi.org/10.1038/s41559-020-1135-4

Doran-Sherlock, R., Sood, P., Struthers, N.A. and Maric, F. 2025. Challenges in nature-based health and therapy research and critical considerations for application in musculoskeletal health. *Frontiers in Public Health* 13. https://doi.org/10.3389/fpubh.2025.1509419

Dumyahn, S.L. and Pijanowski, B.C. 2011. Soundscape conservation. *Landscape Ecology* 26(9): 1327–1344. https://doi.org/10.1007/s10980-011-9635-x

Estrella, I., Pacheco, A., Marin, W., Pacheco-Pumaleque, L., Cuba-Carbajal, N., Pucuhuayla -Revatta, F., Felix-Poicon, E. and Añaños-Bedriñana, M. 2024. Tackling noise: Technology integration for improved noise pollution monitoring. *Environmental Health Insights* 18. https://doi.org/10.1177/11786302241235013

Ewers, R.M., Didham, R.K., Fahrig, L., Ferraz, G., Hector, A., Holt, R.D., Kapos, V. *et al*. 2011. A large-scale forest fragmentation experiment: the Stability of Altered Forest Ecosystems Project. *Philosophical Transactions of the Royal Society B: Biological Sciences* 366(1582): 3292–3302. https://doi.org/10.1098/rstb.2011.0049

Faisal, F., Rahman, N.A. and Kamal, N.A. 2023. Assessment of road traffic noise in selected urban residential and construction areas. *Jurnal Teknologi* 85(4): 123–132. https://doi.org/10.11113/jurnalteknologi.v85.19200

Farina, A. 2014. Soundscape ecology. *Principles, Patterns, Methods and Applications*. London: Springer.

Farina, A. 2018. Perspectives in ecoacoustics: A contribution to defining a discipline. *Journal of Ecoacoustics* 2(2): 10. https://doi.org/10.22261/jea.trzd5i

Fatehimoghadam, S., Molavynejad, S., Rokhafroz, D., Seyedian, S.M. and Sharhani, A. 2023. Effect of nature-based sound therapy on stress and physiological parameters in patients with myocardial infarction. *Iranian Journal of Nursing and Midwifery Research* 28(4): 436–442. https://doi.org/10.4103/ijnmr.ijnmr_221_21

Francis, C.D., Newman, P., Taff, B.D., White, C., Monz, C.A., Levenhagen, M., Petrelli, A.R. et al. 2017. Acoustic environments matter: Synergistic benefits to humans and ecological communities. *Journal of Environmental Management* 203: 245–254. https://doi.org/https://doi.org/10.1016/j.jenvman.2017.07.041

Fritschi, L., Lex Brown, A., Kim, R., Scwela, D. and Kephalopoulos, S. 2011. *Burden of disease from environmental noise: Quantification of healthy life years lost in Europe*. Copenhagen: The WHO European Centre for Environment and Health, Bonn Office, WHO Regional Office for Europe.

Gupta, J., Bai, X., Liverman, D.M., Rockström, J., Qin, D., Stewart-Koster, B., Rocha, J.C. *et al.* 2024. A just world on a safe planet: a Lancet Planetary Health–Earth Commission report on Earth-system boundaries, translations, and transformations. *The Lancet Planetary Health* 8(10): e813–e873. https://doi.org/10.1016/S2542-5196(24)00042-1

Gwee, C.Y., Eaton, J.A., Ng, E.Y.X. and Rheindt, F.E. 2019. Species delimitation within the *Glaucidium brodiei* owlet complex using bioacoustic tools. *Avian Research* 10(1): 36. https://doi.org/10.1186/s40657-019-0175-4

Haile, L.M., Kamenov, K., Briant, P.S., Orji, A.U., Steinmetz, J.D., Abdoli, A., Abdollahi, M. *et al.* 2021. Hearing loss prevalence and years lived with disability, 1990-2019: Findings from the Global Burden of Disease Study 2019. *The Lancet* 397(10278): 996–1009. https://doi.org/10.1016/S0140-6736(21)00516-X

Halim, H. 2019. Comparison of road traffic noise near high, medium and low density residential areas in Nibong Tebal and Juru, Penang. *International Journal of Integrated Engineering* 11(2): 87–98.
Halim, H., Abdullah, R., Nor, M.J.M., Aziz, H.A. and Rahman, N.A. 2017. Assessment of road traffic noise indices in urban residential areas of Klang Valley, Malaysia. *AIP Conference Proceedings* 1892(1): 040002. https://doi.org/10.1063/1.5005682
Han, K.-T. 2003. A reliable and valid self-rating measure of the restorative quality of natural environments. *Landscape and Urban Planning* 64(4): 209–232. https://doi.org/10.1016/S0169-2046(02)00241-4
Hanafi, S., Puan, C.L., Maruthaveeran, S. and Yeong, K.L. 2019. Vocal response of oriental magpie robin (*Copsychus saularis*) to urban environmental factors in peninsular Malaysia. *Sains Malaysiana* 48(10): 2061–2069. https://doi.org/10.17576/JSM-2019-4810-01
Hao, Z., Zhang, C., Li, L., Gao, B., Wu, R., Pei, N. and Liu, Y. 2024. Anthropogenic noise and habitat structure shaping dominant frequency of bird sounds along urban gradients. *IScience* 27(2): 109056. https://doi.org/10.1016/j.isci.2024.109056
Harmon, H. and Wahid, H.A. 2024. Mapping and digitizing Sarawak Bioacoustic for soundscape composition-The Bako National Park Project. *Malaysian Journal of Music* 13(1): 57–78. https://doi.org/10.37134//mjm
Heath, B.E., Sethi, S., Orme, D., Ewers, R. and Picinali, L. 2020. Autonomous rainforest soundscape identification: Quantifying the impacts of data lossy compression, recording length, and index selection. *E-Forum Acusticum* 2020: 3207–3208. https://doi.org/10.48465/fa.2020.0365ï
Heath, B.E., Sethi, S.S., Orme, C.D.L., Ewers, R.M. and Picinali, L. 2021. How index selection, compression, and recording schedule impact the description of ecological soundscapes. *Ecology and Evolution* 11(19): 13206–13217. https://doi.org/10.1002/ece3.8042
Heath, R. 2022. The assessment and development of methods in (spatial) sound ecology. Ph.D. Thesis. Imperial College London. https://doi.org/10.25560/107090
Hing, K.K., Behjati, M., Saleh, V., Meng, Y.K., Majeed, A.P.P.A. and Zheng, Y. 2025. Edge intelligence for wildlife conservation: Real-time hornbill call classification using TinyML. In *Selected Proceedings from the 2nd International Conference on Intelligent Manufacturing and Robotics*, ICIMR 2024, 22-23 August, Suzhou, China, W. Chen, A.P.P. Abdul Majeed, A.H. Ping Tan, F. Zhang, Y. Yan, Y. Luo, L. Huang, C. Liu and Y. Zhu (eds.), pp. 476–488. Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-96-3949-6_40
Holmes, L.B., Kai Tan, M., Japir, R., Chung, A.Y., Anne Salvador, J.G., Macas Nuñeza, O., Aqilah Muhammad, A. *et al*. 2025. Revisiting the calling songs of katydids (Orthoptera: Tettigonioidea) from the tropical forests of Southeast Asia. *Raffles Bulletin of Zoology* 73, 385–418. https://doi.org/10.26107/RBZ-2025-0026
Horton, R. and Lo, S. 2015. Planetary health: a new science for exceptional action. *The Lancet* 386(10007): 1921–1922. https://doi.org/10.1016/S0140-6736(15)61038-8
Hu, Y. and Cardoso, G.C. 2010. Which birds adjust the frequency of vocalizations in urban noise? *Animal Behaviour* 79(4): 863–867. https://doi.org/https://doi.org/10.1016/j.anbehav.2009.12.036
Ismail, N., Karim, K. and Othman, N. 2020. Noise levels in Malaysia primary schools: Are we meeting the international standards? *International Journal of Health Sciences* 4(2): 1140–1150. https://doi.org/10.31436/ijahs.v4i2.176
Jeon, J.Y., Lee, P.J., You, J. and Kang, J. 2012. Acoustical characteristics of water sounds for soundscape enhancement in urban open spaces. *The Journal of the Acoustical Society of America* 131(3): 2101–2109. https://doi.org/10.1121/1.3681938
Johnson, E., Campos-Cerqueira, M., Jumail, A., Yusni, A. S. A., Salgado-Lynn, M. and Fornace, K. 2023. Applications and advances in acoustic monitoring for infectious disease epidemiology. *Trends in Parasitology* 39(5): 386–399.
Kamaruzaman, A.S., Rameli, N.I.A.M., Lappan, S., Bartlett, T.Q., Fadzly, N.R.N., Anuar, M.S.S. and Ruppert, N. 2023. Group densities of endangered small apes (Hylobatidae) in two adjacent forest reserves in Merapoh, Pahang, Malaysia. *Journal of Threatened Taxa* 15(8): 23631–23640. https://doi.org/10.11609/jott.8562.15.8.23631-23640
Kennedy, A.G., Ahmad, A.H., Klinck, H., Johnson, L.M. and Clink, D.J. 2023. Evidence for acoustic niche partitioning depends on the temporal scale in two sympatric Bornean hornbill species. *Biotropica* 55(2): 517–528.

Kok, A.C.M., Berkhout, B.W., Carlson, N.V, Evans, N.P., Khan, N., Potvin, D.A., Radford, A.N. *et al*. 2023. How chronic anthropogenic noise can affect wildlife communities. *Frontiers in Ecology and Evolution* 11. https://doi.org/https://doi.org/10.3389/fevo.2023.1130075

Kong, P.-R. and Han, K.-T. 2024. Psychological and physiological effects of soundscapes: A systematic review of 25 experiments in the English and Chinese literature. *Science of The Total Environment* 929: 172197. https://doi.org/10.1016/j.scitotenv.2024.172197

Krause, B. 1987. Bioacoustics, habitat ambience in ecological balance. *Whole Earth Review* 57(472): 14–18.

Krause, B. and Farina, A. 2016. Using ecoacoustic methods to survey the impacts of climate change on biodiversity. *Biological Conservation* 195: 245–254. https://doi.org/10.1016/j.biocon.2016.01.013

Kueffner, K. 2023. *Utilizing passive acoustic monitoring to investigate occupancy patterns of babblers in native and planted forests in Sarawak, Malaysia*. Washington: The Evergreen State College.

Kunc, H.P. and Schmidt, R. 2019. The effects of anthropogenic noise on animals: A meta-analysis. *Biology Letters* 15(11):20190649. https://doi.org/10.1098/rsbl.2019.0649

Lakdari, M.W., Ahmad, A.H., Sethi, S., Bohn, G.A. and Clink, D.J. 2024. Mel-frequency cepstral coefficients outperform embeddings from pre-trained convolutional neural networks under noisy conditions for discrimination tasks of individual gibbons. *Ecological Informatics* 80: 102457. https://doi.org/10.1016/J.ECOINF.2023.102457

Lau, A.R., Clink, D.J., Crofoot, M.C. and Marshall, A.J. 2018. Evidence for high variability in temporal features of the male coda in Müller's Bornean Gibbons (*Hylobates muelleri*). *International Journal of Primatology* 39(4): 670–684. https://doi.org/10.1007/S10764-018-0061-7

Lau, A.R., Zafar, M., Ahmad, A.H. and Clink, D.J. 2022. Investigating temporal coordination in the duet contributions of a pair-living small ape. *Behavioral Ecology and Sociobiology* 76(7): 91. https://doi.org/10.1007/S00265-022-03193-7

Lau, K.K.S. 2018. Acoustic activity pattern of birds in Ayer Hitam Forest Reserve, Selangor. Thesis. Serdang: Department of Forestry Science, Universiti Putra Malaysia.

Lee, J.S.L., Hosni, N., Rusli, N. and Ghani, N.A. 2023a. Influence of perceived soundscape and sound environment on subjective well-being of park visitors. *Pertanika Journal of Social Sciences and Humanities* 31(4): 1621–1648. https://doi.org/10.47836/PJSSH.31.4.14

Lee, J.S.L., Hosni, N., Rusli, N. and Ghani, N.A. 2023b. Soundscape perception and preference in the context of Malaysian urban parks. *IOP Conference Series: Earth and Environmental Science* 1274(1): 012022. https://doi.org/10.1088/1755-1315/1274/1/012022

Lee, W.H. and Abdullah, S.A. 2019. Framework to develop a consolidated index model to evaluate the conservation effectiveness of protected areas. *Ecological Indicators* 102: 131–144. https://doi.org/10.1016/j.ecolind.2019.02.034

Lee, Y.L., Lim, M.H. and Tan, O.K. 2023. Environmental noise impact assessment from mass rapid transit to the adjacent community. *E3S Web Conference* 422: 03003. https://doi.org/10.1051/e3sconf/202342203003

Li, Q. 2022. Effects of forest environment (*Shinrin-yoku*/Forest bathing) on health promotion and disease prevention —the Establishment of "Forest Medicine"—. *Environmental Health and Preventive Medicine* 27: 43. https://doi.org/10.1265/ehpm.22-00160

Lim, T., Quinton, D.P., Solana-Mena, A., Loo, Y.Y., Loke, V.P.W., Angah, R., Sudin, H., Cherang, T. and Pura, P. 2017. Short notes-Temiar bird names. *Malayan Nature Journal* Special Edition 2017: 21–24.

Loo, Y.Y., Avicena, N.R., Thong, N., Haque, A.M., Nhlabatsi, Y.T., Abakar, S.Y.A., Ng, K.H. and Wong, E.P. 2024. WildTechAlert: Deep learning models for real-time detection of elephant presence using bioacoustics in an early warning system to support human-elephant coexistence. *Advances in Brain Inspired Cognitive Systems* 14374: 385–399. https://doi.org/10.1007/978-981-97-1417-9_36

Loo, Y.Y., Avicena, N.R., Tsin, N., Thong, W. and Wong, E.P. 2025. The use of bioacoustics in biodiversity monitoring and wildlife conservation in Panti Forest Reserve, Johor. *Malaysian Forester* 88(2): 314–330.

Loo, Y.Y., Lee, M.Y., Shaheed, S., Maul, T. and Clink, D.J. 2025. Temporal patterns in Malaysian rainforest soundscapes demonstrated using acoustic indices and deep embeddings trained on time-of-day estimation. *The Journal of the Acoustical Society of America* 157: 1–16. https://doi.org/10.1121/10.0034638

Mah, A.N.M.M.A., Puan, C.L. and Zakaria, M. 2023. Vocal activity patterns of the Changeable Hawk-Eagle (*Nisaetus cirrhatus*) in Peninsular Malaysia during mid-breeding season. *Journal of Raptor Research* 57(3): 393–404. https://doi.org/10.3356/JRR-22-72

Mamat, N.I., Amil, N., Mohd Hanif, M.H., Zuknik, M.H., Norashiddin, F.A. and Jaafar, M.H. 2022. Noise exposure assessment at a secondary school in a city of Pulau Pinang, Malaysia. *International Journal of Environmental Health Research* 32(11): 2547–2561. https://doi.org/10.1080/09603123.2021.1976735

Mammides, C., Goodale, E., Dayananda, S.K., Luo, K. and Chen, J. 2021. On the use of the acoustic evenness index to monitor biodiversity: A comment on "Rapid assessment of avian species richness and abundance using acoustic indices" by Bradfer-Lawrence *et al.* (2020) [*Ecological Indicators* 115: 106400]. *Ecological Indicators* 126: 107626. https://doi.org/10.1016/j.ecolind.2021.107626

Mammides, C., Wuyuan, P., Huang, G., Sreekar, R., Ieronymidou, C., Jiang, A., Goodale, E. and Papadopoulos, H. 2025. The combined effectiveness of acoustic indices in measuring bird species richness in biodiverse sites in Cyprus, China, and Australia. *Ecological Indicators* 170: 113105. https://doi.org/10.1016/j.ecolind.2025.113105

Marler, P.R. 2004. Bird calls: a cornucopia for communication. In *Nature's Music*, P. Marler and H. Slabbekoorn (eds.), pp. 132–177. Cambridge: Academic Press. https://doi.org/10.1016/B978-012473070-0/50008-6

McGarigal, K., Compton, B.W., Plunkett, E.B., DeLuca, W.V, Grand, J., Ene, E. and Jackson, S.D. 2018. A landscape index of ecological integrity to inform landscape conservation. *Landscape Ecology* 33(7): 1029–1048. https://doi.org/10.1007/s10980-018-0653-9

Medvedev, O., Shepherd, D. and Hautus, M.J. 2015. The restorative potential of soundscapes: A physiological investigation. *Applied Acoustics* 96: 20–26. https://doi.org/10.1016/j.apacoust.2015.03.004

Miard, P., Lim, L.-S., Abdullah, N.I., Elias, N.A. and Ruppert, N. 2019. Ultrasound use by Sunda colugos offers new insights into the communication of these cryptic mammals. *Bioacoustics* 28(5): 397–403. https://doi.org/10.1080/09524622.2018.1463294

Mitchell, S.L., Bicknell, J.E., Edwards, D.P., Deere, N.J., Bernard, H., Davies, Z.G. and Struebig, M.J. 2020. Spatial replication and habitat context matters for assessments of tropical biodiversity using acoustic indices. *Ecological Indicators* 119: 106717. https://doi.org/10.1016/J.ECOLIND.2020.106717

Miza, A.M.S. 2025. Preliminary assessment of highland soundscapes using bioacoustic indices in Fraser's Hill, Pahang. Simposium Kebangsaan Kepelbagaian Biologi Dan Persekitaran Tanah Tinggi 2025 (SKEBOT 2025), Fraser's Hill, Pahang. 29-30 October 2025.

Mohamed, A.-M. O., Paleologos, E.K. and Howari, F.M. 2021. Noise pollution and its impact on human health and the environment. In *Pollution Assessment for Sustainable Practices in Applied Sciences and Engineering*, A.-M. O. Mohamed, E. K. Paleologos and F. M. Howari (Eds.), pp. 975–1026. Oxford: Butterworth-Heinemann. https://doi.org/10.1016/B978-0-12-809582-9.00019-0

Müller, J., Mitesser, O., Schaefer, H.M., Seibold, S., Busse, A., Kriegel, P., Rabl, D. *et al.* 2023. Soundscapes and deep learning enable tracking biodiversity recovery in tropical forests. *Nature Communications* 14(1): 6191. https://doi.org/10.1038/s41467-023-41693-w

Muniandy, S.V. 2024) Preserving soundscape heritage as part of immersive planetary health and psycho-social wellbeing indicator. International Conference on Enhancing Art Science in the Age of Sustainability, Universiti Malaya, 12-13 June 2024. *Proceedings ICASAS'24* 82–96.

Muniandy, S.V., Khamis, S., Juhari, M.A.A. and Amin, A. 2025. Soundscape ecology and sonic heritage of Bukit Fraser, Pahang. Simposium Kebangsaan Kepelbagaian Biologi Dan Persekitaran Tanah Tinggi 2025 (SKEBOT 2025), Fraser's Hill, Pahang. 29-30 October 2025. https://www.ukm.my/alafukm/skebot/

Nawi, M.I.H.M., Sulaimi, A.S., Mah, A.N.M.M., Zakaria, M. and Leong Puan, C. 2021. Pair duets and acoustic sexing of Reddish Scops Owl *Otus rufescens*. *Journal of Asian Ornithology* 37: 88–92.

Nurika, O., Zulkifli, C.Z., Gunasegaran, K., Razak, N.A. and Burhanuddin, N.A. 2025. A multinational multi-tenant IoT orchestration framework for bioacoustic-driven biota preservation in Royal Belum State Park, Malaysia. *International Journal of Advanced and Applied Sciences* 12(4): 44–50. https://doi.org/10.21833/IJAAS.2025.04.006

Okuda, T., Matsubara, H., Yamada, T., Chew, W.C., Lau, A.M.S., Paska, J., Nishizaki, H., Omar, N.S.U and Zakaria, M. 2022. Spatial distribution of white-handed gibbon calls in relation to forest vertical components, Malaysia, from a perspective of forest management. *Global Ecology and Conservation* 38: e02245. https://doi.org/10.1016/J.GECCO.2022.E02245

Ong, D. and Shahrudin, S. 2021. The advertisement call of the Perak spadefoot toad *Megophrys aceras* from Langkawi Island, Kedah, Peninsular Malaysia. *Herpetological Bulletin* 156: 34–37. https://doi.org/10.33256/hb156.3437

Ong, D. and Shahrudin, S. 2022a. Advertisement calls of *Limnonectes macrognathus* (Anura: Dicroglossidae) and *Leptobrachium smithi* (Anura: Megophryidae), native frog species from Langkawi, Kedah, Peninsular Malaysia. *Bioacoustics* 31(1): 81–91. https://doi.org/10.1080/09524622.2021.1886170

Ong, D. and Shahrudin, S. 2022b. The diurnal advertisement and response call of *Pulchrana glandulosa* (Anura: Ranidae) (Boulenger, 1882), from Langkawi Island, Kedah, Peninsular Malaysia. *Amphibia-Reptilia* 43(4): 457–462. https://doi.org/10.1163/15685381-bja10113

Othman, H., Abd Jalil, N.A., Bakri, A.F. and Sham, R.J. 2024. Exploring the soundscape components of KLCC Park. *International Journal of Business and Technology Management* 6(S2): 142–156.

Pang, Y.H., Lappan, S., Bartlett, T.Q., Mohd Sah, S.A., Rosely, N.F. and Ruppert, N. 2022. Population densities of *Hylobates agilis* in forests with different disturbance histories in Ulu Muda Forest Reserve, Malaysia. *American Journal of Primatology* 84(7): e23388. https://doi.org/10.1002/ajp.23388

Pavan, G. 2017. Fundamentals of soundscape conservation. In *Ecoacoustics: The Ecological Role of Sounds*, A. Farina and S. H. Gage (Eds.), pp. 235–258. New Jersey: John Wiley & Sons. https://doi.org/10.1002/9781119230724.ch14

Phillips, J.N., Termondt, S.E. and Francis, C.D. 2021. Long-term noise pollution affects seedling recruitment and community composition, with negative effects persisting after removal. *Proceedings of the Royal Society B: Biological Sciences* 288(1948): 20202906. https://doi.org/10.1098/rspb.2020.2906

Pillay, R., Fletcher, R.J., Sieving, K.E., Udell, B.J. and Bernard, H. 2019. Bioacoustic monitoring reveals shifts in breeding songbird populations and singing behaviour with selective logging in tropical forests. *Journal of Applied Ecology* 56(11): 2482–2492. https://doi.org/10.1111/1365-2664.13492

Podos, J. and Webster, M.S. 2022. Ecology and evolution of bird sounds. *Current Biology* 32(20): R1100–R1104. https://doi.org/10.1016/j.cub.2022.07.073

Procheş, Ş., Ramdhani, S., Hughes, A.C. and Koh, L.P. 2021. Southeast Asia as one of world's primary sources of biotic recolonization following Anthropocene extinctions. *Frontiers in Ecology and Evolution* 9: 634711. https://doi.org/10.3389/fevo.2021.634711

Rahim, A.-K.H.A., Puan, C.L., Mah, A.N.M.M.A., Zakaria, M., Jamaludin, N. and Wahaf, N.S.A. 2025. Bioacoustic assessment of mangrove health: Influence of habitat characteristics on bird richness. *Biotropica* 57(1): e13427. https://doi.org/10.1111/BTP.13427

Rahim, A.-K.H.A., Puan, C.L. and Zakaria, M. 2024. Diel soundscape patterns as a potential indicator of mangrove health in Peninsular Malaysia. *Malaysian Forester* 87: 118–136.

Razali, M.H.M., Zakaria, A., Shakaff, A.Y.M., Saad, R.V.F.S.A., Kamarudin, L.M. and Abdullah, N.S.H. 2015. Visualisation of acoustic entropy index for rainforest health monitoring system. *2015 IEEE SENSORS - Proceedings*. https://doi.org/10.1109/ICSENS.2015.7370531

Ross, S.R.P.-J., Friedman, N.R., Dudley, K.L., Yoshimura, M., Yoshida, T. and Economo, E.P. 2018. Listening to ecosystems: data-rich acoustic monitoring through landscape-scale sensor networks. *Ecological Research* 33(1): 135–147. https://doi.org/10.1007/s11284-017-1509-5

Ruan, Q., Li, C., Qiu, M., Wan, L. and Sun, T. 2024. Effects of natural sound therapy on pain and agitation induced by endotracheal suctioning: A real-world study. *American Journal of Critical Care* 33(4): 299–303. https://doi.org/10.4037/ajcc2024570

Sabran, K., Kamaruddin, N., Lasa, I. and Bakhir, N. M. 2018. A study on applicability of sound art as therapy for Alzheimer's patien. *Proceedings of the 4th Bandung Creative Movement International Conference on Creative Industries 2017*: 5–9. https://doi.org/10.2991/bcm-17.2018.2

Sánchez-Giraldo, C., Correa Ayram, C. and Daza, J.M. 2021. Environmental sound as a mirror of landscape ecological integrity in monitoring programs. *Perspectives in Ecology and Conservation* 19(3): 319–328. https://doi.org/10.1016/j.pecon.2021.04.003

Schafer, R.M. 1977. *Our Sonic Environment and The Soundscape: The Tuning of the World.* Vermont: Destiny Books.
Senzaki, M., Yamaura, Y., Francis, C.D. and Nakamura, F. 2016. Traffic noise reduces foraging efficiency in wild owls. *Scientific Reports* 6(1): 30602. https://doi.org/10.1038/srep30602
Senzaki, M., Kadoya, T. and Francis, C.D. 2020. Direct and indirect effects of noise pollution alter biological communities in and near noise-exposed environments. *Proceedings of the Royal Society B: Biological Sciences* 287(1923):20200176. https://doi.org/10.1098/rspb.2020.0176
Sethi, S.S., Jones, N.S., Fulcher, B.D., Picinali, L., Clink, D.J., Klinck, H., Orme, C.D.L., Wrege, P.H. and Ewers, R.M. 2019. Combining machine learning and a universal acoustic feature-set yields efficient automated monitoring of ecosystems. [Pre-print] *BioRxiv*. https://doi.org/10.1101/865980
Sethi, S.S., Ewers, R.M., Jones, N.S., Signorelli, A., Picinali, L. and Orme, C.D.L. 2020. SAFE Acoustics: An open-source, real-time eco-acoustic monitoring network in the tropical rainforests of Borneo. *Methods in Ecology and Evolution* 11(10): 1182–1185. https://doi.org/10.1111/2041-210X.13438
Sethi, S.S., Jones, N. S., Fulcher, B.D., Picinali, L., Clink, D.J., Klinck, H., Orme, C.D.L., Wrege, P.H. and Ewers, R.M. 2020. Characterizing soundscapes across diverse ecosystems using a universal acoustic feature set. *Proceedings of the National Academy of Sciences* 117(29): 17049–17055. https://doi.org/10.1073/PNAS.2004702117
Sethi, S.S., Ewers, R.M., Jones, N.S., Sleutel, J., Shabrani, A., Zulkifli, N. and Picinali, L. 2022. Soundscapes predict species occurrence in tropical forests. *Oikos* 2022(3): e08525. https://doi.org/10.1111/OIK.08525
Sethi, S.S., Bick, A., Chen, M.-Y., Crouzeilles, R., Hillier, B.V, Lawson, J., Lee, C.-Y. *et al.* 2024. Large-scale avian vocalization detection delivers reliable global biodiversity insights. *Proceedings of the National Academy of Sciences* 121(33): e2315933121. https://doi.org/10.1073/pnas.2315933121
Shamsul Miza, A.M. 2025. Preliminary assessment of highland soundscapes using bioacoustic indices in Fraser's Hill, Pahang. Simposium Kebangsaan Kepelbagaian Biologi Dan Persekitaran Tanah Tinggi 2025 (SKEBOT 2025), Fraser's Hill, Pahang. 29-30 October 2025.
Shannon, G., McKenna, M.F., Angeloni, L.M., Crooks, K.R., Fristrup, K.M., Brown, E., Warner, K.A. *et al.* 2016. A synthesis of two decades of research documenting the effects of noise on wildlife. *Biological Reviews* 91(4): 982–1005. https://doi.org/10.1111/brv.12207
Slabbekoorn, H. 2013. Songs of the city: noise-dependent spectral plasticity in the acoustic phenotype of urban birds. *Animal Behaviour* 85(5): 1089–1099. https://doi.org/10.1016/j.anbehav.2013.01.021
Smalley, A.J., White, M.P., Ripley, R., Atack, T.X., Lomas, E., Sharples, M., Coates, P. A. et al. 2022. Forest 404: Using a BBC drama series to explore the impact of nature's changing soundscapes on human wellbeing and behavior. *Global Environmental Change* 74: 102497. https://doi.org/10.1016/j.gloenvcha.2022.102497
Smalley, A.J., White, M.P., Sandiford, R., Desai, N., Watson, C., Smalley, N., Tuppen, J., Sakka, L. and Fleming, L.E. 2023. Soundscapes, music, and memories: Exploring the factors that influence emotional responses to virtual nature content. *Journal of Environmental Psychology* 89: 102060. https://doi.org/10.1016/j.jenvp.2023.102060
Smith, J.W. and Pijanowski, B.C. 2014. Human and policy dimensions of soundscape ecology. *Global Environmental Change* 28: 63–74. https://doi.org/10.1016/j.gloenvcha.2014.05.007
Sodhi, N.S., Koh, L.P., Brook, B.W. and Ng, P.K.L. 2004. Southeast Asian biodiversity: an impending disaster. *Trends in Ecology & Evolution* 19(12): 654–660. https://doi.org/10.1016/j.tree.2004.09.006
Song, I., Baek, K., Kim, C. and Song, C. 2023. Effects of nature sounds on the attention and physiological and psychological relaxation. *Urban Forestry & Urban Greening* 86: 127987. https://doi.org/10.1016/j.ufug.2023.127987
Southworth, M. 1969. The sonic environment of cities. *Environment and Behavior* 1(1): 49–70. https://doi.org/10.1177/001391656900100104
Stowell, D. and Sueur, J. 2020. Ecoacoustics: acoustic sensing for biodiversity monitoring at scale. *Remote Sensing in Ecology and Conservation* 6(3): 217–219. https://doi.org/10.1002/rse2.174
Sueur, J. and Farina, A. 2015. Ecoacoustics: the ecological investigation and interpretation of environmental sound. *Biosemiotics* 8(3): 493–502. https://doi.org/10.1007/s12304-015-9248-x
Sugai, L.S.M., Silva, T.S.F., Ribeiro, J.W. and Llusia, D. 2019. Terrestrial passive acoustic monitoring: Review and perspectives. *BioScience* 69(1): 15–25.

Tan, M.K., Muhammad, A.A., Gorochov, A.V. and Abdullah, N.A. 2024. Taxonomy and bioacoustics of some crickets (Orthoptera: Grylloidea) from Panti Forest Reserve (Peninsular Malaysia: Johor). *Zootaxa* 5501(1): 1–38. https://doi.org/10.11646/ZOOTAXA.5501.1.1

Tengström, Å. 2023. The sound of diversity: the use of soundscapes to measure animal diversity in restored tropical rainforest in Sabah, Malaysia. Thesis. Sweden: Uppsala University.

The Lancet Regional Health – Europe. 2023. Noise pollution: more attention is needed. In *The Lancet Regional Health - Europe* (Vol. 24). Amsterdam: Elsevier Ltd. https://doi.org/10.1016/j.lanepe.2022.100577

Thompson, R., Smith, R.B., Bou Karim, Y., Shen, C., Drummond, K., Teng, C. and Toledano, M.B. 2022. Noise pollution and human cognition: An updated systematic review and meta-analysis of recent evidence. *Environment International* 58: 106905. https://doi.org/10.1016/j.envint.2021.106905

Tidemann, S. and Gosler, A. 2011. *Ethno-ornithology : birds, indigenous peoples, culture and society*. Oxford: Routledge.

Tolentino, V.C.M., Baesse, C.Q. and Melo, C. 2018. Dominant frequency of songs in tropical bird species is higher in sites with high noise pollution. *Environmental Pollution* 235: 983–992. https://doi.org/10.1016/j.envpol.2018.01.045

United Nation Environmental Programme. 2022. Noise, blazes and mismatches : emerging issues of environmental concern. New York: United Nations Environment Programme.

Wang, J., Li, C., Yao, Z. and Cui, S. 2024. Soundscape for urban ecological security evaluation. *Basic and Applied Ecology* 76: 50–57. https://doi.org/10.1016/j.baae.2024.02.007

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A.G., de Souza Dias, B.F., Ezeh, A. *et al.* 2015. Safeguarding human health in the Anthropocene epoch: Report of The Rockefeller Foundation. *The Lancet* 386(10007): 1973–2028. https://doi.org/10.1016/S0140-6736(15)60901-1

World Health Organization. 2010, April 27. Noise. https://www.who.int/europe/news-room/fact-sheets/item/noise

World Health Organization. 2021. World Report on Hearing. https://www.who.int/publications/i/item/9789240020481

Xiang, Y., Meng, Q., Zhang, X., Li, M., Yang, D. and Wu, Y. 2023. Soundscape diversity: Evaluation indices of the sound environment in urban green spaces – Effectiveness, role, and interpretation. *Ecological Indicators* 154: 110725. https://doi.org/10.1016/j.ecolind.2023.110725

Yee, S.A., Puan, C.L., Chang, P.K. and Azhar, B. 2016. Vocal individuality of Sunda Scops-Owl (*Otus lempiji*) in Peninsular Malaysia. *Journal of Raptor Research* 50(4): 379–390. https://doi.org/10.3356/JRR-15-76.1

Yee, S.A., Puan, C.L. and Chang, P.K. 2018. Territorial and duet calls of three Malaysian owl species. *Sains Malaysiana* 47(7): 1439–1445. https://doi.org/10.17576/JSM-2018-4707-11

Yi, J.D., Cobo-Cuan, A., Márquez, R., Sheridan, J.A., Grafe, T.U., Farina, A. and Narins, P.M. 2021. Novel acoustic snapshot of a Sarawak forest. *Journal of Ecoacoustics* 5(1): 1. https://doi.org/10.35995/jea5010001

Yusni, A.S.A. 2023, May. A comparison of traditional and passive acoustic monitoring techniques in a tropical semi-inundated forest patch for hornbill research in Sabah. *8th International Hornbill Conference, Bangkok, Thailand*. https://doi.org/0.13140/RG.2.2.31367.92320

Zhao, Y., Sheppard, S., Sun, Z., Hao, Z., Jin, J., Bai, Z., Bian, Q. and Wang, C. 2022. Soundscapes of urban parks: An innovative approach for ecosystem monitoring and adaptive management. *Urban Forestry and Urban Greening* 71: 127555. https://doi.org/10.1016/j.ufug.2022.127555

Zhu, Y., Huang, N., Weng, Y., Tong, H., Wang, X., Chen, J., Liu, J., Chen, Z., Dong, J. and Wang, M. 2023. Does soundscape perception affect health benefits, as mediated by restorative perception? *Forests* 14(9): 1798. https://doi.org/10.3390/f14091798

Zwerts, J.A., Wiegers, J.N.Y., Sterck, E.H.M. and van Kuijk, M.M. 2022. Exploring spatio-temporal variation in soundscape saturation of an African tropical forest landscape. *Ecological Indicators* 137: 108712. https://doi.org/10.1016/j.ecolind.2022.108712


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 859–875
doi: 10.62613/sonc2025.v3anc14

CHAPTER 14

State of marine fish and fisheries in Malaysia

CHITRA DEVI GOPALAKRISHNAN[1]*, RAYMIE NURHASAN[1], FADZLIEE ASMAT[1], SERENA ADAM[1], ALIAS MAN[2] and NURFATIN WAHIDA PUSPA[1]

Abstract: Malaysia's capture fisheries have long been central to national food security, livelihoods, and cultural heritage, supplying 60% of the country's animal protein and employing over 105,000 fishermen. However, wild fish catches have declined sharply, falling 17% from 1.57 million tonnes in 2016 to 1.39 million tonnes in 2024. Scientific assessments reveal severe depletion: demersal fish biomass has dropped by up to 90% since the 1960s, and catch per unit effort has plunged by 96% in some waters. Overfishing, destructive gears like trawling, habitat loss, and climate change are key drivers, compounded by illegal, unreported, and unregulated (IUU) fishing costing billions annually. This decline threatens food security as Malaysia's fish self-sufficiency ratio fell from 93% in 2019 to 90% in 2022, increasing reliance on imports and raising seafood prices. Coastal communities face deepening poverty, with over 28% of East Coast fishers living in extreme poverty. Ecologically, collapsing stocks disrupt marine food webs and biodiversity. Future strategies must integrate science-based management, spatial protection, and co-management with communities. Strengthening fisheries governance, expanding MPAs, improving traceability, and leveraging blue finance are critical to reversing trends. Without urgent action, Malaysia risks losing both marine biodiversity and the socio-economic lifeline that fisheries provide.

INTRODUCTION

Overview of Malaysia's marine fisheries

Malaysia's capture fisheries are important to the nation's food security, economy, and cultural heritage. Fish and seafood are staples of the Malaysian diet, providing roughly 60% of the country's animal protein (Ahmad *et al.* 2003b). In fact, Malaysia ranks among the world's top seafood consumers, with an average of 49 kg of fish consumed per person in 2020 (FAO 2026). Besides that, the fishing industry supports livelihoods in coastal communities and contributes to the national income by employing about 105,000 fishermen and accounting for RM11.8 billion (0.8%) of Malaysia's Gross Domestic Product (GDP) in 2024 (Department of Fisheries Malaysia 2024a). Capture fisheries also touch on cultural significance, sustaining traditional ways of life in fishing villages and providing many iconic ingredients in Malaysian cuisine.

In recent years, however, Malaysia's wild fish catch has shown clear signs of decline and stagnation. A century-long reconstruction of Malaysian marine landing data (1907 – 2021) confirms that total species landings followed a near-unbroken upward trajectory for ninety years before peaking in 2016 and declining thereafter, with recent trends suggesting commercial stocks may now be locally depleted in multiple fishing grounds (Ng *et al.* 2025). In 2022, total national fishery production reached 1.89 million metric tonnes (mt), with aquaculture contributing approximately 30% of this figure; marine capture fisheries have stagnated due to overfishing and environmental pressures even as aquaculture has

[1] WWF-Malaysia, 1, Jln PJS 5/28 A, Pusat Dagangan Petaling Jaya Selatan, 46150 Petaling Jaya, Selangor, Malaysia.
[2] Department of Fisheries Malaysia (retired), Aras 1-6, Blok Menara 4G2, Presint 4, Pusat Pentadbiran Kerajaan Persekutuan, 62628 Putrajaya, Malaysia.
***Corresponding author: cdevi@wwf.org.my**

expanded (Obi e*t al.* 2025). By 2023, production had fallen further to 1.79 million mt, a 5.5% decline from 2022 with marine capture output contracting from 1.46 million mt in 2019 to 1.27 million mt in 2023 (SEAFDEC 2025).

Overall, it is estimated Malaysia has lost over 90% of its demersal fish stocks in the past half-century due to over-exploitation (Ahmad *et al*. 2003a, 2003c; Ismail *et al*. 2022), with studies revealing that many fish stocks are depleted or under heavy stress. National trawl surveys conducted between 2013 and 2016 found that demersal fish biomass had declined by 88% compared to virgin stock levels recorded in the 1960s (Fisheries Research Institute 2017).

Disaggregated data reveal an even more alarming regional picture: coastal demersal stocks along the West Coast of Peninsular Malaysia now stand at only 4% of their 1960s biomass, while East Coast Peninsular Malaysia coastal stocks are at 3%, substantially worse than the widely cited 88% decline figure and underscoring the near-total collapse of inshore demersal resources in these regions (Fisheries Research Institute 2017; 2018). Prawn stocks are equally alarming with exploitation rates in most peninsular states range from 0.8 to 0.9, indicating severe overfishing across virtually the entire coastline, with the lowest absolute biomass recorded in Kelantan and Terengganu (Fisheries Research Institute 2017; 2018). Many common high-value species such as large groupers, snappers, and croakers that were abundant in the 1960s until 1970s are now rarely seen in the local markets. Reef fish assessments at specific sites corroborate the broader trend where surveys at Kapikan Reef, Sabah found that over 70% of fish were under 5 cm in length with no large-bodied predators present, indicating severe localised stock collapse (Wood and Dipper 2008). Even within formally gazetted marine parks such as Pulau Payar Marine Park and Tun Sakaran Marine Park, fish stocks remain low, with key commercial families including Serranidae, Scaridae, and Lutjanidae recording minimal biomass (Man 2008; Alias 2000; Bavoh and Manjaji-Matsumoto 2022; Bavoh *et al.* 2023).

Large pelagic species are increasingly exhibiting signs of overexploitation alongside the better-documented demersal declines. On the East Coast of Peninsular Malaysia, longtail tuna has been overfished for at least five consecutive years with no recovery measures implemented, with an exploitation rate of 0.67 well above sustainable levels; frigate tuna is classified as at risk (E = 0.54) while Kawakawa remains healthy (E = 0.43) (FRI 2018; Long 2018; WWF-Malaysia 2026). For oceanic tuna species of transboundary relevance, Bigeye tuna is assessed as overfished in the Indian Ocean and Narrow-barred Spanish mackerel is overfished in the Western Pacific as of the 2024 assessments (Fisheries Research Institute 2024; Indian Ocean Tuna Commission 2024, Saleh et al. 2024). Small pelagic stocks show greater regional variation, with Sarawak holding the largest biomass at 521,169 mt and East Coast Sabah the lowest at 154,490 mt, though exploitation rates remain comparatively low in Borneo waters (Fisheries Research Institute 2017; 2018).

Malaysia is ranked as the world's eighth largest elasmobranch fishing nation, yet documented shark and ray landings have fallen dramatically with shark biomass declined approximately 15-fold from 6,487 mt to 438 mt and ray biomass approximately 9-fold, from 11,993 mt to 1,372 mt between 2018 and 2021 alone, suggesting severe population depletion (Department of Fisheries Malaysia data as cited in Loh *et al*. 2023). Equally important, collapsing fish stocks signal marine ecosystem distress. Overfishing does not only remove target species but it also disrupts food webs and degrades biodiversity, as evidenced by the rise in catches of low-value trash fish and juveniles when larger fishes are depleted (FAO 2005). Such declining catch trends and deteriorating stock health have raised serious sustainability concerns.

DRIVERS OF CHANGE AND ENVIRONMENTAL STRESSORS

Malaysia's capture fisheries are declining due to a mix of unsustainable practices and environmental pressures with decades of open-access fishing created excess capacity and severe overfishing. As trawling is the highest contributor to total fish landing in Malaysia, we can deduce that the decline of fish biomass is mainly driven by trawl fisheries in Malaysia. The negative impact of bottom trawl towards fish stock and habitat is well established.

In just a few decades, Malaysia's marine fisheries went from small-scale, traditional methods to an industrialised business. For a long time, coastal people have used handlines, traps, and basic nets to fish in the adjacent areas, only catching what they needed and creating a complex cultural identity at the sea. Between the 1960s to 1970s, modernisation of fishing quickly changed this industry in Malaysia, including the introduction of trawl nets and purse seiners that caused a boom in fish landings and made it possible for boats to fish farther out to sea and catching fish more effectively (Ng *et al*. 2025). Production went up from about 0.8 million tonnes in the middle of the 1980s to more than 1.2 million tonnes by the end of the 1990s (Ahmad *et al*. 2003).

However, it seems that modernity slowly became the "road" to overfishing. In the 1960s and 1970s, heavy trawling for prawns and fish in the shallow areas of the West Coast of Peninsular Malaysia quickly depleted inshore stocks (Kirkley *et al.* 2003). By the end of the 1970s, there were too many boats and fights between traditional fishermen and commercial trawlers. Small-scale fishermen, who could only fish in coastal seas because their boats were too small, saw their catches drop as trawlers picked up fish and prawns in high landings, often moving into areas close to the shore (Kirkley *et al.* 2003). In response, the Malaysian government made big changes in fisheries management in the 1980s in which the trawlers were not allowed to fish in nearshore seas except for artisanal fishing, and a zonal licensing system was put in place to divide fishing fields by vessel size and gear types. This approach was meant to stop overfishing near shore and maintain the livelihoods of local fishermen, while continuing increasing offshore fisheries for profit.

Despite management efforts, the results from scientific assessments by the 1990s were already alarming. The assessments concluded that major fishing areas in Peninsular Malaysia were overexploited, especially the demersal resources (Fisheries Research Institute 2017). Biomass showed drastic declines with only 5 to 10% of the original fish biomass remaining. The exploitation rates of most dominant species far exceeded sustainable levels, with fishing efforts estimated at 1.3 to 2 times the optimal level for maximum sustainable yield. These historical trends set the stage for the 21st century challenge; catches plateaued and now descending, as decades of overfishing have left fisheries' resources in a diminished state.

Illegal, unreported, and unregulated (IUU) fishing either by foreign or some local operators undermines fisheries management, disrupts statistics, and drains resources, costing an estimated RM3 to 4 billion annually. In 2019, Department of Fisheries Malaysia (DOFM) estimated that IUU fishing alone accounted for nearly 30% of total marine fish landings, indicating enforcement gaps of considerable magnitude (DOFM 2019). Destructive and non-selective gears such as trawling remove juveniles and cause bycatch, alongside illegal methods like blast or cyanide fishing, damaging spawning and nursery grounds.

Marine habitat loss from mangrove clearing, coastal development, and reef degradation further suppresses recruitment. Research highlights significant mangrove loss in Malaysia, such as the loss of 2,907.29 hectares (about 1.12% annually) between 2000 and 2019 in southern Peninsular Malaysia (Kanniah *et al.* 2021), which has crucial implications for

species dependent on these habitats, including prawns. The ecological role of mangroves as nursery grounds for prawns is well established, suggesting that such habitat loss has a substantial negative impact on prawn recruitment and population sustainability. The decline in mangrove areas correlates with the reduction in juvenile prawn habitats, affecting the overall prawn fishery productivity in the region.

The development of coastal areas like reclamation, deforestation, housing, and building development has caused siltation and water pollution in the area. The problem of siltation is particularly disturbing since it has a direct impact on the performance and growth of the fisheries industry in this country. Small-scale fishermen are the most vulnerable towards this problem since most of the fish and benthic species have seen a decline in number due to siltation. Their catch is decreasing and their source of livelihood is threatened. Based on the monitoring by the Department of Irrigation and Drainage Malaysia on the west coast, it was found that the rate of siltation in muddy river mouth can exceed one meter per year. Based on personal communication with a farmer in Melaka, the siltation is a very serious problem on the west coast of Malaysia, and many fishermen have difficulty covering their living costs due to low catch.

Climate change acts as a critical threat multiplier, compounding and accelerating damage caused by overfishing, and habitat loss. Rising sea temperatures, ocean acidification, and deoxygenation—the so-called deadly trio—collectively amplify coral bleaching and mortality, biodiversity loss, species range shifts, and disruption to reproduction cycles (Obi *et al.* 2025; WWF-Malaysia 2026). For fisheries, tropical fish stocks are shifting poleward as temperatures rise, reducing catch potential in traditional fishing grounds, while extreme weather, flooding, and salinity changes are increasing mortality and disease in aquaculture operations (WWF-Malaysia 2026).

The 2024 mass bleaching event is now recognised as the fourth global bleaching event and the most spatially extensive in recorded history, with over 80% of the world's reefs experiencing severe heat stress between 2023 and early 2025 (NOAA Coral Reef Watch 2026)—the reefs in Malaysia were severely affected. Over 90% of corals in Malaysian waters bleached at the peak of the bleaching season in April to June 2024 (Reef Check Malaysia 2026). National reef monitoring covering 297 sites showed average live coral cover falling to just under 40% in 2025, down from approximately 45% a year earlier and 50% in 2022 which is a 20% loss in three years, equivalent to the loss of some four million hectares of forest cover (Reef Check Malaysia 2026). In Northeastern Peninsular Malaysia, species-specific bleaching trajectories documented at Pulau Lang Tengah showed that this event was consistent with the most severe thermal stress events on record (Szereday *et al.* 2025). Since coral reefs function as essential nursery and feeding grounds for commercially important fish species, this trajectory of reef degradation directly suppresses future fish recruitment and biomass recovery.

Small-scale fishers in climate-exposed states such as Terengganu face compounding climate vulnerabilities: maximum monthly precipitation in the state is projected to increase by 51%, with a 10% increase in annual rainfall expected, and flooding events such as the 2021 floods caused substantial documented losses to fishing infrastructure and operations (Yamin *et al.* 2025). Besides that, climate change also causes shifting in species distributions, altering reproduction, and disrupting seasons through warmer seas and more unpredictable monsoons. The most significant impact on fisheries is a change in sea current circulation caused by disturbed temperature of seawater.

SOCIOECONOMIC DIMENSIONS OF FISHERIES

The socioeconomic consequences of fisheries decline fall most heavily on small-scale coastal fishing communities, which account for approximately 35% of total national marine landings while comprising the majority of the fishing workforce (DOF 2024a; Mohamad *et al.* 2024). The economic impacts include fluctuating income due to low fish catches, high dependency on fishing, limited access to financial services, and difficulty investing in better equipment or alternative livelihoods. In some rural coastal fishing communities, fishing accounts for over 70% of total household income, leaving families without any meaningful economic buffer against declining catches (Yeo *et al.* 2007; Solaymani and Kari 2014). Approximately 65% of the total fishing population in Malaysia are small-scale fishers, and 70% of Malaysia's overall population of 34.2 million live in coastal zones where marine resource dependency is structurally embedded in livelihoods (WWF-Malaysia 2026).

Poverty is disproportionately concentrated in fishing states: Sabah maintains a poverty rate of 17.7%, with eight of the nine poorest districts in Malaysia located within the state and five within the East Coast Sabah seascape; Kelantan follows at 11.5%, and Sarawak also records elevated coastal poverty rates (WWF-Malaysia 2026). In states like Terengganu and Kelantan, overfishing contributes to economic inequality and poverty among fishermen, where nearly 28% of fishermen in that area live in extreme poverty, and over 82% are considered poor overall, reflecting systemic economic exclusion linked to dwindling fish resources (Rhoumah 2017; WWF-Malaysia 2026).

A quantitative study of small-scale fishers in Penang found that coastal reclamation—a major driver of habitat loss identified independently from overfishing—severely degrades natural capital for artisanal fishers, reducing fish stocks and biodiversity, restricting access to fishing grounds, and raising operational costs including increased travel distances and fuel expenditure. Human and social capital provided bottom-up contributions to adaptive resilience, but financial capital was identified as critically limiting (Bamasood *et al*. 2025). This pattern confirms that the economic impacts of both overfishing and coastal development are synergistic, amplifying each other's effects on household income and food security.

The fisheries sector was valued at approximately RM 16.5 billion in 2023, supporting employment predominantly in coastal and rural areas (WWF-Malaysia 2026). Economically, coastal fisheries have been a safety net for rural communities, and with the stock decline, thousands of jobs and traditional livelihoods are threatened. Sixty percent of Malaysia's longtail tuna landings originate from the East Coast of Peninsular Malaysia, a substantial proportion of which is exported to Thailand, creating an economic dependency and transboundary management imperative that existing domestic governance arrangements are structurally ill-equipped to address (WWF-Malaysia 2026).

This decline of wild fisheries matters not just to fishermen but to the wider public. Total seafood production reached 1.89 million mt in 2022, but domestic demand increasingly outstrips what Malaysian waters can supply sustainably (Obi *et al.* 2025). With Malaysians heavily reliant on fish for protein, any drop in domestic catch threatens national food security. Malaysia's fish self-sufficiency ratio continues to decline as import dependency deepens, from 93% in 2019 to just about 90% in 2022, forcing more seafood imports to meet local demand (Obi *et al.* 2025). To address this shortage and maintain seafood supply, Malaysia increasingly relies on importing fish from other regions, which may involve higher costs, risks related to food safety and quality, and dependence on external sources. Since 2010, Malaysia's seafood import volume has trended upward relative to exports, driven in part by rising consumer preference for imported premium species, reflecting a structural mismatch between depleting local stocks and growing affluent demand (FAO 2026).

While this shifts some pressure away from local fisheries, it can lead to vulnerabilities from global market fluctuations and supply chain disruptions. Overfishing-related income reduction exacerbates poverty by increasing household vulnerability and reducing resilience to economic shocks for small-scale fishers. Other significant implications include increased prices for seafood due to reduced supply and the need to import table fish to secure the country's seafood sufficiency ratio. IUU fishing also contributes to stock depletion and economic losses estimated at billions of Malaysian ringgit, further intensifying poverty risks for small-scale fishers who lack the capacity to compete with larger fishing operations.

GOVERNANCE, POLICY, AND MANAGEMENT CHALLENGES

Marine capture fisheries in Malaysia are in decline, with critical implications for food security, livelihoods, and sustainable development. Overexploitation of coastal and shelf stocks, particularly demersal species along the West Coast of Peninsular Malaysia, has resulted in severe biomass reductions, with historical landings exceeding estimated Maximum Sustainable Yield (Ahmad *et al.* 2003c, Obi *et al*. 2025). This decline reflects a combination of governance, policy, and management deficiencies that have limited the effectiveness of existing interventions.

Governance Challenges

The governance framework for Malaysian fisheries is highly centralised under the Department of Fisheries Malaysia (DOFM), guided by national policies such as the Third National Agricultural Policy (NAP3 1998 – 2010) and the National Agrofood Policy 2021 – 2030 (DAN 2.0). While this structure provides clarity in authority, it has limited mechanisms for stakeholder engagement, particularly for small-scale fishers (Ahmad *et al.* 2003b; Obi *et al.* 2025). Coordination between federal and state authorities is weak, creating silos in management of shared resources such as nearshore waters, islands, and coral reefs (Rahman 2023; Reef Check Malaysia 2025). These governance gaps have hindered the implementation of effective fisheries management measures, enforcement, and long-term strategic planning.

The depth of governance weaknesses is reflected in IUU fishing estimates that have consistently exceeded projections. A 2019 Department of Fisheries Malaysia assessment estimated that IUU fishing accounted for nearly 30% of total marine fish landings, representing a profound enforcement gap relative to the resources deployed for monitoring and control (DOFM 2019). The fisheries sector was worth approximately RM 16.5 billion in 2023, with IUU losses estimated at up to RM 6 billion annually by DOFM, a figure that represents both an economic and ecological burden on the fishery's long-term recovery potential (WWF-Malaysia 2026). Fisheries governance in Malaysia has also been characterised by near-exclusive reliance on input controls such as vessel licensing, gear restrictions, closed areas, and seasonal closures that have demonstrated limited success in addressing persistent overcapacity and compliance failures over the long term (Wong and Yong 2020; Sin *et al*. 2024). The trawler fleet grew from a negligible number in the early 1960s to 4,500 vessels by 1981, with catch per unit effort (CPUE) declining concurrently even as new licences were issued. Without corresponding output controls such as harvest control rules or catch quotas, input restrictions alone cannot prevent stock depletion where fishing capacity systematically exceeds productive limits (Shahrom Abdul Majid 1985).

POLICY CHALLENGES

Policy frameworks have historically prioritised economic growth and commercial expansion, resulting in inequitable distribution of benefits. Large-scale commercial vessels account for approximately 86% of total landings, while small-scale fishers have limited involvement in decision-making, access to markets, and benefit-sharing (Ahmad *et al.* 2003b; Obi *et al.*

2025). National policies, including the National Policy on Biological Diversity 2022 – 2030 (NPBD 2022 – 2030) and the DAN 2.0, acknowledge declining fish stocks and promote sustainability, but gaps in implementation and enforcement persist (Ministry of Natural Resources and Environmental Sustainability 2019; Ministry of Agriculture and Food Industries 2021). Effective policy must therefore address both ecological sustainability and social equity, ensuring that small-scale fishers are empowered to participate in governance and share in the benefits of fisheries.

A further structural challenge lies in the design of fisheries subsidy arrangements, which have historically incentivised the overcapacity and overexploitation that management reforms seek to reverse. Fuel subsidies, extended to small-scale fishers since the 1970s, reduce vessel operating costs and thereby encourage excess fishing effort—accelerating stock depletion and limiting sector modernisation, with compounding risks to long-term food security as stocks continue to decline (WWF-Malaysia 2026). While these schemes were originally designed as poverty alleviation instruments, they have evolved into broadly applied transfer payments with limited evidence of productivity gains, and they align poorly with Malaysia's stated sustainability commitments under the Kunming-Montreal Global Biodiversity Framework and the National Agrofood Policy 2021–2030 (Obi *et al.* 2025; WWF-Malaysia 2026). The reform of fisheries subsidies—redirecting support from fuel and capacity expansion toward enforcement, data systems, and targeted social protection for genuinely vulnerable small-scale fishers—is therefore identified as an essential component of any credible transition to sustainable fisheries management in Malaysia (WWF-Malaysia 2026).

Management challenges

Management deficiencies exacerbate ecological and socio-economic pressures. Chronic overcapacity, proliferation of larger and more powerful vessels, and weak enforcement have contributed to persistent overfishing (Ahmad *et al*. 2003b; Obi *et al*. 2025). IUU fishing, including foreign incursions, imposes significant economic losses, estimated at up to USD 1.3 billion annually (Rahman 2023; Dao 2025). Monitoring and control of fishing effort, catch reporting, and gear compliance remain inadequate due to technical and budgetary constraints (Ahmad *et al*. 2003c; Flewwelling and Hosch 2006). Conflicts between commercial and small-scale fishers, as well as between fisheries, tourism, and conservation interests, further undermine management's effectiveness.

The status of sharks and rays provides one of the sharpest indicators of the broader collapse of Malaysia's marine ecosystem. Malaysia documents at least 65 shark species and 81 ray species, of which at least 22 shark and 41 ray species are classified as threatened with extinction under the IUCN Red List (DOFM 2024b; IUCN 2024). Yet only 11 species receive full protection under the *Fisheries (Control of Endangered Species of Fish) Regulations 1999* (Amendments 2008 and 2019), pursuant to the *Fisheries Act 1985*, thus exposing a critical governance gap. A comprehensive landing site and market survey conducted in Sarawak between January 2017 and December 2019 conservatively estimated that over 26,500 elasmobranchs (approximately 90,000 kg) are locally traded in Sarawak annually, worth approximately USD 125,000 at the market level; endangered and CITES-listed species comprised 26% and 32% of total landings and trade respectively, and high proportions of immature individuals were recorded across conservation-priority species including critically endangered scalloped hammerhead sharks (*Sphyrna lewini*) and bottlenose wedgefish (*Rhynchobatus australiae*) (Booth *et al*. 2021). An electronic camera monitoring programme deployed across trawl vessels in Sabah between 2020 and 2022 estimated that approximately 138,000 sharks and rays are caught as bycatch in Sabah annually, despite no specific fishing licences being issued to target these species, and that approximately 3,500 sea turtles are also incidentally caught each year in the same fisheries (Marine Research Foundation 2024). A 2022 – 2024 study by WWF-Malaysia and partner

universities across five key species found that more than 50% of captured individuals were below their maturity length (L50), providing direct evidence of recruitment overfishing (WWF-Malaysia 2026).

The decline of Malaysian fisheries is driven by interconnected economic, environmental, and social factors. Market demand and technological advances have incentivised overfishing, while population growth and coastal development have increased pressure on nearshore resources (Ahmad *et al.* 2003c). Small-scale fishers, dependent on daily income, often circumvent regulations, highlighting the need for policies that combine enforcement with incentives and alternative livelihood options. Cross-sectoral pressures from tourism, industrial development, and pollution further complicate sustainable management, underscoring the need for integrated, multi-agency approaches.

FUTURE DIRECTIONS FOR SUSTAINABLE FISHERIES IN THE ANTHROPOCENE

Case Studies: Resilience and Regeneration

Fishery Improvement Projects (FIPs) – Marudu Bay, Tun Mustapha Park

Three active Fishery Improvement Projects (FIPs) operating across Malaysian seascapes provide evidence that science-based co-management can be applied across diverse fishery types. The Reef Fishes FIP in Marudu Bay, Tun Mustapha Park, detailed in this chapter, has generated robust biomass data and reduced fish bombing incidents by more than half since 2019 (WWF-Malaysia 2026). The Yellowfin Tuna FIP at Mabul Island, Semporna, launched in 2022, covers approximately 400,000 hectares of Semporna waters impacting around 300 traditional fishers across 16 stakeholder groups including universities and government bodies; Semporna recorded 313 tonnes of yellowfin tuna landings in 2022, among Malaysia's highest volumes, underscoring the economic importance of improving management of this fishery (WWF-Malaysia 2026). The Longtail Tuna FIP at Tok Bali, Kelantan, covers 1.1 million hectares and targets approximately 26 purse seine vessels in a fishery that accounts for 60% of Malaysia's national longtail tuna landings and that has been overfished for at least five consecutive years; WWF-Malaysia is facilitating this FIP with nine stakeholders to develop and implement a strategic action plan to restore healthy longtail tuna stocks and minimise environmental impacts (WWF-Malaysia 2026). Together these three FIPs span reef fish, tuna, and mixed-gear fisheries across three distinct seascapes, demonstrating the model's transferability.

The Reef Fishes Fishery Improvement Program (FIP) in Marudu Bay, Tun Mustapha Park, has become a strong example of ecological, social, and governance resilience since it began in 2019 by gradually transitioning a data-poor, multi-species reef fishery toward science-based co-management. Through a five-year enumerator program in 14 villages, complemented by other stock assessment methods such as Underwater Visual Census and swept area method surveys in 2021, 2022, and 2025, the FIP has generated robust data on fisheries stocks establishing fish biomass and population dynamics for key reef fish families (e.g., snapper, jack/trevally, grouper), enabling the development of reference points using the Beverton Holt yield-per-recruit analysis to develop harvest strategies. At the same time, collective action to curb destructive fishing has reduced fish bombing incidents in Tun Mustapha Park (TMP) by more than half, while annual coral reef health monitoring shows most reef sites in good to moderate condition and ongoing restoration using reef stars and artificial reefs is helping in accelerating recovery. Social and governance resilience have been strengthened through embedded co-management across agencies and communities, with TMP's zonation, community-use areas, and evolving community guidelines such as the Berungus protocol, community use zone supported by the FIP Steering Committee, the TMP Enforcement Plan, and honorary park rangers and wildlife wardens using SMART

patrols and Survey123. Innovative initiatives such as the 2024/2025 shark and ray catch-and-release pilot which released 35 individuals alive and reduced fishing mortality by about two-thirds while generating strong fisher interest illustrate how clear policies, incentives, and continuous engagement can catalyse local stewardship and behaviour change, positioning the Marudu Bay reef fishes FIP as a transferable model for resilient, regenerative reef fisheries in Malaysia and the wider Coral Triangle.

Other Effective area-based Conservation Measure (OECM) — Berungus

The Berungus–Malubang community in Pitas, northern Sabah, has shifted from declining catches to a leading model of community-led marine governance. In the late 1980s, fishers were travelling up to 15 km per trip and spending around 30 litres of fuel daily, signalling worsening stock conditions. After DOF Sabah awareness efforts in the early 2000s, the community began deterring destructive fishing and reporting trawlers and other IUU activities, later partnering with WWF-Malaysia, DOFS, Sabah Parks and the District Office to establish the 1,000 hectares Berungus Marine Managed Area (BMMA) along the Tun Mustapha Park (TMP) boundary, including approximately 70 hectares of no-take zone and a 100-hectare nearshore strip outside TMP under community management. Governance is anchored by the *Protokol Laut Berungus* which was developed since 2018, and a community marine management plan, overseen by a BMMA committee. The protocol sets decision -making rules, FPIC requirements, and safeguards customary tenure and community data sovereignty; the plan operationalises zoning, patrols, IUU reporting, and turtle nest protection.

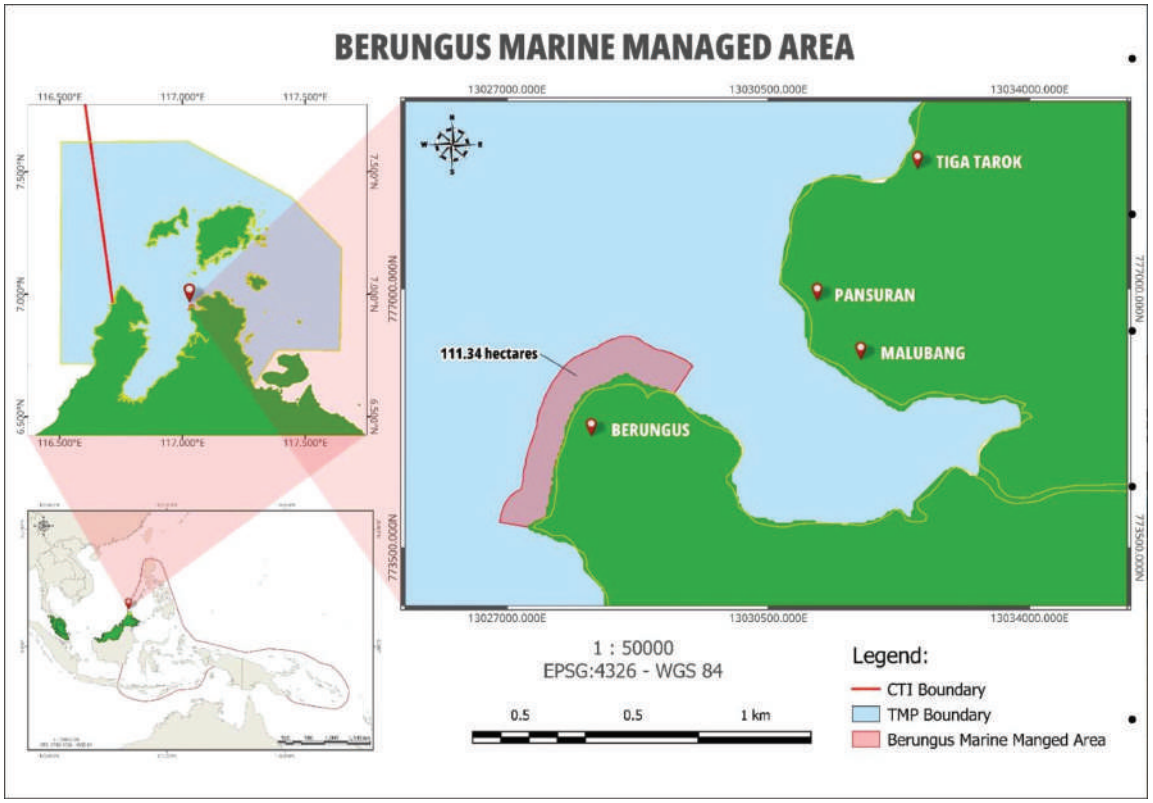


Figure 1. Location of Berungus Marine Managed Area at the boundary of Tun Mustapha Park.

Using daily catch records since 2014 and community knowledge, monitoring indicates average fisher income is 297% higher than the 2014 baseline; surveys also show a 274% increase in reef fish density (2022 – 2025) and stable, moderate live coral cover. Benefits have supported livelihood diversification such as sea cucumber farming, homestays, swiftlet nests, and strengthened TMP by reinforcing the park boundary through community stewardship.

In late 2024, after completing the national OECM assessment, NRES announced Berungus as Malaysia's first coastal and marine OECM candidate; the protocol that is supported by the Pitas Native Court and reinforced by Honorary Wildlife Wardens and an Honorary Park Ranger guides access, consent, data ownership, and benefit-sharing, aligning with national and global biodiversity and seascape commitments.

Small-Scale Fisheries Projects (SSFPs)

Complementing the FIP framework, Small-Scale Fisheries Projects (SSFPs) represent a community-centred approach that explicitly integrates human wellbeing and customary rights into fisheries management planning. Three SSFPs are active or in advanced endorsement stages in Malaysia. The Larapan Island SSFP in Semporna, Sabah (endorsed 2023) covers 200,000 hectares, directly impacting approximately 100 traditional fishers. The Rajang -Belawai-Paloh SSFP in Sarawak (endorsed June 2025) covers 250,000 hectares, supporting approximately 500 traditional fishers across three villages in partnership with the Tanjung Manis District Office. The Kemaman SSFP in Terengganu covers 680,000 hectares and will impact approximately 1,400 traditional fishers in three villages, with the Kemaman Fishers Association and District Fisheries Office as key partners (WWF-Malaysia 2026). Collectively the three SSFPs cover 1.13 million hectares of Malaysian coastal waters. Research confirms that social capital—particularly community networks and leadership—provides a critical bottom-up contribution to the adaptive capacity that these projects seek to build (Bamasood *et al.* 2025).

Artificial reef programme

Habitat-based interventions offer documented potential for partially reversing the socioeconomic impacts of declining catches. A quantitative study of 172 fishermen in Terengganu, where the DOFM has implemented an artificial reef programme specifically designed to protect inshore habitats from trawl damage, found that artificial reef deployment significantly increased fish abundance, reduced the fishing effort required per unit of catch, contributed to higher-value catches, and improved fishermen's household income and socioeconomic status (Sapehee *et al.* 2025). The study further found that 90.7% of respondents were aware of and actively utilised artificial reef sites during fishing, suggesting strong community uptake of this intervention when it is accompanied by effective communication and accessible placement (Sapehee *et al.* 2025). However, equity dimensions require attention: earlier research in Terengganu found that benefits from artificial reefs were not evenly distributed, with larger-engined vessels capturing disproportionate gains, and that gear conflicts within shared artificial reef areas increased fishing costs for smaller operators (Islam *et al*. 2014). Effective artificial reef policy must therefore incorporate user rights frameworks and gear management alongside deployment to ensure equitable benefit-sharing.

Integrating ecological, social, and technological strategies

Malaysia's fisheries sector holds genuine export potential across multiple regions and species categories but realising that potential is contingent on implementing the management reforms outlined in this paper. Stocks currently assessed as overfished or at risk cannot sustain export expansion; the commercial opportunity described below should be read as a recovery dividend, achievable only once the trajectory of stock decline is reversed. On that basis, and with sustainable management as the enabling condition, the export landscape is as follows.

Malaysia's fisheries sector offers significant export potential across multiple regions. On the East Coast of Peninsular Malaysia, opportunities centre on marine fishery products fresh, frozen, and processed alongside shellfish and value-added seafood. Species such as grouper and threadfin are abundant, meeting strong demand for premium seafood in markets like China, Singapore, Japan, and the Middle East. Frozen fish and processed products, including fillets, dried fish, and fish-based snacks, are increasingly attractive to

countries with stringent quality standards such as the EU and the U.S. Terengganu's reputation for blue crabs and shellfish creates further prospects for regional exports to Thailand and Singapore. Rising consumer interest in ready-to-eat seafood supports the development of value-added products such as seafood snacks, fish balls, *keropok lekor*, and pre-cooked meals. Government incentives such as grants, subsidies, and training can help scale up production and aquaculture for export.

In the southern region, fisheries profiles provide detailed data on species availability and quantities, enabling targeted strategies for emerging markets. These profiles inform policy development by addressing overfishing and habitat degradation through data-driven regulations and improved enforcement. They also support research into fish biology and seasonal patterns, guiding sustainable practices and educational programs. Aligning infrastructure development such as ports and processing facilities, with insights from these profiles enhances operational efficiency and sustainability.

The West Coast sector can strengthen economic and ecological resilience through modernisation and conservation. Expanding marine protected areas (MPAs), installing artificial reefs, and diversifying biodiversity safeguard ecosystems while creating opportunities for eco-tourism and higher yields. Targeting high-value species such as green tiger prawns and mantis shrimp can boost income through specialised supply chains. Fleet modernisation with efficient gear and lightweight vessels, coupled with advanced monitoring systems using satellite and artificial intelligence (AI), improves profitability and compliance. Pollution control measures and community engagement further support sustainability.

Sabah, Sarawak, and Labuan hold vast potential for export and innovation. Sabah's tuna resources position it to supply sashimi-grade fish to Japan and the U.S., while Sarawak can diversify into value-added products for Southeast Asian markets. Labuan's offshore fisheries and marine biotechnology initiatives can target premium global markets. These regions can also leverage eco-tourism, community-based management, and marine research to drive growth and conservation. Government support through incentives and training remains critical to enhancing production capacity and competitiveness.

Building resilience to ongoing and future Anthropocene challenges

To reverse the decline of Malaysia's capture fisheries and secure their ecological and socioeconomic viability, a suite of coordinated, adaptive policy measures is required. Evidence consistently shows that the most effective interventions are not isolated enforcement efforts but integrated strategies that combine effort control, spatial management, and participatory governance (Sin *et al.* 2019; Wong *et al.* 2021; Ismail *et al.* 2022).

Effort reduction remains one of the most consistently successful interventions in Malaysia's capture fisheries. Studies of the trawl fisheries along the West Coast and the Indian mackerel fishery in Peninsular Malaysia demonstrate that limiting entry through license caps or buyback schemes increases biomass and catch per unit effort, while improving long-term profitability (Sin *et al*. 2019; Ismail *et al.* 2022). Strengthening the National Fisheries Management Plans with explicit harvest control rules and adaptive seasonal closures would institutionalise evidence-based management. These should incorporate real-time stock data, periodic reassessment of fishing mortality, and integration of local ecological knowledge to ensure adaptive policy responses.

Malaysia's experience with MPAs such as Pulau Payar, Lankayan, and Sibu-Tinggi shows clear ecological gains in fish biomass and coral cover (Teh *et al*. 2008; Fatimah *et al.* 2012; Ariff 2013). However, these benefits are often undermined by weak enforcement and socioeconomic trade-offs that restrict community access (Masud 2015). A national-level MPA framework is needed to integrate marine parks, OECMs, and seasonal closures under

a single spatial management policy. Linking MPAs to fisheries zoning and closed-season regulations (Teh and Teh 2011; Wong *et al.* 2021) will ensure better ecological connectivity and management consistency.

Bottom trawling and other non-selective gears have been identified as major drivers of demersal stock depletion (Yahaya 1988; Wong *et al.* 2021). Empirical studies show that banning trawling in nearshore zones significantly improves juvenile survival rates and helps regenerate degraded habitats (Sin *et al.* 2019). Malaysia's gradual shift toward restricted trawl zones (e.g., Zone B bans) should be accelerated and paired with incentives for gear-switching and retraining. Enforcement agencies such as the Malaysian Maritime Enforcement Agency (MMEA) and Department of Fisheries should coordinate efforts to ensure compliance, backed by clear legal instruments and satellite-based surveillance systems.

Enforcement alone has proven insufficient to secure compliance (Ali and Abdullah 2010). Participatory co-management, which combines local stewardship with regulatory oversight, improves compliance and legitimacy (Ali and Ayob 2005; Masud 2015). Community-based initiatives in Kedah, Perlis, and Mersing show that fisher involvement in monitoring, zoning, and enforcement enhances sustainability (Fatimah *et al.* 2012; Bamasood *et al.* 2025). Institutionalising co-management through national policy, particularly under the Ecosystem Approach to Fisheries Management (EAFM), would empower local groups to participate in decision-making, surveillance, and adaptive management.

Climate-related stressors such as ocean warming, changing currents, and acidification are altering Malaysia's marine productivity and species distributions. Studies emphasise that habitat restoration including mangrove reforestation, coral rehabilitation, and artificial reefs support both climate resilience and fish stock recovery (Saharuddin *et al.* 2012; Ali *et al*. 2013). Integrating climate-smart planning within the Fisheries Master Plan and Marine Spatial Planning (MSP) framework will ensure that stock projections, habitat maps, and sea-level rise scenarios are embedded in decision-making. This approach aligns with global best practices under DAN 2.0 and NPBD 2022 – 2030.

The urgency of embedding climate resilience into fisheries recovery planning has intensified significantly following the 2024 mass bleaching event, the fourth and most widespread global bleaching event in recorded history (NOAA Coral Reef Watch 2026). The 2025 national reef survey by Reef Check Malaysia, covering 297 sites from the tourist -heavy peninsula islands to remote Sabah waters which documented average live coral cover falling to just under 40%, a 20% decline from 50% in 2022 (Reef Check Malaysia 2026). Over four-fifths of surveyed reef sites showed signs of abandoned fishing gear or trash, and more than half bore anchor damage; in parts of Sabah, dynamite fishing damage was recorded at one-third of sites (Reef Check Malaysia 2026).

Since coral reefs function as the nursery and feeding infrastructure underwriting small-scale fisheries productivity, supporting over 140,000 small-scale fisher households in Malaysia—this trajectory of habitat loss must be treated as a fisheries management emergency, not merely a biodiversity concern (Reef Check Malaysia 2026). Recovery strategies combining marine protected area expansion, active coral restoration using the MARRS system (which has rehabilitated 2,122 m^2 in Tun Mustapha Park), and strict enforcement against anchor damage and abandoned gear offer the most evidence-grounded pathway to rebuilding the reef habitat on which fish stock recovery depends (WWF-Malaysia 2026).

Weak data collection remains a systemic challenge. Research advocates for the use of digital monitoring technologies such as vessel monitoring systems (VMS), electronic logbooks, and AI-assisted remote sensing to improve transparency and adaptive management

(Wong *et al*. 2021; Ismail *et al.* 2022). Incorporating these tools into DOFM's monitoring systems would enable real-time tracking of fishing effort and support enforcement coordination. Establishing a centralised national fisheries data platform—integrated across agencies and open for scientific use—would improve stock assessments, subsidy accountability, and value chain transparency.

Fisheries governance in Malaysia remains fragmented across ministries and jurisdictions, limiting cohesive responses to transboundary issues such as IUU fishing and migratory stock management (Yahaya 1988; Saharuddin *et al.* 2012). Establishing a National Fisheries Coordination Council could improve alignment between DOFM, MMEA, Ministry of Finance (MOF), Ministry of Investment, Trade and Industry (MITI), and state governments. At the regional level, Malaysia should strengthen collaboration under the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) and ASEAN mechanisms to harmonise vessel monitoring, share enforcement data, and jointly manage shared stocks such as tuna and small pelagic (Teh and Teh 2011; Bamasood *et al.* 2025). Coordinated transboundary governance is essential to achieving ecological sustainability and economic resilience in an era of rapid environmental change.

CONCLUSION

The decline of Malaysia's capture fisheries is not a crisis in the making, it is a crisis already arrived. What the evidence assembled in this paper reveals is a pattern of systemic failure: a fisheries management architecture built on input controls that have consistently proven insufficient to arrest overcapacity; governance fragmented across ministries, agencies, and federal-state jurisdictions that leaves shared resources without coherent stewardship; subsidy arrangements that incentivise the very excess effort they were never designed to produce; and an enforcement gap so wide that nearly 30% of total marine landings are estimated to occur outside the legal framework altogether (DOFM 2019). These are not technical deficiencies awaiting a technical fix. They are structural features of a governance system that has, over decades, consistently prioritised short-term production over long-term sustainability. The ecological bill is now coming due simultaneously from overfishing and a changing climate that is degrading the reef, mangrove, and seagrass habitats on which fish stock recovery ultimately depends.

The human consequences of this structural failure fall hardest on those least responsible for it. Small-scale fishers who represent the majority of the fishing workforce yet account for only 35% of landings bear the most immediate costs of stock depletion, habitat loss, and coastal development, with limited access to financial services, alternative livelihoods, or meaningful participation in the governance processes that determine their futures (Bamasood *et al*. 2025). The continued exclusion of fishing communities from fisheries decision-making is not simply an equity concern; it is a management failure, because durable recovery will be impossible without the active stewardship of the people who know these waters best and depend on them most directly.

Yet this paper also documents that recovery is achievable. The Berungus Marine Managed Area, Malaysia's first coastal and marine OECM candidate, demonstrates what becomes possible when communities are given formal rights, clear responsibilities, and consistent institutional support: fish density up 274%, fisher incomes up 297% above baseline, and a governance model grounded in customary law and co-management that is now being recognised at the national level (WWF-Malaysia 2026). The three active Fishery Improvement Projects and three Small-Scale Fisheries Projects detailed in this paper spanning reef fish, tuna, and mixed-gear fisheries across Sabah, Sarawak, and East coast of

Peninsular Malaysia show that science-based co-management is transferable across fishery types and seascapes. These are not experiments; they are working models. The challenge is to move them from the margins to the mainstream of Malaysian fisheries governance.

Doing so will require changes of a different order than those Malaysia has historically been willing to make. Output controls such as harvest control rules, catch quotas, and adaptive seasonal closures grounded in real-time stock data must complement and eventually supersede the input controls that have defined management for four decades. The legal protection gap for sharks and rays, the species most sensitive to fishing pressure and most indicative of ecosystem health, must be closed. Fisheries subsidies must be restructured away from fuel and vessel capacity expansion and toward enforcement, monitoring, gear transition, and targeted social protection. Marine spatial planning must be scaled from seascape-level pilots to a nationally coherent, enforceable framework that integrates marine parks, OECMs, fisheries zones, and climate projections into a unified spatial management architecture. Malaysia must invest in the digital monitoring infrastructure such as vessel monitoring systems, electronic logbooks, and real-time surveillance that effective enforcement and adaptive management require (Wong *et al*. 2021; Ismail *et al*. 2022).

None of this is beyond Malaysia's capacity. The knowledge, the community models, and the scientific data needed to chart a recovery trajectory already exist within Malaysian waters and institutions. What has been missing is the political will to embed these approaches within national policy and the institutional capacity to implement them consistently across the country's diverse coastal seascapes. Malaysia's commitments under the Kunming -Montreal Global Biodiversity Framework including the 30×30 ocean protection target and the National Agrofood Policy 2021 – 2030 provide the policy architecture within which these changes can be anchored. The question is whether the urgency that the data demand will translate into the action that the fisheries, and the people who depend on them, now urgently require.

REFERENCES

Ahmad, A.T., Isa, M.M., Ismail, M.S. and Yusof, S. 2003a. Status of demersal fishery resources of Malaysia. In *Assessment, management and future directions for coastal fisheries in Asian countries*, G.T. Silvetre, G. Len, S. Ilona, M. Ahmed, R.A. Valmonte-Santos, C. Lune, L. Lachica-Alino *et al*. (Eds.), pp. 83–136. *WorldFish Center Conference Proceedings* 67. Penang: WorldFish Center. https://hdl.handle.net/20.500.12348/2125

Ahmad, A.T., Salim, K., Chee, P.E., Isa, M.M. and Lim, C.F. 2003b. An overview of the socioeconomic status of fisheries in Malaysia. In *Assessment, management and future directions for coastal fisheries in Asian countries*, G.T. Silvetre, G. Len, S. Ilona, M. Ahmed, R.A. Valmonte-Santos, C. Lune, L. Lachica-Alino *et al*. (Eds.), pp. 517–542. *WorldFish Center Conference Proceedings* 67. Penang: WorldFish Center. https://digitalarchive.worldfishcenter.org/server/api/core/bitstreams/1e71e925-3cf1-4abc-9613-2be3b8b55b2a/content

Ahmad, A.T., Tan, G. and Yasin, A. H. 2003. Overview of the national fisheries situation with emphasis on the demersal fisheries off the west coast of Peninsular Malaysia. In *Assessment, management and future directions for coastal fisheries in Asian countries*, G.T. Silvetre, G. Len, S. Ilona, M. Ahmed, R.A. Valmonte-Santos, C. Lune, L. Lachica-Alino *et al*. (Eds.), pp. 833–884. *WorldFish Center Conference Proceedings* 67. Penang: WorldFish Center. https://digitalarchive.worldfishcenter.org/server/api/core/bitstreams/be677342-7425-4959-8b04-e07b4aa372d2/content

Ali, A., Abdullah, M.P., Hazizi, R., Marzuki, A.H. and Hassan, R.B.R. 2013. Protecting coastal habitats and enhancing fisheries resources using big size artificial reefs in the East Coast of Peninsular Malaysia. *Malaysian Journal of Science* 32(3): 19–36. https://doi.org/10.22452/mjs.vol32no3.3

Ali, J. and Abdullah, H. 2010. Impact of enforcement and co-management on compliance behavior of fishermen. *International Journal of Economics and Finance* 2(4): 113–121. https://doi.org/10.5539/ijef.v2n4p113

Ali, J. and Ayob, A.M. 2005. Pengurusan sumber perikanan secara 'co-management': Kajian kes di Kedah dan Perlis. *Jurnal Intelek* 3(1): 35–49.

Alias, M. 2000. Fisheries status and trends of key species of Pulau Payar waters. In *Proceedings of National Symposium on Pulau Payar Marine Park*, pp. 4–17. Penang: Institut Penyelidikan Perikanan.

Ariff, S.B. 2013. The Impact of Marine Protected Areas to The Fish Stock: Case Study in Pulau Payar, Kedah. PhD Dissertation. Kedah: Universiti Utara Malaysia. https://etd.uum.edu.my/5239/1/s811787.pdf

Bamasood, S.A., Sayed, K., Syakir, M.I., Jaafar, M.H. and Zuknik, M. 2025. Small-scale fishers livelihood strategies amid coastal reclamation in Malaysia. *Fisheries Management and Ecology* 32(6): 529–541. https://doi.org/10.1111/fme.12823

Bavoh, E.M. and Manjaji-Matsumoto, B.M. 2022. Preliminary result of population structure of reef fishes in coral reef restoration sites in Tun Sakaran Marine Park, Semporna, Sabah. *Borneo Journal of Marine Science and Aquaculture* 6(1): 1–7. https://doi.org/10.51200/bjomsa.v6i1.2708

Bavoh, E.M., Manjaji-Matsumoto, B.M., Mapait, A.J., Ahmad, M.N. and Lahum, R.A. 2023. Enhanced fish diversity following active coral reef restoration efforts in Tun Sakaran Marine Park, Sabah, Malaysian coral triangle. *Transactions on Science and Technology* 10(4): 188–197.

Booth, H., Chaya, F., Ng, S., Tan, V., Rao, M., Teepol, B., Matthews, E., Lim, A. and Gumal, M. 2021. Elasmobranch fishing and trade in Sarawak, Malaysia, with implications for management. *Aquatic Conservation: Marine and Freshwater Ecosystems* 31(11): 3056–3071. https://doi.org/10.1002/aqc.3688

Dao, T. 2025, August 11. Malaysia Moves To Toughen Fisheries Law, Minimize IUU Losses. *SeafoodSource*. https://www.seafoodsource.com/news/supply-trade/malaysia-moves-to-toughen-fisheries-law-minimize-iuu-losses

Department of Fisheries Malaysia (DOFM). 2019. *Annual fisheries statistics report: Illegal, unreported, and unregulated (IUU) fishing in Malaysia*. Putrajaya, Malaysia: Ministry of Agriculture and Food Security Malaysia. https://repository.seafdec.org/bitstream/handle/20.500.12066/7070/6.1.1.pdf

Department of Fisheries Malaysia (DOFM). 2024a. *Annual Fisheries Statistics 2023*. Putrajaya: Ministry of Agriculture and Food Security Malaysia. https://www.dof.gov.my/sumber/perangkaan-perikanan-i/

Department of Fisheries Malaysia (DOFM). 2024b. *Malaysia National Plan of Action for the Conservation and Management of Shark 2024 (Plan 3)*. Putrajaya: Ministry of Agriculture and Food Security Malaysia. https://iotc.org/sites/default/files/NPOA_portal/Malaysia/MYS_-_NPOA_Shark_Plan_3_2024-2030.pdf

FAO (Food and Agriculture Organization). 2026. Fishery and Aquaculture Country Profiles Malaysia. *Food and Agriculture Organization*. http://www.fao.org/fishery/facp/mys/en

Fatimah, K., Nurul Huda, M.S. and Salleh, N.H.M. 2012. Income risk vulnerability and perception towards conservation: a community level analysis for Pulau Sibu-Tinggi Marine Park, Mersin. *Journal of Tropical Marine Ecosystem* 2(1). https://spaj.ukm.my/ekomar/jtme/article/view/24

Flewwelling, P. and Hosch, G. 2006. Country Review: Malaysia. In *Review of the State of World Marine Capture Fisheries Management: Indian Ocean*, C. De Young (Ed.), pp. 143–154. *FAO Fisheries Technical Paper* 488. Rome: Food and Agriculture Organization of the United Nations. https://www.fao.org/4/a0477e/a0477e0c.htm

Funge-Smith, S., Lindebo, E. and Staples, D. J. 2005. Asian fisheries today: *The production and use of low value / trash fish from marine fisheries in the Asia-Pacific region*. Bangkok: Asia-Pacific Fishery Commission. https://openknowledge.fao.org/handle/20.500.14283/ae934e

Fisheries Research Institute (FRI). 2017. *Fisheries Resources Survey in Malaysian Waters 2013-2016: Executive Summary*. Putrajaya: Department of Fisheries Malaysia.

Fisheries Research Institute (FRI). 2018. *Fisheries Resources Surveys in Malaysian Waters 2013 – 2016 Volume I: Demersal*. Department of Fisheries Malaysia.

Indian Ocean Tuna Commission (IOTC). 2024. Report of the 27th Session of the IOTC Scientific Committee. Online, 2–6 December 2024. IOTC–2024–SC27–R[E]. Victoria: Indian Ocean Tuna Commission. https://iotc.org/sites/default/files/documents/2025/04/IOTC-2024-SC27-RE_0.pdf

Islam, G.M.N., Noh, K.M., Sidique, S.F., Noh, A.F.M. and Ali, A. 2014. Economic impacts of artificial reefs on small-scale fishers in Peninsular Malaysia. *Human Ecology* 42: 989–998. https://doi-org/10.1007/s10745-014-9692-2

Ismail, I., Failler, P., March, A. and Thorpe, A. 2022. A system dynamics approach for improved management of the Indian mackerel fishery in Peninsular Malaysia. *Sustainability* 14(21): 14190. https://doi.org/10.3390/su142114190

IUCN. 2024. Global red list assessments for chondrichthyans. *IUCN Red List of Threatened Species*. https://www.iucnredlist.org

Kanniah, K.D., Kang, C.S., Sharma, S. and Amir, A.A. 2021. Remote sensing to study mangrove fragmentation and its impacts on leaf area index and gross primary productivity in the south of Peninsular Malaysia. *Remote Sensing* 13(8): 1427. https://doi.org/10.3390/rs13081427

Kirkley, J.E., Squires, D., Alam, M.F. and Ishak, H.O. 2003. Excess capacity and asymmetric information in developing country fisheries: the Malaysian purse seine fishery. *American Journal of Agricultural Economics* 85: 647–662. https://doi.org/10.1111/1467-8276.00462

Loh, K.H., Lim, K.C., Then, A.Y.-H., Adam, S., Leung, A.J.-X., Hu, W., Bong, C.W. *et al.* 2023. Advancing DNA Barcoding to Elucidate Elasmobranch Biodiversity in Malaysian Waters. *Animals* 13(6): 1002. https://doi.org/10.3390/ani13061002

Long, C.Y. 2018. Tuna population analysis, Tok Bali 2018. Penang: Fisheries Research Institute Malaysia. [Unpublished].

Man, A. 2008. Assessment of coral reef fish population at Pulau Payar Marine Park and adjacent waters. PhD Dissertation. Penang: Universiti Sains Malaysia.

Marine Research Foundation (MRF). 2024. Sabah Sharks & Rays Initiative: Annual bycatch estimates 2020–2022. Presented at the Sabah Sustainable Management of Sharks and Rays Workshop, Sandakan, February 29, 2024. [Unpublished]

Masud, M.M. 2015. Communities' Socio-Economic Status and Environmental Conservation Behaviour in Marine Protected Areas: A study of Malaysia. PhD Dissertation. Kuala Lumpur: University of Malaya.

Ministry of Agriculture and Food Industries. 2021. *National Agro-Food Policy 2021-2030.* Putrajaya: Ministry of Agriculture and Food Industries. https://faolex.fao.org/docs/pdf/mal211654.pdf

Ministry of Natural Resources and Environmental Sustainability. 2019. *National Policy on Biological Diversity 2022-2030*. Putrajaya: Ministry of Natural Resources and Environmental Sustainability. https://www.mybis.gov.my/pb/5710

Mohamad, A., Mat Piah, R., Nasir, A. Shaari, N.F., Wahab, M.Z., Kamaruzzaman, Y.N., Ahmad, N. and Abdul Raof, N. *2024. Discerning the Insights of Our Coastal Fisheries Profile in Malaysia*. Petaling Jaya: WWF-Malaysia.

Ng, C.Z.W., Jensen, O.P. and Ong, J.J.L. 2025. Reconstructing a century of marine landings and fishing effort in Malaysia and Singapore. *ICES Journal of Marine Science* 82(2): fsaf008. https://doi.org/10.1093/icesjms/fsaf008

NOAA Coral Reef Watch. 2026, June 2. Current Global Bleaching: Status Update & Data Submission. *NOAA Coral Reef Watch*. https://coralreefwatch.noaa.gov/satellite/research/coral_bleaching_report.php

Obi, C., Dompreh, E.B., Manyise, T., Tan, S.H., Woo, S.P. and Rossignoli, C.M. 2025. Overview of the fishery and aquaculture sectors in Malaysia. *Frontiers in Sustainable Food Systems* 9: 1545263. https://doi.org/10.3389/fsufs.2025.1545263

Rahman, F.A. 2023, December 18. Assessing Malaysia's Maritime Governance Capacity: Priorities and Challenges. *Asia Maritime Transparency Initiative*. https://amti.csis.org/assessing-malaysias-maritime-governance-capacity-priorities-and-challenges/

Reef Check Malaysia. 2025, August 12. Bridging The Gap: Mechanisms to Enable More Holistic Marine Resource Management. *Reef Check Malaysia*. https://reefcheck.org.my/bridging-the-gap-mechanisms-to-enable-more-holistic-marine-resource-management/

Reef Check Malaysia. 2026. The 2025 Reef Check Malaysia Survey Results and What They Mean for Our Coral Reefs. Reef Check Malaysia. https://reefcheck.org.my/2025-reef-check-survey-results-and-what-they-mean-for-our-coral-reefs/

Rhoumah, A.M.O. 2017. Determinants of poverty among coastal fisherman crews in Kelantan and Terengganu, Malaysia. Master's thesis. Serdang: Universiti Putra Malaysia. http://psasir.upm.edu.my/id/eprint/70265/

Saharuddin, A.H., Ali, A., Lokman, M.H. and Salihin, W. 2012. Recent development and management of artificial reefs (ARs) in Malaysia. In *Oceans - Yeosu* 2012, pp. 1–23. Piscataway: IEEE. https://doi.org/10.1109/OCEANS-Yeosu.2012.6263378

Saleh, M.F.M., Arshaad, W.M., Billy, A.N., Azmi, M.S., Jaafar, K. and Mohamad, S.N. 2024. Integrated assessment of neritic tuna resources in Southeast Asia: stock status, population genetics, age estimation, and reproductive patterns. *Fish for the People* 22(3): 26–34. http://hdl.handle.net/20.500.12066/7575

Sapehee, N.H., Samsudin, H., Talaat, W.I.A.W., Othman, N., Fikri, M.M., Hasri, M.N., Repin, I.M. and Abdul Latip, A.R. 2025. The socio-economic impact of artificial reefs on fishing communities in the east coast region of Malaysia. *Wellbeing, Space and Society* 8: 100248. https://doi.org/10.1016/j.wss.2025.100248

SEAFDEC (Southeast Asian Fisheries Development Center). 2025. Fisheries Country Profile: Malaysia. Bangkok: SEAFDEC. https://www.seafdec.org/fisheries-country-profile-malaysia/

Shahrom Abdul Majid. 1985. Controlling Fishing Effort: Malaysia's Experience and Problems. In *Papers presented at the Expert Consultation on the regulation of fishing effort (fishing mortality)*, Rome, 17–26 January 1983: A preparatory meeting for the FAO World Conference on fisheries management and development. *FAO Fisheries Report* 298 Supplement 3. Rome: Food and Agriculture Organization of the United Nations. https://www.fao.org/4/ac750e/AC750E10.htm

Sin, M.S., Gopabala Krishnan, L., Yew, T.S., Azlina, A.A. and Kamaludin, M. 2024. Sustainable fisheries management in marine capture fisheries: systematic literature review. *Journal of Sustainability Science and Management* 19(2): 242–275. http://doi.org/10.46754/jssm.2024.02.013

Sin, M.S., Yew, T.S. and Noh, K.M. 2019. Effort dynamics and alternative management policies: the case of the West Coast Zone B trawl fishery in peninsular Malaysia. *Marine Resource Economics* 34(1): 77–103. https://doi.org/10.1086/702268

Solaymani, S. and Kari, F. 2014. Poverty evaluation in the Malaysian fishery community. *Ocean and Coastal Management* 95: 165–175. https://doi.org/10.1016/j.ocecoaman.2014.04.017

Szereday, S., Chew, K.L. and Voolstra, C.R. 2025. Species-specific bleaching trajectories during the 4th global coral bleaching event in northeastern Peninsular Malaysia. *bioRxiv* [Preprint]. https://doi.org/10.1101/2025.10.14.682322

Teh, L.C.L. and Teh, L.S.L. 2011. A fuzzy logic approach to marine spatial management. *Environmental Management* 47(4): 536–545. https://doi.org/10.1007/s00267-011-9645-0

Teh, L.C.L., Teh, L.S.L. and Chung, F.C. 2008. A private management approach to coral reef conservation in Sabah, Malaysia. *Biodiversity Conservation* 17: 3061–3077. https://doi.org/10.1007/s10531-007-9266-3

Wong, H. S. and Yong, C. C. 2020. Fisheries regulation: A review of the literature on input controls, the ecosystem, and enforcement in the Straits of Malacca of Malaysia. *Fisheries Research* 230: 105682. https://doi.org/10.1016/j.fishres.2020.105682

Wong, H.S., Yong, C.C. and Othman, A. 2021. Bioeconomic approach for assessing status of trawl fishery in the Straits of Malacca. *Asian Fisheries Science* 34(4). https://doi.org/10.33997/j.afs.2021.34.4.010

Wood, E. and Dipper, F. 2008. What is the future for extensive areas of reef impacted by fish blasting and coral bleaching and now dominated by soft corals? A case study from Malaysia. In *Proceedings of the 11th International Coral Reef Symposium*, *Ft. Lauderdale, Florida*, B. Riegl and R.E. Dodge (Eds.), pp. 410-414. Davie: Nova Southeastern University National Coral Reef Institute.

WWF-Malaysia. 2026. *WWF-Malaysia Marine Programme Phase 4 (MP 4.0) FY27–FY31*. Strategy Document, 26 May 2026. Petaling Jaya: WWF-Malaysia. [Unpublished].

Yahaya, J. 1988. Fishery management and regulation in peninsular Malaysia: issues and constraints. *Marine Resource Economics* 5(2): 83–98. https://doi.org/10.1086/mre.5.2.42628923

Yamin, L., Kuo T.-C. and Aziz, N. 2025. Interplay of traditional knowledge and adaptive capacity in climate change adaptation of small-scale fishers in central Terengganu, Malaysia. *Frontiers in Marine Science* 12: 1492131. https://doi.org/10.3389/fmars.2025.1492131

Yeo, B.H., Squires, D., Ibrahim, K., Gjertsen, H., Syed Mohd Kamil, S.K., Zulkifli, R., Groves, T. *et al.* 2007. Fisher profiles and perceptions of sea turtle-fishery interactions: case study of East Coast Peninsular Malaysia. *The WorldFish Center Discussion Series 6*. Penang: The WorldFish Center.


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 877–890
doi: 10.62613/sonc2025.v3anc15

CHAPTER 15

Freshwater ecosystems in Malaysia: Status, pressures and management priorities

DARSHANAA CHELLAIAH*

Abstract: Freshwater ecosystems in Malaysia are highly biodiverse and provide critical ecosystem services, yet they are increasingly degraded by interacting land-use and environmental pressures. Evidence on the status, drivers, and ecological consequences of freshwater change across Malaysian river basins show that widespread freshwater ecological degradation is driven by landscape pressures, with impacts evident across biological communities and ecosystem functioning. Deforestation, agricultural plantation expansion, urbanisation, peatland conversion, and industrial water use collectively alter hydrological regimes, water chemistry, sediment dynamics, and organic matter inputs from headwaters to coastal systems. These changes are associated with shifts in ecosystem structure and function, including reductions in biodiversity, losses of sensitive taxa, and a general transition towards simplified, disturbance-tolerant communities across macroinvertebrates, fish, and other aquatic groups. This has functional change implications, affecting ecosystem processes such as nutrient cycling, organic matter processing, and food web structure, which indicate that ecological impacts extend beyond species loss to ecosystem-wide impacts. Forest loss and fragmentation further disrupt catchment linkages, leading to declines in water quality, habitat complexity, and biological integrity, whereas intact and structurally complex forested landscapes consistently buffer against these impacts. Across studies, catchment land-use condition and riparian integrity emerge as key determinants of freshwater ecosystem health, highlighting the importance of maintaining connected forested systems across upland, riparian, and floodplain zones. This underscores the need for more integrated catchment-scale planning and management of freshwater ecosystemsTo effectively safeguard and restore these ecosystems, there is a need for clear, measurable, catchment-context ecological metrics for effective monitoring andmanagement. Overall, the evidence demonstrates that safeguarding Malaysia's freshwater ecosystems depends on shifting from fragmented management approaches towards integrated, metrics-driven catchment governance capable of sustaining biodiversity, ecosystem functioning, and long-term water security.

INTRODUCTION

Freshwater ecosystems in Malaysia are biologically diverse and ecologically significant, shaped by an equatorial climate, extensive hydrological networks, and longstanding interactions between natural processes and human land use (Furtado and Lee 2022). Malaysia experiences high annual rainfall and relatively stable temperatures throughout the year, supporting a dense network of rivers, floodplains, peat swamps, lakes, and reservoirs (Furtado and Lee 2022). These systems comprise both lotic environments (i.e., flowing waters such as rivers and streams) and lentic environments (i.e., standing waters such as lakes, floodplain wetlands, swamps, and reservoirs), which are closely interconnected with their surrounding catchments (Izam *et al*. 2021; Furtado and Lee 2022).

River systems form the backbone of Malaysia's freshwater landscapes with major basins such as the Pahang River and Klang River supporting not only ecological connectivity across terrestrial and aquatic habitats, but also dense human populations and economic activity (Kandari *et al.* 2018; Yusmah *et al.* 2020; Locke *et al.* 2026). Freshwater ecosystems

University of the Sunshine Coast, 90 Sippy Downs Drive, Sippy Downs, Queensland 4556, Australia.
***Corresponding author: dchellaiah@usc.edu.au**

also provide critical ecosystem services, including water supply, flood and climate regulation, nutrient cycling, fisheries production, and habitat provision for a wide range of aquatic and semi-aquatic biodiversity (Luke *et al.* 2017; Chellaiah and Yule 2018b; Kandari *et al.* 2018; Philip and Tuen 2023; Locke *et al*. 2026), and are therefore central to both ecological integrity and human well-being.

Despite their ecological and socio-economic importance, freshwater ecosystems in Malaysia face increasing threats from land-use change, pollution, sedimentation, hydrological alteration, and climate variability (Mercer *et al.* 2014; Camara *et al.* 2019; Nafi *et al*. 2021). Rivers that originate in upland forested catchments flow through increasingly modified lowland regions, where agriculture, urbanisation, and industrial development exert strong pressures on water quality and hydrological regimes (Harun *et al.* 2015; Razali *et al.* 2018). As a result, many freshwater systems in Malaysia exhibit agradient of ecological conditions ranging from relatively intact headwaters to heavily impacted downstream reaches (Harun *et al.* 2014; Chellaiah and Yule 2018c).

Malaysia contains approximately 189 major river basins, of which an estimated 30% are considered polluted, reflecting growing pressures from land-use change, pollution, hydrological modification and climate variability (Furtado and Lee 2022). Since 1980, steadily increasing water demand (from 8.9 to 15.5 billion m^3), largely by large-scale rice irrigation and industrial growth, has reduced per capita water availability, eroded access to uncontaminated supplies, and sharpened pressures to meet per capita consumption targets (Ahmed *et al.* 2014). These pressures are further intensified by rapid urban expansion and infrastructure development, particularly in major growth corridors; emerging water-intensive industries such as the expansion of data centres and digital infrastructure are now introducing additional demand on freshwater resources (Deepak *et al.* 2024). Collectively, these trends signal growing risks not only to freshwater biodiversity and ecosystem functioning, but also to long-term water insecurity and socio-economic vulnerability for communities and industries along major river basins (Kandari *et al.* 2018; Yusmah *et al.* 2020).

Freshwater ecosystems remain central to national development, supporting domestic water supply, irrigated agriculture (particularly rice cultivation), fisheries, and industrial activities. As such, understanding their condition is essential for informing sustainable water resource management and biodiversity conservation strategies. This chapter provides an overview of the status of freshwater ecosystems in Malaysia and the main anthropogenic and environmental drivers shaping their condition. It summarises how land-use change and related pressures influence hydrological, physicochemical, and ecological processes, and how these changes are reflected in ecosystem functioning and biological responses to support long-term freshwater ecosystem resilience and water security.

ECOSYSTEM FUNCTIONING AND PROCESS-LEVEL CHANGES

Freshwater systems operate as interconnected networks in which water, energy, nutrients, and organisms are continuously exchanged across spatial and temporal scales (Vannote *et al.* 1980; Graça *et al.* 2005). The hydrological and ecological linkages propagate longitudinally from upland catchments to river mouths, where freshwater inputs interact with estuarine and coastal systems, forming a continuous mountain-to-coast continuum of material and energy transfer (Vannote et al. 1980; Furtado and Lee 2022). These linkages are regulated by catchment characteristics, geomorphology, riparian structure, hydrological connectivity, and biological processes, and are further shaped in tropical regions by high rainfall and seasonal monsoon dynamics (Richardson and Sato 2015; Luke *et al*. 2017; Chellaiah and Yule, 2018b; Taniwaki *et al.* 2019; Furtado and Lee 2022). During wet periods, rivers frequently expand into floodplains and wetlands, linking channels with riparian forest and lentic waters (Furtado and Lee 2022).

Forested catchments act as natural infrastructure, regulating water flow, filtering pollutants, stabilising soils, while also supplying organic matter to aquatic systems, and maintaining water availability during dry periods (Gomi *et al*. 2006; Luke *et al*. 2017; Chellaiah and Yule 2018a). Inputs such as leaf litter and deadwood form the energetic foundation of many freshwater food webs, fuelling decomposition and nutrient cycling in typically nutrient-poor tropical waters (Furtado and Lee 2022). These allochthonous subsidies sustain diverse biological communities (Chellaiah and Yule 2018b), yet their functional importance is often overlooked for aquatic management.

The widespread conversion of forested landscapes to urban spaces, infrastructure, and agriculture (especially oil palm) has altered hydrological regimes, increased sediment and nutrient runoff, and reduced the input of high-quality organic matter to aquatic systems (Chellaiah and Yule 2018a 2018b; Wilkinson *et al.* 2018). At the same time, river regulation through damming and channel modification has disrupted natural flow regimes and connectivity, while urban and industrial discharges continue to degrade water quality (Yule *et al.* 2015; Nafi *et al.* 2021).

These interactions can be conceptualised as a cascading framework linking landscape drivers to ecological outcomes (Figure 1). At the catchment scale, land-use change, hydrological modification, and climate variability act as primary drivers that alter flow regimes, sediment dynamics, and the transport and transformation of nutrients and organic matter (Luke *et al.* 2017; Chellaiah and Yule 2018a; Kandari *et al.* 2018). These physicochemical changes reshape habitat structure and resource availability within freshwater systems, influencing species composition, community structure, and functional diversity (Mercer *et al.* 2014; Chellaiah and Yule 2018a, 2018c; Philip and Tuen 2023; Rojas-Castillo *et al.* 2023a). In turn, these biological responses feed back into ecosystem processes such as primary production, decomposition, and nutrient cycling, ultimately affecting the capacity of freshwater ecosystems to deliver key ecosystem services (Chellaiah and Yule 2019).

When these systems are degraded, these interconnected processes are disrupted throughout the network (upstream to downstream coastal zones), increasing vulnerability to floods, water shortages, declining water quality, and loss of ecological integrity. These pressures are also compounded by climate change, which is projected to intensify rainfall variability, increase temperatures, and amplify the frequency and magnitude of extreme hydrological events (Tan *et al.* 2015; Fulazzaky *et al.* 2023). Collectively, these interacting stressors alter not only species composition but also core ecosystem processes, including metabolism, oxygen dynamics, and nutrient cycling.

LANDSCAPE PRESSURES AND FRESHWATER ECOLOGICAL IMPACTS

Catchment-scale drivers of change

The current status of Malaysia's freshwater ecosystems is shaped by multiple, interacting landscape-scale stressors. Habitat loss and fragmentation are primary drivers of ecological change, with rapid and widespread logging and conversion of forested landscapes to agriculture, oil palm and urban land reducing landscape connectivity and degrading freshwater habitats (Camara *et al.* 2019; Ma *et al.* 2024). In Selangor, forest land decreased between 2000 – 2020 as urbanisation and agriculture expanded, leading to a more fragmented ecological network and weakened habitat connectivity (Ma *et al.* 2024). Similarly, in the Johor river basin, forest land declined while oil palm, other agricultural, and urban land all increased between 2000 – 2015 (Hashim *et al.* 2023).

These land-use changes reduce landscape connectivity thereby disrupting the movement of organic matter, nutrients and sediments that underpin aquatic ecosystem functioning (Zaiha and Ismid 2015; Chellaiah and Yule 2018a, 2018b; Camara *et al.* 2019). Increased anthropogenic impacts in areas of intensive agricultural, industrial, and residential development are often associated with poorer downstream water quality with higher nutrients, suspended solids and organic pollution, while unfragmented tropical forest is consistently linked to better water quality (Chellaiah and Yule 2018a; Nafi *et al.* 2021).

Large scale land-use change also modifies hydrological dynamics with river regulation through damming, channelisation and drainage which alters natural flow regimes, reducing discharge variability and constraining habitat availability for aquatic biota, further compounding impacts on water discharge and quality as well as aquatic biodiversity (Chellaiah and Yule 2018c; Wilkinson *et al.* 2018; Philip and Tuen 2023). For instance, environmental flow assessments in the Kenyir Lake Basin indicate that reduced discharges and altered low-flow periods restrict habitat suitability for larger native fish species (Wahab *et al.* 2025). In wetland and peat swamp systems, drainage and land conversion disrupt seasonal flood pulses and reduce the capacity of these systems to provide key ecosystems such as flood regulation and water storage, and sustain the survival of specialised biodiversity (Sulai *et al.* 2015). Additionally, in the Selangor River, impoundments have reduced natural high flows and increased minimum flows, flattening seasonal variability and altering the timing and magnitude of flood and low-flow pulses that structure aquatic habitats (Hairan *et al.* 2021).

Catchment and land-use change in Malaysian river basins not only alters flow regimes, water quality, and aquatic communities but also reshapes landscape hydrological dynamics and flood vulnerability. Malaysia's flood exposure is closely tied to land-use change and urban growth which alter basic ecological structures such as floodplains, riparian vegetation, wetlands and river morphology, which normally store water, slow runoff and trap sediments (Ahmed *et al.* 2014; Chellaiah and Yule 2018a). When floodplains are infilled and rivers are straightened or confined by embankments, channels become shallower and narrower, so high stream flows more easily overtop banks and inundate low-lying areas (Ahmed *et al.* 2014; Kandari *et al.* 2018; Yusmah *et al.* 2020). Unsustainable development and logging accelerates erosion and sediment delivery further degrading river habitats while simultaneously raising flood levels, directly linking ecological degradation to increased nature-related risk (Ahmed *et al.* 2014). About 35% of the Klang River Basin which drains the highly urbanised Klang Valley is developed for residential, commercial, industrial and institutional uses, leading to shallower and narrower streams that discharges during storms overtop banks and flood surrounding low-lying areas (Kandari *et al.* 2018). In Kuantan, rapid urban expansion into lowland, floodplain and coastal settings has similarly increased flood exposure (Yusmah *et al.* 2020). As flood vulnerabilities increase with intense monsoonal rainfall, logging and climate change, understanding and restoring ecological processes such as sediment transport, floodplain inundation, habitat connectivity is essential for designing effective, long-term resilience strategies.

Beyond these pressures, industrial growth and the growth of water-intensive industries, including digital infrastructure such as data centres, are intensifying water abstraction and contributing to thermal and chemical stress in already degraded catchments (Ruslan *et al.* 2022; Raihan 2023). Together, these interacting drivers create complex and cumulative impacts that extend beyond simple water quality degradation, reshaping flow, habitat structure, landscape connectivity and amplifying flood risk across densely settled Malaysian river basins. As a result, conventional physicochemical indicators alone are insufficient to capture the full extent of ecosystem change, and there is a growing need to incorporate biological and functional metrics that reflect alterations in community structure, ecosystem processes, and overall ecological integrity of freshwater systems (Kuglerová *et al.* 2024).

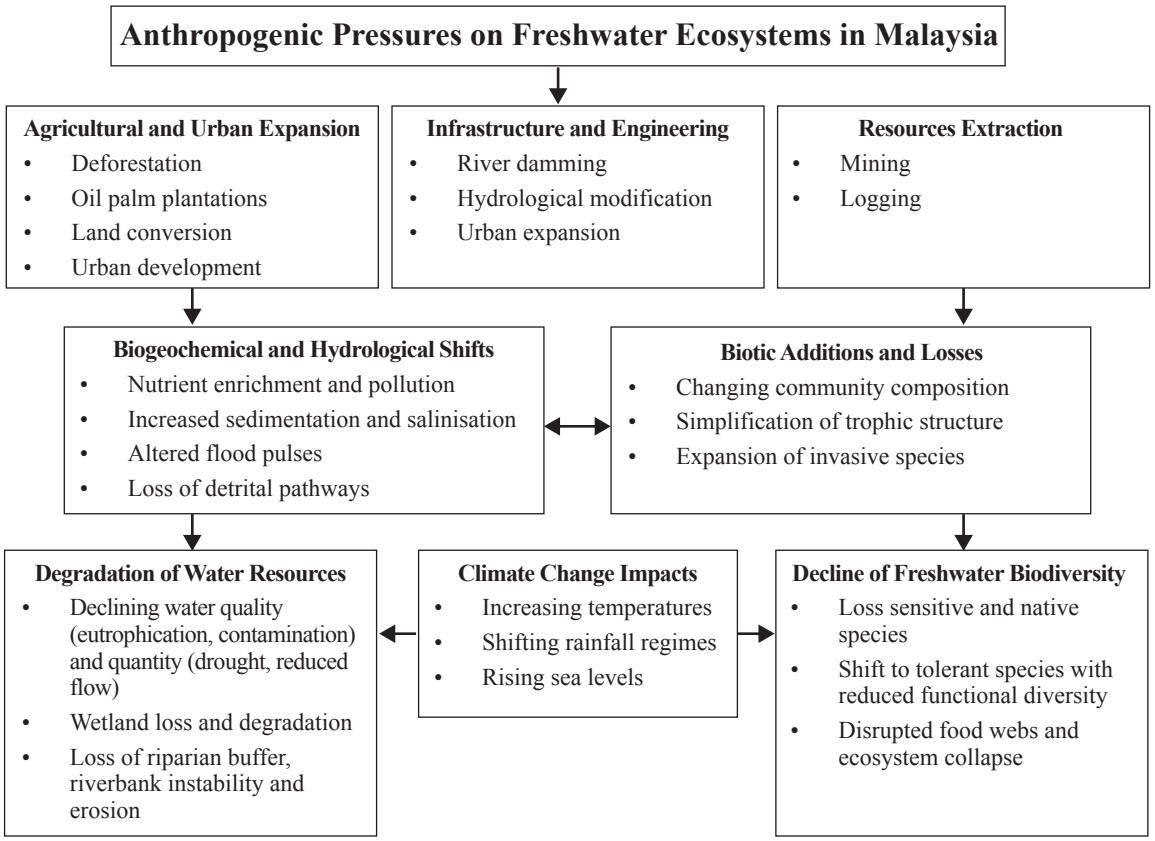


Figure 1. Anthropogenic pressures on Malaysian freshwater systems. Conceptual diagram showing the major human-driven stressors affecting freshwater ecosystems in Malaysia that drive interconnected biophysical response pathways that collectively contribute to ecosystem degradation and biodiversity loss, while interacting with broader climatic drivers that further exacerbate ecosystem-level impacts.

Hydrological and physicochemical responses

Catchment level disturbances typically alter the flow, magnitude, timing and variability of discharge, especially through reduced baseflows and modified storm responses with important consequences for habitat stability, ecological processes and aquatic biota (Hairan *et al.* 2021; Hashim *et al.* 2023). In regulated or heavily modified streams, lower low-flow conditions can constrain habitat availability for flow-specialist native fish and reduce overall habitat stability. At the same time, land-use change often increases surface runoff and shifts streamflow seasonality, with higher wet-season flows and, in some basins, reduced dry-season flows, reflecting combined climate and land-use effects (Aizam and Atkinson 2011; Tan *et al.* 2015)

These hydrological changes are frequently coupled with broader physicochemical responses, particularly increased sediment delivery, nutrient enrichment and altered water quality. Agricultural and oil palm catchments are commonly associated with elevated nutrient and major ions (N, P, Cl-, K+) derived from fertiliser and agrochemical inputs (Harun *et al*. 2014; Chellaiah and Yule 2018a; Itoh *et al*. 2023). In peat swamp systems, drainage and conversion are commonly associated with declines in dissolved oxygen, increased ammonia concentrations, elevated chemical oxygen demand, and more acidic conditions, consistent with organic loading and deteriorated water quality (Gandaseca *et al.* 2015). Constructed drainage systems in plantations on peat may also slightly raise pH relative to natural peat waters while supporting high dissolved organic carbon (DOC) from labile palm litter leachates (Azizan *et al*. 2021).

Altered landscapes further modify organic matter and sediment dynamics. Peat and plantation catchments can export substantial dissolved organic matter (DOM), with major changes in vegetation quantity and quality along major rivers such as the Kinabatangan (Harun *et al.* 2015). This is ecologically important because DOM represents a major basal energy source for aquatic food webs and contributes substantially to ecosystem metabolism. Consequently, land-use change, wetland drainage, channel modification and flow regulation can alter both the quantity and quality of DOM entering freshwater systems, with downstream effects on microbial production, carbon cycling and trophic pathways. Elevated DOC inputs from plantation drains signifies enhanced leaching of labile carbon, which can stimulate microbial respiration and increase oxygen demand, and shift food-web and biogeochemical functioning (Chellaiah and Yule 2018b; Azizan *et al.* 2021). In some cases, conventional metrics like water nutrient levels differ little between forest and plantation streams, implying that shifts in organic matter character and habitat structure may drive much of the ecological response (Luke *et al.* 2017; Chellaiah and Yule 2019).

Salinisation represents an additional physicochemical stressor arising from both natural processes and human activities and is increasingly recognised as a form of land and water degradation (Adnan *et al.* 2021; Izam *et al.* 2021). Salinisation pressures are most pronounced in coastal zones in west Peninsular Malaysia, east Sabah, and the deltas and coasts of Sarawak (Azalina *et al.* 2023; Izam *et al.* 2021) and in intensively farmed uplands such as Cameron Highlands, where high fertilizer and manure inputs, plastic rain-shelter agriculture and intensive land use promote salt accumulation and transport to freshwater bodies (Hashim 2003; Razali *et al.* 2018; Izam *et al.* 2021). Elevated salinity can reduce freshwater species richness and functional diversity, alters trophic pathways by limiting food resources, and promote density stratification, contributing to biodiversity losses in highly saline areas (Mausbach and Dzialowski 2020; Azalina *et al.* 2023). In the Juru River, Penang, a highly degraded system impacted by manufacturing, timber processing, rubber industries, urbanisation, untreated domestic wastewater, and animal waste, the richness and diversity of plankton, fish, and macrobenthos richness and diversity indices were strongly associated with salinity, temperature, total suspended solids (TSS), biochemical oxygen demand (BOD) and pH, underscoring the combined influence of multiple physicochemical stressors on aquatic community structure (Azalina *et al.* 2023).

Hydrological disturbance also enhances erosion, suspended sediment loads and turbidity through deforestation, slope agriculture, and plantation development. In both highland and lowland Malaysian catchments, sediment and chemical oxygen demand (COD) peaks are often associated with wet-season storms, reflecting intensified surface runoff and bank or road erosion (Harun *et al.* 2014; Luke *et al.* 2017; Razali *et al.* 2018). Multi-catchment studies in Sabah further show that logging and oil palm reduce canopy cover, increase sediment benthic cover and simplify channel structure, with hydromorphological impacts persisting more than a decade after logging (Walsh *et al.* 2016; Luke *et al.* 2017). These coupled hydrological and physicochemical changes due to catchment disturbance alter modifying habitat availability, disrupting biogeochemical cycles, and reducing the capacity of aquatic systems to sustain biodiversity and ecosystem services.

Biological responses and community restructuring

Integrated changes in flow regimes, sediment transport, and water and carbon chemistry due to catchment disturbances, constrain habitat suitability and oxygen availability, and nutrient delivery for aquatic organisms, resulting in widespread degradation of biological integrity (Yule *et al.* 2015; Chellaiah and Yule 2018b). In response, aquatic communities typically shift from diverse assemblages dominated by sensitive taxa to simplified systems characterised by smaller numbers of disturbance-tolerant species. Sensitive taxa are frequently lost, while tolerant groups become dominant, reflecting altered habitat structure, sediment regimes, and detrital inputs (Mercer *et al.* 2014; Chellaiah and Yule 2018c; Rojas-Castillo

et al. 2023b). Streams within altered landscapes consistently show reduced abundance, taxonomic richness, and diversity of aquatic biodiversity compared to forested systems, alongside marked shifts in community composition (Chellaiah and Yule 2018c, Ishak *et al.* 2021; Rojas-Castillo *et al.* 2023b). This restructuring reflects loss of sensitive taxa and increased dominance of tolerant groups, driven by altered habitat structure, sediment regimes, and detrital inputs (Mercer *et al*. 2014; Chellaiah and Yule 2018c; Rojas-Castillo *et al.* 2023b).

Macroinvertebrate and semi-aquatic insect communities are particularly responsive to land-use change. In Sabah, Chellaiah and Yule (2018c) reported that overall species richness and diversity of macroinvertebrates were not always significantly reduced in oil palm streams, community composition shifted markedly, suggesting functional changes within these assemblages. In Sarawak, rainforest streams support high macroinvertebrate abundance, richness and diversity, while two entire insect orders (Coleoptera and Hemiptera) were absent from oil palm streams, indicating local taxonomic loss and community reassembly (Mercer *et al.* 2014). Semi-aquatic bugs likewise show 2 to 6-fold declines in abundance and richness from old-growth forest through logged forest to oil palm, with narrow buffer strips providing limited mitigation (Harianja *et al*. 2024a, 2024b).

Along polluted tropical rivers, odonate assemblages become dominated by tolerant damselflies, with adult richness and composition tightly linked to dissolved oxygen, pH, temperature, and riparian vegetation (Abdul *et al.* 2017; Ishak *et al.* 2021). These patterns demonstrate how microhabitat and pollution gradients restructure communities even without large differences in basic water chemistry among reaches, with subsequent implications on secondary production, trophic interactions, and nutrient cycling.

Fish assemblages similarly reflect strong ecological consequences due to anthropogenic stress. Across Sarawak and Sabah, conversion of forest to logged forest and oil palm headwaters reduced fish species richness and functional richness, indicating erosion of ecological roles despite apparently intact fish standing stocks (Wilkinson *et al*. 2018; Philip and Tuen 2023). Any departure from protected forest, regardless of disturbance intensity (including twice-logged and salvage-logged forests), results in persistent impacts on fish communities, with clear losses in native species and functional roles and no evidence of recovery along more intensively modified land-use stages, indicating sustained reductions in fish community diversity following disturbance (Wilkinson *et al.* 2018). Comparable patterns are observed in Peninsular Malaysia, where conversion to mixed-use and oil-palm landscapes substantially reduced native *Macrobrachium* shrimp richness while increasing non-native shrimp abundance, indicating degraded habitat quality and a shift toward less diverse, more invasion-dominated assemblages (Gan *et al*. 2023).

Urbanisation, coastal reclamation, and dredging and associated pollution further intensify these pressures along Malaysia's coasts, modifying habitat structure, reducing fish diversity, and favouring disturbance-tolerant and often non-native species (Hamid *et al.* 2023). In peatland drainage systems converted to oil palm plantations, fish communities are similarly dominated by disturbance-tolerant species, with elevated DOC, temperature and electrical conductivity strongly shaping community composition and growth (Azizan *et al*. 2021).

Additionally, harmful algal blooms represent an emerging and escalating ecological pressure in Malaysia, with blooms becoming more frequent, severe, and including the emergence of previously unrecorded species (Teen *et al*. 2012; Izam *et al*. 2021). Driven by nutrient enrichment from industrialisation, urbanisation, intensive agriculture and domestic effluents, these events are further amplified by climate-driven warming, acidification and deoxygenation of freshwater systems. Algal blooms reduce oxygen and habitat availability

and decrease community evenness, resulting in subsequent declines in aquatic biodiversity (Teen *et al.* 2012). Since 2002, recurrent large blooms have caused recurrent mass fish kills and substantial economic losses, particularly in aquaculture areas such as Penang, highlighting harmful algal blooms as a major and growing threat to freshwater ecosystem health as well as water and food security (Teen *et al.* 2012).

Interacting anthropogenic pressures including deforestation, plantation expansion, urbanisation, industrial water use, and peatland conversion, drive combined hydrological and biogeochemical changes such as changes in runoff, organic matter, nutrients and sediments. These changes propagate from headwaters through river networks to coastal systems, linking upstream land-use change to downstream aquatic degradation. Resulting losses in taxonomic and functional diversity reduce ecosystem functioning across the catchments by disrupting trophic interactions, altering energy transfer pathways, and weakening processes such as nutrient cycling, organic matter breakdown, and secondary production, ultimately reducing ecosystem resilience and stability (Chellaiah and Yule 2019). Collectively, these patterns indicate that biological metrics in terms of composition, functional groups, sensitive-taxa loss can detect and reveal ecosystem degradation even when routine water chemical measurements show minimal differences, emphasising the importance of habitat structure, flow regime, and resource availability in shaping and maintaining healthy freshwater biota.

STATUS AND TRENDS OF FRESHWATER SYSTEMS IN MALAYSIA

Most national and basin-scale assessments rely on Water Quality Index (WQI) and a narrow suite of physicochemical parameters, with limited incorporation of biological or habitat-based indicators (e.g., Malaysian River Integrity Index (MyRII), riparian/large woody debris studies). Overall, Malaysia's freshwater ecosystems exhibit a clear pattern of moderate to degraded condition, with relatively intact water quality in headwater regions but consistent deterioration downstream in intensively developed basins (Goi 2020). Recent trend analyses point to stagnation or worsening in several major systems (Ruhayu *et al.* 2015; Fitri *et al.* 2020). National monitoring data indicate that only around half of rivers can be classified as clean, while the remainder are slightly polluted or polluted, reflecting a long-term decline in overall water quality (Ruhayu *et al.* 2015; Goi 2020; Baharudin *et al.* 2021). Most rivers now fall within intermediate condition ranges, with more severely degraded reaches occurring in urbanised and agricultural lowlands (Fitri *et al.* 2020; Goi 2020).

This upstream-downstream gradient is evident across multiple basins, including the Johor, Langat, and Terengganu rivers, where nutrient loads, suspended sediments, and organic pollution increase downstream (Awal *et al.* 2015; Amir *et al.* 2024; Zaiha *et al.* 2025). Several key basins, such as the Kelantan, Klang, Langat, and Selangor systems, show evidence of worsening trends over time, driven by expanding urbanisation, agriculture, industrial activity, and sewage inputs (Fitri *et al.* 2020; Baharudin *et al.* 2021; Amir *et al.* 2024). Short-term improvements during periods of reduced human activity demonstrate the responsiveness of river systems to reduced pressures (Goi 2020), but overall trajectories suggest stagnation or continued degradation.

Current reporting frameworks therefore primarily capture pollution status rather than broader ecological conditions or resilience. Many rivers classified as "clean" on the basis of chemical thresholds may already exhibit simplified food webs, altered flow-dependent biota, and impaired habitat structure that are invisible to conventional metrics (Chellaiah and Yule 2018c; Azalina *et al.* 2023). Moving beyond pollution control will require routine use of ecosystem-level indicators such as macroinvertebrate indices, fish assemblages, riparian and large woody debris condition, organic matter and flow to safeguard ecological integrity and long-term freshwater ecosystem services. An example is the Malaysian River

Integrity Index (MyRII), an integrated ecological framework combining biological (i.e., Ichthyofaunal Quality Index based on fish and diversity metrics), chemical (Water Quality Index), and physical (River Physical Quality Index including channel and bank stability, riparian condition, canopy cover, pool and riffle availability) indicators to better capture true ecosystem condition beyond conventional water quality assessments, developed for the Malaysian context (Ng *et al.* 2020).

FRESHWATER ECOSYSTEM MANAGEMENT IMPLICATIONS AND WAYS FORWARD

Governance, stakeholders and legal gaps

The effectiveness of freshwater management in Malaysia is constrained by fragmented governance, overlapping federal-state responsibilities, and sectoral approaches that limit integrated river basin management (Rahman and Khalid 2009; Ideres *et al.* 2023). Although legal tools exist such as buffer requirements in drinking-water catchments and state enactments on riparian protection, compliance is often limited (Ligtermoet *et al.* 2009; Chellaiah and Yule 2018a). For example, Sarawak government policy requires buffer widths of 550 m of natural vegetation to be retained along all streams and rivers in drinking water supply catchments, however most of the sites surveyed by Ligtermoet *et al.* (2009) were not meeting guideline widths, especially in logging areas and plantations. While in Sabah, legal requirements for 20 m riparian reserves along larger rivers, and similarly compliance remains uneven (Chellaiah and Yule 2018a; Luke *et al.* 2019).

Certification and sustainability frameworks in the palm oil sector (e.g., RSPO, MSPO)[a] can help embed riparian buffers, reduce agrochemical use and maintain HCV set-asides that provide important ecosystem services, however certification alone, without robust enforcement and complementary national policies, does not fully prevent forest loss or guarantee strong biodiversity and water-quality outcomes (Majid *et al.* 2021; Abidin *et al.* 2024). Strengthening freshwater protection therefore requires not only clearer and better enforced regulations, but also coordinated catchment-scale governance that shifts from reactive and preventative measures to catchment-based conservation and management.

Forest conservation, riparian protection and catchment planning

Effective freshwater protection in Malaysia requires aligning land-use planning, forest conservation, hydrology, and governance with biodiversity and water-quality goals. Catchment-level management is required considering changes to catchment scale forest cover, channel morphology, and flow regimes to re-establish detrital inputs and physical habitat heterogeneity characteristic of forest streams (Luke *et al.* 2017). Maintaining or restoring forested catchments and riparian buffers is therefore a central management strategy (Chellaiah and Yule 2018c). These areas regulate hydrological processes, reduce surface runoff and erosion, filter nutrients and pollutants, and sustain the supply of organic matter that underpins aquatic food webs (Richardson *et al.* 2012; Sweeney and Newbold 2014). They also function as a natural infrastructure by stabilising stream banks, moderating water temperatures through shading, and maintaining connectivity between terrestrial and aquatic ecosystems (Richardson *et al.* 2012).

Empirical evidence from Malaysia and similar tropical systems demonstrates the consequences of riparian and catchment degradation. Conversion to oil palm and logging produces warmer, shallower, more sediment-rich streams with reduced structural complexity and altered nutrient regimes (Mercer *et al.* 2014; Luke *et al.* 2017; Chellaiah and Yule 2018a),

[a] RSPO – Roundtable on Sustainable Palm Oil, an international certification standard for sustainable palm oil production. MSPO – Malaysian Sustainable Palm Oil, Malaysia's national certification standard for sustainable palm oil production.

demonstrating how changes in landscape management can rapidly erode the healthy functioning of freshwater ecosystems on which long-term water security depends. Similarly, in the Bentong River, water quality deteriorated where urban and agricultural patches were fragmented and interspersed, whereas intact forest patches acted as strong buffers, reducing nutrient and organic pollution and serving as indicators of high water quality (Nafi *et al.* 2021).

Recommended measures include establishing and widening riparian buffer zones, sustaining water and riparian connectivity, limiting land-use compactness, and maintaining native, unfragmented forest cover to filter sediments and nutrients and moderate hydrological extremes (Luke *et al.* 2017; Chellaiah and Yule 2018a; Nafi *et al.* 2021; Philip and Tuen 2023). Evidence supports riparian protection as a primary mitigation, but outcomes depend on buffer attributes and broader catchment management. In oil palm plantations in Sabah, streams bordered by intact native-forest buffers had cooler water, lower light levels, more in-stream litter, higher bank stability and better water quality than streams with degraded or no buffers, while channels without any riparian vegetation showed greatly elevated temperatures (up to 4 – 7 °C warmer than forest), higher bank erosion levels and nutrient enrichment (Luke *et al.* 2017; Chellaiah and Yule 2018a). This indicates that relying on narrow, low-quality buffer strips is insufficient and high-quality, forested riparian buffers are needed to restore more natural stream physical and chemical conditions, particularly in agricultural landscapes (Chellaiah and Yule 2018a, 2018c).

Riparian protection must therefore also consider buffer quality, as narrow buffers provide only limited ecological benefit and structurally intact, forested riparian zones are required to deliver effective regulation of stream temperature, sediment inputs, and nutrient loading (Chellaiah and Yule 2018a; Lind *et al.* 2019). Taken together, these findings indicate that catchment and riparian restoration must be embedded within broader catchment-scaleplanning and not treated as a standalone mitigation measure. Maintaining contiguous forest cover including riparian corridors and upland high conservation value (HCV) areas is therefore essential for stabilising hydrological regimes and sustaining long-term freshwater ecosystem function in managed tropical landscapes.

Targeted management metrics

Effective protection and management of freshwater ecosystems require clearly defined, measurable metrics that link environmental change to management action. Given increasing resource vulnerabilities and associated economic risks from freshwater ecosystem degradation, management frameworks must shift towards locally relevant, catchment-specific targets that integrate forest cover, riparian buffer width and condition, water quality thresholds, and flow regime characteristics (Kuglerová *et al*. 2024). Vague or non-operational targets often result in limited implementation, reducing accountability and poor monitoring of ecological recovery. Without such quantifiable targets, it is challenging to credibly demonstrate progress towards resilient freshwater ecosystems and secure water resources.

Relevant biological and functional indicators include ichthyofauna-based indices, fish functional groups, and macroinvertebrate diversity, alongside water-quality metrics such as the Water Quality Index (WQII) and dissolved organic matter character. These are complemented by habitat-based assessments such as the Riparian Quality Index (RPQI) and hydrological metrics including baseflow stability and flow variability, which together provide a more integrated measure of ecosystem condition than nutrient concentrations alone.

However, persistent gaps continue to constrain implementation, including inconsistent designation and protection of water-supply catchments, weak integration between land-use planning and water management, insufficient monitoring and enforcement of buffer and pollution standards, and fragmented institutional responsibilities that slow effective implementation of Integrated Water Resources Management (IWRM) and Integrated River

Basin Management (IRBM) approaches. Moving forward, freshwater management must therefore shift from guideline-based approaches to coordinated, enforceable, and metrics -driven catchment management that links land use, hydrology, riparian and ecological response to safeguard biodiversity and long-term water security in Malaysia.

REFERENCES

Abdul, N.H., Rawi, C.S.M., Ahmad, A.B.U.H. and Al-Shami, S.A. 2017. Effect of environmental disturbances on Odonata assemblages along a tropical polluted river. *Ekológia Bratislava)* 36(4): 388–402. https://doi.org/10.1515/eko-2017-0030

Abidin, Z.M., Fatah, A.F., Noor, W. and Aris, N. 2024. A review on adoption of the Malaysian Sustainable Palm Oil (MSPO) certification scheme. *IOP Conference Series: Earth and Environmental Science* 1397: 012035. https://doi.org/10.1088/1755-1315/1397/1/012035

Adnan, S.S., Isabella, J. and Gisen, A. 2021. Revisiting the salinity condition in the Kuantan estuary. *Physics and Chemistry of the Earth* 124(P2): 103066. https://doi.org/10.1016/j.pce.2021.103066

Ahmed, F., Siwar, C. and Begum, R. A. 2014. Water resources in Malaysia: Issues and challenges. *Journal of Food, Agriculture and Environment* 12(2): 1100–1104.

Aizam, N. and Atkinson, P.M. 2011. Exploring the impact of climate and land use changes on streamflow trends in a monsoon catchment. *International Journal of Climatology* 31: 815–831. https://doi.org/10.1002/joc.2112

Amir, M., Chia, T., Izzat, M., Ma, N., Chala, G.T. and Fariha, N. 2024. Water quality assessment in wet season of Langat River, Selangor, Malaysia. *Jurnal Kejuruteraan* 36(6): 2683–2692.

Awal, K., Kualiti, I. and Sungai, L. 2015. A preliminary study of water quality index in Terengganu River Basin, Malaysia. *Sains Malaysiana* 44(1): 67–73.

Azalina, N., Feisal, S., Haziqah, N., Firdaus, M., Sani, A., Khairulnisa, D., Ahmad, A. *et al.* 2023. Anthropogenic disturbance of aquatic biodiversity and water quality of an urban river in Penang, Malaysia. *Water Science and Engineering* 16(3): 234–242. https://doi.org/10.1016/j.wse.2023.01.003

Azizan, S.N.F., Huynh, M.N., Padfield, R., Evers, S., Kosuke, N. and Hara, H. 2021. The effects of oil palm plantation on fish composition in Selangor Peatlands, Malaysia. *Journal of Advanced Research in Applied Sciences and Engineering Technology* 25(1): 19–36. https://doi.org/10.37934/araset.25.1.1936

Baharudin, F., Kassim, J., Nurulhuda, S., Imran, M. and Ab, M. 2021. Water Quality Index (WQI) classification of rivers in agriculture and aquaculture catchments. *IOP Conference Series: Earth and Environmental Science* 646: 012023. https://doi.org/10.1088/1755-1315/646/1/012023

Camara, M., Jamil, N. R., Fikri, A. and Abdullah, B. 2019. Impact of land uses on water quality in Malaysia: a review. *Ecological Processes* 8: 10. https://doi.org/https://doi.org/10.1186/s13717-019-0164-x

Chellaiah, D. and Yule, C.M. 2018a. Effect of riparian management on stream morphometry and water quality in oil palm plantations in Borneo. *Limnologica* 69: 72–80. https://doi.org/10.1016/j.limno.2017.11.007

Chellaiah, D. and Yule, C.M. 2018b. Litter decomposition is driven by microbes and is more influenced by litter quality than environmental conditions in oil palm streams with different riparian types. *Aquatic Sciences* 80(4): 1–11. https://doi.org/10.1007/s00027-018-0595-y

Chellaiah, D. and Yule, C.M. 2018c. Riparian buffers mitigate impacts of oil palm plantations on aquatic macroinvertebrate community structure in tropical streams of Borneo. *Ecological Indicators* 95: 53–62. https://doi.org/10.1016/j.ecolind.2018.07.025

Chellaiah, D. and Yule, C.M. 2019. Litter quality influences bacterial communities more strongly than changes in riparian buffer quality in oil palm streams. *Aquatic Microbial Ecology* 83: 167–179. https://doi.org/10.3354/ame01909

Deepak, T.J., Norashikin, A.K., Goyal, S.B. and Rajawat, A.S., 2024, December. Digital transformation for the management of water resources in Malaysia. In *International Conference on Innovation & Entrepreneurship in Computing, Engineering & Science Education (InvENT 2024)*, pp. 150–159. Dordrecht: Atlantis Press.

Fitri, A., Maulud, K.N.A., Pratiwi, D., Phelia, A., Rossi, F. and Zuhairi, N.U.R.Z. 2020. Trend of water quality status in Kelantan River downstream, Peninsular Malaysia. *Jurnal Rekayasa Sipil* 16(3): 178–184.

Fulazzaky, M.A., Syafiuddin, A., Muda, K., Yazdi, A., Zulkifli, M., Hisham, N. and Ghani, A. 2023. A review of the management of water resources in Malaysia facing climate change. *Environmental Science and Pollution Research* 30(58): 121865–121880. https://doi.org/10.1007/s11356-023-30967-x

Furtado, J.I., and Lee, P.K. 2022. Ecological challenges to freshwater conservation in Malaysia. *Malayan Nature Journal* 74(1): 109–145.

Gan, L.X., Tan, C.L.Y., Yeo, D.C.J. and Ahmad, A.B. 2023. Forest conversion adversely affects native *Macrobrachium* shrimp assemblages in tropical Malaysian streams. *Aquatic Conservation: Marine and Freshwater Ecosystems* 33(1): 89–101. https://doi.org/10.1002/aqc.3902

Gandaseca, S., Rosli, N., Idris, M.H., Ahmed, O.H., Mustapha, A. and Pazi, M. 2015. Effects of converting tropical peat swamp forest into oil palm plantation on water quality. *American Journal of Applied Sciences Original* 12(8): 525–532. https://doi.org/10.3844/ajassp.2015.525.532

Goi, C.L. 2020. The river water quality before and during the Movement Control Order (MCO) in Malaysia. *Case Studies in Chemical and Environmental Engineering* 2: 100027. https://doi.org/10.1016/j.cscee.2020.100027

Gomi, T., Sidle, R.C., Noguchi, S., Negishi, J.N., Nik, A.R. and Sasaki, S. 2006. Sediment and wood accumulations in humid tropical headwater streams: Effects of logging and riparian buffers. *Forest Ecology and Management* 224(1–2): 166–175. https://doi.org/10.1016/j.foreco.2005.12.016

Graça, M.A.S., Bärlocher, F. and Gessner, M.O. 2005. *Methods to study litter decomposition: A practical guide*. Dordrecht: Springer Dordrecht. https://doi.org/10.1007/1-40203466-0

Hairan, M.H., Jamil, N.R., Noor, M., Azmai, A., Looi, L.J. and Camara, M. 2021. Environmental flow assessment of a tropical river system using hydrological index methods. *Water* 13(18): 2477. https://doi.org/10.3390/w13182477

Hamid, M.A., Sah, A.S.R.M., Idris, I., Nor, S.A.M., Ghaffar, M.A., Peng, C.N.S. and Husin, S.M. 2023. The diversity and distribution of fish at the port and urbanized areas of Pulau Pinang Strait, Malaysia. *Sains Malaysiana* 52(4): 1047–1058. http://doi.org/10.17576/jsm-2023-5204-02

Harianja, M.F., Luke, S.H., Barclay, H., Chey, V.K., Aldridge, D.C., Foster, W.A. and Turner, E.C. 2024a. The impacts of within-stream physical structure and riparian buffer strips on semi-aquatic bugs in Southeast Asian oil palm. *Frontiers in Forests and Global Change* 6: 1203513. https://doi.org/10.3389/ffgc.2023.1203513

Harianja, M.F., Turner, E.C., Barclay, H., Chey, V.K., Aldridge, D.C., Foster, W.A., and Luke, S.H. 2024b. The effects of land-use change on semi-aquatic bugs (Gerromorpha, Hemiptera) in rainforest streams in Sabah, Malaysia. *Freshwater Biology* 69(4): 556–572. https://doi.org/10.1111/fwb.14229

Harun, S., Dambul, R., Abdullah, M.H. and Mohamed, M. 2014. Spatial and seasonal variations in surface water quality of the Lower Kinabatangan River Catchment, Sabah, Malaysia. *Journal of Tropical Biology and Conservation* 11: 117–131.

Harun, S., Baker, A., Bradley, C., Pinay, G., Boomer, I. and Hamilton, L. R. 2015. Characterisation of dissolved organic matter in the Lower Kinabatangan River, Sabah, Malaysia. *Hydrology Research* 4(4): 18195. https://doi.org/10.1016/j.scitotenv.2023.162062

Hashim, G.M. 2003. Salt-affected soils of Malaysia. In *Proceedings of the Workshop on Soil Science in Malaysia towards 2020*, A. Yusoff, Z. Malik and M.Z. Ghazali (Eds.). Kuala Lumpur: Malaysia Society of Soil Science.

Hashim, M., Baiya, B., Mahmud, M.R., Sani, D.A., Chindo, M.M., Leong, T.M. and Pour, A.B. 2023. Analysis of water yield changes in the Johor River basin, Peninsular Malaysia using remote sensing satellite imagery. *Remote Sensing* 15: 3432. https://doi.org/10.3390/rs15133432

Ideres, K.M., Adam, A., Tan, S. and Ling, Y.E.N. 2023. The legal framework for water pollution in Malaysia: An analysis. *Russian Law Journal* 11(3): 2191–2205.

Ishak, M., Norhisham, A. R., Thomas, S.M., Nurhidayu, S., Ghazali, A., Azhar, B. and Silva, K. 2021. Physicochemical properties as driver of Odonata diversity in oil palm waterways. *Frontiers in Forests and Global Change* 4: 613064. https://doi.org/10.3389/ffgc.2021.613064

Itoh, M., Iizuka, K., Kosugi, Y., Lion, M. and Shiodera, S. 2023. Assessing the changes in river water quality across a land-use change (forest to oil palm plantation) in Peninsular Malaysia using the stable isotopes of water and nitrate. *Science of the Total Environment* 859: 160319. https://doi.org/10.1016/j.scitotenv.2022.160319

Izam, A.N., Azman, S.N., Jonit, E., Hanim, S.M., Khairul, D.C., Abidin, M.K.Z. and Farinordin, F.A. 2021. Freshwater ecosystem: A short review of threats and mitigations in Malaysia. *GADING Journal of Science and Technology* 4(1): 109–117.

Kandari, A.N.P., Saudi, M.S.A., Chyang, P.J., Kamarudin, A.K.M., Saad, M.H.M., Azid, A., Saudi, N.S.M. and Mahmud, M. 2018. Flood risk pattern recognition analysis in Klang River basin. *International Journal of Engineering and Technology* 7: 86–90.

Kuglerová, L., Muotka, T., Chellaiah, D., Jyväsjärvi, J., and Richardson, J.S. 2024. Protecting our streams by defining measurable targets for riparian management in a forestry context. *Journal of Applied Ecology* 61: 206–214. https://doi.org/10.1111/1365-2664.14549

Ligtermoet, E., Chambers, J.M., Kobryn, H.T. and Davis, J. 2009. Determining the extent and condition of riparian zones in drinking water supply catchments in Sarawak, Malaysia. *Water Science and Technology: Water Supply* 9(5): 517–531. https://doi.org/10.2166/ws.2009.580

Lind, L., Hasselquist, E.M. and Laudon, H. 2019. Towards ecologically functional riparian zones: A metaanalysis to develop guidelines for protecting ecosystem functions and biodiversity in agricultural landscapes. *Journal of Environmental Management* 249: 109391. https://doi.org/10.1016/j.jenvman.2019.109391

Locke, H., Rockström, J., Plowright, R.K., Laffoley, D., Little Bear, L., Peres, C.A., Wei, F. *et al.* 2026. Nature Positive: halting and reversing biodiversity loss toward restoring Earth system stability. *Frontiers in Science* 4: 1609998. https://doi.org/10.3389/fsci.2026.1609998

Luke, S.H., Barclay, H., Bidin, K., Chey, V.K., Ewers, R.M., Foster, W.A., Nainar, A. *et al.* 2017. The effects of catchment and riparian forest quality on stream environmental conditions across a tropical rainforest and oil palm landscape in Malaysian Borneo. *Ecohydrology* 10(4): e1827. https://doi.org/10.1002/eco.1827

Luke, S.H., Slade, E.M., Gray, C.L., Annammala, K.V., Drewer, J., Williamson, J., Agama, A.L. *et al.* 2019. Riparian buffers in tropical agriculture: Scientific support, effectiveness and directions for policy. *Journal of Applied Ecology* 56(1): 85–92. https://doi.org/10.1111/1365-2664.13280

Ma, T.Z., Teh, B.T. and Kho, M.Y. 2024. Land use change and ecological network in rapid urban growth region in Selangor region, Malaysia. *Scientific Reports* 14: 16470. https://doi.org/10.1038/s41598-02467294-1

Majid, N.A., Ramli, Z. and Sum, S. 2021. Sustainable palm oil certification scheme frameworks and impacts: A systematic literature review. *Sustainability* 13: 3263. https://doi.org/10.3390/su13063263

Mausbach, W.E. and Dzialowski, A.R. 2020. Salinisation reduces biodiversity in neighbouring freshwater patches in experimental metacommunities. *Freshwater Biology* 65: 592–604. https://doi.org/10.1111/fwb.13457

Mercer, E.V, Mercer, E.V, Mercer, T.G. and Sayok, A. K. 2014. Effects of forest conversions to oil palm plantations on freshwater macroinvertebrates: a case study from Sarawak , Malaysia. *Journal of Land Use Science* 9(3): 260–277. https://doi.org/10.1080/1747423X.2013.786149

Nafi, Z., Rohaizah, N. and Zaharin, A. 2021. Spatial variation impact of landscape patterns and land use on water quality across an urbanized watershed in Bentong, Malaysia. *Ecological Indicators* 122: 107254. https://doi.org/10.1016/j.ecolind.2020.107254

Ng, C.K., Ooi, P.A., Wong, W. and Khoo, G. 2020. First development of the Malaysian River Integrity Index (MyRII) based on biological, chemical and physical multi-metrics. *Journal of Environmental Management* 255: 109829. https://doi.org/10.1016/j.jenvman.2019.109829

Philip, S. and Tuen, A.A. 2023. Fish communities of tropical headwater streams under multiple land-use influence. *Borneo Journal of Resource Science and Technology* 13(1): 62–71.

Rahman, S.A. and Khalid, R.M. 2009. Water resource management in Malaysia: legal issues and challenges. *International Journal of Sustainable Development and Planning* 4(3): 258–264. https://doi.org/10.2495/SDP-V4-N3-258-264

Raihan, A. 2023. The economic impact of water supply disruption from the Selangor River, Malaysia. *Blue-Green Systems* 5(2): 102–120. https://doi.org/10.2166/bgs.2023.031

Razali, A., Norkhadijah, S., Ismail, S., Awang, S., Praveena, S.M. and Zainal Abidin, E. 2018. Land use change in highland area and its impact on river water quality: a review of case studies in Malaysia. *Ecological Processes* 7: 19. https://doi.org/10.1186/s13717-018-0126-8

Richardson, J.S., Naiman, R.J. and Bisson, P.A. 2012. How did fixed-width buffers become standard practice for protecting freshwaters and their riparian areas from forest harvest practices? *Freshwater Science* 31(1): 232–238. https://doi.org/10.1899/11-031.1

Richardson, J.S. and Sato, T. 2015. Resource subsidy flows across freshwater–terrestrial boundaries and influence on processes linking adjacent ecosystems. *Ecohydrology* 8(8): 406–415. https://doi.org/10.1002/eco.1488

Rojas-Castillo, O.A., Rohas, S.K., Juen, L., de Assis Montag, L.F., Carvalho, F.G., Mendes, T.P., Chua, K.W.J. *et al.* 2023a. Meta-analysis contrasting freshwater biodiversity in forests and oil palm plantations with and without riparian buffers. *Conservation Biology* 38(1): e14172. https://doi.org/10.1111/cobi.14172

Rojas-Castillo, O.A., Kepfer-Rojas, S., Vargas, N. and Jacobsen, D. 2023b. Forest buffer-strips mitigate the negative impact of oil palm plantations on stream communities. *Science of the Total Environment* 873: 162259. https://doi.org/10.1016/j.scitotenv.2023.162259

Ruhayu, M.-R.N., An, Y.J. and Khairun, Y. 2015. Detection of river pollution using water quality index: A case study of tropical rivers in Penang Island, Malaysia. *Open Access Library Journal* 2: e1209. https://doi.org/10.4236/oalib.1101209

Ruslan, N.I., Abbas, A.R., Salleh, M.S., Alias, M. and Rahim, N. 2022. Future outlook of fresh water supply and demand in Selangor. *IOP Conference Series: Earth and Environmental Science* 1102: 012044. https://doi.org/10.1088/1755-1315/1102/1/012044

Sulai, P., Nurhidayu, S., Aziz, N., Zakaria, M., Barclay, H. and Azhar, B. 2015. Effects of water quality in oil palm production landscapes on tropical waterbirds in Peninsular Malaysia. *Ecological Research* 30: 941–949. https://doi.org/10.1007/s11284-015-1297-8

Sweeney, B.W. and Newbold, J.D. 2014. Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: A literature review. *Journal of the American Water Resources Association* 50(3): 560–584. https://doi.org/10.1111/jawr.12203

Tan, M.L., Ibrahim, A.L., Yusop, Z., Duan, Z. and Ling, L. 2015. Impacts of land-use and climate variability on hydrological components in the Johor River basin, Malaysia. *Hydrological Sciences Journal* 60(5): 873–889. https://doi.org/10.1080/02626667.2014.967246

Taniwaki, R.H., Cassiano, C.C., Fransozi, A.A., Vásquez, K.V., Posada, R.G., Velásquez, G.V. and Ferraz, S.F.B. 2019. Effects of land-use changes on structural characteristics of tropical high-altitude Andean headwater streams. *Limnologica* 74: 1–7. https://doi.org/10.1016/j.limno.2018.10.002

Teen, L.P., Gires, U. and Pin, L.C. 2012. Harmful algal blooms in Malaysian waters. *Sains Malaysiana* 41(12): 1509–1515.

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R. and Cushing, C.E. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37(1): 130–137. https://doi.org/10.1139/f80-017

Wahab, N.A., Kamarudin, M.A.K., Sukki, F.M., Ata, F.M., Rohalin, W.M., and Breckwoldt, A. 2025. Ecohydrological indicators and Environmental Flow Assessment (EFA) in the inlet and outlet reaches of the Kenyir. *Malaysian Journal of Fundamental and Applied Sciences* 21: 2492–2512.

Walsh, R., Nainar, A., Bidin, K.B., Higton, S., Annammala, K., Blake, W., Luke, S. *et al.* 2016. Hydrogeomorphological and water quality impacts of oil palm conversion and logging in Sabah, Malaysian Borneo: a multi-catchment approach. Presented at the *EGU General Assembly 2016*, Vienna, Austria, 17-22 April, 2016. EGU2016-18195.

Wilkinson, C.L., Yeo, D.C.J., Heok, T., Hadi, A. and Ewers, R.M. 2018. Land-use change is associated with a significant loss of freshwater fish species and functional richness in Sabah, Malaysia. *Biological Conservation* 222: 164–171. https://doi.org/10.1016/j.biocon.2018.04.004

Yule, C.M., Gan, J.Y., Jinggut, T. and Lee, K.V. 2015. Urbanization affects food webs and leaf-litter decomposition in a tropical stream in Malaysia. *Freshwater Science* 34: 702–715. https://doi.org/10.1086/681252

Yusmah, M.Y.S., Bracken, L.J., Sahdan, Z., Norhaslina, H., Melasutra, M. D., Ghaffarianhoseini, A., Sumiliana, S. and Farisha, A.S.S. 2020. Understanding urban flood vulnerability and resilience: A case study of Kuantan, Pahang, Malaysia. *Natural Hazards* 101(2): 551–571. https://doi.org/10.1007/s11069-02003885-1

Zaiha, A.N. and Ismid, M.S.M. 2015. Effects of logging activities on ecological water quality indicators in the Berasau River, Johor, Malaysia. *Environmental Monitoring and Assessment* 187: 493. https://doi.org/10.1007/s10661-015-4715-z

Zaiha, N., Azmi, A., Salmiati, S., Syarmimi, A., Mohd, R., Foze, F. and Talib, J. 2025. Water quality assessment of Johor River Basin, Malaysia, using multivariate analysis and spatial interpolation method. *Environmental Science and Pollution Research* 32: 1766–1782. https://doi.org/10.1007/s11356-024-35692-7

State of Nature Conservation in Malaysia 2025, 891–900
doi: 10.62613/sonc2025.v3anc16

CHAPTER 16

High Seas Treaty: Our ocean and beyond Malaysian borders

LAI YUE[1], NG SEAN FONG[1]*,
RIZZA SACRA-DEJUCOS[2] and DONOVAN LOUIS[1]

Abstract: The ocean is the source of life on Earth. At the present, mounting pressures driven by anthropogenic actions are negatively impacting the viability of the ocean and the biodiversity it harbours. The Biodiversity Beyond National Jurisdiction (BBNJ) Agreement, building upon the United Nations Convention on the Law of the Sea (UNCLOS), aims to conserve and sustainably utilise marine biodiversity in areas beyond national jurisdiction. The BBNJ Agreement's four pillars include Marine Genetic Resources, Area-based Management Tools, Environmental Impact Assessments, and Capacity-building and the Transfer of Marine Technology. These are essential keystones that enable Parties to the BBNJ Agreement to equitably and meaningfully participate in the governance and conservation of the ABNJ. While Malaysia is already a signatory to the BBNJ Agreement, it urgently needs to become a Party to the Agreement, where then Malaysia can meaningfully participate in the Agreement's decision-making processes and benefit from global ocean governance.

INTRODUCTION

Our ocean is fundamental to sustaining life on Earth. It covers approximately 71% of the Earth's surface and contains about 97% of the planet's water (World Meteorological Organisation 2026). The ocean produces half of the oxygen and absorbs more than a quarter of carbon dioxide from the atmosphere (United Nations 2022). This influence extends far beyond coastlines. People living in cities and even landlocked countries depend on the ocean for breathable air, climate regulation, food, trade, and other resources that support daily life.

In Malaysia, the ocean underpins the nation's economy, food security, and cultural heritage. Coastal and marine tourism, including recreational diving and nature-based tourism generates income and employment opportunities for the coal communities. It facilitates international trade through the Strait of Malacca, being one of the world's important maritime shipping routes (Bernama 2026). The ocean sustains fisheries that provide food and livelihoods for millions of Malaysians while shaping the traditions, cuisine, and ways of life of coastal communities. According to Southeast Asian Fisheries Development Center (2025), the fisheries sector achieved a self-sufficiency ratio of about 90.7% and had an average of 44.7 kg fish consumption per person, placing Malaysia among the highest in Southeast Asia in 2023.

A healthy ocean depends on resilient coastal ecosystems. Mangrove forests, seagrass meadows, and coral reefs are interconnected through the movement of marine species, nutrients and sediments. Mangrove forests serve as nursery grounds for commercially valuable marine fish such as barramundi (locally known as *siakap*) and toli shad (*terubok*) (Abu Bakar *et al*. 2025); seagrass meadows providing food and refuge to green sea turtles; and coral reefs support and protect a rich diversity of marine life.

[1] Malaysian Nature Society, JKR641, Jalan Kelantan, Bukit Persekutuan, 50480 Kuala Lumpur, Malaysia.
[2] High Seas Alliance.
***Corresponding author: ngseanfong@gmail.com**

This ecological connectivity is not confined to coastal ecosystems. Our world's five recognised oceans: the Atlantic, Pacific, Indian, Arctic, and Southern Oceans, are not separate bodies of water—they are One Ocean (National Oceanic and Atmospheric Administration 2024). Global ocean currents transport nutrients, plankton, and marine larvae across vast distances, connecting marine ecosystems and supporting biodiversity across the world. Migratory species such as turtles and sharks move between habitats and across national boundaries. The concept of One Ocean emphasises that the ocean does not recognise human-made borders, protecting it requires countries to work together, both within and beyond national waters.

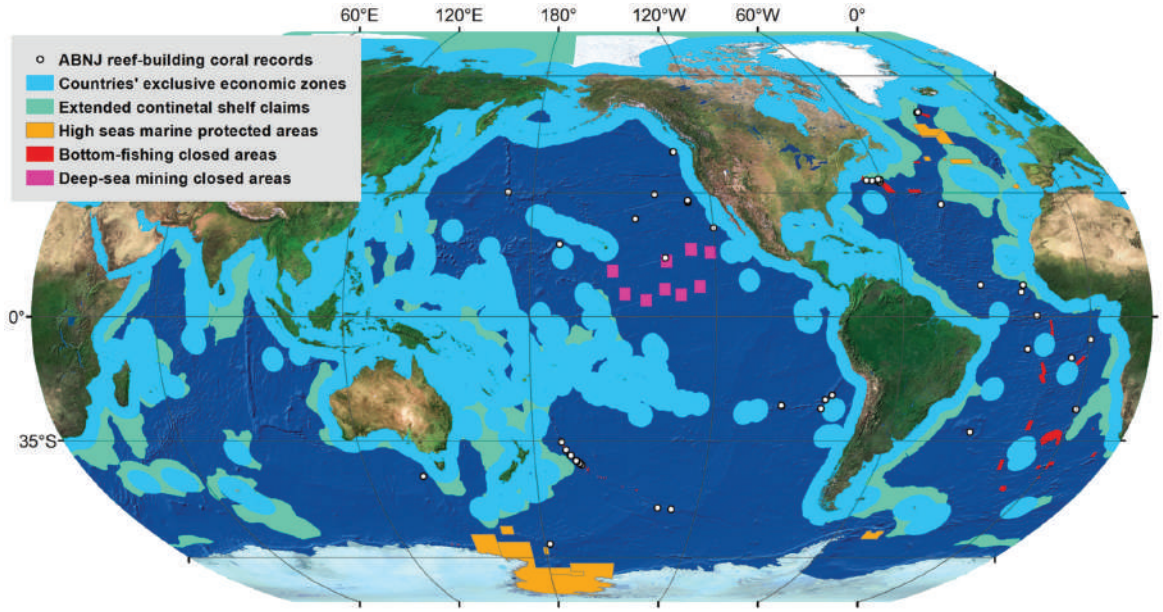


Figure 1. International waters constitute about 60% of the planet's oceanic area, and are the last safe haven for our marine biodiversity. (Source: Wagner *et al.* 2020).

THE AREA BEYOND NATIONAL JURISDICTION

The United Nations Convention on the Law of the Sea (UNCLOS), adopted in 1982, is an international framework governing the world's oceans (International Maritime Organization n.d.; FAO 2026). The framework divides the ocean into different maritime zones (Figure 2). Under UNCLOS, a coastal State—a country with coastline—has sovereignty[a] over its territorial sea, which may extend up to 12 nautical miles (about 22 km) from the coast (*UNCLOS*, Part II, Article 3). Extending up to 200 nm (about 370 km) from the coast is the Exclusive Economic Zone (EEZ) where the coastal States have the sovereign rights to explore, use, conserve and manage its natural resources, including fisheries, oil and natural gas (*UNCLOS*, Part V, Article 56) (Burgess *et al.* 2017). The areas beyond the EEZ are referred to as Areas Beyond National Jurisdiction (ABNJ).

The ABNJ comprises two distinct areas: The High Seas and "The Area". The High Seas refer to the water column beyond national jurisdiction, while "The Area" refers to the seabed, ocean floor and subsoil beyond the State's continental shelf margin (*UNCLOS*,

[a] Sovereignty refers to a State's full authority over its territory, while sovereign rights are limited rights to use and manage resources within specific maritime zones.

Article 89) (Burgess *et al.* 2017; International Seabed Authority 2026). Under UNCLOS, no State may claim sovereignty over any part of the high seas (*UNCLOS*, Article 89). The high seas are open to all States to exercise freedoms of navigation, fishing, and scientific research (*UNCLOS*, Article 87). However, these freedoms are not absolute and must be exercised responsibly (Garg 2026). As human activities expanded and pressures on marine ecosystems increased, countries recognised that freedom must also be accompanied by responsibility and cooperation.

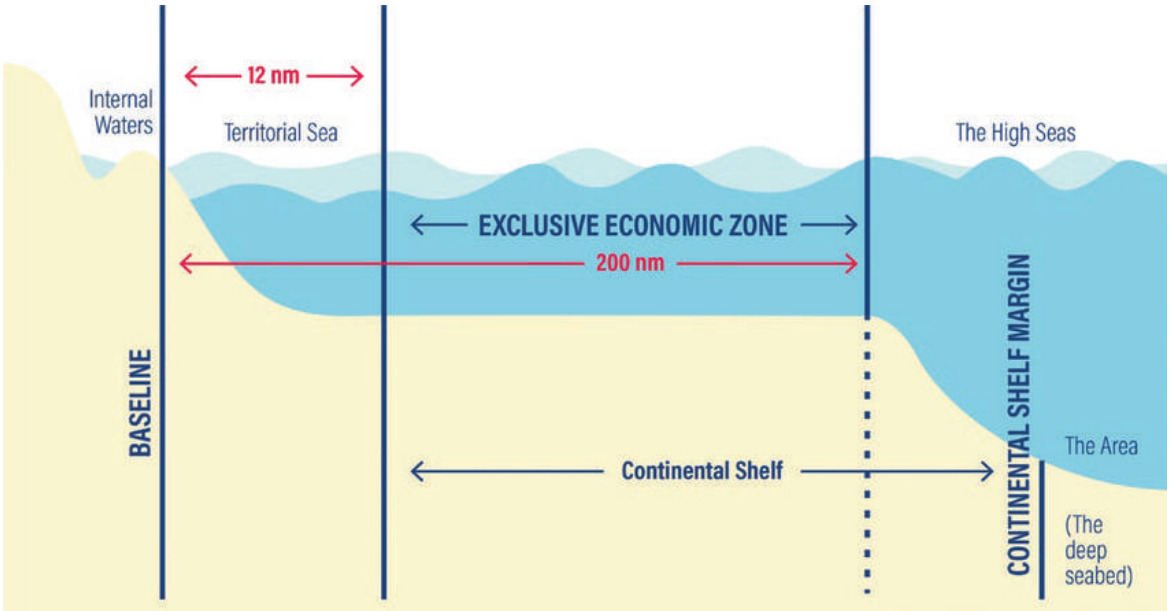


Figure 2. Maritime zones as defined by the United Nations Convention on the Law of the Sea (UNCLOS). (Source: Anders Skoglund, Norwegian Polar Institute 2020).

The High Seas may seem distant but marine species regularly move between them and waters within national jurisdiction. A decade-long study found that Indo-Pacific whale sharks spend most of their lives in the largely unprotected High Seas and migrate across the waters of 13 national jurisdictions and adjacent high-seas areas (Putra *et al.* 2026). Malaysia is also directly connected to the high seas through the fisheries industry. Malaysian fishing vessels operate in the Indian Ocean under conservation and management measures adopted by Regional Fisheries Management Organisations (RFMOs). Measures such as catch limits, fishing seasons, monitoring requirements and actions to combat Illegal, Unreported, and Unregulated (IUU) fishing help to ensure the sustainable management of shared fish stocks, including tuna and other highly migratory marine species (Department of Fisheries Malaysia 2021; European Commission 2026). The health of biodiversity in ABNJ therefore influences the fisheries and ocean resources that Malaysians depend on.

Existing international agreements, frameworks and bodies (IFB) already govern many activities in areas beyond national jurisdiction, but each has a specific sectoral mandate. The International Maritime Organization (IMO) regulates international shipping; RFMOs manage shared fish stocks; and the International Seabed Authority (ISA) manages exploration of mineral-related activities in "The Area". Despite the myriad of IFBs that are currently in force, they do not adequately address the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction.

Why do the High Seas need protection?

For centuries, the High Seas were seen as vast, remote and beyond the reach of human activities. Today, scientific evidence shows human activities now affect even the most remote parts of the ocean, threatening biodiversity and the ecosystem services on which people depend.

One of the best-known examples of pollution in the ABNJ is the Great Pacific Garbage Patch, an accumulation of floating marine debris trapped by ocean currents in the North Pacific (National Oceanic and Atmospheric Administration 2025). According to Lebreton *et al.* (2018), approximately 79,000 tonnes of plastic were floating within an area of 1.6 million km^2, which is nearly thirteen times Sarawak's land area of 124,170 km^2 (Department of Statistics Malaysia 2025). Despite its name, the "patch" is not a solid island of rubbish. Its debris is widely dispersed from the surface to the ocean floor and ranges from large plastic objects to microplastics (National Oceanic and Atmospheric Administration 2025). Marine animals may become entangled in plastic debris or mistake plastic for food. Larger plastic items can also gradually break down into microplastics that spread throughout the marine food web (Evers 2026).

Deep-sea mining (DSM) is another growing concern. The activity involves extracting minerals such as cobalt, nickel and rare earth elements from the ocean floor for use in mobile phones, medical technologies and military equipment (Ashford *et al.* 2025). The full impacts of DSM remain unknown but scientists have warned that it could cause extensive and irreversible biodiversity loss (Deep Sea Conservation Coalition 2025). Sediment plumes, habitat destruction and noise generated by mining could affect species that have yet to be discovered (IUCN NL 2024). As exploration activities expand, DSM has become increasingly controversial, particularly in the Pacific, where Indigenous communities have raised concerns over its potential impacts on marine ecosystems, livelihoods and cultural connections to the ocean (Schertow 2026). More than 940 marine scientists and policy experts have called for a precautionary pause on commercial DSM until sufficient evidence is available, while 46 countries now support a moratorium, precautionary pause or ban on the industry (Deep Sea Conservation Coalition 2025; Greenpeace International 2025).

According to the 2025 fisheries profile for Malaysia by Southeast Asia Fisheries Development Centre (2025), capture fisheries contribute 71.1% of the country's total fisheries production . Nonetheless, the country's marine capture fisheries production declined from 1.46 million metric tonnes in 2019 to 1.27 million metric tonnes in 2023 (Figure 3). Although this decline is influenced by multiple factors like overfishing, destructive practices, climate change and pollution, it underscores the importance of maintaining healthy and resilient marine ecosystems. Malaysian fishing vessels operating in the Indian Ocean depend on healthy fish stocks that migrate through the High Seas and are managed under international conservation measures.

Biodiversity loss in ABNJ can eventually affect Malaysia's coastal ecosystems, fisheries and food security. As human activities exacerbate across the ocean, protecting the ABNJ requires more than managing sectors individually. Countries need to formalise partnerships and undertake shared responsibilities in conserving the biodiversity and ecological processes that connect a common vision of the ocean through a more comprehensive ocean governance regime. This has been the underlying gap that the BBNJ Agreement experienced and was created purposefully to address.

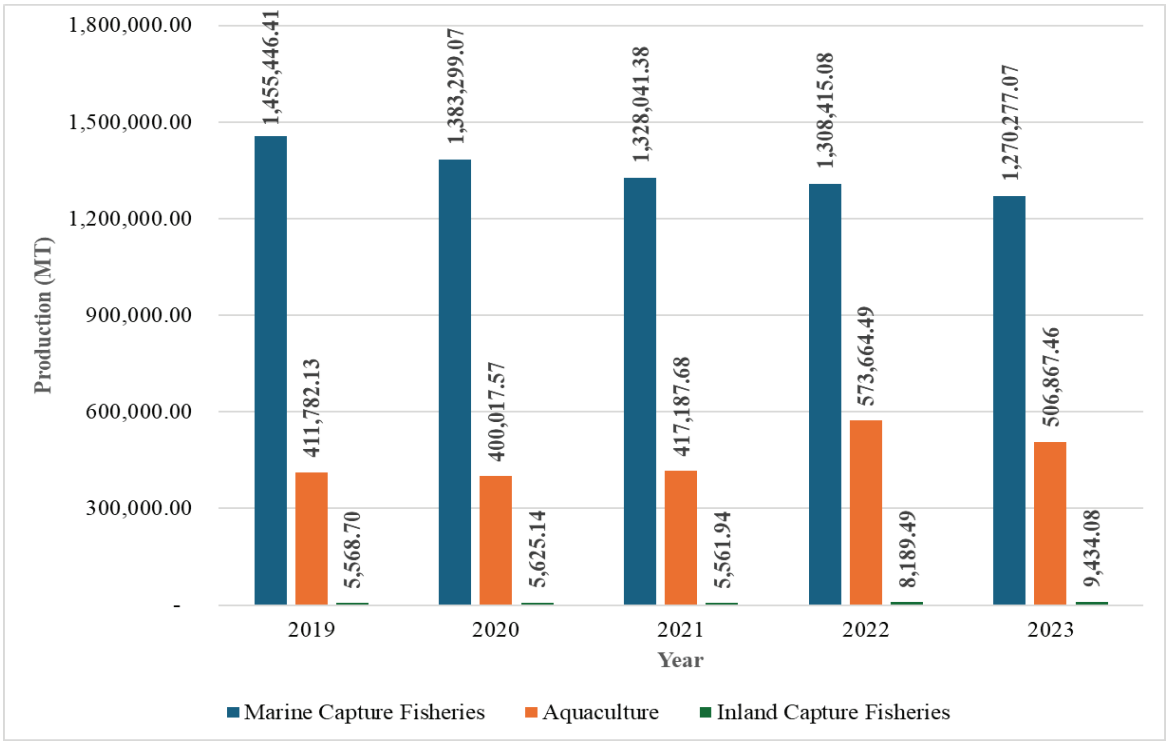


Figure 3. Fishery production of Malaysia in 2019-2023 by quantity (MT). (Source: Southeast Asian Fisheries Development Centre 2025).

THE BBNJ AGREEMENT: A NEW CHAPTER FOR OCEAN GOVERNANCE

Officially, it is termed as the Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ), though it is commonly referred to as the BBNJ Agreement (hereafter referred to as "the Agreement") or the High Seas Treaty. After nearly twenty years of negotiations, the Agreement was adopted on 19 June 2023 and entered into force on 17 January 2026 (Swift and Pickerell 2026; United Nations Indonesia 2026). As at 18 November 2026, it had 145 signatories and 105 Parties [b].

The Agreement builds upon UNCLOS. It promotes cooperation while acknowledging the roles and mandates of existing organisations such as RFMOs, ISA and IMO. The Agreement also sets a legal framework to establish marine protected areas in the ABNJ, which is critical to the achievement of the 30×30 under the Kunming-Montreal Global Biodiversity Framework. This means that Malaysia could be a strong advocate for strengthened international cooperation on ocean conservation through the BBNJ Agreement.

The Four Pillars of the BBNJ Agreement

The Agreement is built around four key pillars that work together to conserve and sustainably utilise marine biodiversity beyond national jurisdiction. Structured as a package deal, each pillar addresses a different aspect of ocean governance, but they are designed to operate as one coordinated framework to ensure the conservation of and equitable governance in the ABNJ.

[b] By becoming a signatory, a country hereby confirms its intent to be bound by the terms of the Agreement. Ratification formally makes the country a Party. When a country ratifies the Agreement, it amends, or gazettes a new legislation for the terms of the Agreement to take effect domestically.

1. Marine Genetic Resources (MGRs): Sharing the Benefits of Ocean Discoveries

MGRs are any material of marine plants, animals, microorganisms or other marine organisms containing functional units of heredity that have actual or potential value (*BBNJ Agreement*, Article 1). These resources may contain unique genes and compounds that can be used to develop new medicines, antibiotics, industrial enzymes, cosmetics and other biotechnology innovations. The Agreement also includes digital sequence information (DSI) of MGRs, which broadly refers to genetic information recorded in digital form, such as DNA sequences. This information allows the researchers to study genetic resources without directly assessing the original biological samples (Epps *et al.* 2025).

Accessing and studying genetic resources requires advanced technology, specialised expertise, and significant financial investment. These resources are not equally available to all Parties (*BBNJ Agreement*, Article 9). The Agreement therefore establishes a framework governing the fair and equitable (1) access to MGRs and associated DSI from ABNJ and (2) sharing of both monetary and non-monetary benefits arising from their use (*BBNJ Agreement*, Article 9 and 14) (Kachelriess *et al.* 2023). It also encourages Parties to share scientific knowledge, research data, technology and expertise through a central platform, known as Clearing-House Mechanism (Cl-HM). The CI-HM improves transparency and accessibility to scientific information, helping to strengthen the scientific, research and technical capacity of developing countries (*BBNJ Agreement*, Article 11 and 12).

2. Area-Based Management Tools (ABMTs): Protect important areas of the ocean

Some parts of the ABNJ are home to important and unique biodiversity or ecosystems that require greater protection (*BBNJ Agreement*, Article 17 and Annex 1). These tools allow countries to work together to protect and manage ecologically important areas of the ABNJ (*BBNJ Agreement*, Article 1). These include Marine Protected Areas (MPAs) and other measures that help conserve biodiversity, strengthen the resilience of marine ecosystems and support sustainable use.

Parties may propose the establishment of new MPAs using best available scientific evidence and, where available, relevant traditional knowledge (*BBNJ Agreement*, Article 19). Proposals undergo scientific review and public consultation involving governments, scientists, Indigenous Peoples, local communities, and other relevant stakeholders (*BBNJ Agreement*, Article 21). After consultation, the Scientific and Technical Body (STB) assesses the proposal and recommends action to the Conference of the Parties (COP), where countries decide whether to establish the proposed MPAs (*BBNJ Agreement*, Article 22).

3. Environmental Impact Assessment (EIA)

EIAs play an important role in the BBNJ Agreement by helping ensure that proposed activities are assessed prior to implementation, in order to prevent, mitigate, and manage significant adverse impacts on marine biodiversity in ABNJ. The process covers screening, scoping, impact assessment and evaluation, management measures and subsequent monitoring and reporting. Assessments must consider cumulative impacts and alternatives, using the best available science and traditional knowledge of Indigenous Peoples and local communities (*BBNJ Agreemen*t, Article 31). Transparency is embedded throughout the EIA process, where EIA reports are to be made publicly accessible, consultations are to be carried out before due consideration can be made in full, and monitoring reports of the approved activities are to be made available through the CI-HM (*BBNJ Agreement*, Articles 32–36).

The Agreement also requires EIAs for proposed activities within marine areas of national jurisdiction, if the responsible Party determines that it may cause detrimental impacts towards the marine environment of ABNJ (*BBNJ Agreement*, Article 27). These assessments may be carried out in accordance with the BBNJ framework or the Party's national process, with monitoring and sharing of relevant information and reports through

the Cl-HM required (*BBNJ Agreement*, Article 28). With respect to the EIA requirements between the Agreement and other IFBs, the EIA carried out is equivalent to the one required under Part IV of the Agreement, and at the same time the requirements for publication of reports, monitoring and review continue to apply (*BBNJ Agreement*, Article 29). To support implementation of its EIA provisions, the Agreement provides for the STB to collaborate with relevant IFBs and develop EIA standards or guidelines for consideration and adoption by the COP (*BBNJ Agreement*, Articles 29 and 38).

4. Capacity-Building and the Transfer of Marine Technology (CB&TMT)

The effective management and conservation of the High Seas requires rigorous scientific knowledge, trained experts and access to advanced technology. Many developing countries face financial, scientific and technical constraints that limit their ability to participate meaningfully in ocean governance (*BBNJ Agreement*, Article 40). CB&TMT aims to bridge these gaps and provide support for the implementation of all three other pillars of the Agreement.

The support of CB&TMT includes training, technical assistance, research collaboration, data sharing, access to equipment, and joint scientific research projects (*BBNJ Agreement*, Annex II). This is complemented by a dedicated CB&TMT Committee that assesses countries' needs, monitor and review CB&TMT implementation, and recommend follow up activities to the COP (*BBNJ Agreement*, Articles 45-46). The BBNJ Agreement strengthens the approach of the UNCLOS to capacity building by creating a monitoring and review process, by establishing a dedicated committee to oversee implementation of the provisions and by establishing a funding mechanism.

Turning agreement into action

The BBNJ Preparatory Commission (PrepCom) was established by the UN General Assembly (UNGA) in April 2024 to lay the groundwork and foundation in preparation for the entry into force and the first meeting of the Conference of the Parties (COP1), which will be held in January 2027. The PrepCom held three meetings, which focused on developing recommendations and drafting decisions on the institutional and financial arrangements needed for the Agreement to deliver on its promise to protect marine biodiversity beyond national jurisdiction (High Seas Alliance 2026a, 2026b).

By the conclusion of PrepCom 3, countries had agreed on the composition and size of most subsidiary bodies, with the Finance Committee remaining unresolved. The proposed arrangements support expert-driven bodies, the establishment of ad hoc working groups and continued work between COP meetings. These provisions would help ensure that the best available science informs implementation, including the assessment and evaluation of planned activities. Negotiations also advanced arrangements for the Special Fund, terms of reference for the Voluntary Trust Fund and draft financial rules.

Countries also agreed to develop a Clearing-House Mechanism prototype before COP1 to support information sharing across the Agreement's four pillars. Progress was made on the process for selecting the Secretariat's seat, with a preference for consensus and, if necessary, a two-thirds majority vote by secret ballot. China, Chile and Belgium have put forward their proposals to host the Secretariat.

Tentative agreement was reached on holding COP meetings primarily in person, allowing virtual meetings only in exceptional cases, and beginning with annual meetings before a later transition to biennial meetings. However, parts of the COP Rules of Procedure, financial rules and institutional arrangements still require further negotiation and will be considered at COP1 (High Seas Alliance 2026b).

MALAYSIA'S NEXT STEPS

The coming COP1 is scheduled on 11 to 22 January 2027, and will mark a significant shift from institution building to effective implementation. Parties will need to adopt COP Rules of Procedure, modalities and terms of reference for subsidiary bodies, financial rules, Secretariat arrangement including its seat, Clearing-House Mechanism, among others.

On 3 September 2025, Malaysia signed the BBNJ Agreement (United Nations 2023); the next step in this process is to carry out the necessary domestic legislative changes and harmonisation before Malaysia can ratify the Agreement. Becoming a Party would allow Malaysia to participate fully in decision-making and the Agreement's implementation, while strengthening its voice in shaping the future of international ocean governance. Associate Professor Dr. Mohd Hazmi Mohd Rusli of the International Islamic University Malaysia has highlighted that ratification would also provide Malaysia, as a developing country, with greater opportunities for capacity-building, marine technology transfer, scientific cooperation and benefit-sharing from marine genetic resources. Delaying ratification could, in contrast, weaken Malaysia's environmental credibility (The Vibes 2025).

According to the Undersecretary of the Strategic Planning and International Division at the Ministry of Natural Resources and Environmental Sustainability and Malaysia's representative in the BBNJ negotiations, the country's next steps include reviewing the Agreement's requirements, continuing relevant negotiations and preparing for implementation. In preparation for and following ratification, this would involve completing the necessary legal processes, reviewing existing laws and policies, strengthening coordination among government agencies, and engaging Malaysian scientific and legal experts. Such preparation would help ensure that Malaysia's interests and biodiversity conservation priorities are effectively represented at both regional and global levels (Tan 2025).

As Malaysia moves towards ratification and implementation, the Agreement presents an opportunity for the country to strengthen its role in global ocean governance. With continued preparation, cooperation and active participation, Malaysia can help shape how the High Seas Treaty is put into practice and contribute to a more equitable and sustainable future for marine biodiversity in areas beyond national jurisdiction.

Acknowledgement: We acknowledge and thank Rizza Sacra-Dejucos from High Seas Alliance for reviewing and contributing to this article. We would also like to acknowledge and extend gratitude to Mr. P. Jeevananth a/l Paliah from the Ministry of Natural Resources and Environmental Sustainability, Mr. Jason Low Tze Hian from the Ministry of Foreign Affairs, Ms. Chitra Devi Gopalakrishnan and Ms. Shantini Guna Rajan from WWF-Malaysia, Associate Professor Dr. Mohd Hazmi bin Mohd Rusli from Universiti Sains Islam Malaysia, Mr. Law Yao Hua from Macaranga, as well as our colleagues from BirdLife International (Dr. Poshendra Satyal, Dr. Hum Bahadur Gurung, and Ms. Ariana Loehr) and High Seas Alliance (Ms. Rizza Sacra-Dejucos, Mr. Duncan Currie and Mr. Daniel Kachelriess) for their help and support in the implementation of the project "Advocating for High Seas Treaty Ratification" in 2024/2025. The project was supported by the High Seas Alliance, administered by BirdLife International, and implemented in Malaysia by MNS.

REFERENCES

Abu Bakar, N.A.W., Mohd Nasir, M.S.A., Mat Jaafar, T.N.A., Bokhari, F., Saperi, S. and Ariffin, N.A. 2025. Genetic diversity and population genetics of tropical shads (*Tenualosa toli*) from Sarawak, Malaysia. *Journal of Sustainability Science and Management* 20(1): 78–100. https://doi.org/10.46754/jssm.2025.01.005

Ashford, O., Baines, J., Barbanell, M. and Wang, K. 2025, July 23. What We Know About Deep-Sea Mining — and What We Don't. *World Resources Institute*. https://www.wri.org/insights/deep-sea-mining-explained

Bernama. 2026, April 6. Strait of Malacca Remains World's Largest Oil Transit Chokepoint. *New Straits Time Online*. https://www.nst.com.my/business/economy/2026/04/1411183/strait-malacca-remains-worlds-largest-oil-transit-chokepoint

Burgess, L., Foulkes, L., Jones, P., Merighi, M., Murray, S. and Whitacre, J. 2017. Chapter 2: Maritime Zones. *The Fletcher School of Law and Diplomacy*. https://sites.tufts.edu/lawofthesea/chapter-two/.

Deep Sea Conservation Coalition. 2025, June 18. Scientists. *Deep Sea Conservation Coalition*. https://deep-sea-conservation.org/solutions/no-deep-sea-mining/momentum-for-a-moratorium/scientists/

Department of Fisheries Malaysia. 2021, July 6. Tuna Licensing. *Department of Fisheries Malaysia*. https://www.dof.gov.my/en/services/captured-fisheries/tuna-licensing/

Department of Statistics Malaysia. 2025. *Current Population Estimates, Administrative District, 2025*. Putrajaya: Department of Statistics Malaysia.

European Commission. 2026, June 23. Regional Fisheries Management Organisations (RFMOs). *European Commission*. https://oceans-and-fisheries.ec.europa.eu/international/regional-fisheries-management-organisations-rfmos_en

Epps, M., Thiele, T., Scholz, A., and Jaspars, M. 2025. *Digital Sequence Information (DSI) as a Means of Financing under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ)*. Gland: IUCN Headquarters.

Evers. J. 2026, July 16. Great Pacific Garbage Patch. *National Geographic Society*. https://education.nationalgeographic.org/resource/great-pacific-garbage-patch/

Food and Agriculture Organization of the United Nations (FAO). 2026, February 6. Explaining the Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction. *Food and Agriculture Organization of the United Nations*. https://www.fao.org/development-law-service/news/detail/explaining-the-agreement-on-the-conservation-and-sustainable-use-of-marine-biological-diversity-of-areas-beyond-national-jurisdiction/en

Garg, R. 2026. Legal Nature of the High Seas: Is Freedom of the Seas Absolute? *Indian Journal of Law and Legal Research* 3(1): 6720–6745.

Greenpeace International. 2025, October 21. Pacific activists protest deep sea mining as US-owned exploration vessel docks in Cook Islands. *Greenpeace*. https://www.greenpeace.org/international/press-release/79252/pacific-activists-protest-deep-sea-mining-us-owned-exploration-vessel-cook-islands/

High Seas Alliance. 2026a, March 10. Preparatory Commission for the BBNJ Treaty. *High Seas Alliance*. https://highseasalliance.org/prepcom/

High Seas Alliance. 2026b, April 16. BBNJ PrepCom 3: Inside the Negotiations. *High Seas Alliance*. https://highseasalliance.org/2026/04/16/bbnj-prepcom-3-inside-the-negotiations/

International Maritime Organization. n.d. United Nations Convention on the Law of the Sea. https://www.imo.org/en/ourwork/legal/pages/unitednationsconventiononthelawofthesea.aspx.

IUCN National Committee of the Netherlands. 2024. The Impact of Deep-sea Mining on Biodiversity, Climate and Human Cultures. IUCN National Committee of the Netherlands. https://www.iucn.nl/en/story/the-impact-of-deep-sea-mining-on-biodiversity-climate-and-human-cultures/

Kachelriess, D., Currie, D. and Metzger, M. 2023. Part II of the BBNJ Agreement: Marine genetic resources including the fair and equitable sharing of benefits. *High Seas Alliance*. https://highseasalliance.org/wp-content/uploads/2023/11/HSA-Briefing-Deep-Dives-Part-II-Marine-Genetic-Resources-including-the-fair-equitable-sharing-of-benefits.pdf

Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose, B., Aitken, J., Marthouse, R., Hajbane, S. *et al.* 2018. Evidence that the Great Pacific garbage patch is rapidly accumulating plastic. *Scientific Reports* 8(1): 4666. https://doi.org/10.1038/s41598-018-22939-w

National Oceanic and Atmospheric Administration. 2024, June 16. How Many Oceans Are There? *National Ocean Service*. https://oceanservice.noaa.gov/facts/howmanyoceans.html
National Oceanic and Atmospheric Administration. 2025. “Garbage Patches”. *Marine Debris Program*. https://marinedebris.noaa.gov/discover-marine-debris/garbage-patches
Putra, M.I.H., Wirasatriya, A., Sianipar, A., Hasan, A., Setyawan, E., Syakurachman, I., Mambrasar, R. *et al.* 2026. Integrating behavioral movement and environmental preferences to map critical habitat of whale sharks using long-term satellite tracking in the Indo-Pacific Ocean. *Frontiers in Marine Science* 13: 1808805. https://doi.org/10.3389/fmars.2026.1808805
Southeast Asian Fisheries Development Center. 2025, September 12. Fisheries Country Profile: Malaysia 2025. *Southeast Asian Fisheries Development Center*. https://www.seafdec.org/fisheries-country-profile-malaysia/
Schertow, J.A. 2026, June 12. Indigenous Peoples Are a Leading Force in the Global Fight Over Seabed Mining. *Intercontinental Cry*. https://icmagazine.org/indigenous-peoples-are-a-leading-force-in-the-global-fight-over-seabed-mining/
Skoglund, A. 2020. Maritime Zones as Defined by the UN Convention on the Law of the Sea. [Infographic]. Tromsø: Norwegian Polar Institute.
Swift, A. and Pickerell, T. 2026, January 15. After 20 Years, an Agreement to Safeguard the ‘High Seas’ Takes Force. *World Resources Institute*. https://www.wri.org/insights/high-seas-treaty-explainer
Tan, Z.Y. 2025, November 19. Regulations: Malaysia’s next steps on the High Seas Treaty. *The Edge Malaysia*. https://theedgemalaysia.com/node/780843
The Vibes. 2025, June 11. Malaysia yet to Ratify High Seas Treaty Amid Calls for Stronger Ocean Governance. *The Vibes*. https://www.thevibes.com/articles/news/109217/malaysia-yet-to-ratify-high-seas-treaty-amid-calls-for-stronger-ocean-governance
United Nations. 2022. The Ocean – the World’s Greatest Ally Against Climate Change. https://www.un.org/en/climatechange/science/climate-issues/ocean
United Nations Indonesia. 2026, January 19. About BBNJ Agreement - Agreement on Marine Biological Diversity of Areas Beyond National Jurisdiction. *United Nations Indonesia*. https://indonesia.un.org/en/308526-about-bbnj-agreement-agreement-marine-biological-diversity-areas-beyond-national
United Nations. 2023, June 13. Agreement under the United Nations Convention on the Law of the SEA on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction. *United Nations Treaty Collection*. https://treaties.un.org/Pages/ViewDetails.aspx?chapter=21&clang=_en&mtdsg_no=XXI-10&src=TREATY
Wagner, D., Friedlander, A.M., Pyle, R.L., Brooks, C.M., Gjerde, K.M. and Wilhelm, T.A. 2020. Coral reefs of the High Seas: Hidden biodiversity hotspots in need of protection. *Frontiers in Marine Science* 7: 567428.
World Meteorological Organization. 2026, July 16. Ocean. *World Meteorological Organization*. https://wmo.int/topics/ocean

State of Nature Conservation in Malaysia 2025, 901–919
doi: 10.62613/sonc2025.v3anc17

CHAPTER 17

Disregarding our future: Malaysia's waste and pollution crisis

MAGESWARI SANGARALINGAM and WONG PUI YI*

Abstract: Malaysia has developed rapidly since the Second World War, transforming from a primarily agrarian country that relied on primary industries, to one with thriving secondary and tertiary industries, with an overarching ambition of becoming a high income nation. As industrialisation, urbanisation, and consumerism expanded, Malaysia has overlooked the development of one important sector—waste management. The challenges posed by waste management in Malaysia are varied and complex. This paper presents a broad overview of the different categories of waste (household waste versus industrial, commercial, and institutional wastes); an examination of the legal framework and actors governing waste management in Malaysia as well as the inherent loopholes, weaknesses and challenges; and lessons learnt from selected case studies of waste mismanagement and pollution.

INTRODUCTION

"Waste" is defined by the Cambridge Dictionary (n.d.) as "*unwanted matter or material of any type, especially what is left after useful substances or parts have been removed*". All waste materials will cause some form of pollution to the soil and water bodies, and to the air if incinerated. However, "pollution" is a broader term that defines damage caused not only by wastes, but also by harmful contaminants or substances released through human activities such as manufacturing (emissions and effluents) or agriculture (fertilisers and pesticides). This chapter will focus largely on pollution caused by the problem of wastes, as industrial pollution is clearly regulated by one agency under one law.

Zero waste and circularity

In recent years, the terms "Zero Waste" (United Nations Environment Programme 2023) and "circularity" have come to dominate discussions on solutions to the problem of waste. Both terms are subject to abuse and need to be qualified. "Zero Waste" has been defined as principles and practices that promote the conservation of all resources through responsible design, production, consumption, reuse and recovery of materials without burning or discharges to land, water, or air (US EPA 2025). In Malaysia, some have dismissed the term "Zero Waste" on the basis that it is impossible not to generate any waste matter at all, while others have co-opted and misused the phrase, for example in taglines such as "zero waste to landfills", in attempts to promote waste management technologies which arguably cause other forms of pollution.

Both approaches have disregarded the other definitions of "waste"—as a noun: "*an unnecessary or wrong use of money, substances, time, energy, abilities, etc*." (the word "wastage" can also be used here), and as a verb: "*to use too much of something or use something badly when there is a limited amount of it*". A complete understanding of "Zero Waste" would focus on these latter two definitions which highlights upstream waste prevention and not just downstream waste management. Thus, it is entirely possible to adopt practices that are not wasteful, and adjust behaviours to generate significantly less waste matter. Meanwhile, "zero waste to landfill" disregards this important principle of waste reduction, merely aiming to decrease the volume of waste going to landfills, usually by presenting a miraculous way to make the waste "disappear", but not to reduce waste generation or wastefulness.

Sahabat Alam Malaysia, No. 10, Jalan Masjid Negeri, 11600 Pulau Pinang, Malaysia.
***Corresponding author: puiyi.wpy@gmail.com**

Similarly, "circularity" or "circular economy" is often misused. The concept seeks to shift from the linear (take-make-dispose) economy towards production cycles that imitate natural cycles in nature, where nothing goes to waste. This would reduce our reliance on natural resource extraction and decrease pollution. As noted by the United Nations Environment Programme (UNEP), circularity, sustainable consumption, and responsible production are essential for the achievement of all multilateral agreements on the environment—the Sustainable Development Goals, the Paris Agreement, the Kunming-Montreal Global Biodiversity Framework, and even the global plastics treaty currently under negotiation, among others (UNEP 2021).

However, far too often, in developing economies including Malaysia, "end-of-pipe" waste management practices and technologies that negatively impact human and environmental health, such as waste incineration and unproven chemical recycling technologies, are promoted as circular solutions. In reality, they destroy materials, create hazardous waste, and do not enable a reduction in virgin material use. Conversely, Europe has recognised that waste incineration is not sustainable (Makavou 2021) nor circular (European Parliament 2020), while the UNEP Circularity Platform acknowledged that the "...recovery of energy are processes used in some countries to manage waste, but the value of the material is consumed once, and not put back into the loop. Therefore, these processes are not developed further on this platform" (UNEP, n.d.). The true definitions of "Zero Waste" and "circularity", reflecting the waste hierarchy that prioritise waste prevention at source, underlines the discussions in this chapter.

Towards a high-income, high-waste country

Malaysia has developed rapidly since the Second World War, transforming from a primarily agrarian country that relied on primary industries to one with thriving secondary and tertiary industries, with an overarching ambition of becoming a high-income country. The industrial growth and rapid urbanisation have brought prosperity, but also a surge in waste and pollution. About 75.1% of the Malaysian population lived in urban areas in the year 2020, compared to 70.9% in 2010 (Department of Statistics Malaysia 2022).

In general, the types of wastes in Malaysia are separated into "solid waste" and "hazardous (scheduled) waste", which can both be further segregated into wastes generated by households, industrial premises (including manufacturing, mining, agriculture), commercial entities, and institutions, as well as construction and public cleansing activities. In 2025, solid waste generation was about 15.38 million tonnes, or over 39,000 tonnes daily (Isamudin 2026), with per capita waste generation amounting to 1.17 kg/day. This was a steady increase from 13.88 million tonnes in 2019, to 13.91 million tonnes in 2020, to 13.95 million tonnes in 2021 (Ministry of Economy 2024). It is projected that solid waste generation will increase to 17.03 million tonnes in 2035, with daily volume continuing to rise at a rate of 1.4 to 1.7% annually (Pfordten 2025).

Figures of waste composition from a 2013 report are still being reported in the media (Pfordten 2025). According to the National Solid Waste Management Department (2013), in Peninsular Malaysia, food waste makes up 44.5% of household solid waste generated, with approximately 16,000 to 17,000 tonnes discarded daily. Plastic waste (13.2%), disposable diapers and sanitary napkins (12.1%), and waste paper (8.5%) make up the top four categories. Others include garden waste (5.8%), glass (3.3%), textiles (3.1%) and tetra pak/aseptic cartons (1.6%). The government spends up to RM2 billion for solid waste management, but only for states who have surrendered jurisdiction over waste management to the federal government (Bernama 2025). Meanwhile, the national recycling rate of about 37.9% in 2024 falls short of the 40% target under the Twelfth Malaysia Plan (Malaysian Investment Development Authority 2026). However, the reported recycling rate has been disputed by waste policy experts as being inaccurately measured and too high (Muslim 2025; Tham and Lee 2026).

Meanwhile, Malaysia's agricultural sector generates approximately 168 million tonnes of biomass annually, including palm oil waste, rice husks, coconut debris, sugar cane waste, urban waste, and forestry waste, most of which are disposed of via open burning or landfilling (Harun *et al.* 2025). Pesticides (Waras *et al*. 2024), including banned pesticides such as paraquat, and chemical fertilisers (Miwil 2025) pose a risk to the environment. The livestock, poultry, and aquaculture sectors also cause odour and environmental pollution emanating from excretion and wastewater (Bernama 2021; Basyir 2022; Shadiqe 2025).

Pollution also occurs from industrial processes as well as the workings of modern cities.[a] Industrial pollution often raises significant environmental concerns in Malaysia. The major sources of industrial pollution in Malaysia are manufacturing plants that discharge effluents, either untreated or inadequately treated waste into water bodies, and emissions released through smokestacks or flues in industrial facilities, especially by power plants. Common types of pollutants generated include heavy metals, particulate matter, volatile organic compounds, sodium dioxide, nitrogen dioxide, carbon monoxide, and chemical waste.

Another problematic type of waste created by businesses is construction waste. A survey conducted in 2012 by the Ministry of Housing and Local Government (KPKT) found that construction and demolition (C&D) waste is responsible for 41% of all solid waste in Malaysia. In a 2019 report by SWCorp, the federal statutory body tasked to implement solid waste management policies in certain states of Peninsular Malaysia and the Federal Territories, approximately 1,446 locations of illegal waste disposal had been discovered between 2014 and 2018 (Amry *et al.* 2023). In Kuala Lumpur, construction waste reportedly accounted for 94.6% of all illegal waste (Bernama 2023), with the rise of illegal dumping correlating with the increase in construction projects. Approximately 25,600 tonnes of C&D waste is produced daily (Ting *et al.* 2022). More than 50% of construction waste is wood waste, which often has been treated with chemical substances and requires special rules (SCP Malaysia 2016).

As for scheduled waste, which includes chemical waste, heavy metals, oil waste, e-waste, and medical waste, the Environmental Quality Report 2024 (Department of Environment 2025) reported the generation of 5,378,977.55 metric tonnes in 2024. Dust, slag, dross or ash formed the highest quantity of waste produced, amounting to 47.35%. A total of 1,879,787.20 metric tonnes of scheduled waste was dealt with under special management, where the waste was reused by industries as fuel or raw material, or was disposed of at sanitary landfill sites. A total of 3,978.04 metric tonnes of scheduled waste were exported.

Malaysia's soil, rivers, coastlines, and communities are increasingly burdened by mismanaged waste, waste crimes, and pollution, threatening public health, biodiversity, ecosystems, and economic resilience. The Environmental Quality Report 2024 report also noted that the air quality throughout Malaysia was only good for 35.2% of the year, while 64.1% of the year had moderate air quality, and 0.7% had unhealthy air quality. In areas close to industries, the air quality is frequently poor. Out of 672 rivers tested, 25% were slightly polluted and 4% were polluted. There is increasing concern about pollution pressures on the river from point sources such as pipelines and sewers and non-point sources such as runoff and atmospheric deposition.

This chapter presents a brief and broad overview of the different categories of wastes; examines the legal framework and actors governing waste management in Malaysia, as well as the inherent loopholes, weaknesses and challenges; and explores lessons learnt from

[a] Pollution caused by cities include heat pollution from air conditioning, air pollution from vehicle combustion, water pollution from sewage treatment systems or sullage from households, and light pollution caused by overuse of lighting at night which affects wildlife and biodiversity. Due to constraints on the word limit, this chapter will not delve deeper into these types of pollution.

selected case studies of waste mismanagement and pollution in the country. Some waste categories that are especially challenging for Malaysia include those from mining, radioactive wastes (including from rare earth processing), solid waste from unplanned urbanisation and construction, ever increasing post-consumer waste (single-use or low quality consumer goods), imported or illegally trafficked wastes (including plastic and electronic wastes), and emerging waste from energy transition to renewables (including solar panels, electric vehicles, lithium ion batteries). It is projected that by 2050, around 80 million tonnes of solar panels will reach the end of their lifespans, and Malaysia could accumulate up to 870,000 depleted EV batteries (Palansamy 2025).

LAW, POLICY, AND PRACTICE: CHALLENGES IN MANAGING WASTE AND POLLUTION

Several laws and institutions govern the management of various types of waste and pollution in Malaysia. An inexhaustive list is summarised in Table 1, covering mainly laws that apply to West Malaysia, and some for Sabah and Sarawak. Some legal gaps exist which the government is already working on, including developing laws to regulate household electrical and electronic waste, extended producer responsibility (EPR) for products that are put on the market, microplastics, and non-industrial pollution (such as pesticide run-off).

Table 1. Legislation related to waste and pollution in Malaysia.

Type of waste / Law	Definition/Explanation
"Solid waste" Solid Waste and Public Cleansing Management Act 2007 (SWCorp)	Solid waste refers to: a. Any scrap material or other unwanted surplus substance or rejected products arising from the application of any process; b. Any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled; or c. Any other material that according to this Act or any other written law is required by the authority to be disposed of, but does not include scheduled wastes as prescribed under the Environmental Quality Act 1974, sewage as defined in the Water Services Industry Act 2006, or radioactive waste as defined in the Atomic Energy Licensing Act 1984." For states in Peninsular Malaysia that have accepted this Act, the Solid Waste and Public Cleansing Management Corporation (SWCorp) is tasked with law enforcement and policy implementation. States that have not accepted this Act regulates waste management through their Local Authorities. For Sabah, there is the Solid Waste Management and Public Cleansing Enactment 2022, implemented by local councils. For Sarawak, there is the Sustainable Resources and Wastes Management Ordinance 2025, implemented by the Sustainable Resources and Wastes Management Authority (SRWMA).
"Controlled solid waste" Solid Waste and Public Cleansing Management Act 2007 (SWCorp)	Controlled solid waste refers to "any solid waste falling within any of the following categories: commercial solid waste; construction solid waste; household solid waste; industrial solid waste; institutional solid waste; imported solid waste; public solid waste; solid waste which may be prescribed from time to time." This definition is reflected in Sabah's Solid Waste Management and Public Cleansing Enactment 2022.

Local Government Act 1976 Street, Drainage and Building Act 1974 Local authority by-laws under these Acts (Local Authorities)	These laws outline the roles of the Local Authorities in maintaining cleanliness in public spaces, streets, drainage systems, and buildings. For Sabah, the corresponding laws include: • Local Government Ordinance 1961 • Public Health Ordinance 1960 • Uniform Building By-Laws 2022 • Uniform (Anti-Litter) By-Laws 2010 • For Sarawak, the corresponding laws include: • Local Authorities Ordinance 1996 • Protection of Public Health Ordinance 1999 • Sarawak Buildings Ordinance 1994
"Pollution" and "Waste" Environmental Quality Act 1974 (EQA) (DOE)	This federal law provides broad environmental standards and pollution control across Malaysia, enforced by the Department of Environment (DOE). Pollution is defined as "any direct or indirect alteration of the physical, thermal, chemical, or biological properties of any part of the environment by discharging, emitting, or depositing environmentally hazardous substances, pollutants or wastes so as to affect any beneficial use adversely, to cause a condition which is hazardous or potentially hazardous to public health, safety, or welfare, or to animals, birds, wildlife, fish or aquatic life, or to plants or to cause a contravention of any condition, limitation or restriction to which a licence under this Act is subject". Waste "includes any matter prescribed to be scheduled waste, or any matter whether in a solid, semi-solid or liquid form, or in the form of gas or vapour which is emitted, discharged or deposited in the environment in such volume, composition or manner as to cause pollution". Regulations under this Act cover the appeal board, scheduled waste and its treatment/disposal facilities, clean air, sewage, industrial effluent, prescribed premises for crude palm oil and raw natural rubber, control of petrol and diesel content, emissions by petrol/diesel engines and motorcycles, motor vehicle noise, lead in motor gasoline, halon management, refrigerant management, and pollution from solid waste transfer stations and landfills. Any pollution caused to rivers by mining or agricultural activities also fall under this Act. Orders under this Act covers the requirements for Environmental Impact Assessments (EIA), marine pollution, open burning, and delegation of powers to various parties across several issues. For Sabah, the EQA is applied together with the Environment Protection Enactment 2002. For Sarawak, there is the Natural Resources and Environment Ordinance (Chapter 84) (1958 Edition) as well as the Environment (Reduction of Greenhouse Gases Emission) Ordinance 2023.
"Scheduled waste" Environmental Quality (Scheduled Wastes) Regulations 2005 (DOE)	These regulations outline requirements for storage, handling and disposing of hazardous or scheduled waste. Scheduled waste refers to waste falling within the categories of waste listed in the First Schedule: metal and metal-bearing wastes (batteries, e-waste); wastes containing principally inorganic constituents which may contain metals and organic materials (asbestos, gypsum); wastes containing principally organic constituents which may contain metals and inorganic materials (acids,

	oil, solvents); wastes which may contain either inorganic or organic constituents (alkalis, drugs, clinical, dioxin, leachate, ash, explosives); residues from treatment of scheduled wastes. The Environmental Quality (Amendment) Act 2026 grants Sabah and Sarawak legislative authority over the management of scheduled waste. Sabah is transitioning from the federal Electronic Scheduled Waste Information System (eSWIS) to Sabah Electronic Scheduled Waste Information System (SESWIS).
"Radioactive waste" Atomic Energy Licensing Act 1984 (AELB)	Radioactive waste refers to any waste which consists wholly or partly of: a. a substance or article which if it were not waste would be radioactive material; or b. a substance or article which has been contaminated in the course of the production, storage or use of any radioactive material, nuclear material or prescribed substance or by contact with or proximity to any other waste within the meaning of paragraph (a) of this definition. The Atomic Energy Licensing Board (AELB) enforces radioactive waste management policy through its licensing procedures.
"Sewage" and "Sewage sludge" Water Services Industry Act 2006 (National Water Services Commission, SPAN)	Sewage means "any liquid discharges containing human excreta, animal or vegetable matters in suspension or solution derived from domestic activities and being generated from household, commercial, institutional and industrial premises including liquid discharges from water closets, basins, sinks, bathrooms and other sanitary appliance but excluding rain water and prohibited effluent." Sewage sludge refers to "residual mixture of solid and liquid produced during the partial or full treatment of sewage but does not include treated sewage effluent discharged through a disposal pipe." For Sabah, the EQA regulation on sewerage is applied together with the Sewerage Services Enactment 2017. For Sarawak, there is the Sewerage Systems and Services Ordinance 2005 (Chapter 63).
Pesticide Act 1974	There are regulations to control the presence of pesticides in food, as well as to control the research, possession or use of unregistered pesticides, and unapproved use of pesticides. However, there is no comprehensive legislation to regulate the management of chemical substances in the environment.
Waste from poultry and livestock farming (DVS)	Poultry and livestock farming is regulated by states under respective enactments, with enforcement by the state Department of Veterinary Services (DVS). The Animals Act 1953 regulates the control of diseases, slaughter, and prevention of cruelty to animals for Peninsular Malaysia, and not environmental pollution.

Incomplete regulatory framework: State-federal conflicts

The following sections will discuss the challenges facing waste management and pollution control in Malaysia. Firstly, legal jurisdiction is fragmented between states and the federal government, and especially between Peninsular Malaysia and the territories of Sabah and Sarawak. Malaysia is rich in natural resources, and the responsibility for managing these resources is distributed among state authorities and across several federal ministries. High levels of coordination is required among state authorities and ministries so that the environment is protected for future generations. Problems arise when states with limited financial resources exploit their natural resources for short-term profits, e.g., by granting permits for logging, mining, or quarrying. While such activities require state approval, the pollution caused by the activities and the obligation to meet international commitments on environmental protection (forest cover, biodiversity, marine protected areas, carbon emissions, hazardous substances) often fall under the responsibility of the federal government.

Jurisdiction over solid waste management is also split between the federal government and the local government, depending on whether the state has accepted the federal solid waste law. The Solid Waste and Public Cleansing Management Act 2007 (Act 672) is only applied in six states: Johor, Melaka, Negeri Sembilan, Kedah, Perlis, and Pahang, and the Federal Territories of Kuala Lumpur and Putrajaya. In these states, SWCorp is tasked with law enforcement and policy implementation (e.g., the Community Service Order for public littering, effective 1 January 2026), while the National Solid Waste Management Department (JPSPN) develops relevant policies and strategies. Both fall under the federal Ministry of Housing and Local Government (KPKT).

Five states have yet to adopt the Act, namely Penang, Selangor, Perak, Kelantan, and Terengganu, although Penang and Selangor have indicated intention to adopt it. In these states, Local Authorities (LAs) are responsible for providing solid waste management services within local authority areas under the Local Government Act 1976. The services comprise mainly waste collection and transport to disposal sites, public cleansing, as well as the operation of some recycling centres. LAs either provide the services directly or contract them out to private sector service providers. The State Governments oversee the LA activities and play a role in the provision of land for disposal facilities. KPKT, the Ministry of Health (MOH) and the Ministry of Economy provide local authorities with technical and financial assistance to better manage their wastes. Act 672 was established to standardise solid waste management (household, commercial, construction, industry) and public cleansing across all local authorities regardless of revenue levels, but the incomplete adoption of the Act has hindered efforts to institute nationwide reforms for waste management. Sabah and Sarawak have separated waste management systems respectively, and have been granted increasing autonomy in recent years (Soo 2026).

Fragmented institutional framework and weak policy implementation and coordination

Act 672 mandates waste separation at source by law. Failure to comply can lead to a fine not exceeding RM 1,000. The government announced the implementation of waste separation at source in 2015 under this Act, but until today, there is still no enforcement of this practice, due to administrative hurdles and lack of manpower to enforce the law. In addition, other provisions on take-back systems are also under-developed.

Another challenge is the separate jurisdiction over "plastic waste" versus "hazardous waste", and "solid waste" versus "pollution control". Plastic and solid wastes fall under the jurisdiction of JPSPN and KPKT, while hazardous waste and pollution fall under the jurisdiction of the Department of Environment (DOE) and the Ministry of Natural Resources and Environmental Sustainability (NRES). This has caused confusion and inaction over waste problems. One such example is the issue of plastic waste imports and its ensuing pollution. While JPSPN was in control of permits and volumes of imported plastic waste

allowed into the country,[b] the regulation of pollution by recycling facilities or open burning of wastes fell to the DOE, while illegal dumping is under the Local Authorities or SWCorp. There is currently no legal framework in Malaysia to regulate microplastic pollution or chemicals leached from plastic waste piled in the outdoors.

Furthermore, on the issue of plastic pollution, the previous iterations of NRES, formerly known as the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) and then the Ministry of Environment and Water (KASA), had developed several roadmaps:

- Malaysia's Roadmap Towards Zero Single-use Plastics 2018 – 2030 (by MESTECC)
- Malaysia Plastics Sustainability Roadmap 2021 – 2030 (by KASA)
- National Marine Litter Policy and Action Plan 2021 – 2030 (by KASA)

NRES is also tasked with leading negotiations at the Intergovernmental Negotiating Committee meetings to develop an internationally legally binding instrument on plastic pollution, including in the marine environment. However, the ministry has no legal jurisdiction over plastic pollution and plastic waste, and has no legal means to implement these policies. The single-use plastics roadmap is coordinated by a Joint Ministerial Committee co-chaired by the ministers of NRES and KPKT and Joint Steering Committee co-chaired by the secretary generals of the same two ministries (Regional Knowledge Centre for Marine Plastic Debris 2026), but progress has been minimal.

Separately, KPKT has launched the "National Strategic Plan for Solid Waste Management 2005" towards Vision Malaysia 2020, the "National Solid Waste Management Policy 2016", the "National Cleanliness Policy (2020 – 2030)" in 2019, and recently the "Circular Economy Blueprint for Solid Waste 2025 – 2035". KPKT also chairs the National Circular Economy Council for Solid Waste.

Meanwhile, the Ministry of Economy (formerly the Economic Planning Unit (EPU) under the Prime Minister's Department (PMD)) spearheads the 13th Malaysia Plan 2026 – 2030 which contains "Strategy D6.3: Enhancing implementation of circular economy and improving waste management". This ministry also produced the National Sustainable Consumption and Production (SCP) Blueprint (2016 – 2030). It is extremely unfortunate, however, that the SCP Blueprint reviewed waste incineration uncritically, without the consideration of the lack of circularity and pollution caused by burning (SCP Malaysia 2016).

Finally, the Ministry of Investment, Trade and Industry (MITI) has developed the "Circular Economy Policy Framework for the Manufacturing Sector in Malaysia". All these policies and plans indicate that policymakers in Malaysia finally view waste management as a priority in the pursuit of further economic progress. Nevertheless, the efforts remain fragmented, short sighted, and lack adequate follow through. Weak data and monitoring systems for all these plans further compound the problem.

Lack of infrastructure and genuine initiatives

Improper waste separation occurs not only because of a lack of implementation and enforcement, but also due to infrastructure gaps. The lack of dedicated collection service for recyclables and compostable, composting facilities able to divert organic and food waste, and material recovery facilities able to divert recyclable waste, have inadvertently exacerbated pollution caused by waste in the country. Overflowing landfills are susceptible to pollution from microplastics and hazardous leachate and chemicals, as well as the creation of greenhouse gas emissions such as methane as organic matter decomposes underground without oxygen (Ghosh 2023).

[b] The issuance of import permits for plastic waste has been taken over by SIRIM beginning 1 July 2025.

Worsening the problem is the fact that there are 114 non-sanitary landfills throughout Malaysia, essentially open dumps in the ground, and only 22 sanitary landfills (Malaysian Investment Development Authority 2026). Meanwhile, 21 landfills managed by SWCorp are set to reach full capacity by 2041 (Pfordten 2025). However, a larger challenge looms even before waste separation, which is Malaysia's absence of waste collection services and infrastructure in rural, remote, mountainous areas or islands, leading to open dumping. In addition, too many irresponsible parties resort to illegal dumping to avoid landfill tipping fees (Lee 2025), while it has become an unhealthy practice in Malaysia for landowners to convert their lands into illegal dumpsites to earn money by charging lower tipping fees compared to official landfills.

The lack of priority given to collecting and recovering materials in domestic wastes have seen recyclables such as plastic and paper, and compostables such as food and garden wastes, continue to be released into the environment, clogging up landfills, and soon, to be burnt in incinerators. Turning to incinerators instead of focusing on improving collection and separation-at-source appears to be the "easy" and "profitable" way out of the waste crisis. But it merely transfers the pollution from land to the air, and replaces one waste stream with another.

The promotion of waste incineration as part of the circular economy is a "false solution" to the waste crisis. According to the Environmental Justice Foundation (2025), false solutions can be defined as:

> "approaches or policies that are presented as solutions to a given collective problem, but reject, avoid, devalue, delay or otherwise pose burdens to social, economic, political or infrastructural reforms that address the root cause of the problem, and may generate other problems or shift the burden to future generations, other ecological systems, or other parts of the human society, especially marginalised groups."

False solutions refer to approaches that would ultimately prove unsuccessful in solving the problem at hand, because the measures do not address the root of the problem, which is unregulated production and high consumption rates, especially for single-use plastics seen as disposable. False solutions include prioritising recycling, waste-to-energy incinerator facilities, and bio-based/biodegradable disposable plastics without first considering waste reduction measures that can change systems of design, production, consumption, and disposal. Genuine solutions that tackle the root causes of waste must include reduction-enabling upstream policies such as non-toxic reuse-and-refill systems for packaging, strict controls of chemicals, and bans of toxic and non-essential products.

From the broader perspective of sustainability, incinerators are a losing proposition and are fundamentally incompatible with a closed-loop circular economy, where materials ought to be recovered for reuse. Incinerators do not eliminate waste, but instead have a voracious appetite for waste, often locking-in Local Authorities to contracts that require them to commit to delivering a minimum amount of waste for incineration, or suffer financial penalties. They also produce large quantities of hazardous ash (amounting to as much as 30% of the total waste burned), which must then be disposed of. Incinerator ash is highly toxic and should not be used carelessly. Communities living around incinerators are also at high risks of cancers, respiratory disease, miscarriage, premature birth, and congenital abnormalities (Arnika 2024). Incinerators destroy discarded products and materials, but merely transfer the pollution to the air and concentrate toxicity in the ashes.

Conquered by industrial capitalism

Malaysia's growth model, one that places gross domestic product (GDP) expansion ahead of other wellbeing indicators, replicates that of Western industrialised capitalist economies. In this model, when the priorities of MITI and the Ministry of Economy clash with those of the Ministry of Health or NRES, the former is likely to prevail. Economic wealth measured in GDP tends to take precedence over human and environmental health. However, a key difference between Malaysia and the industrialised countries is that, even as the societies became wealthier, they have managed to offshore polluting industries as well as their toxic wastes to other countries. Malaysia is unfortunately catching up in this era of late-stage capitalism, and needs to struggle to seek solutions for domestically generated wastes while being a recipient of polluting industries and wastes from advanced economies.

Malaysia has depended heavily on natural resource extraction (including fossil fuels, minerals, and timber), urbanisation, and ever expanding industrialisation to move up the economic ladder. Approaches, policies, and legal frameworks on the environment do not reflect a public mandate to protect the rights of citizens to clean air, clean water, and a healthy, thriving environment and ecosystems. Instead, our environmental laws have been constrained to controlling specific activities, instead of taking a more integrated approach to matters concerning the environment. Provisions within the EQA, enforced by the DOE, are currently limited to pollution control or minimisation, when in fact, environmental management should also protect, preserve, and conserve the natural environment.

In addition, the DOE may issue licenses to companies, as a temporary measure, that allow them to release discharges that exceed pollution control limits. These are, in essence, permits to pollute at set levels. Some industries are given a grace period to deal with pollution problems, but these licenses end up incentivising delayed remedial actions. The standards set for pollution parameters must be high enough to ensure environmental improvement and should be appropriate to our environmental conditions. It is insufficient to only ensure that each individual facility meets the prevailing parameters for pollutants in their wastewater discharges. For example, when approving the construction of more facilities that discharge effluents into the river, the total maximum daily load of pollutants in the river must be taken into account, especially in estuaries that are vulnerable to trapping pollutants due to tidal flows that are unable to wash pollutants out to sea.

The mindset of placing wealth and convenience ahead of health is observed across all levels of society, from businesses guilty of non-compliance with environmental regulations to lower their operational costs, to criminals involved in waste trafficking and illegal dumping, to villagers who lease out their agricultural lands to be used as dumping sites for a fee, down to the individual litterbug.

CASE STUDIES: THE COST OF GROWTH

Risking our rivers: Sungai Juru and Sungai Kim Kim

The pollution of Sungai Juru affecting the community of Kampung Kuala Juru in Penang is a landmark case that catalysed the environmental movement in Malaysia in the 1970s (Sekaran 2025). The Juru River basin is a case of chronic river pollution due to industrial discharge, domestic waste, and other effluents. Major rehabilitation and restoration efforts are being undertaken to improve the river water quality until today. However, the root cause of the pollution should be addressed to ensure sustainability.

While the Sungai Juru pollution has been a long-pending crisis, the pollution of Sungai Kim Kim in Johor was a sudden disaster that occurred when toxic chemical waste was illegally dumped into the river in March 2019. A total of 5,039 students and residents

in the area were affected, with 1,228 hospitalised and 26 treated in Intensive Care Units (Chinnayah 2019), and 111 schools in Pasir Gudang were also forced to close. Despite cleanup efforts of Sungai Kim Kim, a second wave of pollution happened merely weeks after, and smaller-scale contamination incidents have been reported over the years.

Sungai Kim Kim became a national scandal, highlighting weak enforcement and lack of emergency preparedness. Together, these two cases of river pollution demonstrate the spectrum of Malaysia's pollution challenges, from chronic neglect to acute emergencies, illustrating Malaysia's continuous struggle to balance industrial growth with environmental health.

Corporate impunity: Bukit Merah radioactive waste disaster and Raub gold mine cyanide controversy

Malaysia's rapid industrial and resource extraction activities often come at the expense of community and environmental health. Two landmark cases, the Bukit Merah radioactive waste dump in Perak and the Raub gold mine cyanide controversy in Pahang, exemplify systemic weaknesses in industrial waste management, corporate impunity causing devastating harm on communities, and community resistance through grassroots activism and community lawsuits.

In 1982, Asian Rare Earth (ARE), a joint venture involving Mitsubishi Chemical from Japan, began processing rare earth in Bukit Merah. The plant generated radioactive thorium waste, which was improperly disposed of in nearby residential areas. Villagers suffered from elevated rates of leukaemia, lead poisoning, birth defects, infant deaths, and miscarriages (Consumers' Association of Penang, n.d.). For the first time in Malaysian legal history, an entire community, with the crucial support of the Consumers' Association of Penang and Sahabat Alam Malaysia, went to court over an environmental issue, to protect their health and environment from radioactive pollution. The grassroots activism and lawsuits eventually forced the plant's closure in 1994.

Decades later, a gold processing company, used cyanide leaching to extract gold in Bukit Koman, Raub. Villagers complained of skin diseases, respiratory problems, and water contamination linked to cyanide tailings. Air monitoring by the community using portable gas analysers showed hydrogen cyanide levels in the air were excessive periodically. The Ban Cyanide Action Group (BCAG) mobilised protests, including rallies with thousands of supporters, and legal challenges with the support of Sahabat Alam Malaysia. The company responded with defamation suits against activists and media outlets, winning some cases. Although the company operations eventually ceased, the case highlighted how corporations can use litigation to silence dissent rather than address environmental risks.

These two cases are powerful narratives for advocacy, reminding Malaysia that industrial growth must never come at the expense of human health and environmental safety. This is particularly necessary as Malaysia is embarking on rare earth mining and processing. By placing profits above precaution, we risk perpetuating the same mistakes that have marred our environmental history and undermined public health.

Waste colonialism: Plastic waste and electronic waste imports

In addition to Malaysia's challenges dealing with domestic wastes, the country became the top destination for plastic waste exports from industrialised countries in 2018, after China banned the import of solid waste. That year, Malaysia received more than 850,000 tonnes of plastic waste exported by countries such as the United Kingdom, the United States, Japan, Germany, France, and Spain. While a portion of these imports were recycled into plastic

pellets, a significant amount of low-quality post-consumer waste was illegally dumped and burned. Residents from Kuala Langat, Klang and Sungai Petani organised themselves into environmental associations to protest against the constant air pollution and bad odours caused by the processing and burning of plastic waste. They patrolled their neighbourhoods, gathered locations of plastic waste recycling facilities, and organised demonstrations in front of factories. From 2019 to June 2020, the DOE had officially seized and returned 225 containers of plastic waste to the countries of origin, as well as carried out 316 operations against illegal factories (Wong 2021, 2024).

Plastic waste imports decreased after 2021, due to tighter global and national regulations and strengthened enforcement, including the Plastic Waste Amendments to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, which allowed Parties to control the import of plastic wastes using the Basel Convention (Basel Convention, n.d.). Soon after that, Malaysia became a top destination for electrical and electronic equipment waste (e-waste), particularly from the United States (Basel Action Network 2025). Raids at illegal facilities in Selangor found teenagers being exploited as forced labor (Rahim 2023). Illegal dumpsites were soon covered with piles of microplastics from e-waste casings and shredded cable residues. As of May 2026, 803 containers of e-waste were reportedly retained at Port Klang (Camoens 2026), while three massive inter-agency coordinated enforcement actions were carried out to inspect or raid e-waste facilities nationwide (Ops Hazard 1.0, 2.0 and 3.0) in 2025 and 2026, involving hundreds of officers (Hisham 2026).

Waste trafficking affected Malaysia not only in terms of peoples' health and the environment, but also heightened the risks of graft and illegality, as well as placed a heavy burden on enforcement agencies. The costs of this waste colonialism, where clean air, water, land, labor, and health of recipient countries are "conquered" and "exploited" to the benefit of others, extends beyond pollution. This is an intersecting issue of governance, national security, human rights, and environmental justice, too often driven by illicit activity and businesses avoiding costs in exporting countries. In July 2025, Malaysia tightened import regulations for plastic waste, and in April 2026, Malaysia completely banned the import of e-waste.

"Homoplastikus": The unique problem of plastic waste

In 1950, the world produced 1.5 million tonnes of plastic. In 2023, the European Union (EU) shipped more than 1.3 million tonnes of plastic waste to third countries. Reasons for export included the lack of capacity, technology, or financial resources to treat the waste locally (European Parliament 2014). It is, however, difficult to imagine a developing country like Malaysia having more capacity, technology and resources than the EU. Not only does this demonstrate the developed world's longstanding inability to properly handle the incredibly high levels of plastic consumption and subsequent waste it produces, but also the scale of negative impacts this has on receiving communities, and on the planet.

In Malaysia, unregulated plastic use and excessive plastic packaging have led to villagers in rural areas with no waste management services resorting to open burning and dumping in rivers, mangrove areas, beaches and mountains, particularly in islands or in the remote frontiers of Sabah and Sarawak. Over time, this plastic waste degrades into microplastics, which subsequently enter the food chain. Malaysian scientists have found microplastics in 93.3% of 180 Indian mackerel analysed (Najihah *et al.* 2025) and in all cockles (Mohan *et al.* 2024) . The study highlighted that cockles accumulate microplastics, which could potentially result in bioaccumulation and biomagnification in humans through consumption.

The question of solving plastic pollution is being debated currently by an Intergovernmental Negotiating Committee on Plastic Pollution led by the UNEP. There must be caution and due diligence when it comes to technologies or substitutes that negatively impacts human health and the environment, yet do not address problems of overproduction, such as incineration as discussed above. Other such technologies include chemical recycling and refuse-derived-fuel. Meanwhile, upstreamplastic waste prevention and minimisation must be prioritised, and single-use plastic products should not be replaced by regrettable substitutes such as bio-based, biodegradable, and compostable plastics, which have been shown to contain toxic chemicals (Zimmerman *et al.* 2020) and heavy metals (Jang *et al.* 2022).

OPPORTUNITIES: SOLUTIONS AND INNOVATIONS

Prevention and minimisation: The waste hierarchy

Malaysia is a Party to various multilateral environmental agreements (MEA), which means the country has pledged to abide by and enforce international obligations to protect the environment, including by strengthening the domestic policy and legal framework. The MEAs related to waste and pollution and Malaysia's obligations are summarised in Table 2. Each MEA would provide technical guidance to Parties who have ratified or accepted the agreements, on how to meet their obligations on waste and pollution. The Basel Convention has also released guidelines on how to manage waste in an environmentally sound manner.

Table 2. MEAs related to waste and pollution and Malaysia's obligations.

MEAs	General Obligations
ASEAN Agreement on Transboundary Haze	To control open burning and haze
Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal	To prohibit the import of hazardous waste from OECD countries
Paris Agreement - UN Framework Convention on Climate Change (UNFCCC)	To reduce greenhouse gas emissions
Montreal Protocol on Substances that Deplete the Ozone Layer	To eliminate ozone depleting substances such as chlorofluorocarbons (CFCs), etc.
Rotterdam Convention	Prior informed consent procedure for certain hazardous chemicals and pesticides in international trade
United Nations Convention on the Law of the Sea (UNCLOS)	To control pollution from ships
Vienna Convention for the Protection of the Ozone Layer	Framework for cooperation regarding ozone layer
Minamata Convention on Mercury	To control anthropogenic releases of mercury throughout its lifecycle Malaysia signed, but has yet to ratify
Stockholm Convention on Persistent Organic Pollutants	To reduce and/or eliminate persistent organic pollutants Malaysia signed, and preparing to ratify
Intergovernmental Science-Policy Panel on Chemicals, Waste and Pollution	To bridge the gap between scientific knowledge and global policy
Global Framework on Chemicals - For a Planet Free of Harm from Chemicals and Wastes	To regulate the use of chemicals across its lifecycle, including products and waste.

All these agreements are based on the prevention principle and the precautionary principle first developed at the Rio Declaration in 1992. In addition, the waste hierarchy and the Cartagena Declaration on the Prevention, Minimization and Recovery of Hazardous Wastes and Other Wastes (2011) emphasises waste prevention over waste management. Malaysia is currently in the negotiation process towards a Global Plastic Treaty, and these prior agreed principles on environmental protection should form the foundation of the agreement.

A revolution: Community-based initiatives, Zero Waste movements

As examined in the introduction, Zero Waste is an approach to resource use that ensures efficiency, recovery, and protection of scarce natural resources. It can be both a goal and a plan of action aimed at ending waste disposal in incinerators, dumps, and landfills. Zero Waste represents a revolution in our relationship with waste, aiming to safeguard health and improve the quality of life for everyone who interacts with waste, including producers, handlers, and the broader community.

The key elements of a Zero Waste approach include: reducing consumption; reuse and refilling systems; product redesign to be non-toxic and durable; banning waste incineration; composting or bio-digestion of organic materials; comprehensive waste segregation and safe recycling; active citizens and worker participation, and; policies, regulations, incentives, and financing structures to support these systems.

Several bottom-up initiatives have created Zero Waste movements, including Zero Waste Malaysia (54,400 members), Zero Waste Sabah (18,200 members), and Zero Waste Perak (579 members). Zero Waste retail outlets have also been set up, without receiving any support from the government. By adopting a genuine Zero Waste approach, including by developing public policies that support genuine upstream community-led solutions on waste prevention, Malaysia would be able to significantly reduce its reliance on incineration, conserve natural resources, decrease landfill use, and lower carbon emissions. This transition will contribute to a more sustainable and resilient waste management system, benefiting both the environment and the community.

Responsible businesses initiatives

Converting agricultural waste into bioenergy may offer a sustainable pathway for Malaysia to achieve its renewable energy goals, mitigate greenhouse gas emissions, and support rural economic development. Key challenges exist, however, including high initial capital costs, limited technical expertise, regulatory complexities, and low public awareness, which hinder the scalability of solutions like anaerobic digestion, biomass pelletization, and biochar production. Supportive policy measures could be set out to facilitate private sector leadership, such as bioenergy-specific subsidies and carbon pricing, public-private partnerships and community engagement. Using agricultural waste could offer a way for Malaysia to align economic and environmental aims (Harun *et al.* 2025).

To enhance the governance of chemicals in Malaysia, the government should consider developing a Pollutant Release and Transfer Register (PRTR) (United Nations Institute for Training and Research, n.d.). PRTR is an open-access national database of releases and transfers of harmful (and potentially harmful) chemicals to the environment. The data can be collected from point sources of pollution, such as directly from factories as required by the EQA, as well as from diffuse sources, such as agricultural farms or transportation, which Malaysia has yet to regulate. PRTR could require reporting on releases to air, water, and land, and waste transported to treatment and disposal sites. The data will be collected through annual reporting by industrial facilities and estimation of emissions from diffuse sources to allow tracking of trends over time; the use of common identifiers for chemicals, comparison and aggregation of the data; standardisation of data

for ease of analysis, and; dissemination of the information made available to the public through a National PRTR website. Having such a transparent system would guide Malaysia towards more responsible and environmentally sound management of waste and pollution.

To address post-consumer waste, Malaysia's circular economy and Extended Producer Responsibility (EPR) laws and policies are being developed, but upstream measures such as eco-design, material substitution, and producer accountability remain under-emphasised, compared to downstream recycling efforts and waste management. Manufacturers must be made responsible for the entire lifecycle of the products that they put into the Malaysian market, including for imports. EPR must begin at the product concept stage, incorporating holistic eco-design where durability, repairability, and the use of non-toxic materials are pertinent. Strengthening upstream strategies is critical to reduce waste generation and reliance on downstream partial recycling.

CONCLUSION AND RECOMMENDATIONS

Malaysia's pollution and waste crisis disproportionately affects marginalised communities. Communities living downstream of sources of pollution, farmers whose yields have decreased due to pollution, riverine fishers, and indigenous communities reliant on rivers for sustenance, are among those who bear the heaviest burdens. Communities near waste-burning sites, illegal dumpsites, and industrial zones face higher risks of respiratory problems, including asthma, bronchitis, and lung cancer due to prolonged exposure to polluted air. Polluted rivers and groundwater not only increase the risks of water-borne diseases, but also disrupt the water supply to consumers, such as in the case of frequent unscheduled water cuts in Selangor. Toxic exposure from hazardous waste, including radioactive waste, poses severe risks. Children in particular are especially vulnerable, with toxic exposure linked to developmental delays and neurological damage.

In addition, we are experiencing the triple planetary crisis of pollution, climate change, and biodiversity loss. Malaysia is one out of only 17 megadiverse countries in the world, but extreme weather events, rising sea levels, and chemical and waste pollution (largely driven by unsustainable production and consumption) threaten not only the wellbeing of our people, but also the survival of all species of wildlife on land and in the sea.

This reality—we all contribute to waste and it affects all of our existence—demands urgent multifaceted responses at global, regional, national, and local levels, with dialogue among all stakeholders, especially those negatively impacted. To find long-term solutions to waste and pollution, there should also be more multistakeholder dialogues across topics: development (wellbeing, post-growth, post-capitalist economics), labour (health and safety), conservation, climate change, gender, indigenous peoples, and more.

The different types of wastes and pollution call for different solutions. However, the solutions lie on a spectrum in terms of effectiveness, whether they actually offer a genuine solution, or simply "kick the can down the road" and would end up causing even more problems in the future. Crucially, taglines such as "waste to wealth" are misleading and ought to be stopped. Waste management is costly, costing the Malaysian government more than RM2 billion annually. Waste is a responsibility, and if not addressed adequately, will leave repercussions for future generations.

The underlying principles have already been set out by the United Nations General Assembly, which declared that everyone on the planet has a right to a clean, healthy and sustainable environment (United Nations Environment Programme 2022). In a resolution passed in 2022, the General Assembly said that "climate change and environmental

degradation were some of the most pressing threats to humanity's future". The human right to a healthy environment highlights the urgent need for procedural rights such as public participation and access to information in decision-making, and access to remedy in the face of violations, emphasising grassroots empowerment and local action, to support substantive rights such as the rights to clean air and clean water. Policy implementation and law enforcement are crucial in protecting these rights, and there must be environmental and human rights due diligence before adopting various technologies to deal with wastes. The state has a duty to protect and promote the human right to a healthy environment, while businesses have the duty to respect those rights (United Nations Office of the High Commissioner of Human Rights 2012).

In practice, waste minimisation measures should be prioritised, including but not limited to:

- reuse and refill infrastructure that emphasises the circulation of standardised and safe reusable packaging;
- mandatory extended producer responsibility (EPR) that prioritises durable product design, waste prevention, and reverse logistics for waste collection and safe recycling, informed by comprehensive life cycle assessments to ensure verifiable environmental benefits; and
- mandatory prior informed consent and data transparency for waste imports.

Finally, there must be due diligence, and adoption of the precautionary principle and the prevention principle, when it comes to technologies or substitutes that do not holistically address the root cause of waste and pollution—overproduction—and negatively impacts human health and the environment. These technologies include chemical recycling, waste incineration, refuse-derived-fuel, and regrettable single-use plastic substitutes such as bio-based, biodegradable, and compostable plastics, which only create further problems of pollution. Malaysia has committed to meeting the Sustainable Development Goals (Department of Statistics Malaysia 2025) and has developed The National Planetary Health Action Plan (Academy of Sciences Malaysia 2025). It's time for Malaysia to view waste and pollution as a policy priority.

REFERENCES

Academy of Sciences Malaysia. 2025. *The National Planetary Health Action Plan*. Kuala Lumpur: Academy of Sciences Malaysia. https://www.akademisains.gov.my/nphap-exec-sum/

Amry, N.N.S., Mohd Noor, M.Z. and D'Silva, J.L. Recovering construction industry: Incorporate circular waste management towards lower construction waste. *International Journal of Academic Research in Business and Social Sciences* 13(14):199–207. http://doi.org/10.6007/IJARBSS/v13-i14/18369

Arnika. 2024, September 3. *Report: Waste incineration drives the triple planetary crisis*. *Arnika*. https://arnika.org/en/news/report-waste-incineration-drives-the-triple-planetary-crisis

Basel Action Network. 2025, October 22. Brokers of shame: The new tsunami of American e-waste exports to Asia. *Basel Action Network*. https://www.ban.org/reports/brokers-of-shame

Basel Convention. n.d. Plastic Waste Amendments. *Basel Conventions*. https://www.basel.int/implementation/plasticwaste/amendments/overview/tabid/8426/default.aspx

Bernama. 2021, August 10. Poultry farm given one week to clean up sewage system – Exco. *The Sun*. https://thesun.my/news/malaysia-news/poultry-farm-given-one-week-to-clean-up-sewage-system-exco-ik8185956

Basyir, Mohamed. 2022, September 28. Conventional pollution control at pig farms cause of water pollution in the area. *New Straits Times*. https://www.nst.com.my/news/nation/2022/09/835101/conventional-pollution-control-pig-farms-cause-water-pollution-area

Bernama. 2023, January 11. SWCorp intensifying enforcement to combat illegal dumping of construction waste in KL, says director. *Malay Mail*. https://www.malaymail.com/news/malaysia/2023/01/11/swcorp-intensifyingenforcement-to-combat-illegal-dumping-of-construction-waste-in-kl-saysdirector/49677

Bernama. 2025, August 21. Ministry exploring single agency for waste management. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2025/08/21/ministry-exploring-set-up-of-single-agency-for-waste-management

Cambridge Dictionary. n.d. Waste. https://dictionary.cambridge.org/dictionary/english/waste.

Camoens, A. 2026, April 15. MCBA launches major push to remove 150 illegal e-waste containers by May 1. *New Straits Times*. https://www.nst.com.my/news/nation/2026/04/1418006/mcba-launches-major-push-remove-150-illegal-e-waste-containers-may-1

Cartagena Declaration on the Prevention, Minimization and Recovery of Hazardous Wastes and Other Wastes. 2011. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. https://www.basel.int/portals/4/basel%20convention/docs/meetings/cop/cop10/cartagenadeclaration.pdf

Chinnayah, T., Abdul Aziz, S., Che Mat Din, S.N., Mahdan, N.B., Rosli, N., Ibrahim, M.F., Khida, N. *et al*. 2019. Largest acute chemical incident in Malaysia, March 2019: Opportunity to assess the preparedness and response capacity. *Medical Journal of Malaysia* 74(Supplement): 37.

Consumers' Association of Penang. n.d. Chronology of events in the Bukit Merah Asian Rare Earth development. https://consumer.org.my/chronology-of-events-in-the-bukit-merah-asian-rare-earth-development/

Department of Environment (DOE). 2025. *Environmental Quality Report 2024*. Putrajaya: Department of Environment. https://edl.doe.gov.my/overview2?bibnumber=51542

Department of Statistics Malaysia (DOSM). 2022, February 14. Launching of report on the key findings, population and housing census of Malaysia 2020. *Department of Statistics Malaysia*. https://www.dosm.gov.my/portal-main/release-content/launching-of-report-on-the-key-findings-population-and-housing-census-of-malaysia-2020

Department of Statistics Malaysia (DOSM). 2025, December 17. Malaysia steps firmly towards Agenda 2030 with 82% of SDG Indicators available. *Department of Statistics Malaysia*. https://www.dosm.gov.my/uploads/release-content/file_20260312132234.pdf

Environmental Justice Foundation. 2025. *False solutions: unmasking policy gaps in addressing plastic pollution in Thailand and Southeast Asia*. London: Environmental Justice Foundation. p. 6. https://ejfoundation.org/reports/false-solutions-en

European Parliament. 2020, March 24. Parliamentary question. *European Parliament*. https://www.europarl.europa.eu/doceo/document/P-9-2020-000678-ASW_EN.html

European Parliament. 2024. Plastic waste and recycling in the EU: Facts and figures. *European Parliament*. https://www.europarl.europa.eu/topics/en/article/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures

Ghosh, A., Kumar, S. and Das, J. 2023. Impact of leachate and landfill gas on the ecosystem and health: Research trends and the way forward towards sustainability. *Journal of Environmental Management* 336: 117708. https://www.sciencedirect.com/science/article/pii/S0301479723004966

Harun, S.N., Alias, A. and Siregar, K. 2025. Toward a sustainable energy future: Agricultural waste as a bioenergy resource in Malaysia. *Journal of Climate Change and Space Science* 1(1): 3. https://doi.org/10.17576/jccass.0101.2025.03

Hisham, H. 2026, April 7. GOF uncover 8 illegal e-waste sites under Op Hazard 3.0. *The Malaysian Reserve*. https://themalaysianreserve.com/2026/04/07/gof-uncover-8-illegal-e-waste-sites-under-op-hazard-3-0/

Isamudin, D. 2026, May 20. Malaysia urges faster shift to circular economy as waste levels near critical threshold. *New Straits Times*. https://www.nst.com.my/business/esg/2026/05/1443933/malaysia-urges-faster-shift-circular-economy-waste-levels-near

Jackson, T. 2026. *The insatiable machine: How capitalism conquered the world*. New York: W.W. Norton & Company.

Jang, F.H., Wong, C., Choo, J., Sia, E.S.A., Mujahid, A. and Müller, M. 2022. Increased transfer of trace metals and *Vibrio* sp. from biodegradable microplastics to catfish *Clarias gariepinus*. *Environmental Pollution* 298(1): 118850. https://doi.org/10.1016/j.envpol.2022.118850

Lee, B. 2025, December 12. 3,634 illegal dumpsites shut down. *The Star*. https://www.thestar.com.my/news/nation/2025/12/12/3634-illegal-dumpsites-shut-down

Makavou, K. 2021, May 26. The EU is clear: Waste-to-Energy incineration has no place in the sustainability agenda. *Zero Waste Europe*. https://zerowasteeurope.eu/2021/05/wte-incineration-no-place-sustainability-agenda/

Malaysian Investment Development Authority. 2026. Turning waste into wealth: Malaysia's circular economy in action. *Malaysian Investment Development Authority.* https://www.mida.gov.my/turning-waste-into-wealth-malaysias-circular-economy-in-action/

Ministry of Economy. 2024. *SDG Roadmap for Malaysia Phase II 2021 – 2025*. Putrajaya: Ministry of Economy. p. 92. https://ekonomi.gov.my/sites/default/files/2024-09/SDG_Roadmap_for_Malaysia_Phase2_%282021-2025%29_0.pdf

Miwil, O. 2025, April 17. Kitingan: Uncontrolled chemical fertiliser use among contributors to Sabah's water pollution problem. *New Straits Times*. https://www.nst.com.my/news/nation/2025/04/1203437/kitingan-uncontrolled-chemical-fertiliser-use-among-contributors-sabahs

Mohan, P., Hamid, F.S., Furumai, H. and Nishikawa, K. 2024. Beneath the surface: Exploring microplastic intricacies in Anadara granosa. *Marine Environmental Research* 199: 106581. https://doi.org/10.1016/j.marenvres.2024.106581

Muslim, N. 2025, September 9. Malaysia hopes EPR will stem tide of plastic waste. *Bernama*. https://www.bernama.com/en/news.php?id=2461915

Najihah, M., Ali, M.M., Jansar, K.M., Yaacob, K.K.K. and Asgnari, N.H. 2025. Microplastic contamination in Indian mackerel: A study of prevalence and potential health risks for Malaysian consumers. *Physics and Chemistry of the Earth, Parts A/B/C* 138: 103864. https://doi.org/10.1016/j.pce.2025.103864

National Solid Waste Management Department. 2013. *Survey on solid waste composition, characteristics and existing practice of solid waste recycling in Malaysia*. Putrajaya: National Solid Waste Management Department. p. 74. https://jpspn.kpkt.gov.my/jpspn/resources/Images%20JPSPN/Sumber%20Rujukan/Kajian/Final_Report_REVz.pdf

Palansamy, Y. 2025, March 5. By 2050, 870,000 EV batteries will need recycling: How is Malaysia tackling the challenge? *Malay Mail*. https://www.malaymail.com/news/malaysia/2025/03/05/by-2050-870000-ev-batteries-will-need-recycling-how-is-malaysia-tackling-the-challenge/167510

Pfordten, D. 2025, July 31. Landfills to hit full capacity by 2041. *The Star*. https://www.thestar.com.my/news/nation/2025/07/31/landfills-to-hit-full-capacity-by-2041

Rahim, R.N.R. 2023, September 21. Polis selamatkan 4 remaja jadi buruh. *Harian Metro*. https://www.hmetro.com.my/mutakhir/2023/09/1012075/polis-selamatkan-4-remaja-jadi-buruh

Regional Knowledge Centre for Marine Plastic Debris. 2026. Laws and regulations. https://rkcmpd-eria.org/malaysia/ministries-and-coordination-mechanism

SCP Malaysia. 2016. *The National SCP Blueprint 2016–2030 - The Pathways for Sustainable Consumption and Production in Malaysia*. Kuala Lumpur: SCP Malaysia. p. 10. https://www.oneplanetnetwork.org/sites/default/files/malaysia_the_national_scp_blueprint_2016_-_2030.pdf

Sekaran, R. 2025, September 17. Flowing change into Sungai Juru. *The Star*. https://www.thestar.com.my/metro/metro-news/2025/09/17/flowing-change-into-sungai-juru

Shadiqe, J. 2025, September 23. Chicken farm pollution suspected in mass Johor river fish kill. *New Straits Times*. https://www.nst.com.my/news/regional/2025/09/1279525/chicken-farm-pollution-suspected-mass-johor-river-fish-kill.

Soo, W.J. 2026, February 25. Parliament passes Environmental Quality (Amendment) Bill 2026 to empower Sabah and Sarawak on scheduled waste. *Malay Mail*. https://www.malaymail.com/news/malaysia/2026/02/25/parliament-passes-environmental-quality-amendment-bill-2026-to-empower-sabah-and-sarawak-on-scheduled-waste/210434

Tham, B. and Lee, C. 2026, March 27. Is Malaysia’s waste crisis an accountability issue? *The Star.* https://www.thestar.com.my/esg/2026/03/27/is-malaysias-waste-crisis-an-accountability-issue

United Nations Environment Programme (UNEP). n.d. Understanding circularity. *UNEP Circularity Platform*. https://buildingcircularity.org/

United Nations Environment Programme (UNEP). 2021, February 22. Circularity to advance sustainable development. *United Nations Environmental Programme*. https://www.unep.org/news-and-stories/speech/circularity-advance-sustainable-development.

United Nations Environment Programme (UNEP). 2022, July 8. In historic move, UN declares healthy environment a human right. *United Nations Environmental Programme*. https://www.unep.org/news-and-stories/story/historic-move-un-declares-healthy-environment-human-right

United Nations Environment Programme (UNEP). 2023. *Towards Zero Waste: A catalyst for delivering the Sustainable Development Goals*. Nairobi: United Nations Environmental Programme. https://wedocs.unep.org/items/502ab056-1911-4cda-8146-4ac761145c67

United States Environmental Protection Agency. 2025, December 17. How communities have defined zero waste. *United States Environmental Protection Agency*. https://www.epa.gov/transforming-waste-tool/how-communities-define

United Nations Institute for Training and Research. n.d. Pollutant release and transfer registers. *UNITAR*. https://unitar.org/sustainable-development-goals/planet/our-portfolio/pollutant-release-and-transfer-registers

United Nations Office of the High Commissioner of Human Rights. 2012. *Guiding Principles on Business and Human Rights: Implementing the United Nations 'Protect, Respect and Remedy' Framework*. New York: United Nations Office of the High Commissioner of Human Rights. https://www.ohchr.org/en/publications/reference-publications/guiding-principles-business-and-human-rights

Ting, S.N., Sakawi, A.M.F., Lau, H.H. and Whyte, A. 2022. Minimisation of construction waste using the principles of waste management. *ASM Science Journal* 17: 1–9. https://doi.org/10.32802/asmscj.2022.1352

Waras, M.N., How, V., Yahaya, N., Shahrun, M.S., Mohd Hijrah, N.N., Sidek Ahmad, Z.N., Shah Ruddin, N.I.A. and Abdul Rahaman, S.R. 2024. Assessing pesticide exposure and regulatory challenges in Malaysia: A review of population monitoring, food residue, and environmental contamination. *Ibnosina Journal of Medicine and Biomedical Sciences* 16: 149–161. https://doi.org/10.1055/s-0044-1793952

Wong, P.Y. 2021, March 16. Malaysia is not a "garbage dump": Citizens against corruption, complacency, and climate crisis. *Center to Combat Corruption and Cronyism*. https://c4center.org/malaysia-is-not-a-garbage-dump-citizens-against-corruption-complacency-crime-and-climate-crisis/

Wong, P.Y. 2024. Exporting pollution, colonizing heatlh: The true costs of plastic waste exports to Malaysia. In *Plastic Waste Trade: A New Colonialist Means of Pollution Transfer*, S. Gündoğdu (Ed.). Switzerland: Springer Nature. https://www.springerprofessional.de/en/exporting-pollution-colonizing-health/26804502

Zimmermann, L., Dombrowski, A., Völker, C. and Wagner, M. 2020. Are bioplastics and plant-based materials safer than conventional plastics? In vitro toxicity and chemical composition. *Environment International* 145: 106066. https://doi.org/10.1016/j.envint.2020.106066


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 921–938
doi: 10.62613/sonc2025.v3anc18

CHAPTER 18

Malaysia's rare Earth gamble: A critical examination of its high-risk REE future

THEIVA LINGAM* and A. LALITH KUMAR

Abstract: This paper critically examines Malaysia's ambitions and advancements in the rare earth elements (REE) industry, highlighting key national and state-level initiatives. It briefly evaluates the environmental repercussions of REE extraction alongside the disproportionate impacts on Indigenous Peoples and Local Communities (IPLCs) whose lands overlap 70% of reserves. It questions whether short-term economic gains, projected at RM747 billion (Aziz 2025), is worth jeopardising sustainable legacies for future generations through insufficient safeguards. This paper also offers recommendations urging the Malaysian government to thoroughly evaluate its options before fully committing to the development of the REE sector.

INTRODUCTION

Overview of critical minerals

Numerous countries designate certain minerals as critical or strategic minerals through official lists or policies, driven by economic security, clean energy transitions, and supply chain vulnerabilities. There is no one standard definition to which mineral is critical and it varies across nations. The terminology varies across different countries: while Malaysia and China commonly refer to these as 'strategic minerals', other nations use terms such as 'strategic and critical minerals' or 'energy transition minerals' to describe resources essential for technological advancement and the energy transition.

For example, according to the US Energy Act of 2020, the US Secretary of State defines any non-fuel mineral, element, substance or material as critical if it meets three key criteria: it is vital to economic or national security; its supply chain is susceptible to disruption, and; it serves as an essential function in one or more energy technologies (U.S. Department of Energy, n.d.), the absence of which would have serious consequences. The list becomes critical depending on geopolitics and changes in technology. The US has a list of 60 critical minerals, with 10 classified as new critical minerals and 15 rare earth elements (USGS 2025).

These minerals are essential resources that underpin the development and functioning of sectors such as technology, defense, energy, and manufacturing. Their importance stems from serving as foundational components in advanced technologies, including renewable energy infrastructure and defense systems. Key examples of critical, strategic, or energy transition minerals include rare earth elements (REE), copper, manganese, lithium, cobalt, and nickel. Malaysia has classified five strategic minerals in its New Industrial Master Plan 2030 and they include REE, tin ore, silica, kaolin and bauxite (MITI 2023).

Global drivers for rare earth elements (REE)

In relation to rare earths, China is said to have the highest reserves with 44 million metric tons with Brazil second with 21 million metric tons and India third with 6.9 million metric tons (Pistilli 2025). According to the International Energy Agency (IEA), China dominates 60% of the global production of rare earths and about 90% of the processing and refining

Sahabat Alam Malaysia, No. 10, Jalan Masjid Negeri, 11600 Pulau Pinang, Malaysia.
***Corresponding author: theiva.lingam@gmail.com**

(White 2023). It is a paradoxical cycle that in the effort to transition away from fossil fuels due to climate change, countries are increasingly mining critical or strategic minerals for renewable energy. This process in itself causes comparable environmental harm.

From consumer electronics to electric vehicles, military equipment, artificial intelligence, nanoelectronics, information and communication technologies, and medical biotechnology, the relentless demand against the monopolised REE supply chain has created geopolitical tension. This is especially so since China announced its export ban of technology to make rare earth magnets in addition to the bank of technology to extract and separate REE in 2023 (Liu and Patton 2023).

Even before China's move to protect its dominance in the supply with its domino-effect on the dependent industries, countries had shifted their focus to frenetically diversify and secure the supply chain to protect their own national industries and interests. Malaysia intends to leverage on this by attracting investments and collaboration with countries that vie for entry into the Malaysian REE industry (Reuters 2025a).

What is Rare Earth Element?

Rare earth elements (REEs) are a group of 17 chemically similar elements, including the 15 lanthanides plus scandium and yttrium (Hoatson *et al.* 2011). While common in the Earth's crust, their extraction is complex and often environmentally challenging. REEs are classified into light (LREE) and heavy (HREE) categories, with LREEs like neodymium used in magnets for wind turbines and data storage, and HREEs, which are rarer and more valuable, used in hybrid cars, fibre optics, and medical devices. Scandium is unique and not part of either category.

REEs do not exist on their own as native metals. They are found in low concentrations in a number of minerals including silicates, carbonates, oxides, phosphates and halides. Separating these elements from other elements is typically hard.

THE MALAYSIAN MINING & REE CONTEXT

History of mining and legacy of waste

Malaysia's mining history dates back to the early 19th century with small scale mining of minerals by local communities to the operation of large tin mines in Perak to the extraction of rare earth element (yttrium) from monazite by Asian Rare Earth Sdn Bhd (ARE) in 1979 in Bukit Merah, Perak and now the processing of lanthanide concentrate (a partially processed mineral product that contains REE) imported from Mount Weld, Australia at the Lynas Advanced Materials Plant (LAMP) (Lynas Malaysia) in Kuantan, Pahang (Consumer's Association of Penang 1993, 2011; Badd 2019).

Mining in Malaysia has also left a legacy of waste behind with little lessons learnt especially in relation to the Bukit Merah ARE case. In the Bukit Merah case, many residents from the town of Papan, Perak, suffered the effects of cancer as a result of radioactive pollution within a few years from the start of the operations by ARE (Bradsher 2011). A representative action was filed by the 10,000 strong residents of Bukit Merah in 1985 against ARE and others. They won at the Ipoh High Court in 1992 and in 1993, the then Supreme Court overturned the decision of the High Court. Despite this loss, it was public pressure that forced the shutdown of the ARE plant in 1994 (Badd 2019). Today, the radioactive waste—thorium hydroxide, which is the property of the Perak state government—is permanently buried in a long-term storage facility somewhere in the Kledang Range, behind Papan town in Perak, entombed under more than 20 feet of clay and granite (Yong 2011).

Apart from the Bukit Merah case, Malaysians will also need to contend with more radioactive waste generated from the LAMP facility in Gebeng, Kuantan, Pahang, for generations to come. The water leach purification (WLP) residue—one of two types of waste generated during the processing of the lanthanide concentrate—contains radioactive wastes of thorium radionuclides among others, which will remain radioactive for another 14 billion years due to its long half-life.

A total of 1.6 million tonnes of this radioactive waste will be permanently disposed off in a facility in Gebeng, Pahang right next to the LAMP. Unlike the thorium hydroxide waste in the Kledang Range, which was buried deep in the hill, the WLP residue will be kept in "near surface repositories with limited regulatory control" according to the 2021 Environmental Impact Assessment Report (DOE 2021).

The Ministry of Science, Technology and Innovation (MOSTI) has recently approved a 10-year licence (Lo 2026) for Lynas Malaysia signalling the government's continued willingness to host rare earth processing operations despite persistent public concerns. In granting this long-term approval, MOSTI effectively provides regulatory certainty for the company's investment and operations, including downstream activities tied to Malaysia's broader ambition to participate in the rare earth value chain. This decision raises questions about the adequacy and robustness of existing environmental and radiological safeguards, as well as the extent to which community feedback and independent scientific assessments were integrated into the licensing process.

In spite of Malaysia's challenging history with mining-related environmental damage and hazardous waste, the government is resolute in its pursuit of the economic benefits offered by rare earth mining. To reassure the public, several sustainability measures have been introduced, such as communication, education, and public awareness (CEPA) programmes, the engagement of Canadian technical expertise, and the proposed implementation of sustainability certification schemes. Nonetheless, these efforts do not fundamentally address the underlying issue: Do the environmental risks and harms associated with rare earth mining outweigh its financial gains?

MALAYSIA'S POLICY FRAMEWORK AND INITIATIVES FOR RARE EARTH ELEMENT (REE) INDUSTRY DEVELOPMENT

Malaysia has established a comprehensive set of policies, plans, and regulatory frameworks to support and advance mineral development, including REE mining. Among the principal policies is the Second Mineral Policy (*Dasar Mineral Negara 2* – DMN2), which has been in force since 2009 and prioritises sustainable mineral development. Additionally, the Framework for the National Mineral Industry Transformation Plan 2021 – 2030 or *Kerangka Pelan Transformasi Industri Mineral Negara 2021 – 2030* (TIM 2021 – 2030) sets out transformation objectives for the mineral sector. Both the National Mineral Industry Transformation Plan and the New Industrial Master Plan 2030 further reinforce the integration of REE into downstream processing strategies.

While the DMN2 is still the main policy in force, the Third Mineral Policy (*Dasar Mineral Negara 3* – DMN3) is still underway after the 3rd National Mineral Council Meeting approved the framework in July 2024 (Ajos 2023). The government held stakeholder consultations in developing the action plans under this third framework. The time frame for this policy will be until 2030. The core objectives of this policy include legislative enhancements with the strengthening of coordination between federal and state governments and emphasis on environmental social governance (ESG) standards. DMN3 will be aligned with the 13th Malaysia Plan 2026 – 2030 or *Rancangan Malaysia Ke-13 2026 – 2030* (RMK13).

The RMK13 will focus on: building local capacity in REE mining, purification and separation; develop talent, infrastructure and incentives; enhance REE resource mapping, and; federal-state governance and cooperation. The TIM 2021 – 2030 has identified five strategic minerals which are: 'non-radioactive' rare earth elements (NR-REE), bauxite, tin ore, silica sand, and kaolin (KeTSA 2021).

The term 'non-radioactive' is used to define REE although these minerals all contain naturally occurring radioactive materials (NORM). The current focus of Malaysia is to extract REE from ion-adsorption clay (IAC) deposits using an In-Situ Leaching (ISL) method where rare earth carbonate (REC) would be the final product.

According to the TIM 2021 – 2030 framework, Malaysia possesses approximately RM4.11 trillion in mineral resources, encompassing both metallic and non-metallic minerals. Of this total, metallic minerals account for around RM1.03 trillion, while non-metallic minerals are valued at approximately RM2.96 trillion. The country is estimated to hold 16.2 million tonnes of rare earth oxides, with about 70% of these deposits located in the states of Terengganu, Kelantan, Kedah, and Perlis (Aziz 2025). The majority of rare earth reserves remain underground, often situated in permanent reserved forests, environmentally sensitive areas, hills, and mountainous regions. Malaysia aims to capitalise on these substantial resources by advancing the development of IAC rare earth elements. Recognising Malaysia's promising potential in the REE sector, numerous states across the country have expressed keen interest in advancing the development of this industry, as one would see below.

During a recent Parliamentary session, the Minister of Natural Resources and Environmental Sustainability (NRES), Arthur Joseph Kurup, announced on 20 January 2026 that the Department of Minerals and Geoscience, undertook a study under the 12th Malaysia Plan and has estimated the presence of 274,144 metric tonnes of REE within a surveyed area of 103.9 km^2 across nine states: Terengganu, Perak, Kedah, Sarawak, Negeri Sembilan, Pahang, Kelantan, Selangor, and Johor (Dewan Rakyat Hansard 2026). The Minister also mentioned that the government will ensure that the industry is developed responsibly and sustainably taking into account economic prosperity and the well-being of the people.

Policy ban on export of REE raw materials

In September 2023, the Malaysian Prime Minister, Dato' Seri Anwar Ibrahim announced the development of a policy to ban exports of REE raw materials to avoid exploitation and loss of resources (Anathalakshmi and Nguyen 2023). The moratorium came into effect on 1 January 2024 following its endorsement at the Cabinet Meeting held on 27 October 2023 and it is subject to review every six months (NRES 2024).

As it follows, a critical aspect of the moratorium on exports of REE raw materials was to develop the value-adding midstream (Bernama 2025a) and downstream industries as opposed to solely mining. In January 2025, the Prime Minister also confirmed that Malaysia would be seeking the assistance of Japan to develop a REE processing plant in Malaysia (Mahari 2025). This follows through the announcement by the former Minister of NRES, Nik Nazmi Nik Ahmad in Parliament in November 2024 that Malaysia had great potential to develop the REE downstream industry as a super magnet producing country to support the electric vehicles (EVs) manufacturing sector (Bernama 2024c).

In 2025, Malaysia announced a RM600 million neodymium-iron-boron super magnet plant in Kuantan, Pahang. Led by Malaysia's Lynas Rare Earths Ltd. and South Korea's JS Link Co., the facility aims to produce 3,000 tonnes of high-performance magnets yearly for EVs and electronics. With land secured and investments confirmed, the project is set for groundbreaking under the MOSTI's oversight (Reuters 2025c).

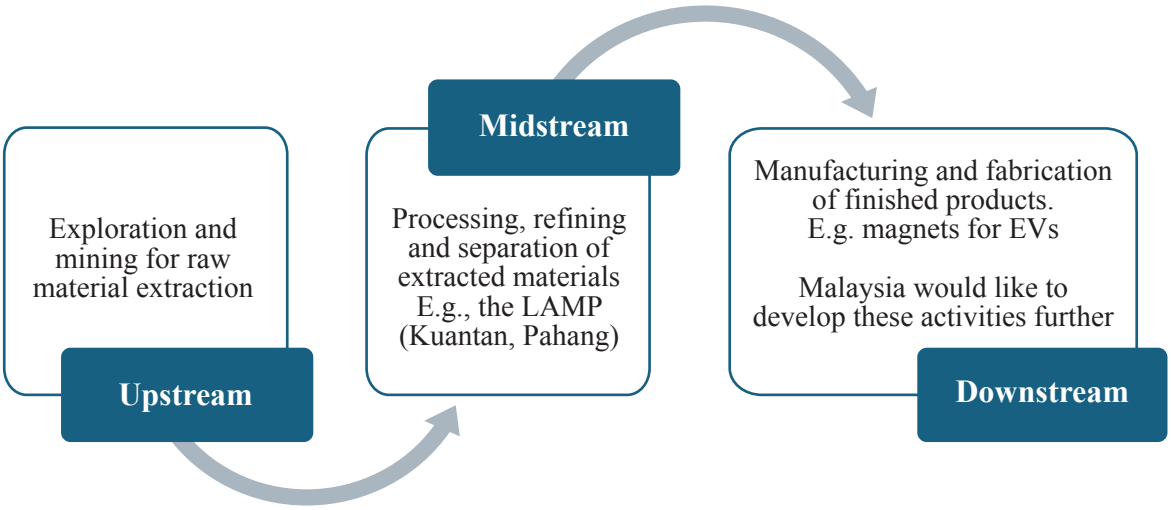


Figure 1. Value chain of the REE industry (Source: MOSTI 2023).

The US Malaysia Agreement on Reciprocal Trade (ART)

On 26 October 2025, Malaysia signed the Agreement on Reciprocal Trade (ART) and a Memorandum of Understanding (MOU) on Critical Minerals Cooperation (The White House Washington 2025a) with the United States during President Donald Trump's visit to Malaysia. This pact promotes collaboration across the critical minerals supply chain, including exploration, extraction, processing, refining, manufacturing, recycling, and recovery of rare earth elements and other key materials vital for technology and green energy transitions. One of the key terms of the ART, in Annex III, Section 6 (in particular Article 6.2) is as follows,

> "Malaysia has committed to refrain from banning, or imposing quotas on, exports to the United States of critical minerals or rare earth elements. Malaysia has committed to the expedient development of its critical minerals and rare earths sectors in partnership with U.S. companies, including granting extended operating licenses to create certainty for businesses to increase production capacity. Malaysia has committed to ensure no restrictions are imposed on the sale of rare earth magnets to U.S. companies" (The White House Washington 2025b).

Although Malaysia has pledged not to impose export bans or quotas on critical minerals destined for the United States, the export ban is still in force at the time of writing (Reuters 2025a). However, on 20 February 2026, in a 6 – 3 majority decision, the US Supreme Court ruled against President Trump's tariffs imposed under the International Emergency Economic Powers Act (IEEPA) (Library of Congress 2026). Following this ruling, the minister of Ministry of Investment, Trade and Industry (MITI), Johari Ghani confirmed that the ART has been nullified (FMT 2026). However, this remains to be seen as there is no formal proof that Washington has confirmed the same and a group of PKR lawmakers has requested for a formal communication between both countries (Malay Mail 2026).

Legal framework related to the mining and mineral industry

The governance of Malaysia's mining and mineral industry is overseen by the Department of Mineral and Geoscience Malaysia (JMG) under the NRES ministry, with significant contributions from other key agencies such as MOSTI, MITI, and the Department of Atomic Energy Malaysia (ATOM) (Reuters 2025b). The legal foundation rests on core statutes like

the Mineral Development Act 1994 (MDA 1994), which governs licensing and state mineral rights, and the Environmental Quality Act 1974 (EQA 1974), which ensures environmental protection through mandatory Environmental Impact Assessments (EIAs) reports. Importantly, mining falls under state jurisdiction, granting state governments primary authority over mineral licensing, local regulations, and the enforcement of environmental and safety standards, thereby playing a central role in regulating and shaping sustainable mining practices in Malaysia.

The following is a list of key policies and legislation that are related to the mining industry in Malaysia (Table 1). The laws also include their corresponding regulations, guidelines and circulars that regulate the mining and mineral industry.

Table 1. Relevant policies and laws applicable to the mining and mineral industry in Malaysia.

Policies	**Laws**
Second National Mineral Policy (DMN2)	Mineral Development Act 1994 and State Mineral Enactments
National Industrial Master Plan 2030	National Forestry Act 1984 & State Forestry Enactments
Framework Plan for the Transformation of the Malaysian Mineral Industry 2021 – 2030 (TIM 2021 – 2030)	Environmental Quality Act 1974
National Advanced Materials Technology Roadmap 2021 – 2030	Town and Country Planning Act 1976
Green Technology Master Plan Malaysia (GTMP)	Natural Resources and Environment Ordinance 1993 (Cap. 84) (1958 Ed.) (Sarawak)
National Green Technology Policy	Environment Protection Enactment 2002 (Sabah)
Standard Operating Procedure (SOP) of Non-Radioactive Rare Earth Elements (NR-REE) Mining Malaysia	Geologists Act 2008
4th National Physical Plan	Geological Survey Act 1974
Development plans for each state in Peninsular Malaysia (local, structure and special area plans)	Occupational Safety and Health Act 1994

On 10 March 2023, the government approved the Standard Operating Procedure (SOP) for Non-Radioactive REE Mining (NR-REE) (JMG 2023) to regulate the emerging REE mining sector through standardised guidelines across the various federal and state agencies on the pretext of promoting sustainable mining. The SOP purports to address feasibility studies and licensing during pre-mining exploration, licensing for mining operations, environmental impact assessments, safety protocols and rehabilitation plans during the operational phases, and post-mining export controls and royalties to prevent resource loss and promote downstream processing.

To date, only Perak, Pahang, and Negeri Sembilan have formally adopted the SOP. As mining falls under state jurisdiction, it is ultimately the responsibility of each state government to formally adopt the SOP, making any necessary modifications to suit their specific requirements.

Standard Operating Procedures (SOP) – A critical examination

The SOP provides guidance on development, operation, environmental management, safety, and mine closure, specifically for mining 'non-radioactive' rare earth elements using the ISL method and processing of IAC deposits. Notably, it does not require a Radiological Impact Assessment (RIA) for ISL mining of IAC deposits, unlike open-pit mining.

The SOP attributes the term 'non-radioactive' to REE mining solely based on the consideration that activity concentration of radioactive elements such as thorium (Th) and uranium (U) is usually below 1 Bq/g in IAC deposits, meeting the clearance level required by Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011. However, this may not always hold true, as concentrations can vary by location, and tailings produced could result in 'technologically enhanced naturally occurring radioactive materials' (TENORM) that might exceed safe limits (Findeis and Schaeffer 2017). The omission of RIA requirements is therefore questioned.

While the SOP covers technical, environmental, socioeconomic, and governance aspects, its focus seems more on reassuring and attracting investors than on robustly protecting the environment or affected communities. Environmental protections are largely superficial, lacking comprehensive measures for long-term hazardous waste management, monitoring, or remediation.

The SOP claims to prohibit mining in conservation areas, but there are no strong safeguards to enforce this. Jurisdictional friction between federal and state authorities further complicates effective implementation, as land and mineral resources fall under state control, allowing states to amend or adapt the SOP as they see fit. There is no clear moratorium preventing states from exploiting conservation or environmentally sensitive areas, rendering the SOP primarily a guide for investors rather than a strict regulatory framework.

State plans on REE

In recent years, several states have taken proactive steps to capitalise on their significant REE deposits (Table 2). Among the frontrunners is Perak, which made headlines as the first state to approve *in situ* mining and beneficiation of lanthanide-rich ion-adsorption clays (Sahabat Alam Malaysia 2022), followed by ambitious plans in Negeri Sembilan and a strong policy stance in Sarawak (Sarawak Department of Premier 2025). These initiatives, while poised to boost economic growth and technological advancement, have also raised important questions about environmental impacts, regulatory compliance, and the equitable sharing of benefits. The evolving REE mining sector in Malaysia teeters on a fine line: unlocking high-value resources concentrated in biodiverse forest reserves, while confronting profound environmental risks like habitat destruction, toxic tailings, and irreversible harm to indigenous peoples and local communities and ecosystems.

RISKS AND IMPACTS OF REE MINING ON THE ENVIRONMENT AND PUBLIC HEALTH

Illegal REE mining

In addition to the rapid push by various state governments to explore and mine REE, the issue of illegal mining also persists. Over the past few years, there have been several documented cases of illegal REE mining in the Bukit Enggang Forest Reserve in Sik (Ikhsan and Abdul Rahman 2023), Kuala Pilah, Negeri Sembilan in 2023 (New Strait Times 2023), in Perak in 2023 (Reuters 2023) and in Selangor and Kelantan in 2024 (Azmi 2024). These incidents represent a small fraction of the broader and more complex challenges associated with REE mining. Since REE deposits are typically located deep within forest reserves and other environmentally sensitive areas, it is likely that further unreported illegal mining activities may be occurring undetected.

Table 2. Development or proposed development of the REE industry by states in Malaysia.

States	Key initiatives / plans	Scale and/or location	Economic focus	Environmental/social issues
Perak – Kenering pilot project	First state to approve an *in situ* mining and beneficiation of lanthanide rich ion adsorption clays in the Kenering district. The federal government allowed for an exemption to the nationwide moratorium, permitting the export of raw materials. [1]	The project site is located along Federal Route 4 (East-West Highway) segment of Jalan Baling-Gerik. It is on 2,161 ha in ESA Rank 1 within the Central Forest Spine Primary Linkage 8, overlapping several forest reserves (Kenderong Forest Reserve, Bintang Hijau (Hulu Perak) Forest Reserve and Belukar Semang Forest Reserve).	The state claims to have collected RM 71.5 million in royalties from rare earth carbonate exports since February 2023. [2]	Mining activities were suspended in November 2025 after reports of discolouration in the Perak River was reported. This prompted investigations by DOE. The cause for the discolouration remains undisclosed, but authorities have committed to releasing the findings. [3]
Perak – future plans	Three additional districts (Kuala Kangsar, Kinta, Larut Matang & Selama) with large REE reserves have been identified. [4]	Estimated 1.7 million metric tonnes of REE, mainly in forest reserves.	The government intends to collaborate with South Korea (downstream) and France (midstream) to build higher value industry. [5,6]	Further expansion would likely intensify land-use and conservation conflicts and long term governance of the waste.
SG4 (Kedah, Terengganu, Kelantan, Perlis)	A joint statement on REE governance and benefit sharing under Ninth Schedule powers (Federal Constitution) was issued by the SG4 states in October 2025. [7]	*Data not yet available given that this is only a joint-statement on REE governance as of writing.*	The states support the full value chain ecosystem but with transparent revenue sharing and avoidance of past oil royalty inequities.	Further expansion would likely intensify land-use and conservation conflicts and long term governance of waste.
Pahang	In April 2025, the state approved 220 hectares in Sungai Wang, Hulu Jelai sub-district, Lipis as a pioneer mining site for REE, with other areas identified in Raub and Bentong.	The state claims that there is an estimated 1.4 million metric tonnes of REE worth RM37.4 billion. [8] About 70% of this resource is in forest reserves and ESAs. The approved project is in Sungai Wang, Hulu Jelai district, Pahang. [9]	This was an early-stage project announcement with limited follow up.	The Orang Asli of Pos Lanai from the Semai tribe, living in close proximity to this proposed project site will be most impacted if this project takes off. They have been opposing this project since 2020 when the government had

				proposed the same project on a larger area (about 660 hectares). In 2021, this community filed a civil suit at the High Court in Pahang amongst others, seeking recognition of their native customary rights. Their legal suit is still pending in court. [10]
Negeri Sembilan	Two Jelebu sites have been identified with pilot projects planned to start in 2026 and revenue expected in 2027. [11]	One of the proposed mining sites is in Ulu Klawang in Mukim Ulu Triang. The site overlaps the Gapau Permanent Reserved Forest and is also on an ESA Rank 2 with high value biodiversity.	The projects target future REE revenues for the state and positions the state within the national REE development timeline.	The recent EIA report for the Ulu Klawang project published in December 2025 was rejected. However, there is no legal barrier to repeated EIA report resubmissions by the project proponent. [12]
Sarawak	In October 2025, the state government explicitly prohibited the export of REE raw materials. They are retaining them as strategic assets essential for domestic high-value industries. A new mining policy will be rolled out in 2026. [13]	The state has indicated they have national REE reserves valued at about RM809.6 billion.	Sarawak aims to emulate China's protectionist model, promoting domestic technology manufacturing and full upstream midstream downstream integration with digitised, transparent operations.	The state has tightened mineral export rules in December 2025 to prevent extraction only operations with emphasis on sustainable development. [14] There may be a possibility of land-use and conservation conflicts on the ground including issues surrounding the rights of indigenous communities.

References: [1] Lawrence 2025; [2] Arif 2025; [3] Khairi 2025; [4] Ahmad 2025; [5] Bernama 2024a; [6] Goh and Ng 2026; [7] FMT 2025; [8] Bernama 2025c; [9] Bernama 2024b ; [10] Bernama 2023; [11] Singh 2025; [12] EIA; [13] Bernama 2025b; [14] Bong 2025.

REE mining within permanent reserve forests contravenes the National Forestry Act 1984
The risks of mining for REE be it in Permanent Reserved Forests (PRFs) or Environmentally Sensitive Areas (ESAs) are real. REE is not a forest produce within the meaning of Section 2 of the National Forestry Act (NFA 1984). Hence, mining or extraction of REE within any PRFs will contravene Section 2 of the said Act. Having said this, nothing prevents the authorities from amending the NFA 1984 to include a new definition or degazetting PRFs in the pursuit of REE.

Further, as seen in the Kenering pilot project above, the approving of such mining activity in an ESA Rank 1 ecosystem is clearly in violation of the federal government's own planning policy and can in no way be viewed as a sustainable activity. In fact, Section 12 of the NFA 1984 also provides for the land excised from a PRF to be replaced with an equal or bigger area of land. However, according to the 2022 amendment to the 1984 Act (National Forestry Act 1984, Section 11), an excision of the PRF has to take place subject to the conduct of a public inquiry (*siasatan awam*), in accordance with the rules which are to be drawn up subsequently by each state. So far, this amendment has only come into force in Perlis on 1 April 2023 and the Federal Territories of Kuala Lumpur, Putrajaya and Labuan on 1 February 2025. Not all states have adopted this amendment and until they do so, PRFs remain at risk of being degazetted for REE extraction without any public consultation or scrutiny.

No clear moratorium prohibiting mining of minerals in ESAs and PRFs
There is no clear moratorium prohibiting mining of any minerals in ESAs and PRFs apart from what is stated in the SOP. The SOP only serves as a guideline for states, allowing each state the flexibility to adopt it fully, partially, or to modify and supplement it according to their own legal framework and practices.

The federal-state jurisdictional divides
The Federal Constitution has assigned lands, mines, and forests as sources of revenue to states (Federal Constitution, Article 110). Further, 10% of the revenues collected by the federal government from export duties on tin, iron, and minerals ores will also be allocated to the producing states (Abdul Jalil and Karim 2009). Currently, there is no real and adequate financial incentive for state governments to protect their forests. Dependence on land and forests as the main source of revenue means state governments would be less inclined to gazette land and forests for conservation purposes as totally protected areas. This has resulted in misaligned economic incentives for the states to exploit natural resources instead of protecting high conservation value (HCV) areas. This situation will continue unless clear, lasting, and enforceable mechanisms are established to enable states to effectively conserve their forests. Without permanent solutions—such as robust legal frameworks, consistent funding streams, and strong regulatory safeguards—states may continue to face pressure to exploit forest resources for economic gain.

Environmental and public health concerns of REE Mining
REE mining poses significant environmental and public health risks, including radioactivity and pollution from intensive energy use and waste generation throughout all stages of production. The process uses large amounts of water, acids, and solvents, resulting in substantial waste byproducts that can contaminate groundwater with acids, heavy metals, and radioactive elements like thorium and uranium. It is estimated that processing one tonne of REE can produce up to 1.4 tonnes of radioactive waste (Findeis and Schaeffer 2017).

Disturbances to geomorphology can lead to landslides
Besides risks of eutrophication, ISL could also lead to mine collapse and landslides when the RE mining is done at a geologically unsuitable site. If the chosen site for ISL does not have the suitable levels of permeability or positioned over a solid bedrock without fissures,

the disturbance caused to the geomorphology (i.e., soil structure, stability, etc.,) by the direct injection of the leachate into the IAC ore body could very well destabilise the landscape. ISL also carries the risk of the capillary forces (such that exist between liquid and solid surface that moves liquid in narrow spaces without external force) surrounding the narrow leaching holes to attract the leaching solution back to the topsoil layer, destroy the vegetation and plants on the surface, all of which can make rehabilitation even more difficult. In the Ganzhou region in China, over 100 reported landslides are already attributed to ISL practices. It is imperative therefore for proper caution to be exercised and best practices followed to prevent destabilisation of the geomorphology at the mining site (Yang *et al.* 2013).

CASE STUDIES ON IMPACTS OF MINING ON LOCAL COMMUNITIES AND MINING

Case study 1: Consumption of heavy metal polluted water by Indigenous Community

One of the ways iron ore is mined through the process of washing iron ore rich soils, where water is mixed with the soil to break apart the clumps; afterwards the slurry is passed through either a washing trough or magnetised drum, where the iron particles and nuggets are separated from the slurry for further processing. The slurry flows into a series of tailing ponds, where the sediment and other particulate matter settle to the bottom of the ponds, while the water is reutilised as washing liquid. This occurs in a closed-circuit iron ore mining setup.

In some cases, the iron ore rich soils also bear other metallic elements, such as aluminium, chromium, and manganese, henceforth referred to as heavy metals, that can be detrimental to human health. When exposed to water, oxygen, and in suitable conditions, these heavy metals are dissolved and mobilised, enabling them to move with the water flow and increasing the risk it being consumed, absorbed, or adsorbed by living things and the natural environment. Heavy metals are highly toxic, and its effects are dependent on the exposure period and dosage received. Its effects include organ damage, degenerative diseases, cancer, and in serious cases, death. Examples historical occurrences of mass heavy metal poisoning include the Minamata disease, Itai-Itai disease, Grassy Narrows First Nation mercury pollution, and the Zamfara State lead pollution.

Kampung Kelaik, Kelantan and its surrounding forests and rivers are home to about 200 Indigenous Peoples of the Temiar ethnic subgroup. Over the years, especially after the opening of the Gua Musang – Cameron Highlands highway, the community had to contend with increasing landscape changes and encroachment into their territories, way of live, and agency. Mines and plantations appeared in the landscape, followed by deforestation, loss of access to forest products, and adverse changes to the environment, including decreased river water quality.

In 2024, it came to light that tailing and effluent from nearby iron ore mines have entered into the nearby natural environment. At the discharge point where the slurry escapes into the environment, it was found that the concentrations for aluminium, arsenic, chromium, iron, and manganese have exceeded the Department of Environment's limit for Class III river, by multiple magnitudes (Table 3). Blood sample of one villager shows elevated levels of chromium, aluminium, arsenic, and iron.

Table 3. Heavy metals in water samples from mining effluent release points, August 2024.

Heavy Metals (mg/L)	Aqua Orion	Redstar Capital	DOE Limit (Class III River)*
Aluminium	87.1	4.44	0.06
Arsenic	0.002	<0.001	0.4
Chromium**	2.6	0.183	2.5 (Chromium-3) 1.4 (Chromium-6)
Iron	47.4	5.86	1
Manganese	9.93	0.41	0.1

* DOE Class III River: River that can be used for livestock and fisheries, extensive treatment needed to be used for water supply.
** Testing was for total chromium.

(Reports on the plight of Kampung Kelaik were authored by Vinothaa and Razak, and accessed through the Pulitzer Center; Razak and Vinothaa 2024; Vinothaa 2024).

Case study 2: Mamut Copper Mine and its Legacy

The Mamut Copper Mine (MCM) is located in Sabah, where it sits at the east-southeast border of the Kinabalu Park. MCM was in operation for 24 years (1975 – 1999), where the leased area of 1,942 hectares was mined for copper and gold. Throughout the operation of the MCM, 250 million tonnes of overburden and waste rock and 150 million tonnes of tailings were produced, which were deposited in Lohan Valley and Lohan tailings facility, respectively (van der Ent and Edraki 2016).

The weathering of the overburden and tailing, as well as heavy metal leaching from rain resulting in heavy metal contamination of the surrounding environment, as well as the Mamut River. A study compared the concentration of 10 selected heavy metals in the soil adjacent to the Mamut River and a control river (Kipungit River); it found that the level of heavy metals in the soils from Mamut River were 10 – 100 times higher than the heavy metal level in Kipungit River (Ali *et al.* 2004). A study focused on the concentration of heavy metals in the liver of the River Toad [*Bufo juxtasper* (Inger)] collected from the Mamut River, Laganan River, Tabin Wildlife Reserve, and Crocker Range. It found that copper, cadmium, and nickel concentrations are relatively higher in the River Toads from the Mamut River, compared to the three other sites (Lee and Stuebing 1990).

The rehabilitation of MCM is possible, but it faces challenges such as the large volume of waste materials and high levels of rainfall (van der Ent and Edraki 2016). It was estimated that the rehabilitation of MCM will cost up to RM500 million (Santos 2022). At the present, MCM and its facilities remain an environmental risk should structural failure occurs, and still continue to leach heavy metals and other environmental contaminants into its surroundings.

RECOMMENDATIONS

As the government continues to proceed with developing the REE industry, it is crucial that this is approached with utmost care. The government must prioritise the well-being of people and the protection of the environment above profit and carefully consider the following recommendations to guide responsible and sustainable decision-making.

No-go zones

It is strongly recommended that NRES recognises PRFs, ESAs and indigenous customary territories as no-go zones for REE mining, and that their status (whether through laws or policies) must not be altered in any way to circumvent this rule.

This is aligned with the recent UN Secretary-General's Panel on Critical Energy Transition Minerals report (UN 2024) that recommends "governments to consider declaring other protected and conserved areas as 'no-go areas' for activities related to critical energy transition mineral value chains, taking into account national legal contexts". Hence, the government must proactively identify and officially designate specific regions as 'no-go zones or areas' and therefore strictly prohibit REE mining in these areas.

Recognition of indigenous peoples' customary territories and FPIC

While the ESAs are defined by the National Physical Plan, the complexity surrounding the indigenous customary land rights must also be acknowledged too. This complexity is linked to how such territories are often unilaterally determined by the state, without proper consultation, transparency and information access for the people. Compounding the matter, state authorities have also been known to erroneously interpret that indigenous customary land rights do not exist in gazetted forests and conservation areas, when neither their rights were properly extinguished nor adequate compensation was ever paid to the affected communities.

What is urgently needed in this country, is the formal recognition of Indigenous Peoples as right-holders. Without such safeguards in place, as is the status quo now, rights of project proponents as registered land owners or licensees will always supersede the rights of Indigenous Peoples who are associated with the land for decades or centuries before project proponents, simply because they do not possess the documentary evidence of their land rights. As Indigenous Peoples, most often than not, have their territories overlap with PRFs and ESAs, recognising their rights as such would at least keep mining or any other environmentally destructive projects from encroaching into their areas (Sahabat Alam Malaysia 2011). Indigenous Peoples are the primary guardian of our forests after all.

Meaningful public consultations

Meaningful public consultation and participation following the FPIC principles is also key. Oftentimes when public consultations are carried out, they are done in a manner that exaggerates the project benefits to the affected community, and conceal the adverse impacts of the projects to elicit positive response to the project by the communities on ground prior to project approval. A meaningful consultation here means, the communities are told in unambiguous and unequivocal terms, what exactly the project purports to carry out, how that will affect them as right-holders, and the project's adverse impacts to their health and environment. They must be given an option to say "no" to the project, and have their choice respected.

No biodiversity offsets

Biodiversity offsets cannot be considered as a mitigating measure in the ESG standard. Incorporating offset requirements into mining project approvals or biodiversity offset is a false solution and also a form of greenwashing. Offset is based on the problematic assumption (Mariet *et al.* 2024) that the ecological damage caused by the project can be cancelled out or offset by restoring biodiversity elsewhere other than the proposed project area. ESAs and other ecosystems cannot simply be replaced elsewhere, especially when measures should be in place to increase such areas instead of eliminating or reducing them.

There should also be a meaningful participatory process for civil society organisations, community-based organisations, and any concerned citizen to provide feedback/input to the standard, and there should be a response from the government on how they have considered the feedback in the process.

Any claim of ESG-compliance, responsible and/or sustainable mining are just forms of greenwashing, if the government, mining companies, and financial institutions are **not** able to forgo these mineral-rich ESAs or lands of Indigenous Peoples involving their customary rights.

Comply with transparency and open data policies

The government must also abide by its commitments to transparency and open data policies. The government should not simply make such announcements in the media and stop there, but instead, take active steps in implementing these policies. This means making technical reports of impugned projects ready available to affected communities and not to give them a run around under the guise that such technical reports are not made mandatory to be published into the public domain or that they are the intellectual property of the project proponent.

Remove the misleading classification of IAC REE as non-radioactive

The government should rectify the blanket mislabelling of all IAC deposits in Malaysia as a "non-radioactive" source of REE within the SOP. Currently, the SOP relies on a single preliminary radioactivity analysis at a proposed REE mine, which concluded that the Naturally Occurring Radioactive Materials (NORM) present were below the 1 Bq/g clearance threshold set by the Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011. However, there is no guarantee that other IAC deposits across Malaysia, or the tailings generated from In-Situ Leaching (ISL), will consistently meet this threshold.

It is highly concerning that the SOP uses this isolated preliminary study to justify exempting all future ISL projects from the requirement to conduct a Radiological Impact Assessment (RIA). Without a mandated RIA process, there is no reliable way to determine the potential radiological impacts of an ISL project on the surrounding environment and local communities. Therefore, it is vital that an RIA framework is given the same regulatory force as the Environmental Impact Assessment (EIA) framework, especially since the government is actively encouraging the expansion of the REE industry to capitalise on its economic benefits.

Incentives for states to safeguard our forests

The international agreements that Malaysia has signed onto (i.e., the Paris Agreement and Convention on Biological Diversity), provide financial support for developing countries to pursue forest and biodiversity conservation efforts. Malaysia is a developing country and is entitled to receive financial resources to meet our international commitments. The international funds available are the Green Climate Fund, Adaptation Fund, Global Environment Facility, and Special Climate Change Fund.

Federal-state jurisdictional divisions have been highlighted by many as the key challenge when addressing conservation issues in Malaysia. Given the federal-state jurisdiction dichotomy, international climate funds is one of the first steps that we need to take to address some of the drivers of deforestation. The federal government needs to help diversify state revenue streams. The Ecological Fiscal Transfer (EFT) is one of the finance mechanisms to encourage the gazetting of protected areas by state governments. At a minimum, these will alleviate the pressure faced by state governments that are dependent on the exploitation of forests and other natural resources for their income generation.

Seeking international climate funds is also consistent with the call in 12th Malaysia Plan 2021–2025 to diversify conservation funds. Together with the various financial instruments planned and created in Malaysia to incentivise forest and biodiversity conservation efforts, international climate funds can add to the pool of funding and diversify the funding sources

for conservation efforts in Malaysia, while acknowledging that there are other systemic causes/root causes in deforestation and violation of the rights of indigenous peoples and local communities.

Compliance, monitoring and waste management

If the government continues to proceed with building the REE sector, the authorities must enforce strict compliance with laws, rules, and regulations for managing radioactive and toxic waste from REE mining, whether using traditional or ISL methods. Waste management including site selection for waste and pollution control should be a top priority and strictly implemented. There must also be continued independent monitoring of the status of the waste and the critical health markers of the surrounding environment by the relevant authorities.

In relation to extraction, while ISL is theoretically less destructive than open pit mining, comprehensive geological and technical surveys are crucial to accurately assess ore quantities and ensure minimal environmental impact. Failure to properly conduct these studies can result in low resource recovery (as low as 5%) and unnecessary environmental harm and risk to public health.

CONCLUSION

Malaysia should not risk repeating mistakes of the past by hastily pursuing the REE industry purely for immediate gains while disregarding long-term sustainability. Our history with mining has already left a legacy of environmental harm and significant radioactive waste in Perak and, more recently, in Pahang. Unless a thorough and transparent cost-benefit analysis is conducted and a permanent, effective waste management solution is put in place for both radioactive and non-radioactive by-products, we risk further eroding our remaining biodiversity and the territories of indigenous peoples. We should not rush into this sector at the expense of our environment and indigenous peoples and local communities.

REFERENCES

Abdul Jalil, A.Z. and Karim, N.A.-H. 2009. Understanding Malaysian state governments fiscal behavior: The role of intergovernmental transfers. *Chulalongkorn Journal of Economics* 20(2): 85–111.

Ahmad, S. 2025, April 17. Tiga Daerah di Perak dikenal pasti kawasan baharu NR-REE. *Sinar Harian*. https://www.sinarharian.com.my/article/723340/edisi/perak/tiga-daerah-di-perak-dikenal-pasti-kawasan-baharu-nr-ree

Ajos, E.G. 2023, July 2. Majlis Mesyuarat Mineral setuju kerangka Dasar Mineral Negara Baharu. *Berita Harian*. https://www.bharian.com.my/berita/nasional/2024/07/1266174/mesyuarat-majlis-mineral-setuju-kerangka-dasar-mineral-negara-baharu

Ali, M., Heng, L., Ratnam, W., Nais, J. and Ripin, R. 2004. Metal distribution and contamination of the Mamut River, Malaysia, caused by copper mine discharge. *Bulletin of Environmental Contamination and Toxicology* 73: 535–542.

Anathalakshmi, A. and Nguyen, M. 2023, September 11. Malaysia to ban export of rare earth to boost domestic industry. *Reuters*. https://www.reuters.com/markets/commodities/malaysia-ban-export-rare-earths-boost-domestic-industry-2023-09-11/

Arif, Z.M. 2023, December 2. Perak collects RM715m rare earth carbonate royalties since 2023. *New Straits Times*. https://www.nst.com.my/news/regional/2025/12/1328514/perak-collects-rm715m-rare-earth-carbonate-royalties-2023

Aziz, A. 2025, March 13. Cover story 1: Can Malaysia unlock potential of its rare earth deposits? *The Edge Malaysia*. https://theedgemalaysia.com/node/746650

Azmi, H. 2024, December 17. Raids on illegal mines spotlight Malaysia's rare earth ambitions. *South China Morning Post*. https://www.scmp.com/week-asia/politics/article/3291067/raids-illegal-mines-spotlight-malaysias-rare-earth-ambitions

Bradsher, K. 2011, March 8. Mitsubishi quietly cleans up its former refinery. *The New York Times*. https://www.nytimes.com/2011/03/09/business/energy-environment/09rareside.html
Badd. 2019, June 7. 30 years ago, a huge radioactive incident happened in Perak and they are still cleaning it up. *Cilisos*. https://cilisos.my/30-years-ago-a-huge-radioactive-incident-happened-in-perak-heres-the-story-behind-it/
Bernama. 2023, April 10. 147 Orang Asli Pos Lanai seek declaration as holders of customary rights of land. *The Vibes.com*. https://www.thevibes.com/articles/news/90056/147-orang-asli-in-pos-lanai-seek-declaration-as-holders-of-customary-rights-of-land
Bernama. 2024a, April 26. Perak looks to Korean tie-up for rare earth project. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2024/04/26/perak-looks-to-korean-tie-up-for-rare-earths-project
Bernama. 2024b, May 10. Sungai Wang approved as pioneer Nr-ree mine, Pahang State Assembly told. *Bernama*. https://bernama.com/en/news.php?id=2296206
Bernama. 2024c, November 11. Malaysia has great potential in downstream REE industry, supporting EV manufacturing – Nik Nazmi. *Bernama*. https://www.bernama.com/en/news.php?id=2361906
Bernama. 2025a, November 13. Moratorium on raw REE export aimed at supporting midstream industry development – NRES. *Bernama*. https://www.bernama.com/en/news.php?id=2490550
Bernama. October 2025b, October 29. Sarawak will not export rare earth elements – Abang Johari. *Bernama*. https://bernama.com/en/news.php?id=2484795
Bernama. 2025c, December 10. Pahang's rare earth reserves worth RM37.4bil, estimated at 1.4mil tonnes. *New Straits Times*. https://www.nst.com.my/business/corporate/2025/12/1334006/pahangs-rare-earth-reserves-worth-rm374bil-estimated-14mil
Bong, K. 2025, December 11. Sarawak tightens mineral export rules, outlaws raw extraction only – ops to drive full value-chain development. *Dayak Daily*. https://dayakdaily.com/sarawak-tightens-mineral-export-rules-outlaws-raw-extraction-only-ops-to-drive-full-value-chain-development/
Consumers' Association of Penang. 1993. *Wasted lives. Radioactive poisoning in Bukit Merah*. Penang: Consumers' Association of Penang.
Consumers' Association of Penang. 2011. Chronology of events in the Bukit Merah Asian Rare Earth development. *Consumers' Association of Penang.* https://consumer.org.my/chronology-of-events-in-the-bukit-merah-asian-rare-earth-development/
Dewan Rakyat Hansard. 2026, January 20. Pemberitahuan Pertanyaan Dewan Rakyat Mesyuarat Pertama, Penggal Kelima Parlimen Kelima Belas Tahun 2026, Soalan 69: 191–192.
DOE. 2021. Environmental Impact Assessment (EIA) Report of 'The Proposed Development of a Permanent Disposal Facility (PDF) for Water Leach Purification (WLP) Residue on Lot 31375, Gebeng Industrial Estate (GIE), Mukim Sungai Karang, Kuantan, Pahang'. December 2021. pp. 1–14. Putrajaya: Department of Environment.
DOE. 2025. Environmental Impact Assessment (EIA) Report for the 'Proposed Mining of Rare Earth Element (REE) on about 357 ha of Agricultural Lands on Part of Lot 2180, Part of Lot 20223 and Pt 579 in Mukim Ulu Klawang, and Pt 1848 in Mukim Ulu Triang, Daerah Jelebu, Negeri Sembilan' (2025) C-118. Putrajaya: Department of Environment.
Findeis, M. and Schaeffer, A. 2017. Fate and environmental impact of thorium residues during rare earth processing. *Journal of Sustainable Metallurgy* 3(1): 179–189.
Free Malaysia Today (FMT). 2025, October 30. National REE development must involve resource states, say SG4 MBs. *FMT.* https://www.freemalaysiatoday.com/category/nation/2025/10/30/national-ree-development-must-involve-resource-states-say-sg4-mbs
Free Malaysia Today (FMT). 2026, March 15. Johari confirms Malaysia – US trade deal nullified. *FMT*. https://www.freemalaysiatoday.com/category/nation/2026/03/15/johari-confirms-malaysia-us-trade-deal-cancelled
Goh, M. and Ng, D. 2026, February 3. Malaysia has potential to be a global leader in rare earth production: French special envoy. *Channel News Asia*. https://www.channelnewsasia.com/asia/malaysia-france-envoy-benjamin-gallezot-rare-earth-interview-5902671
Hoatson, D.M., Jaireth, S. and Miezitis, Y. 2011. *The major rare-earth-element deposits of Australia: geological setting, exploration, and resources*. Canberra: Geoscience Australia.
Ikhsan, M.H. and Abdul Rahman, N. 2023, February 6. Rare earth elements mining once again detected in Bukit Enggang forest reserve. *New Straits Times*. https://www.nst.com.my/news/nation/2023/02/876876/rare-earth-elements-mining-once-again-detected-bukit-enggang-forest

Kementerian Tenaga dan Sumber Asli (KeTSA). 2021. *Kerangka Pelan Transformasi Industri Mineral Negara 2021 – 2030*. Putrajaya: KeTSA. pp. 4.
Khairi, M.L. 2025, November 3. DoE: Rare earth, tin mines under probe after Sungai Perak turns blue. *New Straits Times*. https://www.nst.com.my/news/nation/2025/11/1307505/doe-rare-earth-tin-mines-under-probe-after-sungai-perak-turns-blue
Lawrence, A. 2025, December 3. Perak granted special exemption by Federal Government to export REE – Saarani. *The Star*. https://www.thestar.com.my/news/nation/2025/12/03/perak-exempted-from-moratorium-to-continue-nr-ree-exports-says-mb
Lee, Y. and Stuebing, R.B. 1990. Heavy metal contamination in the River Toad *Bufo juxtasper* (Inger), near a copper mine in East Malaysia. *Bulletin of Environmental Contamination and Toxicology* 45: 272–279.
Library of Congress. 2026, February 23. Supreme Court rules against tariffs imposed under the International Emergency Economic Powers Act (IEEPA). *Congress.Gov*. https://www.congress.gov/crs-product/LSB11398
Liu, S. and Patton, D. 2023, December 22. China bans export of rare earths processing tech over national security. *Reuters*. https://www.reuters.com/markets/commodities/china-bans-export-rare-earths-processing-technologies-2023-12-21/
Lo, T.C. 2026, March 2. Lynas Malaysia secures 10-year operating licence renewal. *The Star*. https://www.thestar.com.my/news/nation/2026/03/02/lynas-malaysia-secures-10-year-operating-licence-renewal
Mahari, H. 2025, January 10. Malaysia seeks Japan's involvement for non-radioactive REE plant. *New Straits Times*. https://www.nst.com.my/news/nation/2025/01/1158966/updated-malaysia-seeks-japans-involvement-non-radioactive-ree-plant
Malay Mail. 2026, March 16. Is the US trade deal officially cancelled? PKR lawmakers press Putrajaya for proof. *Malay Mail*. https://www.malaymail.com/news/malaysia/2026/03/16/is-the-us-trade-deal-officially-annulled-pkr-lawmakers-press-putrajaya-for-proof/212840
Malaysian Department of Minerals and Geoscience (JMG). 2023. *Malaysian Mining and Sustainability Report*. Putrajaya: JMG.
Marien, N., Fernandez, M., Counsell, S., Dellasta, H., Hache, F., Gilbertson, T.L., Martinez, V.F., and Lim, L.C. 2024. The biodiversity market mirage. *Friends of the Earth International.* https://foe-malaysia.org/articles/the-biodiversity-market-mirage/

Ministry of Investment, Trade and Industry (MITI). 2023. New Industrial Master Plan 2030 Mineral Industry. Kuala Lumpur: MITI.
Ministry of Natural Resources and Environmental Sustainability (NRES). 2024, July 9. Answer to the oral question posed by Datuk larry Soon @ Larry Sng Wei Shien (Julau) at the 3rd term of the 15th Parliamentary Session of 2024, Question 11.
New Straits Times. 2023, May 24. Illegal mining of rare earth elements detected in Kuala Pilah. *New Straits Times*. https://www.nst.com.my/news/nation/2023/05/913011/illegal-mining-rare-earth-elements-detected-kuala-pilah
Pistilli, M. 2025, February 5. Rare earth reserves: Top 8 countries. *Investing News Network*. https://investingnews.com/daily/resource-investing/critical-metals-investing/rare-earth-investing/rare-earth-reserves-country/
Razak, A. and Vinothaa, S. 2024, December 9. Heavy metals found in Kelantan Orang Asli blood, community fears it is poisoned by mining. *Pulitzer Center*. https://pulitzercenter.org/stories/heavy-metals-found-kelantan-orang-asli-blood-community-fears-it-poisoned-mining
Reuters. 2023, December 14. Malaysia arrests 31 people suspected of illegal rare earths mining – state media. *Reuters*. https://www.reuters.com/world/asia-pacific/malaysia-arrests-31-people-suspected-illegal-rare-earths-mining-state-media-2023-12-14/
Reuters. 2025a, October 22. Malaysia seeks foreign partnerships to develop rare earth sector, state media reports. *Reuters*. https://www.reuters.com/world/asia-pacific/malaysia-seeks-foreign-partnerships-develop-rare-earth-sector-state-media-2025-10-22/
Reuters. 2025b, October 29. Malaysia's ban on raw rare earths exports remains despite U.S. deal, trade minister says. *Reuters*. https://www.reuters.com/world/asia-pacific/malaysias-ban-raw-rare-earths-exports-remains-despite-us-deal-trade-minister-2025-10-29/
Reuters. 2025c, November 3. Malaysia's Anwar says $186 million magnet plant to boost rare earth sector: Report. *The Straits Times*. https://www.straitstimes.com/asia/se-asia/malaysia-pm-anwar-says-185-million-magnet-plant-to-boost-rare-earth-sector-state-media-reports

Sahabat Alam Malaysia. 2011. Indigenous customary land rights and the modern legal system, a seven part series. *Sahabat Alam Malaysia*. https://foe-malaysia.org/articles/indigenous-customary-land-rights-and-the-modern-legal-system/

Sahabat Alam Malaysia. 2022. Briefing on the proposed mining and beneficiation of lanthanide element ion-adsorption deposit in Mukim Kenering, Daerah Hulu Perak. Penang: Sahabat Alam Malaysia. https://foe-malaysia.org/wp-content/uploads/2022/09/220904-Kenering-Briefing-Booklet.pdf

Santos, J. 2022, August 25. Cost to treat acidic water in Mamut mine could reach RM500 mil. *The Vibes*. https://www.thevibes.com/articles/news/69635/cost-to-treat-acidic-water-in-mamut-mine-could-reach-rm500-mil

Sarawak Department of Premier. 2025, April 26. Sarawak to introduce new mining policy by 2026. *Sarawak Department of Premier*. https://premierdept.sarawak.gov.my/web/subpage/news_view/16920/UKAS

Singh, S. 2025, November 4. Rare earth elements mining to start at two Jelebu sites in 2026. *The Star*. https://www.thestar.com.my/news/nation/2025/11/04/rare-earth-elements-mining-to-start-at-two-jelebu-sites-in-2026

The White House Washington. 2025a, October 26. Memorandum of Understanding between the government of the United States of America and the government of Malaysia concerning the cooperation of to diversify global critical minerals supply chains and promote investments.

The White House Washington. 2025b, October 26. Joint Statement on United States – Malaysia Agreement on Reciprocal Trade.

United Nations. 2024. *Resourcing the energy transition: Principles to guide critical energy transition minerals towards equity and justice*. New York: UN Secretary-General's Panel on Critical Energy Transition Minerals.

U.S. Department of Energy. What are critical minerals and materials?

U.S. Geological Survey (USGS). (2025). 2025 List of Critical Minerals of the US.

van der Ent, A. and Edraki, M. 2016. Environmental geochemistry of the abandoned Mamut Copper Mine (Sabah) Malaysia. *Environmental Geochemistry and Health* 40: 189–207.

Vinothaa, S. 2024, December 11. Red rivers and death: Natives fight iron ore mining in Kelantan rainforest. *Pulitzer Center*. https://pulitzercenter.org/stories/red-rivers-and-death-natives-fight-iron-ore-mining-kelantan-rainforest

White, E. 2023, December 21. China bans export of rare earth processing technologies. *Financial Times*. https://www.ft.com/content/5b031db7-23dd-43d3-afe1-cef14817296f?syn-25a6b1a6=1

Yang, X.J., Lin, A., Li, X.-L., Wu, Y., Zhou, W. and Chen. Z. 2013. China's ion-adsorption rare earth resources, mining consequences and preservation. *Environmental Development* 8: 131–136.

Yong, N. 2011, November 5. Malaysian town recalls rare earth mining woes. *Voice of Asia (VOA*). https://www.voanews.com/a/malaysian-town-recalls-rare-earth-mining-woes-133330653/147816.html

State of Nature Conservation in Malaysia 2025, 939–950
doi: 10.62613/sonc2025.v3anc19

CHAPTER 19

Examining gaps in the EIA framework

A. LALITH KUMAR[1], THEIVA LINGAM[1], ARHWIN KALAI CHELVAN[2]*, SHEELASHEENA DAMIAN[2], VANESSA A. JIPIU[2], MARYELL IRISHA HILLARIAN[2], WELTSON DIUS[2], PRESCILLA JANE PETER[2], ESTHER MAWAN[2], STANDLEY BAWIN ANAK BUNSI[2] and NURFATIN WAHIDA BINTI PUSPA[2]

Abstract: While the existing Environmental Impact Assessment (EIA) framework continue to play a crucial role in environmental management, it is not without systemic shortcomings that require continuous review and improvement. This chapter examines the gaps within Malaysia's EIA framework across Peninsular Malaysia, Sabah and Sarawak, recognising that these shortcomings are not intended as criticism of any stakeholder, but rather an exercise to identify structural issues that require reform. It is hoped that identifying these gaps and corresponding recommendations will assist policymakers and relevant agencies in undertaking the necessary changes to the EIA framework so that it can better fulfil its role in protecting Malaysia's environment and natural resources.

INTRODUCTION

Like all systems, the framework governing Environmental Impact Assessments (EIAs) is far from perfect and will always be subject to the need for continuous improvements by its very nature. The framework plays a vital role in regulating the impact posed by anthropogenic activities on the environment and involves many hardworking individuals from various stakeholders, and this is important to acknowledge. Nevertheless, it is always a useful exercise to periodically review the system and any shortcomings with full frankness and objectivity to evaluate how it can be improved further and how any flaws can be addressed.

It is to be borne in mind that any criticism is not intended to be an attack on any stakeholder or party. Instead, it is imperative to recognise the systemic flaws that should not be ignored and need to be addressed. Some of these flaws are inherited and as a result of certain market, societal, and political pressures beyond the control of the various stakeholders playing their respective parts within the framework. Hopefully, addressing these flaws will then enable the contributions of the many hardworking individuals working to regulate the state of Malaysia's environment to be maximised effectively.

EIA frameworks for Malaysia at the federal level, Peninsular Malaysia, Sabah and Sarawak

The primary tool of environmental management and control of certain development projects, used worldwide, is the EIA. In Malaysia, a federation comprising Peninsular Malaysia, Sabah and Sarawak, there is no single unified, comprehensive legislation that governs environmental management and environmentally significant development projects across the entire country. Instead, regulatory frameworks, including compliance with the need for EIA reports and enforcement mechanisms vary between these distinct regions.

[1] Sahabat Alam Malaysia, No. 10, Jalan Masjid Negeri, 11600 Pulau Pinang, Malaysia.
[2] WWF-Malaysia, Jln PJS 5/28 A, Pusat Dagangan Petaling Jaya Selatan, 46150 Petaling Jaya, Selangor, Malaysia.
***Corresponding author: akchelvan@wwf.org.my**

The requirement to conduct an EIA at the federal level and in Peninsular Malaysia is provided for in the Environmental Quality Act 1974 (EQA 1974). The states of Sabah and Sarawak also have their own state enactments, namely the Environment Protection Enactment 2002 (EPE 2002) and the Natural Resources and Environment Ordinance 1993 (NREO 1993) respectively, reducing the application of the EQA 1974 in these two states. The EQA 1974, EPE 2002 and NREO 1993, and their respective subsidiary legislation shall hereafter be referred to collectively as "the Environmental Legislation".

The administrative authority charged with the evaluation and approval of EIA reports at the federal level (primarily Peninsular Malaysia but also with limited scope over Sabah and Sarawak) is the Department of Environment (DOE), in Sabah, the Environment Protection Department (EPD), and in Sarawak, the Natural Resources Environment Board (NREB). DOE, EPD and NREB shall hereafter be referred to collectively as "the Environmental Agencies".

When a project proponent wishes to undertake a project involving a 'prescribed activity', they are required to engage an external EIA consultant team registered with the Environmental Agencies to carry out the EIA study. Typically, such EIA consultants are employed within an environment-related technical consulting firm. The work to carry out an EIA study is then usually awarded to these consulting firms either through an open-market tender or a direct appointment issued by the project proponents.

For EIAs under the EQA 1974, prescribed activities are listed in the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015 (EIA Order 2015) where they are divided according to two schedules with differences on how they are processed and treated. Schedule II EIAs must be publicly displayed and are usually processed by DOE at the federal level, whereas Schedule I EIAs do not require public display and are processed by DOE at the state level.

Sabah and Sarawak's EIA frameworks operate within a distinct constitutional and legal context arising from its autonomy under the Federal Constitution, the Malaysia Agreement 1963 (MA63), and the Inter-Governmental Committee (IGC) Report (Cobbold Commission 1962). While this greater autonomy compared to the other states in Peninsular Malaysia allows these two states to tailor environmental governance to local conditions, it has also resulted in differing procedural safeguards compared to the federal EIA framework, particularly in relation to public participation, transparency, and accountability.

For EIAs under the EPE 2002, the list of prescribed activities are listed in the (Prescribed Activities) Environmental Impact Assessment Order 2005. Under this order, activities are divided into two schedules, the 1st Schedule is made up of prescribed activities requiring a proposal for mitigation measures (PMM) report and the 2nd Schedule consists of prescribed activities requiring an EIA report instead. Activities under both schedules are the same and only differentiated by the size and volume involved, in which smaller-scaled activities will fall under Schedule 1 while bigger activities fall under Schedule 2.

EIAs under Schedule 2 of the Environment Protection (Prescribed Activities) (Environmental Impact Assessment) Order 2005 can be further classified into two types of EIA, namely Normal EIAs and Special EIAs. Normal EIAs are usually conducted for projects where the environmental impacts are localised, and the local sensitivities are not significantly affected. Special EIAs are conducted for projects having special magnitude and sensitivity regarding the environmental impacts which may extend beyond the geographical boundaries of the project site and/or can adversely affect the welfare of local communities. A comprehensive and detailed assessment of the primary and key environmental issues and impacts are required to evaluate the significance of the environmental impacts, and to formulate appropriate mitigation measures and monitoring programmes.

For EIAs under the NREO 1993, the list of prescribed activities requiring an EIA is set out in the Natural Resources and Environment (Prescribed Activities) Order 1994 (First Schedule). Unlike the EIA Order 2015 and the framework in Sabah, Sarawak's prescribed activities are not divided into distinct schedules with different processing rules. All listed activities require submission of an EIA to the NREB. Apart from that, mandatory public display and differentiated procedural tracks do not exist under this regime.

ADEQUACY OF THE EIA PROCESS AND HOW IT FITS IN THE PROJECT PLANNING CYCLE

No limitation to the number of times an EIA can be submitted

One significant shortcoming of the EIA process under the Environmental Legislation is the absence of a statutory limit on the number of times an EIA can be resubmitted for the same project following an initial rejection. This loophole allows project proponents to repeatedly revise and resubmit their EIA reports, using feedback from both the Environmental Agencies and public opposition to make only the minimal improvements necessary to satisfy regulatory requirements. As a result, the collective efforts of concerned communities and experts—who frequently provide substantive arguments about the potential negative impacts on health and the environment—are often rendered ineffective. Despite robust public objections and expert-backed evidence demonstrating the risks posed by such projects, the iterative resubmission process ultimately leads to eventual approval by the Environmental Agencies, undermining public participation and the intended protective function of the EIA process.

For EIAs under the EQA 1974, there are no processing fees for EIA resubmissions. For the EPD, there is a prescribed processing fee for EIA submissions and resubmissions. The applicable fees are RM 200 for a Terms of Reference (ToR), RM 500 for a Special TOR, RM 1,000 for an EIA, and RM 2,000 for a Special EIA. Under Sarawak's environmental framework administered pursuant to the NREO, prescribed processing fees apply not only to initial submissions but also to resubmissions. Under the NREO framework, the applicable fees include RM 100 per project for the prescription of mitigation measures, RM 200 per project for a TOR for an Environmental Management Plan (EMP), RM 500 per project for a TOR for an EIA, RM 1,000 per project for the submission of an EMP, RM 2,000 per project for the submission of an EIA report, RM 2,000 per project for the resubmission of an EMP, and RM 4,000 per project for the resubmission of an EIA report. However, these relatively modest fees may not constitute a significant financial deterrent against repeated revisions or resubmissions, thereby contributing to the ongoing issues associated with multiple EIA resubmissions.

Nevertheless, through some consultation sessions conducted since 2024, it appears that DOE is exploring the option of charging a processing fee for reviewing EIAs (Looi 2025). At the moment, the Environmental Agencies have no choice but to review EIA resubmissions, as they are required to review any subsequent EIA reports submitted for a project, regardless of how many times the EIA has been revised, resubmitted, or set aside. This could also be the result of the implications of a rejection by the Environmental Agencies to an EIA.

The Environmental Agencies at the moment are empowered to only approve or reject an EIA. They have no real say in bigger questions such as whether a project should be shelved, or whether the project proponent should return the project site to the government, or whether an area should be gazetted instead for protection due to the discovery of rare species. As a result, project proponents are presently incentivised to resubmit EIAs until approval is secured as they have already bought the said land and made other investments

to the project and may not have other options to develop the said land. Perhaps a better mechanism should be developed to ensure that rejected EIAs trigger a process of re-evaluating the best land use for the project site and working towards a win-win situation for all parties, including the project proponent and the environment.

Breaking up projects into smaller components for tactical and commercial reasons
It is a fairly common practice for project proponents to fragment large-scale projects into smaller components for tactical or commercial reasons. This fragmentation often serves to circumvent the more stringent requirements imposed by environmental regulations for large-scale developments.

For EIAs under the EQA 1974, by fragmenting the project into smaller components, project proponents may ensure that the individual components fall under Schedule I rather than Schedule II of the EIA Order 2015, or escape EIA scrutiny entirely. This distinction is critical because Schedule II activities mandate a public display period where comments from the public, experts, and other stakeholders are solicited. Consequently, shifting a project to Schedule I effectively bypasses the mandatory public participation process, reducing transparency and public oversight.

Across all EIAs under the Environmental Legislation, project fragmentation is further facilitated by the absence of clear cumulative impact assessment requirements. Large infrastructure projects, particularly roads, dams, plantations, and extractive industries are frequently approved as discrete components, despite forming part of a single broader development corridor or landscape-scale project. This practice prevents meaningful evaluation of cumulative deforestation, hydrological disruption, and wildlife habitat fragmentation across river basins and indigenous territories.

Such tactical breaking up of projects into smaller components is a recognised flaw of the system and there are instances where this has been attempted to be addressed. For instance, the EIA Order 2015 specifies that "any prescribed activity which has been divided into a size or quantum smaller than the size or quantum specified in the First Schedule and the Second Schedule" is also a prescribed activity [a]. The framework in Sabah on the other hand contains provisions on Master Environmental Impact Assessments (MEIAs) which provides the director of EPD with the power to request the submission of a MEIA where the prescribed activities consist of smaller individual development activities to be carried out in stages. Nevertheless, in practice it is not clear whether these provisions have been effective in preventing tactical breaking up of projects as it is subject to the discretion of the authorities.

NEED FOR CUMULATIVE AND HOLISTIC EIA

No requirement for Strategic Environmental Assessment (SEA)
A fundamental gap in the current framework is the absence of a mandated law or policy requiring SEA. While the law mandates EIAs for specific prescribed activities, these are project-specific and do not address the cumulative cross-border impacts of development. SEAs play a significantly different role compared to typical EIAs. They may inform planning processes that determine the zoning and future land use of certain areas at an early stage as the data obtained will enable decision-makers to assess the feasibility of development projects and the appropriateness of zoning decisions as opposed to the typical EIA which only exposes environmental problems at the end of the project planning cycle when most approvals have been obtained and significant investments into the project have been made.

[a] Environmental Quality (Prescribed Activities)(Environmental Impact Assessment) Order 2015, s. 3(4)

SEAs are loosely incorporated into Sarawak's high-level planning through the Post COVID-19 Development Strategy (PCDS 2030), Sarawak Sustainability Blueprint (SSB) 2030 and Regional Corridor Plans (SCORE). These policies position environmental sustainability alongside economic prosperity, focusing on balancing industrial growth with environmental stewardship. However, SEAs are not formally or systematically integrated into the EIA process in Sarawak, which regulates only project-based EIAs for development. While project-level EIAs are mandatory under NREB regulations, they often lack the cumulative impact assessment aspect provided by SEAs.

Nevertheless, there is progress from the state of Sarawak to further enhance the EIA process to develop screening guidance to support compliance with the First Schedule of the Prescribed Activities Order, 1994. It will outline strategic directions and key action to promote state aspiration while promoting environmental protection and resource efficiency Dayak Daily 2025).

Regulatory lag and emerging technologies

The Environmental Legislation all have the same approach of defining prescribed activities that require EIAs. However, by its nature, these laws have failed to keep up with rapid technological advancements since their enactment. Infrastructure developed to support new technologies often do not fall within the legal definition of "prescribed activities", thereby escaping the EIA process entirely.

A pertinent example is the development of data centres. Despite being known to consume significant quantities of energy and water for cooling systems (Raman 2024), data centres are not currently categorised as a prescribed activity under the existing provisions. Similarly, infrastructure for Carbon Capture and Storage (CCS) and Carbon Capture, Utilisation and Storage (CCUS)—with mounting criticism that such technologies may drive up emissions rather than reduce them—are also not adequately regulated under the Environmental Legislation (Raman 2025). Offshore CCS and subsea infrastructure pose additional risks to benthic habitats, fisheries, and marine food webs through potential CO_2 leakage, seabed disturbance, and pipeline failures (Queirós *et al*. 2014). These risks remain poorly addressed within current EIA schedules.

TRANSPARENCY AND PUBLIC PARTICIPATION IN EIA

Regional inconsistencies in public participation

Under the EQA 1974 framework, it is mandatory for all projects listed as Schedule II prescribed activities to undergo a public participation process. However, this requirement is not uniform across the federation. In Sabah, public display is only required for Special EIAs as determined by the EPD. In Sarawak, public participation is not a legal requirement under the NREO 1993. The decision on whether to conduct public consultation rests almost entirely with the project proponent, subject to NREB's discretion. To ensure equitable environmental justice, there is a pressing need for public participation to be mainstreamed and to be granted as a mandatory public right rather than subject to the discretion of the authorities across all jurisdictions in Peninsular Malaysia, Sabah, and Sarawak.

Limitations of the public display process

Although the law mandates public participation for Schedule II projects via "public display" under the EQA 1974 framework, the process remains grossly inadequate. Crucially, this mandatory requirement does not apply to Schedule I activities, despite the potential for significant environmental impact. There is no real justification for why Schedule I activities should be exempt from public display.

Furthermore, the mechanisms for access are restrictive. The public can typically access EIA reports during the display period in two ways:

1. The most common way would be through digital access of the documents by scanning the relevant QR code on the DOE's website or notices, users can then view the digital copy of the EIA. However, these documents are often restricted to "view only" settings and may not be downloaded.
2. A physical copy of the EIA could be accessible in the DOE library. However, photography or photocopying of the contents are usually strictly prohibited.

As this method of socialising the EIA reports, though effective in widespread dissemination of the same, especially to those situated in urban areas—still pose a significant barrier for rural communities and those without smartphones and computers. Additionally, there are generally no public hearings in conjunction with the EIA process; the public only have the option of submitting comments digitally after viewing the report.

There is no requirement under the EPE 2002 to have a public display for EIA reports. However, the Director has the power to prescribe guidelines as deemed necessary. The Handbook on EIA developed by the EPD specifies that any Special EIA would require public display. A period of 14-days or such period as determined by the Director is given to the public to submit their views and comments on any pertinent environmental issues and concerns that should be addressed in the Special EIA study. The Special EIA will be uploaded into the EPD's website for the public to view. While this channel is made available, in most cases, there is no active outreach to the public to ensure that their concerns and feedback are adequately captured. Considering that this is a Special EIA, 14 days for comments are too short to provide comprehensive and in-depth comments.

The requirement for public display is only triggered for prescribed activities under Schedule 2 of the EPE 2002 framework when they are elevated in status to a Special EIA. While projects that do not require Special EIAs may be smaller in scale, this does not equate to lower environmental risk. In ecologically sensitive areas, even moderate-scale developments can result in significant habitat fragmentation, hydrological alteration, or cumulative impacts. The absence of mandatory public display for these activities may therefore undermine transparency and meaningful stakeholder participation, reinforcing the need to extend public display requirements beyond only Special EIA projects.

Quality of engagement and the FPIC deficit

It ought to be noted that accessing an EIA report alone would not constitute meaningful and effective public participation. While EIA consultants are often required to conduct focused group sessions with affected communities, it is doubtful whether these consultations adhere to the principles of Free, Prior, and Informed Consent (FPIC), particularly in relation to indigenous communities, or if they are even effectively and adequately conducted.

Consultations often devolve into "box-ticking" exercises intended to advance the project rather than genuinely solicit feedback that can be used to influence the project design or determine its viability. Consultants may skew sample sizes or "cherry-pick" participants to manufacture favourable public opinion. Furthermore, communities are rarely given the option to reject a project; discussions frequently focus on alleged economic benefits—which often prove to be false promises—rather than the cost of consequential environmental damage.

The technical complexity of EIA reports further alienates indigenous peoples and local communities, who lack the expertise to decipher the technical jargon EIA reports are inundated with. Only a handful of Civil Society Organisations (CSO) focusing on

environmental issues and independent consultants usually possess the capacity to analyse these reports and assist communities. Language also becomes an issue especially if only the main languages of communication are used (e.g., Bahasa Malaysia or English), sometimes without considering other languages used by communities including those from the deaf community.

Further, it is also common for project proponents, for strategic reasons, to only rely on the village heads for consultation. Although elected by the community, village heads are endorsed and paid allowances by the government. This creates a conflict of interest where village heads may agree to projects despite community objections, opening avenues for corruption and manipulation by project proponents (Friends of the Earth Malaysia 2023). Without meaningful participation, the EIA process becomes a token exercise rather than a genuine tool for risk assessment and environmental protection.

Barriers to access to information

Oftentimes, only the EIA reports that are published during the public display are accessible during a specified timeframe of usually a month. Thereafter, public access to the final EIA report that has been approved, the terms and conditions upon which the approval was given, and improvements made to the document pursuant to public participation, are all effectively barred as the document that was finally approved by the Environmental Agencies is not published and not mandated to be published anywhere. When a written request for access is made, the stance often taken by the Environmental Agencies is that any such request for access must be channeled to the project proponent directly as the EIA is the project proponent's intellectual property.

However, the Environmental Legislation does not expressly classify approved EIA reports as confidential nor prohibit their disclosure after approval. The reliance on intellectual property as a basis for non-disclosure therefore appears to be administrative practice rather than a clear statutory requirement. There are further no legal precedents that prohibit DOE or other related agencies from sharing EIA or other technical reports with the rationale that such technical reports are intellectual property of project proponents. Conversely, there is legal authority that supports the notion that principles of natural justice demand that technical reports be made available to those who are adversely affected by an impugned project [b].

There are multiple consequential problems due to this: (i) the marginalised and affected community are not able to apprise themselves of the subject matter of the EIA approval and how it might affect them; and (ii) without access to the final approved EIA report, these communities encounter significant obstacles when attempting to challenge the approval, as the absence of complete and finalised information severely limits their ability to pursue legal action.

In such situations, affected communities, particularly those in rural areas, find themselves powerless, forced to watch as environmental damage unfolds and impacts their lives and livelihoods before they have any real opportunity to intervene.

The paymaster dilemma and conflict of interest

The current system governing the procurement of EIA consultants in Malaysia lacks sufficient regulation and independence. Although legislation stipulates that only consultants accredited by the Environmental Agencies are authorised to prepare and publish EIA reports, oversight is often limited strictly to accreditation. Once a consultant is approved, the Environmental Agencies do not intervene in the financial or contractual relationship between the EIA consultants and project proponents.

[b] *Mohamad Yusof bin A Bakar & Anor v Datuk Bandar Kuala Lumpur* [2019] MLJU 1098

Practically, this means project proponents are restricted to hiring approved consultants, but the integrity of the EIA process is compromised by the financial arrangement: project proponents directly pay the consultants. This creates an inherent conflict of interest, as consultants may feel pressured to deliver findings that favour the interests of those funding them. Consequently, there is a risk that EIA consultants may produce assessments that only satisfy the minimum legal requirements necessary to secure approval from the Environmental Agencies, prioritising their financial security over rigorous environmental scrutiny.

The phrase "the hand that feeds will not be bitten" aptly describes this dynamic, highlighting the vulnerability of the EIA process to undue influence from project proponents. Recognising these shortcomings, the Malaysian government is considering legislative amendments to address the direct payment system. The proposed reforms seek to establish a separate, regulated payment mechanism, aiming to safeguard the independence and credibility of EIA consultants and promote more objective environmental assessments.

Another potential conflict of interest gap exists under the EIA implementation process. Conditions of approval of the EIA and the approved EIA report will usually be binding on the project proponent. This can take different forms. For instance, under the framework under the EPD in Sabah, the Agreement of Environmental Conditions (AEC) legally binds the project proponent to implement and finance all approved environmental mitigation measures and monitoring programmes. In practice, these requirements are implemented by the project proponent with the Environmental Officer responsible for day-to-day regulatory compliance during the project implementation stage, and will work closely with the appointed registered Environmental Consultant who will carry out impact monitoring and submit the Environmental Compliance Reports (ECR) to the EPD.

However, the Environmental Officer and the Environmental Consultant are engaged by the project proponent, creating a conflict of interest and potentially undermining the objectivity and credibility of monitoring data and compliance reporting. This concern is further compounded by the limited capacity and resources of the regulatory authority to independently and continuously verify compliance, resulting in a heavy reliance on self-monitoring and self-reporting and weakening the overall effectiveness of enforcement.

FLAWS IN IDENTIFYING LAND UNDER NATIVE CUSTOMARY RIGHTS (NCR) CLAIMS

Most of the time, community consultations often consist of superficial interview sessions conducted during the data gathering stage of an impact assessment study. In some cases, local communities are unaware of the proposed project at the time the EIA consultants approach them. Only when the communities' opinions about the proposed project are needed, will the EIA consultants briefly explain the project to the communities.

Besides this, local communities are not consulted or requested to give their official consent to draft maps of their territorial boundaries or shown copies of the final version of those maps (Raman *et al.* 2008). This is indeed a serious concern as the federal and states' interpretation on NCR has been shown to be in direct conflict with its indigenous communities.

In addition, the failure to properly identify and recognise NCR lands within EIA studies is systemic. For instance, in Sarawak, mapping exercises are often based on outdated cadastral data or state-sanctioned interpretations of NCR that exclude *pemakai menoa* and *pulau galau* concepts recognised by indigenous communities (Friends of the Earth Malaysia 2021). Communities are rarely given the opportunity to verify or contest maps used in EIAs, resulting in the systematic erasure of customary territories from environmental assessments.

CLIMATE CHANGE CONSIDERATIONS STILL NOT TAKEN INTO ACCOUNT

Despite being signatory to key international climate treaties under the United Nations Framework Convention on Climate Change (UNFCCC) and projects having climate impact, considerations such as greenhouse gas emissions and the reduced carbon storage capacity that a project causes to the environment are usually not required to be reported in EIAs and do not usually determine whether a project should be allowed or not, despite the obvious impacts this creates on climate change. Mitigation measures on carbon emissions, if any, are often minimal and do not usually require a project to be carbon neutral or net zero, for instance.

This significantly undermines Malaysia's climate goals and commitments as projects that drive up carbon emissions keep getting approved, creating more distance between the achievability of such targets. What is worse is that EIA approval often brings about the perception that climate considerations have been accounted for and sufficiently mitigated. However, this is not the case.

WILDLIFE IMPACT ASSESSMENTS AND IMPLEMENTATION

EIAs typically underprioritise wildlife in favour of anthropogenic concerns or human-centric impacts. Assessments typically catalogue flagship species via short-term inventories, neglecting ecosystem-wide effects like habitat fragmentation, wildlife corridor disruptions, species migration disruptions, gene flow interruptions, and cumulative impacts from serial developments within Malaysia's biodiversity hotspots.

This inadequacy stems from several structural flaws:

- Absence of mandatory long-term ecological modelling or population viability analyses;
- Limited integration of indigenous and local knowledge, despite Article 8(j) of the Convention of Biological Diversity (CBD 2026);
- Weak enforcement of post-EIA monitoring;
- Insufficient expertise among EIA consultants, many of whom may lack wildlife ecology training; and
- Methodology applied for wildlife surveys are often generalised and not specific to different species.

The consequences undermine Malaysia's international treaty obligations including the Kunming-Montreal Global Biodiversity Framework (KMGBF) and exacerbates human-wildlife conflicts and ecosystem service losses. Wildlife impact assessments within the EIA process remain largely superficial and procedurally weak. EIAs approved by the Environmental Agencies routinely treat wildlife as an ancillary consideration rather than a core determinant of project viability.

Wildlife surveys conducted are typically short-term, seasonal, and designed to only determine species presence, often relying on rapid biodiversity assessments conducted over limited timeframes. Such approaches fail to account for species detectability bias, seasonal movement patterns, breeding cycles, and long-term population viability. This is particularly problematic for wide-ranging and low-density species such as orangutans, elephants, and large carnivores, whose ecological requirements extend far beyond the immediate project footprint.

Wildlife crossings, buffer zones, and connectivity measures, where proposed, are often generic, non-species-specific, and unsupported by empirical data. Implementation and post-construction effectiveness monitoring are rarely enforced. As a result, EIAs fail to

capture the compounded effects of logging, plantations, dams, and road networks that progressively erode ecological integrity across entire ecosystems. Post-EIA monitoring and compliance relating to wildlife impacts are notably weak. Although mitigation measures may be included as conditions of approval, there is no systematic, transparent mechanism for independent verification of compliance or ecological outcomes.

The failure to conduct robust wildlife impact assessments has contributed directly to escalating human wildlife conflict, including crop raiding, livestock depredation, roadkill incidents, and displacement of wildlife into human settlements. These impacts are treated as secondary social issues rather than as indicators of flawed ecological planning and assessment.

LAND USE AND ZONING

The relationship between land use and EIAs can be a paradox of sorts. In the current scenario, land use and zoning is often determined without the involvement of EIAs. These decisions are often qualified on the basis that projects will be subjected to EIAs later and any problems will be dealt with at that stage. At a much later stage when the EIA is conducted, the EIA may reveal that the project site is unsuitable for the intended purpose. However, the project is often still pushed through by the project proponent as investments have been made to the project. Environmental mitigation measures are often kept to a minimum to ensure the project remains financially viable. Having SEAs for the purpose of determining land use and zoning may solve this gap. However, there is no requirement to do so in the current system.

Another problem with land use is that some prescribed activities are only triggered if a site has a certain zoning classification. However, some of these zoning classifications can be manipulated to avoid the EIA process. For example, projects in 'environmentally sensitive areas' (ESAs) may trigger the EIA process. However, an ESA can be rezoned to an area that is not an ESA (despite anything to the contrary on the ground) and this would enable the said project to escape the EIA process.

This possibility became apparent when the Kelantan State Government proposed to remove huge areas of forest areas from their classification as ESAs in 2023 (PLANMalaysia Kelantan 2023) despite ESAs typically consisting of forest reserve areas, among others. The current status of this proposed change remains uncertain.

RECOMMENDATIONS

Based on the gaps identified above, here are some recommendations identified to help improve the EIA framework in Malaysia:

- Harmonising the different EIA frameworks across Peninsular Malaysia, Sabah and Sarawak;
- Adopt SEAs in land use planning throughout Malaysia;
- Prohibit breaking up of projects for tactical reasons and making cumulative impact assessments a mandatory part of EIAs;
- Frequent revisions of the activities that qualify as "prescribed activities" to keep up with emerging technology;
- Mainstreaming public participation in the EIA process and ensure that engagement is meaningful and effective;
- Implementing and mainstreaming FPIC in all community consultations;
- Make access to information easy (user-friendly) and mandatory;

- Introduce clear climate change assessment and mitigation requirements and methodologies into the EIA processes and guidelines;
- Introduce a statutory limit to the number of times an EIA can be revised;
- Introduce and/or revise processing fees for EIAs and related documents;
- Set up a mechanism to re-evaluate the land use suitability of a project site based on EIA findings upon rejection of an EIA;
- Ensure independence of EIA consultants, environmental officers, and environmental auditors by delinking direct payments/influence by project proponents;
- Make public hearings mandatory;
- Mandatory provision of grounds for rejection of feedback;
- Ensuring robust wildlife assessments in EIA reports;
- Enshrining the right to a clean and healthy environment in the Federal Constitution; and
- Introducing/strengthening appeal processes and oversight mechanisms for affected communities to create more objective accountability and reduce reliance on discretion in the approval process of EIAs.

CONCLUSION

The EIA framework in Malaysia is not perfect and will greatly benefit from continuously being evaluated and improved upon. Whilst the system as it currently is still provides numerous benefits and continues to play a vital role in regulating environmental impacts of development, the environmental and climate crisis demands for more to be done. It is hoped that the above exercise of identifying some of the pertinent gaps in the system and the corresponding recommendations may assist the relevant agencies and decision-makers to undertake the necessary changes needed to allow EIAs to achieve much greater potential in protecting Malaysia's environment and natural resources.

REFERENCES

CBD. 2026. Article 8(j) - Traditional Knowledge, Innovations and Practices. *Convention on Biological Diversity.* https://www.cbd.int/traditional/default.shtml

Cobbold Commission. 1962. Malaysia: Report of the Inter-governmental Committee. [Reprint]. Kota Kinabalu: The Government Printing Department, Sabah. https://sagc.sabah.gov.my/sites/default/files/law/IGCReport.pdf

Dayak Daily. 2025, October 1. Sarawak drafts new environmental rules ahead of full governance powers under MA63. *Dayak Daily*. https://dayakdaily.com/sarawak-drafts-new-environmental-rules-ahead-of-full-governance-powers-under-ma63/

Friends of the Earth Malaysia. 2021, December 6. Indigenous Customary Land Rights and the Modern Legal System (6). *Friends of the Earth Malaysia.* https://foe-malaysia.org/articles/indigenous-customary-land-rights-and-the-modern-legal-system-6

Friends of the Earth Malaysia. 2023, December 10. Indigenous Residents' Association in Sarawak Urge the Government to Resolve Problems Faced by Rural Communities. *Friends of the Earth Malaysia.* https://foe-malaysia.org/articles/indigenous-residents-associations-in-sarawak-urge-the-government-to-resolve-problems-faced-by-rural-communities

Looi, J. 2025, May 27. Department of Environment seeks public feedback on proposed amendments to the Environmental Quality Act 1974. *Skrine Advocates & Solicitors*. https://www.skrine.com/insights/alerts/may-2025/department-of-environment-seeks-public-feedback-on

PLANMalaysia Kelantan. 2023. Cadangan Pengubahan Rancangan Pemajuan di Negeri Kelantan. Kelantan: Jabatan Perancangan Bandar dan Desa Negeri Kelantan (PLANMalaysia Kelantan).

Queirós, A.M., Norling, K., Amaro, T., Nunes, J., Cummings, D., Yakushev, E., Sorensen, K. *et al.* 2014. *Potential impact of CCS leakage on marine communities*. ECO2 Deliverable, D4.1 . Plymouth Marine Laboratory, 86 pp. Kiel: Helmholtz Centre for Ocean Research Kiel (GEOMAR). https://doi.org/10.3289/eco2_d4.1

Raman, M., van Shaik, A., Richter, K. and de Clerck, P. 2008. Malaysian palm oil - Green gold or green wash? A commentary on the sustainability claims of Malaysia's palm oil lobby, with a special focus on the State of Sarawak. *Friends of the Earth International* Issue 114. https://www.foei.org/wp-content/uploads/2014/08/04-foei-sarawak-full-report-lr.pdf

Raman, M. 2024, July 4. Data Centres Are Big Energy and Water Guzzlers. *Friends of the Earth Malaysia*. https://foe-malaysia.org/articles/data-centres-are-big-energy-and-water-guzzlers

Raman, M. 2025, March 10. Robust Safeguards on Carbon Capture Needed Before Any Implementation. *Friends of the Earth Malaysia*. https://foe-malaysia.org/articles/robust-safeguards-on-carbon-capture-needed-before-any-implementation

State of Nature Conservation in Malaysia 2025, 951–958
doi: 10.62613/sonc2025.v3anc20

CHAPTER 20

The need for an express right to clean, healthy environment

KWONG CHIEW EE[1]*, ABHILAASH SUBRAMANIAM[2]
and MOGANASUNDARI MAHALINGAM[3]

Abstract: This paper examines the growing recognition of the right to a safe, clean, healthy and sustainable environment and the implications of this development for Malaysia's constitutional framework. Recent developments, including the 2025 ICJ Advisory Opinion on Climate Change, UNGA Resolution 76/300, and the ASEAN Declaration on the Right to a Safe, Clean, Healthy and Sustainable Environment, reflect an emerging expectation that states recognise and give effect to environmental rights within their domestic legal systems. In Malaysia, environmental rights remain implicit and are primarily derived through judicial interpretation of Article 5(1) of the Federal Constitution. While Malaysian courts have recognised that the right to life encompasses the right to live in safe and healthy environment, such protection remains dependent on judicial interpretation and is therefore inherently fragile. The absence of an express constitutional guarantee creates legal uncertainty, weakens environmental governance, and put Malaysia at the risk of misalignment with international and regional developments. Malaysia must move beyond implied recognition and expressly recognise the right to a safe, clean, healthy and sustainable environment within its constitutional framework, supported by complementary statutory reforms.

INTRODUCTION

The escalating environmental crisis—manifested through climate-induced floods, toxic pollution, biodiversity collapse, and the degradation of Malaysia's remaining forests—has placed unprecedented pressure on the country's legal and institutional frameworks.

In recent years, a wave of global, regional and judicial developments has crystallised one central proposition: the right to a safe, clean, healthy and sustainable environment is a fundamental human right, essential to the enjoyment of life, health, equality and dignity. The recognition of this right, which was once considered aspirational, has now hardened into a legal obligation, reinforced by the International Court of Justice (ICJ), the United Nations General Assembly (UNGA), and most recently, the Association of Southeast Asian Nations (ASEAN).

Yet within Malaysia, this right remains implicit, inferred from Article 5(1) of the Federal Constitution, rather than expressly protected. Without express constitutional recognition, environmental protection becomes vulnerable.

The Right to a Clean and Healthy Environment In International Law

The recognition of a right to a clean, healthy, and sustainable environment under international law is no longer aspirational rhetoric. It has crystallised into a recognised right through judicial pronouncement at the ICJ and multilateral consensus, thus transforming it into a normative standard that demands domestic constitutional expression.

[1] Rahmat Lim & Partners, 33, The Gardens North Tower, Lingkaran Syed Putra, Mid Valley City, 59200 Kuala Lumpur, Malaysia.
[2] Abhilaash Subramaniam & Co., Level 16, 11, Wisma UOA Damansara, Common Ground Damansara Heights, Penthouse 16-1, 6, Changkat Semantan, Bukit Damansara, 50490 Kuala Lumpur, Malaysia.
[4] Messrs Sundari, Level 9, Tower B, Menara UOA Bangsar 5, Jalan Bangsar Utama 1, Bangsar, 59000 Kuala Lumpur, Malaysia.
***Corresponding author: kwong.chiewee@rahmatlim.com**

The most authoritative articulation of this development came recently from the ICJ in its Advisory Opinion of 23 July 2025 on the *Obligations of States in Respect of Climate Change*. For the first time, the world's highest court provided a comprehensive and authoritative synthesis of states' legal obligations in relation to climate change. The Court did not merely describe the state of international law; it clarified the standard of conduct expected of states moving forward.

In doing so, the Court affirmed that climate change constitutes an urgent and existential threat to humanity, ecosystems, and global stability. This characterisation is significant, as it elevates environmental protection from a matter of policy discretion to one engaging the highest level of state responsibility. The Court further recognised that states owe obligations *erga omnes* to prevent environmental and climate harm. These obligations, owed to the international community as a whole, reinforce the collective interest in environmental protection and underscore that breaches are not confined to bilateral disputes between states.

Importantly, the Court articulated the substantive content of these obligations. It emphasised that states are required to undertake "deep, rapid and sustained" reductions in greenhouse gas emissions. This formulation is prescriptive in nature: it establishes a standard of conduct that is immediate, continuing, and incapable of being deferred on grounds of convenience or competing priorities. In parallel, the Court made clear that states must regulate fossil fuel activities, including by adopting environmental impact assessment regimes that account for full life-cycle emissions. This reflects an expectation that domestic regulatory frameworks must be sufficiently robust to address the systemic causes of climate harm, rather than merely its downstream effects.

Crucially, the Court also affirmed that the right to a clean, healthy and sustainable environment is intrinsic to the enjoyment of other fundamental human rights, including the rights to life, health, and equality. This recognition situates environmental protection within the broader architecture of international human rights law. In turn, the Court observed that a state's failure to take adequate climate action, or its adoption of measures that exacerbate environmental harm, may give rise to international responsibility, including obligations to make reparation. This introduces a clear legal consequence for inaction or regression, reinforcing that environmental obligations are enforceable rather than merely aspirational.

For Malaysia, the implications of the ICJ's Advisory Opinion are both direct and unavoidable. As a member of the international community, Malaysia is required to organise its domestic legal and institutional framework in a manner that enables compliance with these obligations. It is no longer sufficient for domestic law to passively accommodate environmental considerations. Rather, it must actively facilitate environmental protection by embedding enforceable standards that guide state conduct and constrain executive discretion.

This trajectory was already evident prior to the ICJ's pronouncement. In July 2022, the UNGA adopted Resolution 76/300, formally recognising "the human right to a clean, healthy and sustainable environment". Although the Resolution is not legally binding, its significance lies in its articulation of the content of the right and the expectations placed upon states. It calls for the strengthening of environmental laws and standards, the protection of biodiversity, the reduction of pollution, and the guarantee of public participation and access to justice. It also situates environmental protection within the broader context of the "triple planetary crisis" of climate change, biodiversity loss, and pollution. These elements collectively demonstrate that the right to a healthy environment is both substantive and procedural in nature, requiring not only outcomes but also processes that ensure accountability and inclusivity.

Critically, the Resolution recognises that environmental rights are interdependent and indivisible with all other human rights. Malaysia voted in favour of the Resolution alongside 160 other countries.

More importantly, Resolution 76/300 contributes to the formation of *opinio juris*, reflecting a growing belief among states that the recognition and protection of environmental rights are matters of legal obligation rather than political preference. This is further reinforced by developments at the regional level. On 26 October 2025, ASEAN Member States adopted the ASEAN Declaration on the Right to a Safe, Clean, Healthy and Sustainable Environment at the 47th ASEAN Summit in Kuala Lumpur, marking a significant achievement in the evolution of regional human rights norms. This is a historic milestone: ASEAN now formally recognises this right as part of its regional human rights architecture.

The Declaration is notable as the ASEAN Declaration affirms the right to a clean, healthy, and sustainable environment as a universal human right within the regional context, aligning Southeast Asia with broader international developments. It also incorporates key procedural guarantees, including access to environmental information, public participation in decision-making, and access to justice. These procedural rights are not merely ancillary; they are essential mechanisms through which substantive environmental rights are realised. Without them, environmental protection risks remaining illusory, lacking the means of enforcement and accountability.

Both Resolution 76/300 and the ASEAN Declaration, while not directly binding, are evidence of *opinio juris* [a]. Taken together, the ICJ Advisory Opinion, Resolution 76/300, and the ASEAN Declaration reflect a converging body of international norms that collectively point towards the recognition of a right to a clean, healthy, and sustainable environment.

THE POSITION IN MALAYSIA

In this context, the question for Malaysia is no longer whether such a right exists at the international level. Rather, the more pressing question is whether Malaysia's domestic legal framework, and in particular its Federal Constitution, is adequately equipped to give effect to that right. The absence of an express constitutional guarantee represents a gap between Malaysia's international commitments and its domestic laws.

Malaysia does not yet provide express constitutional protection for environmental rights. Courts have suggested that the right to a clean and healthy environment is implied into Article 5(1) of the Federal Constitution [b]. This reliance on implication renders the right precarious, subject to the vagaries of judicial interpretation.

Judicial and extra-judicial recognition of the right

In this regard, whilst the Federal Court has not had the direct opportunity to consider this matter, such right has been recognised by both the Malaysian High Court and the Court of Appeal as implicit from the right to life under Article 5(1) of the Federal Constitution.

A leading authority in this respect is *Tan Tek Seng v Suruhanjaya Perkhidmatan Pendidikan & Anor* [1996] 1 MLJ 261, where Gopal Sri Ram JCA adopted a purposive and liberal interpretation of Article 5(1). His Lordship held that the expression "life" does not

---

[a] Draft Conclusions on Identification of Customary International Law (Final Outcome) (International Law Commission [ILC]) UN Doc A/73/10, para.65, GAOR 73rd Session Supp 10, 119

[b] Tan Tek Seng v Suruhanjaya Perkhidmatan Pendidikan & Anor [1996] 1 MLJ 261; Raub Australian Gold Mining Sdn Bhd v Hue Shieh Lee [2016] MLJU 1781; Public Prosecutor (Sarawak Forestry Corporation) v Toh Tung Kit @ Tou Tung Kit [2022] MLJU 2819

refer to mere existence, but encompasses those facets that give life its quality and meaning. In particular, His Lordship expressly recognised that the right to life includes the right "to live in a reasonably healthy and pollution free environment".

In another Court of Appeal case, David Wong Dak Wah JCA observed in *obiter* that the right to life, as developed in Malaysian jurisprudence, includes the right to live in a safe and healthy environment. This line of reasoning has been carried forward and articulated with even greater clarity in a more recent High Court authority. In *Public Prosecutor (Sarawak Forestry Corporation) v Toh Tung Kit @ Tou Tung Kit* [2022] MLJU 2819, the court expressly affirmed that the constitutional guarantee of "life" under Article 5(1) has been interpreted broadly to encompass environmental protection, drawing on earlier authorities such as *Tan Tek Seng*. The force and clarity of Christopher Chin Soo Yin J's reasoning in *Toh Tung Kit* is such that it bears reproduction in full:

> ***"In Malaysia, "life" in Article 5(1) of the Federal Constitution has been interpreted broadly to include the right to the environment.***
>
> *Human beings cannot exist in a void. We exist in this world only because of the natural environment which supports our existence. This environment is in a delicate balance.* ***When the biodiversity is upset by the culling of wild animals, the balance is upset and with it comes the threat to our own survival.*** *The death of a protected animal for profit is a death of part of our eco system and a breach to our delicate biodiversity which supports us. Put bluntly, stealing from the forests is stealing from humankind.*
>
> ***The degradation of the environment adversely affects all and not an isolated segment of society, both for the present and for time to come.*** *It is a given that the term "environment" must include by definition, our entire natural environment encompassing the air, earth, sea, forests all of which we need to stay alive and flourish, and which is kept in balance by the flora and fauna that nurture and sustain them.* ***There is "privity" in the legal sense amongst all mankind in this respect for the simple reason being that we stay on and share a single earth."***

The court in *Toh Tung Kit* further drew on extra-judicial reflections by former Chief Justice Tun Arifin Zakaria (2017), who articulated the concept of environmental rule of law as comprising three essential elements: a comprehensive legal framework regulating environmentally impactful human activity; consistent application of such laws, and; effective and impartial enforcement irrespective of status or influence. These elements collectively underscore that environmental protection must be systemic, principled, and non-discriminatory. Crucially, the High Court noted the former Chief Justice's views of the role of the judiciary to "*uphold our constitutional guarantees which must include the right to a clean environment both for the present generation and the future unborn generations …*"

Indeed, the recognition of the right was also reinforced by another extra-judicial observation by the former Chief Justice Tengku Maimun Tuan Mat. In a speech delivered in 2020, her Ladyship, citing *Tan Tek Seng*, affirmed in clear terms that the right to life and personal liberty under Article 5(1) does not denote mere animal existence, but encompasses the broader conditions necessary for meaningful human life (Tengku Maimun Tuan Mat 2020). Importantly, Her Ladyship expressly recognised that this includes the right to a clean environment.

It is also worth noting, in support of the broader interpretive approach, that Article 5(1) of the Federal Constitution is materially similar to Article 21 of the Constitution of India, both of which guarantee the right to life. The Indian Supreme Court has adopted a markedly expansive interpretation of Article 21, recognising that the right to life includes the right to a clean and healthy environment [c]. While decisions of the Indian courts are not binding on Malaysian courts, they are highly persuasive, particularly given the pari materia nature of the constitutional provisions.

Notwithstanding judicial and extra-judicial recognition of the rights outlined above, the argument that Article 5(1) encompasses a right to a clean and healthy environment is not without difficulty. A central challenge lies with certain arguments that Article 5(1) should be construed narrowly and not "*those facets that are an integral part of life itself and those matters which go to form the quality of life*" [d]. In this context, the reliance on implication alone is therefore inherently precarious.

Malaysia's international law commitment

The argument that Article 5(1) of the Federal Constitution encompasses a right to a clean and healthy environment is further strengthened when viewed through the lens of Malaysia's established approach to the interpretation of domestic law in light of international obligations. Malaysian courts have consistently affirmed that, where ambiguity exists, domestic law should be construed in a manner that accords with, rather than departs from, international law.

This principle was clearly articulated by the *Court of Appeal in CAS v MPPL & Anor* [2019] 4 MLJ 243, where Nallini Pathmanathan JCA emphasised that where statutory language is ambiguous, courts are under a duty to interpret it in conformity with international law. This includes not only the interpretation of statutes, but also the development of the common law by reference to statutory policy informed by international norms. The Court of Appeal's approach reflects a broader judicial recognition that domestic law does not operate in isolation, but must be situated within Malaysia's international legal commitments.

This interpretive principle has been reiterated and refined in *Sundra Rajoo a/l Nadarajah v Menteri Luar Negeri, Malaysia & Ors* [2021] 5 MLJ 209, where the Federal Court affirmed that, in a dualist system such as Malaysia's, international law does not automatically override domestic legislation. However, where domestic law is ambiguous and admits of more than one plausible interpretation, courts ought to prefer the interpretation that places the state in compliance with its international obligations. Conversely, courts should avoid adopting an interpretation that would put the state in breach of international law, whether arising from treaty commitments or customary international law. This reflects a principled judicial reluctance to attribute to Parliament an intention to legislate in violation of Malaysia's international obligations, absent clear and express language to that effect.

The same approach is evident in *Noorfadilla bt Ahmad Saikin v Chayed bin Basirun & Ors* [2012] 1 MLJ 832, where the High Court held that, in interpreting constitutional guarantees under Article 8(2), the court must take into account Malaysia's international commitments, including obligations under conventions such as CEDAW (Convention on the Elimination of All Forms of Discrimination against Women). The court went so far as to state that it had "no choice" but to refer to such instruments in clarifying the meaning and scope of constitutional rights.

---

[c] *Virender Gaur v. State of Haryana* (1995) 2 SCC 577; *M.C. Mehta v Kamal Nath* (2000) 6 SCC 213; *Karnataka Industrial Areas Development Board v C. Kenchappa* (2006) 6 SCC 371

[d] *Pihak Berkuasa Negeri Sabah v Sugumar Balakrishnan* [2002] 3 MLJ 72, 101

However, this line of reasoning must be approached with caution in light of a divergent strand of authority that underscores the limits of reliance on international law within Malaysia's dualist legal system. In *AirAsia Bhd v Rafizah Shima bt Mohamed Aris* [2014] 5 MLJ 318, the Court of Appeal took a more restrictive view, emphasising that international conventions such as CEDAW do not have the force of law in Malaysia unless and until they are expressly incorporated into domestic legislation. Ratification alone, the Court held, does not render treaty provisions enforceable in municipal law. The Court further observed that the Federal Constitution is silent on the primacy of international law *vis-à-vis* domestic law, and that in the event of conflict, domestic legislation prevails. This reflects the orthodox dualist position: international law may inform interpretation where ambiguity exists, but it cannot override clear domestic provisions.

In a later case, the Federal Court in *Letitia Bosman v Public Prosecutor and other appeals* (No 1) [2020] 5 MLJ 277 reaffirmed the Rafizah Shima's orthodox dualist position that international instruments do not form part of Malaysian law unless and until they are incorporated into domestic legislation. The Court emphasised that international norms should not be used as a guide to interpret the Federal Constitution. The "ultimate touchstone of constitutionality", the Court reiterated, is the Constitution itself, and not external principles or unincorporated international standards. The Court further underscored that where domestic provisions are clear and unambiguous, there is no scope to resort to international instruments to interpret or modify their meaning. In such circumstances, international law cannot be invoked—whether directly or indirectly—to introduce rights or obligations that have not been adopted by Parliament.

This reinforces the central thesis of this article. The recognition of environmental rights through judicial interpretive techniques remains inherently fragile. It is susceptible to doctrinal retrenchment and dependent on the interpretive disposition of the courts.

IMPORTANCE OF EXPRESS CONSTITUTIONAL RECOGNITION OF THE RIGHT

Notwithstanding the emerging judicial recognition outlined above, the absence of an express constitutional right to a clean and healthy environment remains a fundamental weakness within the Malaysian legal framework. The current position, where such a right is implied through judicial interpretation of Article 5(1), is inherently fragile, incomplete, and raises various issues as outlined below.

First, the reliance on implication leaves environmental protection vulnerable to shifting judicial attitudes. As the legal cases discussed above demonstrate, the recognition of environmental rights under Article 5(1) is the product of an expansive and purposive interpretive approach. However, this approach is not settled. In the absence of an express provision in the Federal Constitution, there is no guarantee that future courts will maintain, let alone develop, this broader understanding of the existence of such right implicit in Article 5(1).

Secondly, the lack of a clearly articulated constitutional right allows environmental protection to be treated as subordinate to competing policy considerations, most notably economic development. Within a purely statutory or policy-driven framework, environmental concerns are often balanced against and frequently outweighed by short-term economic priorities. Without a constitutional recognition of the right, there is no principled baseline against which such trade-offs are to be assessed. An express right would recalibrate this balance by requiring that environmental protection be treated as a fundamental consideration for governmental policy-making and actions.

Thirdly, this lacuna undermines Malaysia's ability to effectively discharge its obligations under international and regional law. As outlined earlier, developments at the level of the ICJ, the UNGA, and ASEAN reflect a converging expectation that states will recognise and give effect to environmental rights within their domestic legal systems. The absence of an express constitutional right places Malaysia at risk of normative misalignment, where its domestic legal framework does not adequately reflect the standards it has endorsed at the international and regional levels. This, in turn, may weaken the coherence and credibility of Malaysia's legal position in cross-border and transnational environmental matters.

Fourthly, an express recognition of the right would provide a unifying interpretive principle across the fragmented body of environmental legislations. Statutes such as the Environmental Quality Act 1974, the National Forestry Act 1984, and the Wildlife Conservation Act 2010 currently operate separately. An express constitutional right would enable courts to interpret these statutes coherently, guided by a common objective of safeguarding environmental integrity. This would reduce inconsistencies and ensure that legislative provisions are construed in a manner that advances, rather than undermines, environmental protection.

Fifthly, constitutional recognition would strengthen the standards of judicial review in environmental-related cases. Courts would be empowered to evaluate whether state action substantively complies with constitutional environmental obligations. This would enable a more rigorous form of review, particularly in cases involving large-scale or irreversible environmental harm.

Lastly, an express constitutional right would impose positive obligations on the federal and state governments. Environmental protection would cease to be merely a matter of restraint (i.e., avoiding harm), and would instead require proactive measures to protect ecosystems, preserve biodiversity, and address climate change. This aligns with emerging international norms, which increasingly recognise that states must take active steps to prevent environmental degradation and ensure ecological sustainability.

Taken together, these considerations demonstrate that the absence of an express constitutional right is a deficiency with real legal and practical consequences. It leaves environmental protection uncertain and misaligned with international norms.

DOMESTIC LEGISLATIVE REFORM: CONSTITUTIONAL AND STATUTORY PATHWAYS

The most direct and principled approach is to amend the Federal Constitution to expressly recognise that every person has the right to a safe, clean, healthy, and sustainable environment. Such an amendment would bring Malaysia into alignment with a growing number of jurisdictions that have constitutionalised environmental rights, and would give clear and unequivocal expression to a principle that Malaysian courts have already begun to recognise.

However, constitutional reform—while necessary—may not be immediate. Pending such reform, Malaysia must at minimum take steps to incorporate this right within its legislative framework, particularly through the anticipated National Climate Change Bill. This presents a critical opportunity to embed environmental rights within primary legislation, thereby establishing a rights-based foundation for climate governance.

In parallel, there must be a systematic review and recalibration of existing environmental statutes to ensure consistency with a rights-based approach. This includes, but is not limited to the Environmental Quality Act 1974; National Forestry Act 1984;

Wildlife Conservation Act 2010; Town and Country Planning Act; and other relevant state enactments. Such a review should not be limited to technical amendments. It must be guided by the objective of transitioning from a purely regulatory model to a rights-based framework, where environmental protection is not merely permitted or managed, but required and enforceable.

Ultimately, while statutory reform can mitigate some of the deficiencies in the current framework, it cannot substitute for constitutional recognition. Legislation remains subject to amendment, repeal, and political compromise. Only a constitutional right can provide the permanence, clarity, and normative force necessary to ensure that environmental protection is treated as a fundamental and enduring legal obligation.

CONCLUSION

At the international level, the recognition of a right to a clean, healthy, and sustainable environment has moved decisively from aspiration to normative expectation, as reflected in the pronouncements of the ICJ, the UNGA, and regional developments within ASEAN. These developments establish not only that such a right exists in principle, but that states are increasingly expected to give it meaningful effect within their domestic legal systems. At the domestic level, through decisions such as *Tan Tek Seng, Raub Australian Gold Mining Sdn Bhd v Hue Shieh Lee* [2016] MLJU 1781, and *Public Prosecutor (Sarawak Forestry Corporation) v Toh Tung Kit @ Tou Tung Kit* [2022] MLJU 2819, the judiciary has already recognised implicitly that environmental protection is intrinsic to the constitutional guarantee of life under Article 5(1). Extra-judicial statements from the apex court further affirm that this right is both conceptually embedded within the Constitution and normatively necessary. Yet, it leaves room for argument that the right is unentrenched in our Federal Constitution as it is dependent on judicial interpretation. The consequence is a legal dissonance, where Malaysia has, on the one hand, aligned itself with international and regional developments recognising environmental rights; on the other, its domestic legal framework has yet to recognise the same. The central thesis of this article is that this gap must now be resolved. The question is no longer whether a right to a clean and healthy environment can be recognised within Malaysian law. The question is whether that recognition will remain implicit, or whether it will be given clear and durable constitutional expression. In this regard, an express right would consolidate existing jurisprudence, align Malaysia with the trajectory of international law, and provide a coherent normative foundation for environmental governance domestically. It would transform environmental protection from a matter of policy and regulation into a matter of constitutional obligation that binds all branches of government and endures beyond shifting political and economic priorities. More fundamentally, constitutional recognition is about safeguarding the conditions necessary for human life itself. As the courts have already acknowledged, human beings do not exist in a vacuum; our survival depends on a functioning and balanced ecosystem. To recognise a right to life, while failing to protect the environment that sustains it, is to render that right incomplete.

REFERENCES

Inns of Court Malaysia. 2017, January 13. Make clean environment a clear right in the Constitution, says CJ. *Inns of Court Malaysia.* https://innsofcourtmalaysia.org/2017/01/13/make-clean-environment-a-clear-right-in-the-constitution-says-cj/

Tengku Maimun Tuan Mat. 2020, December 2. Welcome Address by the Right Honourable The Chief Justice of Malaysia, Tun Tengku Maimun binti Tuan Mat at SUHAKAM Training Workshop. https://www.kehakiman.gov.my/sites/default/files/documents/teks_ucapan/2020/CJ_SPEECH.pdf

State of Nature Conservation in Malaysia 2025, 959–969
doi: 10.62613/sonc2025.v3anc21

CHAPTER 21

Gaps in environmental policy and legislation: Overview of the legislative and policy framework governing the environment

ARHWIN KALAI CHELVAN*, SHANTINI GUNA RAJAN, SHEELASHEENA DAMIAN, VANESSA A. JIPIU, MARYELL IRISHA HILLARIAN, ESTHER MAWAN, STANDLEY BAWIN ANAK BUNSI, NURFATIN WAHIDA BINTI PUSPA, AIDIL IMAN AIDID and LEE PEI XIAN

Abstract: When the words 'policy' or 'legislation' come up, they immediately create the impression of something far-removed and out of reach of the ordinary layperson, instead belonging exclusively to the realm of lawyers, judges, parliamentarians and ministers. Yet, nearly every aspect of the society is governed or impacted by policies and legislation, including the environment. Conservation projects often have policy and legislative changes as the final outcomes that they are lobbying and striving for. It is therefore useful for all stakeholders, including conservationists, academics and the general public, to gain an understanding of policies and legislation. Understanding this framework and the relationships between its various components provides a useful foundation for engaging with environmental issues. Policies and legislation are also often shaped by certain rights, principles, and othe socioeconomic forces. Within the context of the environment, having an idea of what these are and how they function will be useful in understanding broad fundamental gaps within the framework. Finally, given the vastness of the environmental field, discussions on gaps of policies and legislation can potentially become too theoretical unless it is focused on application in a certain context. The chapter will therefore provide a first point of reference to the various policies and legislation governing different aspects of the environment and to help readers build an understanding of and appreciation for this important framework.

INTRODUCTION

This chapter intends to provide an overview and a starting point in navigating the environmental policies and legislation governing Malaysia. It is by no means exhaustive. For the sake of clarity, what is meant by 'policy' here refers specifically to official directives from the executive branch of government. Legislation are laws passed by the federal or state legislatures. Legislation forms a big part of the more general term "law" which also includes other sources of law such as secondary legislation, judicial precedent, and international law (which has no force in domestic courts).

In Malaysia, Federal legislation is generally known as 'acts', whereas state legislation is usually known as 'ordinances' or 'enactments'. Secondary legislation is usually known as 'regulations', 'orders', or 'by-laws.' A related point to note is that each policy and legislation often has an implementing government ministry, agency or department, which may be further self-regulated with internal circulars and practice directions among others. Hence, readers may wish to explore this aspect as well, for a more complete picture.

There are certain policy documents that are cross-cutting and cover many areas, including various aspects of the environment, like the Malaysia Plans (the current Malaysia Plan in force is the 13th Malaysia Plan). Apart from that, there are policies covering certain

WWF-Malaysia, Jln PJS 5/28 A, Pusat Dagangan Petaling Jaya Selatan, 46150 Petaling Jaya, Selangor, Malaysia.
***Corresponding author: akchelvan@wwf.org.my**

thematic areas and certain regions. There are also examples of clear joint enforcement or implementation activities such as the Operasi Bersepadu Khazanah (Berita RTM 2024), where multiple government agencies with different expertise collaborate to take down crimes involving cross-cutting issues such as the illegal wildlife trade.

As the term 'environment' is so broad and can mean so many different things, it is important for this chapter to also define its scope. Areas that will be specifically covered include environmental quality, solid waste, freshwater resources and supply, forestry, protected areas, wildlife, biological resources, climate change, as well as land use and spatial planning. This chapter will specifically exclude the following areas, although they do have a bearing on the environment, such as development, energy, agriculture, mining, indigenous peoples, nuclear energy and management, as well as tourism and ecotourism.

SCHEDULE 9 OF THE FEDERAL CONSTITUTION AS THE SKELETON OF THE FRAMEWORK

The Federal Constitution is considered the supreme law of Malaysia [Federal Constitution, Article 4(1)]. Article 74 specifically defines the subject matters that the federal or state legislatures may legislate on, drawing reference to the Ninth Schedule. The Ninth Schedule consists of five lists, namely List I – Federal List; List II – State List; List IIA – Supplement to State List for States of Sabah and Sarawak; List III – Concurrent List; and List IIIA – Supplement to Concurrent List for states of Sabah and Sarawak.

If a subject matter is listed in the Federal List, it is to be legislated by the federal legislature. If it is in the State List, it is to be legislated by the state legislature. And if it is in the Concurrent List, both state and federal legislatures may legislate on it. There are some exceptions for Sabah and Sarawak per the supplementary lists. It is also worth noting that Article 77 grants residual powers to the states to legislate on any matters not in the lists of the Ninth Schedule.

The term "environment" is not listed anywhere in the Ninth Schedule. However, various aspects affecting the environment can be found in these lists. For example, the Federal List consists of, among others, maritime and estuarine fishing and fisheries, welfare of the aborigines, prevention of plant diseases, and tourism. The State List includes subject matters such as land, forests, as well as turtles and riverine fishing. Subject matters in the Concurrent List include protection of wild animals and wild birds, national parks, town and country planning, public health etc.

Due to this, environmental legislation would consist of a mixture of both state and federal legislation. In addition to that, there are many laws that are strictly speaking, not environmental laws, but would have an impact on the environment. For instance, public works (this would regulate the construction industry), agriculture (expansion of agriculture may lead to deforestation), and external affairs (this governs Malaysia's international commitments to environmental treaties).

This fragmented distribution of power creates a complex administrative landscape that is evident in the grey areas of maritime jurisdiction, for instance. While the State List grants individual States authority over "land" which includes the seabed and subsoil within state waters (typically three nautical miles), the Federal List reserves authority over "maritime and estuarine fishing and fisheries".

This jurisdictional overlap creates a unique legal paradox regarding coral reefs. As reefs are physically attached to the seabed, they are technically categorised as "state land". However, under the Fisheries Act 1985, "fish" is defined broadly to include corals and other aquatic flora. Consequently, the management of these living resources falls under Federal jurisdiction. This duality means that while a state can regulate activities affecting the physical seabed (such as land reclamation), the Federal government regulates the "life" of the reef, such as prohibiting the collection of corals. A similar distinction exists between turtles and riverine fishing (state) and maritime fishing (federal).

Apart from that, it is also worth noting that there are a few other provisions in the Federal Constitution describing the operation of the lists in the Ninth Schedule at Part VI of the Federal Constitution. Due to this, the Federal Constitution, and particularly the Ninth Schedule, can be considered the skeleton for the framework that governs environmental policy and legislation.

Environmental Quality

The key environmental quality legislation in Malaysia is the Environmental Quality Act 1974, and it mainly governs issues such as pollution, primarily concerning air and water. It is the origin of various secondary legislation such as Environmental Quality (Control of Emission from Petrol Engines) Regulations 1996 and the Environmental Quality (Delegation of Powers on Marine Pollution Control) Order 1994. The National Policy on the Environment is the main environmental policy document in force since 2002.

For Sabah, both the Environmental Quality Act 1974 and the Environmental Protection Enactment 2002 apply in governing the environment. The Environmental Protection Enactment 2002, as administered by the Environment Protection Department of Sabah, applies to activities falling within the State's jurisdiction, including activities concerning the exploitation, development, and utilisation of land and natural resources, including water, soil, minerals, forests, and other natural resources.

In Sarawak, environmental quality is primarily governed through the Natural Resources and Environment Ordinance 1949 (NREO), administered by the Natural Resources and Environment Board (NREB). The NREO provides the overarching framework for pollution control, environmental impact assessment, and regulation of activities affecting air, water, and land quality within the State.

At the policy level, environmental quality objectives are embedded within broader development strategies, notably the Post-Covid-19 Development Strategy 2030 (PCDS 2030) and the Sarawak Sustainability Blueprint 2030, which integrate environmental protection with economic development. Sector-specific policy direction is further provided through the Sarawak Energy Transition Policy (SET-P) and the Green Economy Policy, both of which have implications for air quality, emissions management, and sustainable resource use.

Although Federal legislation such as the Environmental Quality Act 1974 applies in Sarawak in limited aspects, environmental regulation in practice is largely implemented through the State framework, particularly for activities involving land use and natural resource exploitation.

Solid waste

Solid waste legislation in Peninsular Malaysia can be quite complex. There is the Solid Waste and Public Cleansing Management Act 2007. However, this act only applies to the States of Perlis, Kedah, Pahang, Negeri Sembilan, Malacca and Johor, as well as the

Federal Territories of Kuala Lumpur and Putrajaya. Besides this legislation, solid waste is a component covered under the Local Government Act 1976 which governs how local authorities operate.

Key national policies include the National Solid Waste Management Policy 2016, the National Strategic Plan for Solid Waste Management 2019 – 2030 and the National Cleanliness Policy 2019. A critical evolution in Malaysia's waste policy is the recognition that land-based waste is the primary source of marine pollution. To address this, the government launched the National Marine Litter Policy and Action Plan 2021 – 2030 (NMLPAP). This policy bridges the gap between terrestrial waste management and marine conservation, acknowledging that mismanaged plastic waste on land inevitably enters the maritime domain, threatening biodiversity and the ocean economy.

For Sabah, the key legislation on solid waste is the Solid Waste and Public Cleansing Management Enactment 2022. This and related state policies for solid waste and urban cleanliness fall under the jurisdiction of the Sabah Ministry of Local Government and Housing.

In Sarawak, solid waste management is primarily implemented by local authorities under the Local Authorities Ordinance 1996, which empowers local councils to regulate refuse collection, disposal, and public cleanliness through by-laws and enforcement mechanisms. Public health considerations related to improper waste handling are supported under the Protection of Public Health Ordinance 1999, particularly where the accumulation or mismanagement of solid waste poses sanitation and health risks.

At the policy level, solid waste and urban cleanliness are addressed through broader planning instruments such as the PCDS 2030 and urban-specific initiatives including the Kuching Smart City Masterplan, which incorporates waste management, circular economy principles, and service efficiency into municipal planning.

Freshwater resources and supply

For Peninsular Malaysia, key legislation include the Suruhanjaya Perkhidmatan Air Negara Act 2006 and the Water Services Industry Act 2006, both of which regulate water supply and sewerage services. Sewerage is also governed by the Sewerage Services Act 1993. Then there is the Street, Drainage and Building Act 1974, which regulates drainage, among other things. Apart from that, there is the Waters Act 1920, which provides for the control of rivers and streams. However, it only applies to the states of Negeri Sembilan, Pahang, Perak, Selangor, Malacca, Penang, and the Federal Territories.

In each state in Peninsular Malaysia, there tends to be a water supply enactment and a water resources enactment. The water resources enactment provides the power to manage water resources such as rivers, catchment areas, etc., whereas the water supply enactment typically focuses on water supply to domestic and commercial users. Key national policies affecting freshwater include the Water Sector Transformation 2040 and the National Water Resources Policy.

The Water Resources Enactment 1998 is the primary legislation governing water resources in Sabah, providing for sustainable water management, efficient water use, and the establishment of Water Conservation Areas and Water Protection Areas.

In Sarawak, the Sarawak Rivers Ordinance 1993 governs the management, use, and protection of rivers and riverine environments, while the Water Ordinance 1994 regulates water supply services and water resource utilisation.

These legal instruments are complemented by strategic policy direction under the PCDS 2030 and the Sarawak Sustainability Blueprint 2030, which emphasise water security, sustainable catchment management, and resilience to climate-related impacts such as flooding and drought.

Forestry

The framework governing forestry legislation in Peninsular Malaysia is quite interesting. Although "forest" is under the State List in the Ninth Schedule of the Federal Constitution, there is a national act known as the National Forestry Act 1984 that is intended to apply across Peninsular Malaysia (National Forestry Act 1984, Section 1). However, by itself, the National Forestry Act 1984 does not apply in the respective states and only applies directly to the Federal Territories of Malaysia. Section 1(2) specifically provides that, "*...This Act shall not come into force in a State unless it has been adopted by a law made by the Legislature of the State...*"

As a result, each state in Peninsular Malaysia has had to enact a state legislation to adopt the National Forestry Act 1984 into its own set of laws:

- National Forestry (States of Malaysia)(Adoption) Enactment (Johor 12 of 1985)
- National Forestry (States of Malaysia)(Adoption) Enactment (Kedah 2 of 1986)
- National Forestry (States of Malaysia)(Adoption) Enactment (Kelantan 11 of 1985)
- National Forestry (States of Malaysia)(Adoption) Enactment (Malacca 4 of 1985)
- National Forestry (States of Malaysia) (Adoption) Enactment (Negeri Sembilan 5 of 1986)
- National Forestry (States of Malaysia)(Adoption) Enactment (Pahang 6 of 1986)
- National Forestry (States of Malaysia)(Adoption) Enactment (Penang 2 of 1986)
- National Forestry (States of Malaysia)(Adoption) Enactment (Perak 3 of 1985)
- National Forestry (States of Malaysia)(Adoption) Enactment (Perlis 1 of 1988)
- National Forestry (States of Malaysia)(Adoption) Enactment (Selangor 5 of 1985)
- National Forestry (States of Malaysia)(Adoption) Enactment (Terengganu 1 of 1986)

While the adoption of the National Forestry Act 1984 in different states give the impression that the Act itself is applicable throughout Peninsular Malaysia, in actual fact, what applies is technically a copy of the said act and not the act itself. This becomes evident when there are amendments to the original act or the respective state enactments. For example, the Selangor enactment was amended in 2011 to include a public inquiry requirement in the state forestry enactment [Selangor National Forestry Act (Adoption)(Amendment) Enactment 2011]. However, this only changed the forest enactment in Selangor and had no bearing on the original National Forestry Act 1984 nor the respective state enactments in all the other states.

Amendments to the National Forestry Act 1984 also require adoption in each state legislature to take effect, and states may even choose parts to adopt and whether to adopt these amendments at all (Raman 2025). For example, as of March 2025, only Perlis and the Federal Territories of Kuala Lumpur, Putrajaya and Labuan had adopted the National Forestry (Amendment) Act 2022, more than two years after it had been passed (Raman 2025).

The key document for forest policy in Malaysia is the Malaysia Policy on Forestry 2022. Interestingly, it functions as a compilation of the forestry policies of Peninsular Malaysia, Sabah, and Sarawak into a single document. However, the policies for the three regions are still kept separate within the policy document itself (i.e., there are separate parts for Peninsular Malaysia, Sabah, and Sarawak within this document). Besides that, there are forest connectivity policies such as the Pelan Induk Rangkaian Ekologi Central Forest Spine Masterplan 2022 (PIRECFS 2022), and the Sabah Heart of Borneo Strategic Plan of Action 2021 – 2030.

Protected areas

Protected areas here refer to areas that are legally protected primarily for the conservation of biodiversity and ecosystems. However, due to the legal complexity involved, a state park in one state may be managed very differently to a state park in another state, despite both being called state parks. It is worth noting that there is a lot of push from international platforms to call for gazettement and better management of protected areas. These include accreditations and recognitions such as UNESCO World Heritage sites, CA|TS, IUCN Greenlist, RAMSAR sites, and Important Bird and Biodiversity Areas (IBAs).

However, these accreditations and recognitions do not by themselves confer legal protection. Instead, it is the domestic laws that actually provide the sites involved with legal protection. For Peninsular Malaysia, protected areas can be gazetted via the National Forestry Act 1984 (or rather the corresponding state enactments). Section 10 of the Act provides for different classifications for forest reserves including "soil protection forest", "water catchment forest", "state park", and "forest sanctuary for wild life" among others.

Apart from "timber production forest", other forest classes are generally implied to be protected and not logged, in order to perform the purpose of their respective functional class. However, there have been cases of logging occurring within forests classified under these protected classes. It is also important to take note that the default classification of forest reserves is "timber production forest" and that most forest reserves fall under this category.

Besides that, there are national park and state park legislation such as the Taman Negara Enactment (Kelantan) 1938, Taman Negara Enactment (Pahang) 1939, Taman Negara Enactment (Terengganu) 1939, National Parks Act 1980, National Parks (Johor) Corporation Enactment 1989, Perak State Parks Corporation Enactment 2001, Selangor State Parks Corporation Enactment 2005, Terengganu State Parks Enactment 2017, and Pahang State Parks Corporation Enactment 2021. It is worth noting that "national parks" in Johor are actually state parks as they are managed completely by the Johor National Parks Corporation, a state entity. The Taman Negara enactments in effect create three different state parks via their respective states and consolidates it into a national park that is under the control of the Federal government. State parks can also be constituted via the state forestry enactments, which was the case for the Perlis State Park (MyBIS 2025).

There are other forms of protected areas that can be gazetted under the Wildlife Conservation Act 2010 such as wildlife reserves and wildlife sanctuaries Wildlife Conservation Act 2010, Section 47). Land can also be conserved for general or public purposes, either directly or indirectly for biodiversity conservation through the National Land Code, Land Conservation Act 1960, National Heritage Act 2005, and possibly other legislation. The key policy document driving the advancement of protected areas is the National Policy on Biological Diversity 2022 – 2030.

In Sabah, the Forest Enactment 1968 is the main law governing forest reserves. Under section 5 of this Enactment, protected areas can be gazetted under different classes of protection: Protection Forest (Class I), Virgin Jungle Reserve (Class VI), and Wildlife Reserve (Class VII). The Parks Enactment 1984 governs the establishment and management of state parks and national reserves (terrestrial and marine) under Sabah Parks. Wildlife sanctuaries are gazetted under section 9 of the Wildlife Conservation Enactment 1997 to ensure protection of wildlife habitat, biodiversity values, and protection of significant species.

In Sarawak, certain ecologically significant landscapes are designated for conservation purposes despite not being gazetted as protected areas under statutory instruments. One such example is Ulu Sungai Menyang, which was designated by the Sarawak Forestry Corporation as a Special Conservation Area in 2015 due to its importance for orangutan habitat and landscape connectivity. This recognition does not confer legal protection under the National Parks and Nature Reserves Ordinance 1998 or the Forests Ordinance 2015. Rather, it represents a policy and administrative designation that informs land-use planning, environmental assessment, and conservation management. In practice, such areas function as *de facto* conservation areas and align conceptually with Other Effective Area-Based Conservation Measures (OECMs), where conservation outcomes are achieved outside formally designated protected areas.

Unlike terrestrial protected areas, which are predominantly state-managed, Marine Protected Areas (MPAs) in Malaysia are governed by a dual-track system depending on their location and the specific living resources being protected. For instance, Federal Marine Parks (Peninsular Malaysia and Labuan): The primary legal instrument for marine conservation is the Fisheries Act 1985. Under Part IX (Sub-sections 41), the federal government has the power to establish Marine Parks or Marine Reserves. These are officially gazetted through the Establishment of Marine Parks Malaysia Order 1994 [Perintah Penubuhan Taman Laut Malaysia (Pindaan) 2023]. These areas typically extend two nautical miles from the low-water mark of gazetted islands and are "no-take zones," meaning fishing and coral collection are strictly prohibited.

Wildlife

Wildlife conservation laws differ across Peninsular Malaysia, Sabah and Sarawak. Nevertheless, at the federal level, there are uniform laws to deal with the international illegal wildlife trade. The key legislation for this is the International Trade in Endangered Species Act 2008, which essentially translates Malaysia's international commitments under the Convention on International Trade in Endangered Species of Wild Fauna and Flora, of which Malaysia is a signatory, into domestic legislation.

For Peninsular Malaysia, the main legislation for wildlife is the Wildlife Conservation Act 2010. The Schedules in this Act determine whether a species of wildlife is protected, totally protected, controlled, or allowed for aborigine consumption. However, aquatic wildlife is governed by a different set of rules. Under the Fisheries Act 1985, the definition of "fish" is broad enough to include marine mammals.

Specifically, the Fisheries (Control of Endangered Species of Fish) Regulations 1999 (and its 2019 Amendment) serve as the primary protection for marine wildlife. These regulations prohibit the fishing, disturbing, or possessing of species listed in the Schedule. Notable protected species include marine mammals (all species of whales, dolphins, and dugong) as well as sharks and rays, where the 2019 Amendment significantly expanded protection to include the whale shark and several species of hammerhead sharks and manta rays.

While fishing remains an important part of diet, culture, and livelihoods in Malaysia, it is carefully regulated to maintain sustainable stocks. Measures such as licensing, gear restrictions, catch limits, seasonal closures, and spatial protections are applied, with decisions on which species need strict protection informed by scientific assessments, population trends, ecosystem roles, and socio-economic considerations.

Apart from that, specific state enactments protect unique aquatic species, such as the Kedah River Terrapin Enactment 1972 and the Terengganu Turtles Enactment 1951, which manage nesting habitats that fall under State land jurisdiction.

The key policy document on biodiversity and wildlife is the National Policy on Biological Diversity 2022 – 2030. Besides that, there are certain policy documents that are focused on selected key species such as the National Tiger Conservation Action Plan, the National Elephant Conservation Action Plan, the Malayan Tapir Conservation Action Plan, the National Plan of Action for the Conservation and Management of Sharks, and the National Plan of Action for the Conservation and Management of Sea Turtles.

For Sabah, the legislation for wildlife is the Wildlife Conservation Enactment 1997 (WCE) which covers both flora and fauna, and the Sabah Inland Fisheries and Aquaculture Enactment 2003 (SIFAE), which covers marine species and its habitat. Schedules in the WCE determine wildlife that are totally protected and those that are partially protected for which hunting or harvesting license is required. The provisions in the SIFAE provide protection to selected species and habitat protection.

Wildlife conservation in Sarawak is governed by the Wildlife Protection Ordinance 1998, which provides for the protection, management, and regulation of both fauna and flora. The Ordinance establishes schedules of protected species and regulates hunting, trade, and possession of wildlife. At the policy level, wildlife conservation objectives are articulated through the Sarawak Biodiversity Master Plan (SBMP), which provides strategic direction for biodiversity conservation, research, and sustainable use.

Biological resources

Some aspects of this are already covered in other parts of this article (i.e., forests and wildlife). This section therefore focuses on areas that have not yet been covered. At the federal level, key legislation include the Access to Biological Resources and Benefit Sharing Act 2017 and the Biosafety Act 2007. In terms of policy, the National Policy on Biological Diversity 2022 – 2030 is also the key policy document for this area.

In Peninsular Malaysia, states may also take charge of their biological resources and create legislation for this, although this is rare. At the moment, Pahang seems to be the only state that has done so (Pahang Biodiversity Enactment 2021). In Sarawak, there is the Sarawak Biodiversity Centre Ordinance 1997, which supports biodiversity research, documentation, and access-and-benefit-sharing mechanisms.

In addition to the above, Malaysia's signing of the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement in 2025 marks an important development for the governance of biological resources beyond national jurisdiction. While the Agreement focuses on marine areas outside national boundaries, it has direct implications for Malaysia's approach to access to marine genetic resources, benefit-sharing, and scientific research cooperation. The BBNJ Agreement introduces new international obligations on the conservation and sustainable use of marine biological resources, including requirements for transparency, environmental impact assessments, and equitable sharing of benefits arising from the utilisation of marine genetic resources.

Over time, this is expected to influence domestic legal and policy frameworks, particularly the implementation of the Access to Biological Resources and Benefit Sharing Act 2017 and the National Policy on Biological Diversity 2022 – 2030, to ensure alignment with emerging global standards on marine biodiversity governance.

Climate change

Climate change governance in Malaysia is anchored upon a combination of international commitments, national policies, and sector-specific and in some instances, state-specific legal instruments. Malaysia is currently developing a climate change bill and it remains to be seen how this legislation will look like in due course. In the meantime, national governance is being shaped by several factors in the absence of specific legislation.

International commitments
Malaysia's climate governance is fundamentally shaped by its obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, under which Malaysia has submitted successive Nationally Determined Contributions (NDCs). Malaysia's Third NDC (2025) commits to an absolute reduction of 15 – 30 $MtCO_2eq$ by 2035, including conditional reductions subject to international finance, technology transfer and capacity building. Importantly, the Third NDC also incorporates adaptation strategies, including the development of the Malaysia National Adaptation Plan (MyNAP), which is underway.

Climate action is further reinforced through Malaysia's commitment to the 2030 Agenda for Sustainable Development, particularly SDG 13 on Climate Action. Increasingly, other international frameworks are embedding climate considerations, including the Kunming -Montreal Global Biodiversity Framework (GBF) 2030 under the Convention on Biological Diversity (CBD), which Malaysia is also party to. Notably, Target 8 focuses on minimising climate impacts through ecosystem-based approaches and enhancing resilience, while Target 11 emphasises nature-based solutions to maintain ecosystem services critical for climate adaptation and disaster risk reduction. These commitments reinforce the interlinkages between climate action, biodiversity conservation and ecosystem resilience.

National legal framework
At the national level, Malaysia does not yet have a single overarching law that operationalises its UNFCCC and Paris Agreement obligations. Instead, climate governance has evolved through sector-specific and issue-based legislation, predominantly focused on mitigation.

Key legislative instruments include:
- Environmental Quality Act 1974 – Malaysia's core environmental statute, regulating pollution and environmental impacts, though not explicitly climate-focused.
- Renewable Energy Act 2011 – Establishes feed-in tariffs to promote renewable energy generation.
- Energy Efficiency and Conservation Act 2024 – Regulates energy efficiency across large energy users, buildings and appliances, supporting emissions reduction and carbon neutrality goals.
- Carbon Capture, Utilization and Storage Act 2025 – Governs carbon capture and storage activities, reflecting a mitigation-driven and economically-oriented approach to emissions reduction, and which remains silent on environmental and social viability and safeguards.

While these laws contribute to mitigation, they do not adequately address adaptation, resilience, accountability, or climate justice, nor do they provide an integrated framework for coordinating federal and state action.

National policy landscape: Mitigation and adaptation
Malaysia's climate governance is currently more robust at the policy level. The National Climate Change Policy 2.0 (2024) is the central coordinating framework, integrating Paris Agreement requirements and providing guidance for regulatory instruments, including the proposed Climate Change Act. Through its five strategic thrusts, the policy seeks to advance low-carbon development while enhancing climate resilience.

On mitigation, key policies include the National Energy Transition Roadmap (NETR), National Energy Policy 2022 – 2040, Low Carbon Mobility Blueprint 2021 – 2030, New Industrial Master Plan 2030, Green Technology Master Plan 2017 – 2030, and the National Construction Policy 2030. Collectively, these policies target decarbonisation of energy, transport, industry and the built environment, largely through technology deployment, efficiency gains, and market-based instruments.

On adaptation and resilience, policies such as the National Policy on Biological Diversity 2022 – 2030, Malaysia Policy on Forestry (2021), National REDD Plus Strategy, National Agrofood Policy 2021 – 2030 (NAP 2.0), Water Sector Transformation 2040, and the Fourth National Physical Plan play a critical role. These frameworks to some extent promote ecosystem-based adaptation, food and water security, sustainable land use planning and forest conservation, aligning with reported MyNAP priorities.

The 13th Malaysia Plan (2026 – 2030) consolidates these efforts by positioning energy transition and climate resilience as central pillars of sustainable development, while the National Action Plan on Business and Human Rights (NAPBHR) 2025 – 2030 strengthens environmental and social safeguards within corporate climate action.

Climate finance and the role of Bank Negara Malaysia

Under the leadership of Bank Negara Malaysia, climate governance has expanded into the financial sector. Key initiatives include the Climate Change and Principle-based Taxonomy, climate-related risk management guidelines, and growing emphasis on ESG integration and climate-related financial disclosures. These measures aim to align financial flows with low-carbon and resilient development pathways.

Sabah

Sabah recently enacted the Climate Change and Carbon Governance Enactment 2025. This legislation provides the legal framework for the State in governing carbon-related activities, the protection of Sabah's carbon assets, and in building institutional climate resilience. Through this law, the Sabah Climate Action Council (SCAC) was established serving as the State's top policy advisory body on climate issues. The SCAC functions as the policy-making body, while a director will oversee carbon-related activities and greenhouse gas emissions.

Key provisions under this law include the creation of a Climate Fund and Inventory Centre to support climate related projects and for managing climate related data; mandated emissions reporting by listed entities; affirmations that carbon rights belong to the state government; mandated participation of indigenous communities, especially for projects on customary land; requirements for emissions balancing, and; mitigation and adaptation planning for the State.

Sarawak

Climate change governance in Sarawak is characterised by a state-led, policy-driven approach supported by sectoral legislation. While there is no single comprehensive climate change statute governing all aspects of climate action, Sarawak has taken a proactive stance through the Environment (Reduction of Greenhouse Gases Emission) Ordinance 2023 and enacting climate-relevant provisions under the Land Code 1958 and Forests Ordinance 2015, particularly where land use and forest carbon are concerned.

Key policy instruments include the PCDS 2030, Sarawak Sustainability Blueprint 2030, and the Sarawak Energy Transition Policy (SET-P), which collectively frame Sarawak's approach to emissions reduction, renewable energy development, and low-carbon economic transformation.

Land use and spatial planning

In Peninsular Malaysia, the framework for land use and spatial planning is largely provided for under the framework of the National Land Code 1965 and the Town and Country Planning Act 1976. The latter provides a zoning system at the national, state and local levels, leading to the development of the national physical plan, the state structure plans, and finally local and special area plans. The zoning of these plans are binding and strictly regulate the kind of projects and activities that are permitted in each area.

Policies influencing land use in Peninsular Malaysia include the 2nd National Urbanisation Policy and the National Rural Physical Policy 2030. There are also regional spatial planning projects like the Cameron-Kinta-Lojing (CEKAL) region.

For Sabah, the main legislation that regulates land use and spatial planning is the Town and Country Planning Ordinance. This Ordinance regulates the preparation and enforcement of planning schemes such as the State Structure Plan, District Plans, and Local Plans. These plans determine the kind of development allowed according to its zoning. The Sabah Structure Plan is the highest-level statutory spatial planning instrument in the State, providing the strategic framework that guides land use, development, and infrastructure planning for Sabah.

Land use and spatial planning in Sarawak are governed by the Sarawak Land Code 1958, which provides the foundational legal framework for land administration, alienation, and use. Strategic land use direction is articulated through the Sarawak Land Use Master Plan, which guides development patterns, infrastructure planning, and conservation priorities.

These instruments are supported by broader policy frameworks such as the PCDS 2030, ensuring integration between spatial planning, economic development, and environmental sustainability. Coastal and marine spatial considerations are informed by national-level initiatives such as the Rancangan Fizikal Zon Pesisiran Pantai Negara (RFZPPN) and state-centric Integrated Coastal Zone Management Plans and Integrated Shoreline Management Plans, where applicable.

CONCLUSION

As demonstrated throughout this paper, the environmental policy and legislative framework in Malaysia is extensive and multifaceted, comprising both federal and state laws that operate across different sectors and jurisdictions. It is hoped that this article is able to provide a functional overview on the policy and legislative landscape governing the environment and that readers will be better able to navigate through this realm more effectively with its help.

REFERENCES

Berita RTM. 2024, October 21. Operasi Bersepadu Khazanah, 240 kertas siasatan dibuka. *Berita RTM*. https://berita.rtm.gov.my/nasional/senarai-berita-nasional/senarai-artikel/operasi-bersepadu-khazanah-240-kertas-siasatan-dibuka/

MyBIS. 2025. Perlis State Park. https://www.mybis.gov.my/pa/212

Raman, M. 2025, March 21. State Governments Must Immediately Adopt the National Forestry (Amendment) Act 2022. *Friends of the Earth Malaysia*. https://foe-malaysia.org/articles/state-governments-must-immediately-adopt-the-national-forestry-amendment-act-2022


PERSATUAN PENCINTA ALAM MALAYSIA
MALAYSIAN NATURE SOCIETY

State of Nature Conservation in Malaysia 2025, 971–980
doi: 10.62613/sonc2025.v3anc22

CHAPTER 22

Returning borrowed time: Rethinking progress in the context of Malaysia's gross domestic product (GDP)

ZARA PHANG[1], SHANTINI GUNA RAJAN[2]* and NUR ELISHA REHAN[2]

Abstract: While gross domestic product (GDP) remains an important measure of economic activity, it does not account for the depletion of natural capital or deterioration of ecosystem services that underpin long-term prosperity. Drawing on concepts such as ecological overshoot and planetary boundaries, this paper examines how Malaysia's current development model risks borrowing from the future by prioritising short-term economic growth over ecological sustainability. Therefore, this paper seeks to present the environmental context for the need to transition towards a measure of progress beyond Malaysia's GDP. This perspective nonetheless represents only one dimension of the broader conversation, as the case for measuring progress beyond GDP also includes social and economic considerations. The discussion does not seek to exclude or diminish these factors, but rather to contribute a focused lens to the broader dialogue.

INTRODUCTION

Over the past half-century, Malaysia has charted a remarkable development trajectory. From an economy once heavily reliant on commodities such as rubber and tin, the country has transformed into a diversified middle-income nation integrated into global manufacturing and services value chains. Industrialisation, infrastructure expansion, and sustained economic growth have lifted millions out of poverty and significantly improved living standards.

Measured through conventional economic indicators, the story is compelling. Malaysia's gross domestic product (GDP) has expanded dramatically since independence, reaching more than USD 420 billion in recent years. Poverty rates have fallen from nearly half the population in the 1970s to below six per cent today. Investments in education, healthcare, and infrastructure have reshaped both urban and rural landscapes, while industrial clusters and development corridors have strengthened Malaysia's role as a regional economic hub.

For decades, GDP growth became the default measure of national progress. When economic output expands, employment opportunities increase, incomes rise, and governments gain the fiscal capacity to invest in social services and public infrastructure. As a measure of market activity, GDP remains an important indicator of economic dynamism.

Yet beneath these reassuring numbers, another story is unfolding. Across the world, the natural environment is under increasing strain, biodiversity is declining at unprecedented rates, and ecosystems, on which economic activities depend, are being pushed toward ecological limits. This raises an increasingly urgent question: ***Does GDP alone capture the full meaning of progress?***

Economic expansion can occur alongside ecological decline. Forests may shrink even as output grows. Fisheries may be depleted while national accounts record rising economic activity. Biodiversity may disappear without leaving any trace in the economic

[1] Independent.
[2] WWF-Malaysia, Jln PJS 5/28 A, Pusat Dagangan Petaling Jaya Selatan, 46150 Petaling Jaya, Selangor, Malaysia.
***Corresponding author: srajan@wwf.org.my; shantinigunarajan@gmail.com**

statistics that guide policy. In such circumstances, societies may find themselves confronting a difficult reality: some of the prosperity enjoyed today may have been built on borrowed ecological time—drawing down the natural capital that future prosperity depends upon.

NATURE'S CONTRIBUTIONS : A STABILISING FORCE AND ECONOMIC INPUT

The term "natural capital" highlights the role that nature plays in the economy like financial or built capital, natural capital provides essential resources and services for economic activity. The term refers to the world's stocks of natural assets (e.g., forests, soils, rivers, oceans, and biodiversity) that generate services such as food production, water purification, climate regulation, and habitat for wildlife.

Examples of how nature acts as (typically unaccounted for) inputs to the economy include the provision of reliable and clean water to industries and agriculture, material production for industry, recreational spots for tourism, pollination of crops for agriculture, and heat reduction and flood mitigation for all. Where nature is degraded, so are the services they provide, causing damages and raising production costs, with the potential of even leading to the loss of viability for industries that depend on these services.

Malaysia's natural wealth under pressure

Malaysia is widely recognised as one of the world's megadiverse countries. Its tropical rainforests, mangroves, coral reefs and river systems support extraordinary biodiversity and provide essential ecosystem services. These ecosystems regulate water flows, store carbon, stabilise coastlines and sustain fisheries that feed millions of people. Yet these natural systems face mounting pressure.

The Malaysian population of the Sumatran rhinoceros was declared extinct in 2019 following the death of the last known individual in captivity (WWF-Malaysia 2019). Populations of the Malayan tiger have fallen to critically low levels (WWF-Malaysia, n.d.), while once abundant nesting populations of leatherback sea turtles along the east coast have nearly vanished (Mortimer 2024). The disappearance of these species not only symbolise the larger destruction and deterioration of their habitats, but will also, in turn, impact the ecosystem of these habitats, reducing their resilience.

Marine ecosystems have experienced significant strain. Historical studies indicate that demersal fish catch rates in some Malaysian waters declined by as much as 89 – 96% between 1967 and 1997. Meanwhile, employment in marine capture fisheries increased by roughly 40% between 1999 and 2022 while landings remained largely unchanged— the need for increasing fishing effort for stagnant yields illustrates clearly how the deterioration of natural capital negatively impacts the economy.

On land and in rivers, rapid development and land use change can intensify sedimentation, pollution and flood risks. The extreme flooding at the end of 2021 was estimated to have cost the nation RM 6.1 billion (The Malaysian Reserve 2022). Despite numbers like this, the cumulative impacts on biodiversity and ecosystem services of economic developments often remain poorly reflected in economic reporting.

Ecological overshoot and Malaysia's environmental reality

One way to understand the tension between economic growth and environmental limits is through the concept of Earth Overshoot Day. Earth Overshoot Day marks the date each year when humanity's demand for ecological resources exceeds what the planet can regenerate within that same year. From that point onward, humanity operates in ecological deficit—drawing down natural capital.

When natural capital is depleted faster than they can regenerate, societies effectively begin borrowing from the future. The implications are profound: forests deplete faster than they regrow, overfishing beyond replenishment rates, carbon dioxide emit faster than ecosystems can absorb it, and degradation of soils and freshwater systems all reduce nature's capacity to sustain future consumption. Over time, ecosystems lose resilience and may approach tipping points where recovery becomes difficult or impossible. Malaysia's ecological footprint illustrates this challenge.

In 2026, Malaysia's National Overshoot Day is estimated to fall on 8 May. As this date falls less than halfway through the year, this means that if everyone on Earth consumed resources at the same rate as the average Malaysian, humanity would require more than two planets to sustain that lifestyle.

Malaysia's overshoot day has been trending earlier over the years - moving forward nearly a month from 1 June in 2020 to its current date, signalling both an increase in consumption patterns and a decrease in biocapacity. In other words, Malaysia of 2020 has already borrowed from Malaysia of 2026, reducing the production of resources for us to sustainably consume, while paradoxically we consume more. The continuation of this trend in the future—higher consumption of fewer and fewer available resources—leads to an increasingly fragile foundation for wellbeing and economic stability.

Paradoxically, the same period has seen positive economic performance. Malaysia's GDP grew from approximately USD 344.7 billion in 2020 to about USD 422.6 billion in 2024—an increase of more than 20%. These gains are real and significant. Yet they should be understood alongside a growing ecological deficit that may constrain future prosperity. When a country consumes beyond what its ecosystems can sustainably regenerate, it risks undermining the natural foundations that support long-term economic output, resilience, and wellbeing.

Planetary boundaries and the limits of the Earth system

The concept of ecological overshoot reflects a broader scientific understanding of planetary limits. The planetary boundaries framework identifies the environmental thresholds that regulate the stability of the Earth system. These include climate change, biodiversity integrity, land system change, freshwater use, ocean acidification, nutrient cycles, and chemical pollution.

Crossing these thresholds increases the risk of destabilising the ecological systems upon which human societies depend. Scientific assessments suggest that several planetary boundaries—including climate change, biodiversity loss, land system change and nutrient cycles—have already been breached at the global level. Economic systems ultimately operate within the biosphere, not outside it. When planetary limits are exceeded, the environmental foundations of prosperity begin to erode.

GDP: POWERFUL BUT INCOMPLETE PICTURE OF PROGRESS

The Gross Domestic Product (GDP) was developed as a macroeconomic accounting tool to measure the value of goods and services produced within an economy. It provides an important snapshot of economic activity. GDP was never intended to measure overall societal wellbeing. As economist Simon Kuznets cautioned when developing national income accounts, national income statistics should not be interpreted as indicators of welfare. However, GDP's numerical clarity and comparability have made it an attractive proxy for development.

A system that only measures the value of goods and services produced by an economy, however, will fail to account for the loss of natural ecosystems and subsequently ecosystem services. When forests are cleared or minerals extracted, the economic transactions involved may increase GDP. Yet the loss of vital ecosystem services (e.g., flood mitigation, reliable water sources, pollination, and biodiversity habitats) is not accounted for until their impacts are seen, and therefore very rarely considered in decision-making. In this sense, GDP can record the economic activity associated with environmental damage while ignoring the depletion of natural capital that sustains long-term prosperity.

Global efforts beyond GDP

Recognition of GDP's limitations has grown steadily over recent decades. Under the global Sustainable Development Goals (SDG) framework adopted by the United Nations, countries are committed to integrating economic, social, and environmental dimensions of development. Importantly, SDG 17 Target 19 calls on governments to develop measurements of progress on sustainable development that complement GDP.

Several conceptual frameworks have emerged to guide this shift. The "wedding cake" model of the SDGs, developed by the Stockholm Resilience Centre, illustrates how the economy sits within society, and both depend upon the biosphere (Figures 1 and 2). Environmental sustainability, therefore, forms the foundation upon which social well-being and economic prosperity ultimately depend. Similarly, the concept of Doughnut Economics, developed by Kate Raworth, proposes that societies should operate within a safe and just space defined by ecological ceilings and social foundations (Figure 3).

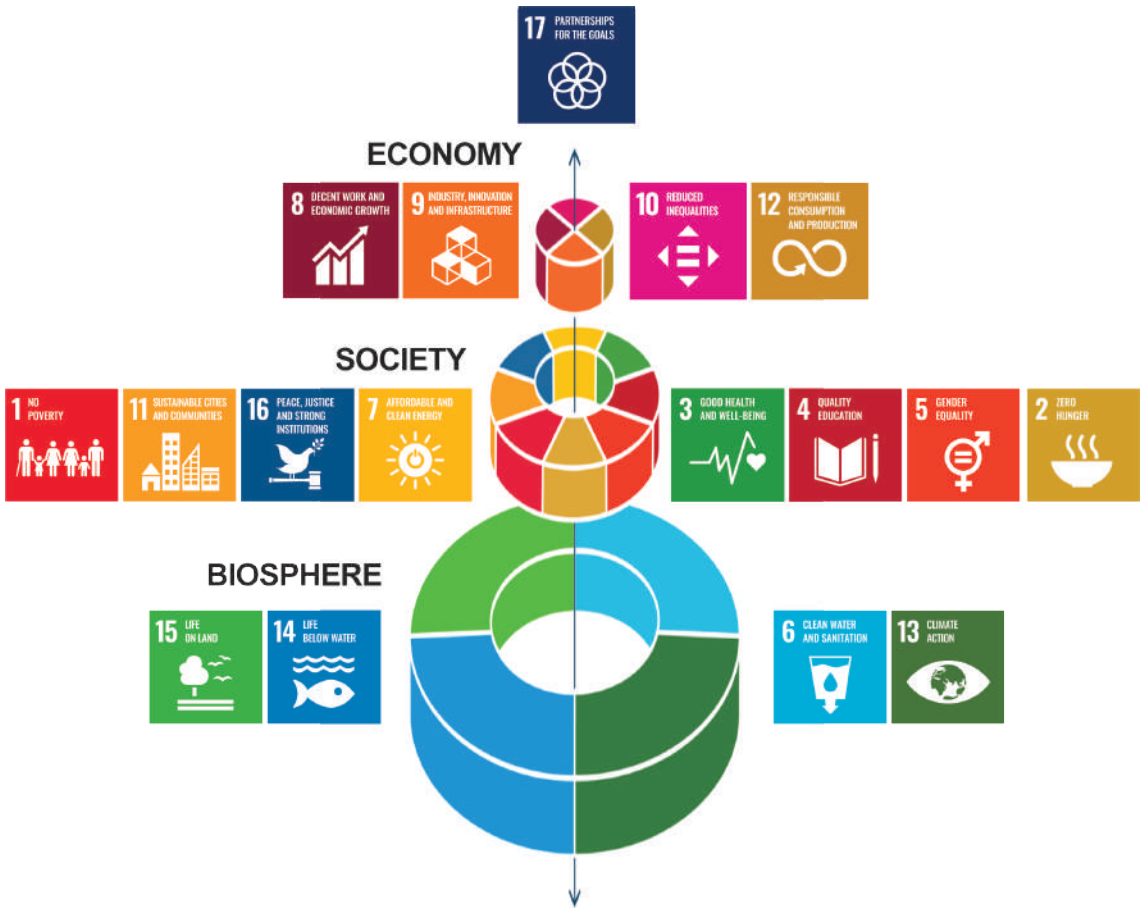


Figure 1. Azote for Stockholm Resilience Centre, Stockholm University CC BY-ND 3.0.

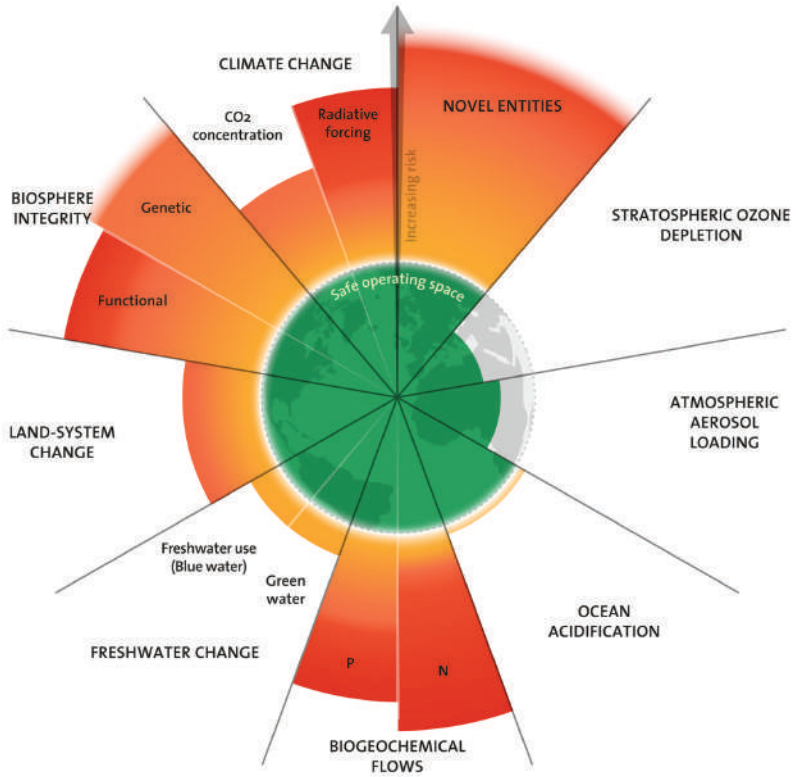


Figure 2. Azote for Stockholm Resilience Centre, based on analysis in Sakschewski *et al*. (2025).

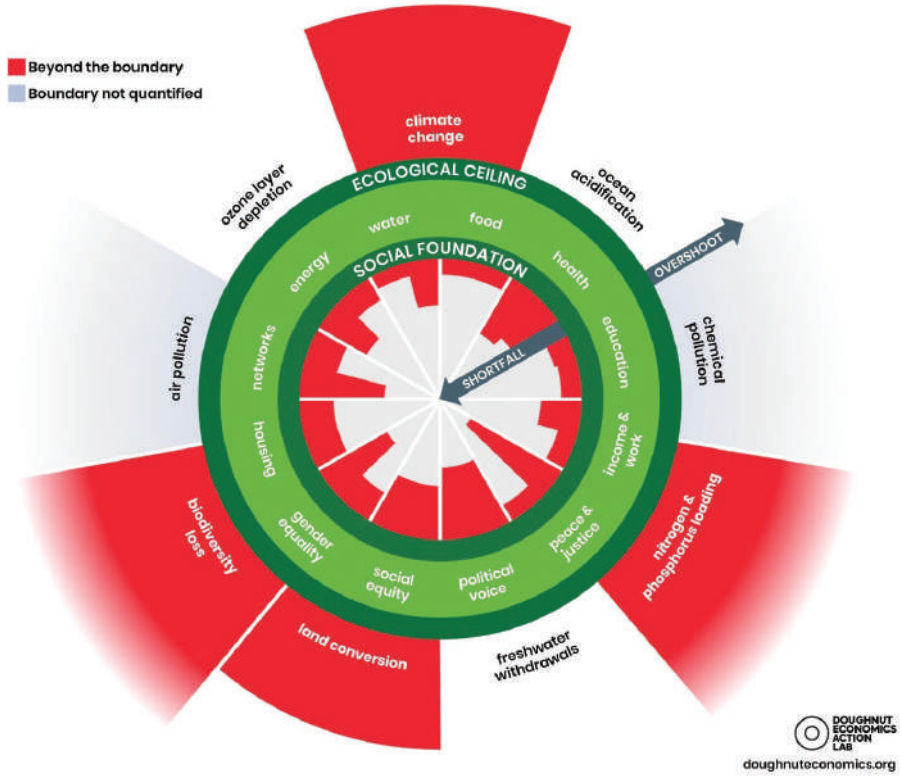


Figure 3. The Doughnut of social and planetary boundaries.
Photo credit: Kate Raworth and Christian Guthier CC-BY-SA 4.0.

Another emerging field, Planetary Health, emphasises the interdependence between human health, economic stability and the condition of the Earth's natural systems. At the international policy level, the adoption of the Kunming Montreal Global Biodiversity Framework further underscores the need to align economic systems with ecological limits, calling for the transformation of economic sectors to halt and reverse biodiversity loss. Together, these initiatives reflect a growing consensus: economic progress must be understood not only through flows of income, but through the condition of the natural systems that sustain life.

The Policy Landscape: GDP Centric Laws and Institutional Structures

Malaysia's policy architecture reflects the historical prioritisation of economic growth. Several laws, policies, and institutions illustrate how GDP-centric development objectives shape environmental governance.

National development planning

Malaysia's five-year development plans allocate national budgets and investment priorities across sectors. While environmental sustainability is increasingly recognised, economic expansion remains the primary objective. Large infrastructure projects (e.g., highways, ports, industrial zones, and energy developments) are frequently justified based on their projected contribution to economic growth and regional competitiveness.

Resource-driven economic policies

Several sectors critical to Malaysia's GDP rely heavily on natural resource extraction (e.g., oil and gas, palm oil and plantation agriculture, timber and forestry, mining and mineral extraction). Policy frameworks governing these sectors historically emphasised production targets, export revenues, and investment attraction. Although sustainability standards have improved in recent years, such as certification schemes in forestry and palm oil, the underlying economic incentives continue to prioritise output growth.

Environmental regulation as a mitigation framework

Malaysia's primary environmental legislation, the Environmental Quality Act 1974, provides the legal basis for pollution control and environmental impact assessments. However, this regulatory approach often functions as a mitigation framework rather than a development filter. Projects are assessed for environmental impacts, but approval decisions frequently involve balancing environmental costs against economic benefits. In practice, this balancing process tends to favour projects with strong economic justification, particularly those linked to national development goals.

Economic corridors and resource development

Malaysia's regional development corridors illustrate how economic growth strategies intersect with environmental considerations.

GDP in motion: When economic priorities override environmental considerations

Why metrics matter

Metrics shape attention, priorities, and accountability. When governments measure only GDP, or output, they manage for output; when they measure ecological health and wellbeing, they can manage for resilience. Better indicators lead to better decisions for both the environment and long-term prosperity, because they make trade-offs visible earlier, help prevent slow-moving damage from being ignored, and enable the public to hold institutions accountable for outcomes that matter across generations. In short, what gets measured gets managed. Several recent and ongoing developments illustrate how GDP centric considerations can dominate when environmental objectives collide with economic ambitions.

Carbon Capture, Utilization and Storage (CCUS) legislation
The 2025 Carbon Capture, Utilization, and Storage (CCUS) Act illustrates how economic growth imperatives continue to shape Malaysia's climate and environmental governance. By framing CCUS—the capture and long-term storage of CO_2 from industrial sources—as a catalyst for economic growth in meeting climate mitigation targets, the Act emphasises measurable economic outputs, reinforcing a GDP-centric approach to climate progress. In tandem with the passing of the CCUS Act, Malaysia has pursued international agreements to import carbon, signaling a prioritisation of economic gains from international trade, even as broader regulatory frameworks to enable and facilitate national climate action remain underdeveloped.

This contrast raises questions about how progress is defined in Malaysia's climate agenda. The country has committed to achieving net-zero emissions by 2050, and the National Energy Transition Roadmap identifies CCUS as one pathway. Yet, despite longstanding intentions to establish an overarching Climate Change Act as a comprehensive governance framework, it has not materialised. Instead, the CCUS Act was rapidly developed and passed while the Climate Change Bill has taken years to pass and is currently still pending, reflecting how economically framed interventions can advance more quickly than holistic climate governance.

Issues with CCUS technology itself are also present. Globally, CCUS deployment often falls short of expectations. Many facilities achieve less than the widely cited 90% capture rate, and none consistently exceed 80%. In Malaysia, CCUS could account for roughly 13% of projected energy transition spending (RM160 – 170 billion), while delivering only about 5% of total emissions reductions. The technology also carries risks, including CO_2 leakage, groundwater contamination, ecosystem disruption, and uncertainties around long-term storage.

While CCUS may have a role in hard-to-abate sectors such as cement and steel, it risks becoming a "false solution" if it prolongs fossil fuel dependence, delays renewable energy expansion, or justifies further oil and gas development alongside the environmental risks named above. This tension highlights the need to consider whether policy focus should instead prioritise more on proven and cost-effective strategies, including energy efficiency, renewable energy scaling, and ecosystem protection—approaches that can deliver more reliable environmental and climate outcomes.

Large hydropower and industrial corridors in Sarawak
Hydropower development in Sarawak has supported the industrialisation agenda under the Sarawak Corridor of Renewable Energy. While hydropower provides low carbon electricity for industry, large dam projects have raised concerns about ecosystem loss, displacement of indigenous communities, and long term ecological impacts.

Infrastructure expansion and forest fragmentation
Major infrastructure projects such as highways and rail developments have contributed significantly to economic connectivity and trade. However, such projects can also fragment forest landscapes and wildlife habitats if ecological safeguards are not fully integrated into planning processes.

Plantation expansion and land use change
Palm oil remains one of Malaysia's most important export commodities and a major contributor to GDP. While sustainability standards have improved, plantation expansion has contributed to deforestation and peatland conversion in some regions.

A structural challenge

These examples reveal a structural challenge in policymaking: economic ministries, development agencies, and investment frameworks are typically designed to maximise growth, while environmental institutions are tasked with managing impacts after decisions have already been made.

Breaking this pattern requires moving environmental considerations upstream into economic decision making itself. Only when nature is recognised as a core economic asset—rather than an external constraint—can Malaysia truly move beyond GDP and ensure that development no longer borrows from the future.

MALAYSIA'S EMERGING POLICY LANDSCAPE

Malaysia has begun expanding how progress is measured. Successive Malaysia Plans have referred to increasing the Malaysian Well Being Index, and have increasingly aligned national development priorities with the Sustainable Development Goals. The SDG Roadmap Phase 2 highlights the need to strengthen national measurement systems and explore approaches that move beyond GDP-centric indicators. Policy discourse has also begun recognising emerging economic paradigms such as the green economy, blue economy, and the planetary health agenda, which emphasise the relationship between ecological integrity and human wellbeing.

Malaysia has developed a National Planetary Health Action Plan, reflecting growing awareness that environmental degradation carries significant implications for public health, food security, and economic stability. Within the national statistical system, the Department of Statistics Malaysia has expanded environmental economic accounting aligned with the international System of Environmental Economic Accounting framework.

These alternative frameworks offer several important benefits. First, they enable the systematic collection and documentation of data that GDP excludes, including environmental quality, ecosystem condition, social outcomes, and distributional impacts. Second, they help reveal trade offs and interlinkages between economic, social, and environmental objectives, supporting more integrated analysis. Third, they provide a foundation for evidence-based policymaking that goes beyond monetary aggregates, potentially facilitating better-targeted interventions, improved policy coherence, and enhanced transparency.

Despite these advances, significant limitations remain. In most cases, these frameworks function as supplementary or parallel reporting mechanisms rather than as core decision -making tools. They are rarely embedded into binding policy mandates, budget allocation criteria, or institutional performance assessments. GDP continues to dominate planning, budgeting, and policy evaluation, reinforcing its primacy in the national development agenda. As a result, alternative indicators often coexist with, rather than challenge, GDP-based priorities, leading to situations where environmental and well-being objectives are subordinated when they conflict with growth targets.

The fragmentation challenge

One of the paradoxes of the "Beyond GDP" conversation is that while many alternative indicators now exist, they often remain fragmented. Environmental indicators, wellbeing indices, sustainability metrics and natural capital accounts are increasingly developed across ministries and international frameworks.Yet these indicators rarely carry the same influence as GDP in shaping budgets, policies and institutional incentives.

In practice, GDP remains the dominant organising principle of decision making systems. Alternative indicators frequently function as informational systems without decision authority. This illustrates a deeper challenge: redefining progress requires not only better indicators but also a redesign of the relationship between indicators within governance systems. Unless ecological and wellbeing metrics carry institutional authority in planning, budgeting and performance evaluation, they risk remaining isolated achievements rather than transformative tools.

Governance, justice, and future generations

Borrowing from the future is not only an environmental issue—it is also a question of justice. If progress is to be meaningful, it must protect these rights over time, not secure short-term gains by transferring harm to those who come after us.

Environmental degradation often disproportionately affects communities with fewer resources, limited political voice, or greater dependence on local ecosystems in the present. Polluted water, degraded fisheries, haze-related health impacts, and climate-driven disasters tend to fall most heavily on vulnerable populations, particularly those who rely heavily on healthy ecosystems for their livelihoods.

Intergenerational equity adds another dimension. Future generations inherit environmental conditions created by present decisions, yet have little influence over them. Reversing these human-made impacts takes years or decades, meaning those who did not contribute to their degradation must bear the long-term ecological and economic consequences.

Globally, there is growing recognition that development must safeguard the wellbeing of both present and future generations. A rights-based approach therefore requires policies to identify and reduce disproportionate impacts, ensure access to remedy where harm occurs, and prioritise protections for those at greatest risk. This also elevates procedural environmental rights (i.e., access to information, meaningful participation in decision-making, and access to justice) as essential safeguards to prevent foreseeable harm and to ensure that development choices are made transparently, fairly, and with accountability.

Future generations can also be taken into account through multiple policy tools. Denmark and France have used a Youth Climate Council and Youth Forum respectively to give youths a formally recognised voice for climate policy, while Wales and Hungary have Commissioners or Ombudsmen for future generations. The UN has its Declaration on Future Generations which links sustainable development and risk reduction with duties to ensure future generations can thrive. From a technical point of view, the 2006 Stern Review (The London School of Economics and Political Science 2006) went against economic convention to use a low "social discount rate" when calculating future costs and benefits to reflect the ethical view that the welfare of future generations should not be heavily discounted simply because it occurs later in time (Heiling 2021).

RETURNING BORROWED TIME

The challenge facing societies today is not simply one of measurement but of governance. We are already seeing the impacts of ecological degradation, and, if this continues unchecked, future generations will inherit diminished natural systems and fewer development options. Returning borrowed time therefore requires aligning economic decision making with environmental limits.

Potential policy directions include:

- Integrating natural capital accounting and cost-benefit analysis into fiscal and development planning, respectively;
- Strengthening ecological indicators in sectoral and institutional policies and performance assessments;
- Embedding ecological thresholds within national planning frameworks;
- Linking budget allocations to sustainability performance;
- Operationalising sustainability pillars within national development strategies; and
- Embedding intergenerational equity and environmental rights in governance, including through participatory mechanisms and long-term decision tools.

These reforms require not only technical capacity but also institutional courage. Malaysia's forests, rivers and seas are not merely resources for present use. They are part of a shared inheritance connecting past generations with those yet to come. True progress must therefore mean strengthening economic opportunity while restoring the ecological systems that sustain it. The opportunity to do so still exists, but it depends on what societies choose to measure and ultimately, what they choose to value.

The clock is still ticking.

REFERENCES

Heiling, E. 2021, June 20. The Social Discount Rate. *ClimaTalk*. https://climatalk.org/2021/06/20/the-social-discount-rate

Mortimer, J.A. 2024, March 26. The Once-Thriving Leatherback Population at Terengganu, Malaysia. *SWOT Report* Vol. 19. https://www.seaturtlestatus.org/articles/2024/2/14/the-once-thriving-leatherback-population-at-terengganu-malaysia

Sakschewski, B., Caesar, L., Andersen, L., Bechthold, M., Bergfeld, L., Beusen, A., Billing, M. *et al.* 2025. Planetary Health Check 2025. *Stockholm Resilience Centre.* https://www.stockholmresilience.org/publications/publications/2025-11-29-planetary-health-check-2025.html

The London School of Economics and Political Science. 2006, October 30. The Economics of Climate Change: The Stern Review. *The London School of Economics and Political Science*. https://www.lse.ac.uk/granthaminstitute/publication/the-economics-of-climate-change-the-stern-review

The Malaysian Reserve. 2022, March 17. December, January flood disasters cost RM6.1b losses. *The Malaysian Reserve*. https://themalaysianreserve.com/2022/03/17/december-january-flood-disasters-cost-rm6-1b-losses

WWF-Malaysia. 2019, November 25. Loss of Iman Signifies Time to Focus on Protecting Wildlife. *WWF-Malaysia.* https://www.wwf.org.my/?27425/Loss-of-Iman-Signifies-Time-to-Focus-on-Protecting-Wildlife

WWF-Malaysia. n.d. Status of Malayan Tigers. *WWF-Malaysia*. https://www.wwf.org.my/tiger_facts/status_of_malayan_tigers

State of Nature Conservation in Malaysia 2025, 981–992
doi: 10.62613/sonc2025.v3anc23

CHAPTER 23

Environmental Governance: Constitutional gaps and the need for a Federal Constitution adapted to planetary crisis in the 21st century

NG SEAN FONG

Abstract: Environmental governance is a complex framework, with a firm foundation established by international conventions, national legislations, and the agencies mandated to discharge their duties. Over the years, an increasing number of international conventions relating to the environment were adopted and implemented, in response to issues such as climate change, biodiversity loss, and pollution. Malaysia, being a Party to many of such international conventions, have undertaken the necessary actions to meet its obligations to the conventions, such as developing and implementing national strategic action plans. However, the fundamental constitutional gaps that persist could be an impediment to the successful implementation of the national strategic action plans. This Chapter elucidates the basis of this argument, linking the intertwined relationship of development needs with environmental governance and conservation, and the need for a review of the Federal Constitution, to prepare Malaysia for the planetary crisis in the 21st century.

INTRODUCTION

When the voices of nature begin to disappear, it signals that ecosystems are experiencing stress. In the years following World War II, the booming industries brought about numerous innovations. One of which was the widespread use of dichlorodiphenyltrichloroethane (DDT), a potent synthetic pesticide used to eradicate pests, especially in the United States (United States Environmental Protection Agency 2026). DDT is a persistent organic pollutant, where it can remain in the environment for prolonged periods, gradually accumulating in the fatty tissues of organisms and becoming increasingly concentrated as it moves up the food chain (van den Berg *et al.* 2025).

An adverse effect of DDT on bird population was the thinning of eggshells, causing the eggs to break prematurely as parent birds attempt to incubate them (Kolaja and Hinton 1977). The result was a silent spring—with the absence of birdsong and little to no juvenile birds in the wild. The prolific usage of DDT and its adverse impacts were captured by Rachel Carson's The Silent Spring, published in 1962 following four years of meticulous research and literature review. It took another 10 years before the domestic usage of DDT was outlawed in the United States. This represents just one example of the myriad stresses that the planet and the environment that home humanity have been experiencing over the past two centuries.

More than half a century after Carson's warning, humanity continues to confront a veritable range of environmental pressures. The continued reliance on and usage of fossil fuels, alongside unsustainable land-use practices, contribute significantly to climate change, which in turn alters weather patterns. In the tropics and temperate zones, the wet seasons are becoming wetter while dry seasons are becoming drier (Konapala *et al.* 2020); and in the polar zones, more ice melts during summer, and less ice is refrozen during winter. These changes carry profound implications for food security and livelihoods. The flowering and fruiting cycles of food crops shifted drastically as a result of changes in rainfall patterns and

Malaysian Nature Society, JKR 641, Jalan Kelantan, Bukit Persekutuan, 50480 Kuala Lumpur, Malaysia.
***Corresponding author: ngseanfong@gmail.com**

temperatures, negatively influencing the agricultural industry and food sovereignty as a whole (Hultgren *et al.* 2025). Accelerated weakening and glacial melt also increase risks of devastating glacier floods, as witnessed in Nepal in 2026. In vulnerable regions like Madagascar, recurrent droughts have further exposed the fragility of local communities' economy and resilience to extreme weather events (Ridgen *et al.* 2024). Malaysia is not spared from these environmental pressures, as we face more frequent floods and heatwaves. Along the coasts, rising sea level temperatures have devastated our fisheries stocks. These impacts are particularly concerning for local communities that depend directly on agriculture and fisheries.

SNAPSHOT OF MALAYSIA'S BIODIVERSITY IN THE PAST THREE DECADES

In 1992, Malaysia along with other heads of States and Governments around the world participated in the United Nations Conference on Rio Earth Summit. It was a momentous occasion, where the world collectively recognised and agreed that decades of human activity on Earth has adversely impacted our home planet. From this began a series of multilateral environmental agreements, such as the United Nations Framework Convention on Climate Change (UNFCCC), followed by the Convention on Biological Diversity (CBD) that were signed at the Rio Summit in 1992. At the Rio Earth Summit, the Malaysian delegation led by the then Prime Minister, Tun Dr. Mahathir, pledged to keep at least 50% of Malaysia's land as forest and tree cover in perpetuity (Ministry of Science, Technology and the Environment, Malaysia 1992).

Due to the variety of habitats contained from its mountaintops to the deep oceans, high levels of insolation and productivity, and succession of evolutionary processes that took place for millions of years, Malaysia have magnificent biological diversity that has not been fully explored and inventoried even to this very day. The table below illustrates the growth and understanding of Malaysia's biological diversity between 1997 and 2019.

Table 1. Species diversity of various taxonomical groups in Malaysia in 1997 and 2019.

Taxa	Number of species in 1997 (Ministry of Science, Technology and the Environment 1997)	Number of species in 2019 (Ministry of Energy and Natural Resource 2019)
Mammals	286	306
Avifauna	736	742
Reptiles	268	567
Amphibians	158	242
Marine Fishes	4,000	1,619
Freshwater Fishes	449	449
Invertebrates	Estimated 150,000	Estimated 150,000
Flowering Plants	Estimated 15,000	Estimated 15,000
Fungi	400 (PM), 300 (EM)	>4,000
Mosses	432 (PM), 400 (EM)	522

Note: PM = Peninsular Malaysia; EM= East Malaysia (Sabah and Sarawak)

Looking from the macro perspective, Malaysia's first *National Policy on Biological Diversity 1998* has stated that "Over the period 1970 to 1992, natural forest in the whole of Malaysia was reduced by 19.3 percent, mainly in conversion to the agricultural crops, oil palm and rubber." Comparing our first and sixth National Report of Malaysia to the CBD, submitted in the years of 1998 and 2019 respectively, the reports showed that (1) forest cover have decreased by about 600,000 hectares within this timeframe, and (2) monoculture

plantations (e.g., oil palm, rubber, and timber) have increased in area from 4.49 million hectares in 1997 to approximately 5.96 million hectares (0.109 million hectares of certified forest plantations and 5.85 million hectares of oil palm plantations)[a] in 2019.

The importance and contribution of extractive industries to Malaysia's development and growth cannot be denied. As Malaysia progresses from primarily agrarian and raw material exports to multi-sectoral manufacturing industries, there is a need for Malaysia to perceive its natural environment not just as a source of potential revenue, but recognised as a safe deposit for climate security and social wellbeing.[b]

DIVISION OF LEGISLATIVE POWERS IN ENVIRONMENTAL GOVERNANCE

Malaysia is a federation of 13 States and three Federal Territories. The supreme law is the Federal Constitution, where it *inter alia*, outlines the separation of powers (the Executive, Legislative, and Judiciary), State (the 13 States in Malaysia) sovereignty and constitutions, as well as the division of legislative powers between the Federal and State Governments. Specifically in the context of environmental governance, the Ninth Schedule outlines the subject matters, which the Federal and State Governments have the mandate to solely or jointly govern over (Table 2).

Table 2. Division of legislative powers between the Federal and State Governments.

Subject matter List	Party	Areas of jurisdiction
List I - Federal List	Federal Government	• External affairs, including implementation of treaties and conventions with other countries; • Trade, commerce and industry, including development of mineral resources, the sale, import, and export of minerals and mineral ores, and petroleum products. • Shipping, navigation and fisheries, including maritime and estuarine fishing and fisheries, excluding turtles. • Federal works and power, including water supplies, rivers and canals, except those wholly within one State or regulated by an agreement between all the States concerned. • Control of agricultural pests; protection against such pests; prevention of plant diseases. • Income Tax • Police
List II - State List	State Government	• Land including land tenure, colonization, land improvement and soil conservation, Malay reservations or in the States of Sabah and Sarawak, native reservations, mining leases and certificates, and easements. • Agriculture and forestry, including agriculture and forests. • State works and water, including rivers and canals but excluding water supplies and services, control of silt, and riparian rights. • Turtles and riverine fishing.

[a] The 6th National Report to the CBD did not disclose the hectareage of rubber plantations in Malaysia.

[b] Despite Malaysia's extensive environmental legislation and regulatory institutions, the Federal Constitution contains no environmental rights provision, and statutes like the Environmental Quality Act 1974 regulate pollution without framing environmental protection as a basic human right, i.e. right to a clean and healthy environment.

List III - Concurrent List	Federal and State Governments	• Protection of wild animals and wild birds; National Parks. • Town and country planning, except in the federal capital. • Drainage and irrigation. • Rehabilitation of mining land and land which has suffered soil erosion.
List IIIA - Supplement to Concurrent List for States of Sabah and Sarawak	Sabah and Sarawak State Governments	• Preservation of heritage. • Maritime and estuarine fishing and fisheries. • The production, distribution and supply of water power and of electricity generated by water power. • Agricultural and forestry research, control of agricultural pests, and protection against such pests; prevention of plant diseases.

According to Elagupillay (2004), the framers of the Malaysian Constitution considered traditional subject matters under State List because they have been long managed by the states, even before they were colonised. Therefore, only the State Governments have accorded jurisdiction over them. The Concurrent List includes matters such as wild animals and wild bird protection and national parks as both Federal and State Governments have been managing these matters prior to independence. Both Federal and State governments have passed legislation on some of these subject matters through their Parliament and State Assemblies to manage these resources. In 1980, the Federal Government passed the National Park Act with Penang National Park being the only protected area designated under this federal law. On the other hand several states, namely Sabah, Sarawak, Johor, Perak, Terengganu and Pahang have passed their own protected areas legislation to designate new national or state parks.

STRUCTURAL ISSUES COMPOUNDING ENVIRONMENTAL GOVERNANCE GAPS

Vertical fiscal imbalance

As seen in Table 2, the mandate to manage land, forests, and rivers is placed upon the State Governments and they are often vilified for their lack of or inadequacies in conserving natural resources within their state boundaries. However, the Ninth Schedule must be read alongside the Tenth Schedule, which outlines the grants and sources of revenue assigned to States. This includes, *inter alia*, capitation grant, state road grant, and revenue from lands, mines, and forests; whereas the States of Sabah and Sarawak receive special grants and additional sources of revenue such as from export duty on timber and other forest produce. The vertical fiscal imbalance may be depicted through the Federal Government's annual budget, as well as the State Government's annual budget for five highest GDP States in Malaysia (i.e., Selangor, Johor, Sarawak, Penang, and Sabah) for the year 2025 (Figure 1).

The State Governments' annual budgets are extremely underfunded due to their limited sources of revenue, with income tax coming under the jurisdiction of the Federal Government. Most states resorted to the extraction and exploitation of natural resources, including forest and land, found within their boundaries to fund their development needs. This was highlighted in a study by Maniam (2019) that examined Malaysia's federalism in the implementation of the Central Forest Spine (CFS). In an interview with a State's Forestry Department, an official explained that some States are extremely dependent on forestry revenue, and it even forms a part of the State Forestry Department's Key Performance Index (KPI). As a piece of forested land is leased out to logging concessionnaires, they are compelled to pay timber royalty, land premium, as well as other costs to the State Governments, which constitutes the state's forestry revenue (Law 2020).

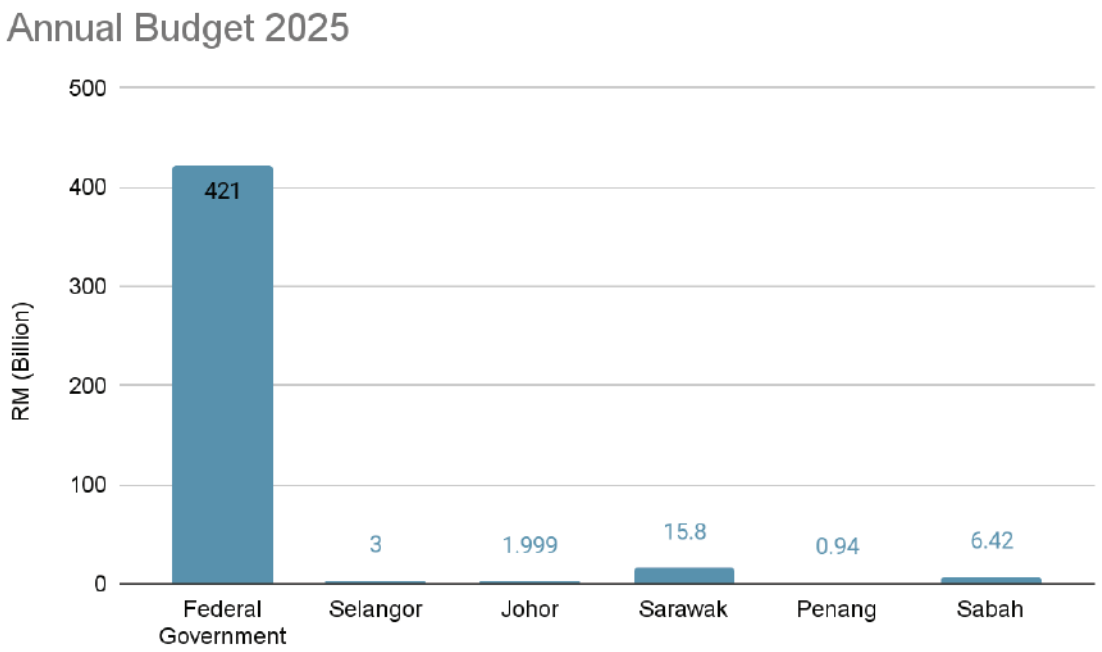


Figure 1. Comparison of annual budgets between the Federal Government and selected State Governments. (Source: Aqil 2024; Ling 2024; Miwil 2024; Nambiar 2024; The Malaysian Reserve 2024; The Sun 2024)

In the past, forestry was an integral component of a state's economic portfolio. However, the State Governments have diversified its uses for forested areas over the decades. Other than selective logging, forests may now be clearfelled before it is converted into monoculture plantation of rubber, timber species, or oil palm; alternatively the land is mined for gold, bauxite, or rare earth elements. When the land is no longer suitable for agricultural or extractive activities, it may be repurposed for residential or commercial developments.

For the cash-strapped State Governments, it is far more lucrative to carry out clearfelling before converting it into a monoculture plantation or mine, as opposed to waiting 20 – 30 years after selective logging for the forests to regenerate. However, it is a negative sum game in the long-term; clearfelling renders the environment inhabitable for the majority of forest-specialised fauna; the lack of mature mother trees within a landscape hinders natural regeneration, and in extreme cases creates opening for non-native species to colonise the open area (Padmanaba and Sheil 2014); intensive cultivation of agrocommodities such as oil palm quickly degrades soil (Guillaume *et al.* 2016), adding to maintenance costs; open/strip mining entirely removes the topsoil layer and deposits nutrient-poor overburden onto the surface, which is not suitable for planting. This is to say nothing of the mitigation of climate crises, droughts and floods, water security, and other ecosystem services that our forests provide.

Land-use and conversion

One crucial and at times overlooked link in this conversation is land-use and land-use conversion. Land-use is simply the assigned function to a particular plot of land at a particular time, and the owner of that land parcel must develop/utilise the land according to its assigned function, in order to secure the required licenses/permits to develop/utilise said land parcel. The authority to manage and plan land-use is vested in descending order to

these agencies—the Federal Department of Town and Country Planning, the State Department of Town and Country Planning, and the local governments/municipal councils, which produces the National Physical Plan, *Rancangan Struktur Negeri*, and *Rancangan Tempatan Daerah*, respectively. In rare cases, the authorities that hold the power to make developmental decisions may go against land-use planning documents listed above, or carry out subterfuge to change the land-use of, or legitimise the proposed development on a particular plot of land (Box 1).

Box 1. The fate of Taman Rimba Kiara, as decided in the Federal Court case of *Datuk Bandar Kuala Lumpur* v *Perbadanan Pengurusan Trellises & Ors* (2023)

Taman Rimba Kiara is a public green space adjacent to Bukit Kiara to its north, located in Taman Tun Dr. Ismail (TTDI). With the increasing scarcity of available land for development in the Greater Klang Valley, new developments began to gradually chip away and encroach into the remaining green spaces.

In the Kuala Lumpur Structure Plan 2004, Taman Rimba Kiara was zoned as a green open space. It was similarly zoned as a public park and a green open space when the draft Kuala Lumpur Local Plan was presented for public feedback in May 2008. However, when the finalised Kuala Lumpur Local Plan was gazetted in 2018, the land-use of Taman Rimba Kiara was changed to "mixed development".

From 2016 to 2017, residents of TTDI became aware of attempts to clear Taman Rimba Kiara, through the erection of development notice signage (for the development of condominiums) by Dewan Bandaraya Kuala Lumpur, as well as public hearings, and land survey works by the proposed developer. In response, residents of TTDI filed for a judicial review of the Development Order issued by Dewan Bandaraya Kuala Lumpur for development on Taman Rimba Kiara. While the High Court ruled that the Development Order was legally issued and denied the TTDI residents' application to quash the Development Order in 2018, the TTDI residents filed for appeal with the Court of Appeal to contest the ruling made by the High Court. After multiple rounds of hearing throughout 2020, the Court of Appeal unanimously quashed the Development Order, thereby halting the proposed development in Taman Rimba Kiara. While Dewan Bandaraya Kuala Lumpur *et al.* appealed this ruling, the Federal Court in 2023 upheld the decision by the Court of Appeal in quashing the Development Order, closing the chapter on attempts to develop Taman Rimba Kiara into condominiums, for now.

Source: *Datuk Bandar Kuala Lumpur* v *Perbadanan Pengurusan Trellises & Ors* (2023)

Land-use planning documents are valid for a range of years, ranging between 10 to 20 years, before they are revised and gazetted for a new timeframe. During the revision period, draft land-use planning documents are open for public viewing and feedback, as local residents may wish to object to proposed land-use changes in their vicinity. This is important as protected areas, i.e. forest reserves form integral components of land-use planning, and its land-use function can be changed, with endorsement from the State Government entities such as its Department of Town and Country Planning, local governments, as well as the Forestry Department. The forest reserve must be excised/degazetted by the State Forestry Department; the land-use zoning of the land must be converted from forest into agriculture, mining, infrastructure, and others. along with the permissible activities to be carried out within it by the Department of Town and Country Planning and/or local government, the Environmentally Sensitive Area (ESA) categorisation must be removed, if any, are examples of bureaucratic steps to be taken for development to take place in forest reserves.

In certain cases over the years, the norm was not followed. Instead, deliberate subterfuge was undertaken to legitimise development within forest reserves and forested areas. Cases that make for further reading include the recently concluded Bukit Cherakah Forest Reserve case (Ho 2026), Kuala Langat North Forest Reserve public campaign that spanned two years (Free Malaysia Today 2023), Bukit Ibam conversion (Law 2022a, 2022b), as well as the degazettement of Jemaluang and Tenggaroh Forest Reserves (Lee 2021). These cases highlight the legal backbending undertaken by the State Government and State-level agencies, at times with pressure from the State Royalty, pertaining to forest clearing, conversion, and development.

In the light of consistent habitat fragmentation and degradation in the terrestrial and marine realms, the Federal Government began drafting policies with the intent to resolve this (i.e., *Pelan Induk Rangkaian Ekologi Central Forest Spine*, *National Policy on Biological Diversity 2022-2030*, *Malaysia Policy on Forestry*, and the upcoming *Dasar Mineral Negara 3*). These policies rightly highlight the importance of conservation and sustainability, optimising yields and reducing adverse environmental impacts through best available technologies, and provide a pathway for the industries to pivot towards a more sustainable path.

This reflects the Federal Government of Malaysia, as Malaysia's representative in the international arena, attempting to fulfill its commitment to multilateral environmental agreements, as the following Section shall elaborate. However, without addressing the gap of revenue sources (that is workable land, the resources contained therein, and the potential tax/premium/royalty that can be derived from it) for the State Governments that is currently limited by the Federal Constitution; to garner the support, buy-in, and implementation by the State Governments will likely remain unsatisfactory.

INTERNATIONAL RESPONSES TO PLANETARY CRISIS

Environmental governance at the international and national levels employs a mix of precautionary/proactive and reactive approaches. As humankind continues to consume natural resources and produce waste and by-products, new stresses and adverse impacts upon the environment becomes apparent, new governance mechanisms are mooted, or existing mechanisms are amended to address the emergent stresses and impacts. It is a matter of back and forth, as humankind living on a planet with finite resources, attempt to balance its appetite for growth and utilisation of resources, with its capacity to mitigate and adapt to the effects of its actions, vis-à-vis the planetary crisis of climate change, biodiversity loss, and pollution.

Since the 1972 United Nations Conference on the Human Environment (also known as the 1972 Stockholm Convention), multilateral environment agreements (MEAs) have become important international tools of cooperation and accountability to conserve our planet. MEAs are legally/non-legally binding agreements painstakingly negotiated and crafted by nations over a number of years, before it is finalised and becomes open for country signatories [c] and ratification [d] or accession. Examples of MEAs that Malaysia is a Party to are the United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD), Convention on Fishing and Conservation of the Living Resources of the High Seas, among others.

[c] By becoming a signatory, a nation hereby confirms its intent to be bound by the terms of the MEA.

[d] When a nation ratifies a MEA, it amends or gazettes a new legislation for the terms of the MEA to take effect domestically. When this occurs, the nation becomes a Party to the MEA that it has ratified.

MEAs organise Conference of the Parties (COP) on an annual/biennial basis, where Parties will meet to discuss, negotiate, and chart ways forward relevant to the particular MEA. Significant outcomes from COPs include the Paris Agreement for UNFCCC and the Kunming-Montreal Global Biodiversity Framework for CBD. The key component of many, if not all MEAs is achieving consensus, as the potency of MEAs hinges on the support and buy-in of nations to implement it domestically. It may also work against it, as nations of certain interests and lobbyists may alter the substance of the negotiation, refuse to adopt stronger actions, or lead negotiations in circles until the COP concludes, with minimal results to show.

Due to the level of uncertainty and slow pace associated with MEAs, certain private sector industries have banded together and provided solutions for addressing environmental degradation, through market-based voluntary certification. Examples of voluntary certification schemes include Forest Stewardship Council (FSC) certification, Roundtable on Sustainable Palm Oil (RSPO), and EU Ecolabel. With the wide range of voluntary certification schemes presently in the market, it is inevitable for prospective certificate holders to window shop for schemes that fit their business model and willingness to pay for environmentally friendly practices. This leads to accusations and allegations of greenwashing and whitewashing, inability to address environmental and/or social issues, and drive the abandonment of certificate holders to the voluntary certification scheme. It would seem that market forces remain a dominant driver in influencing international, national, and even industry-driven conservation initiatives. Economic and developmental interests (where present in dominant numbers) will always trump environmental interests.

Over the past five years, fossil fuel-producing nations have successfully weakened resolutions of several COPs of the UNFCCC (Lakhani 2023), and stalled ongoing negotiations for the Global Plastics Treaty (Dauvergne *et al*. 2025). The ambitious European Union Deforestation Regulation (EUDR) aims to eliminate deforestation in the supply chain of commodities entering the EU market was adopted by the EU Commission in 2023, was slated to enter into force by the end of 2024, have been delayed twice, and tentatively will enter into force by 2027 (European Commission n.d.).

At the same time, the relentless pursuit of optimising the utilisation of natural resources and nature-derived products has not resulted in meaningful conservation outcomes; instead it may have caused the opposite as lowered costs of production has made goods cheaper and more accessible to the masses, thereby driving consumption and by extension, environmental degradation (Sears *et al.* 2018). This is coupled with the usage of economic and demographic statistics as measurements of growth, which do not factor in the costs of environmental degradation to humankind and to the environment itself.

While there are ongoing international dialogue regarding circularity, the degrowth movement, measurement indexes beyond Gross Domestic Product (GDP), these are long term discussions that are currently being stoked by the intensifying planetary crisis. Malaysia will undoubtedly play a role in such dialogues, but local conservation actions must, and are already being implemented nationally.

NATIONAL INITIATIVES

In the Rio Earth Summit of 1992, the principle of *Common But Differentiated Responsibilities and Respective Capabilities* (CBDR-RC) was formalised as a part of the UNFCCC. The CBDR-RC was mentioned as follows:

> "*The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.*"
>
> Article 3, Principle 1
> UNFCCC Convention Text

Without delving too deeply into the historical greenhouse gas emissions of various countries, ranging from the Industrial Revolution until today, CBDR-RC acknowledges that all countries are responsible for contributing to climate change, and needs to address it. However, CBDR-RC also recognises that not all countries are equally responsible for climate change. As such, Parties to the UNFCCC shall contribute towards addressing climate change within their means and capacity, with assistance from wealthier countries, where available. In essence, CBDR-RC espouses equity and justice in addressing global issues.

CBDR-RC is an important approach in recognising and resolving environmental issues in Malaysia. Lofty policies and goals should not be drafted by the Federal Government and imposed upon State Governments, without consideration of their needs; likewise, State Governments should not forcibly convert and/or evict Indigenous Peoples and Local Communities (IPLCs) from their ancestral territories without their Free, Prior, and Informed Consent (FPIC) in order to generate revenue for the State in the form of timber sales or carbon projects [e]. Similarly, the public and local communities should have a greater voice and a perpetual seat at the table with regards to environmental decision-making, such as the degazettement of forest reserves, public feedback to environmental impact assessments, and public consultation for land-use and town planning processes.

Over the past decade, the Malaysian government has been developing and implementing the National Policy on Biological Diversity (NPBD 2016-2025 and 2022-2030 variants). The NPBD outlines key metrics, pathways, and indicators towards conserving and sustainably managing Malaysia's biodiversity, through several principles such as Shared Responsibility, Participatory (approach), Good Governance, among others. More effort and greater political will is required for the mainstreaming of biodiversity and nature conservation into the rest of the government at various levels.

Examples of innovative, albeit interim approaches to address environmental degradation and biodiversity loss in Malaysia include the Ecological Fiscal Transfer (EFT), where the Federal Government disburses funds to the State Governments as incentive for conserving protected areas); the Biodiversity Protection and Patrolling Programme (BP3) which involves community rangers comprising of military and police veterans, as well as the Indigenous Peoples in carrying out monitoring and enforcement patrols in protected

[e] At the time of writing, Free, Prior, and Informed Consent is not recognised in Malaysia at all. In some instances, Prior and Informed Consent may be required but it is not equivalent to the internationally recognised Free, Prior, and Informed Consent outlined in the United Nations Declaration on the Rights of Indigenous People and Indigenous and Tribal Peoples Convention 1989.

areas; the establishment of the Malaysian Forest Fund as a means to channel external funding towards forest conservation; and the establishment of the voluntary carbon market under the Bursa Carbon Exchange for the trading of carbon markets.There was a push from the legal fraternity and civil space to push for the right to a clean, healthy, and sustainable environment as a fundamental right of all Malaysians.

Malaysia's commitment to CBD and various multilateral conventions, as well as its placement as a developing country made the Malaysian Government eligible for foreign assistance funding towards environmental management and conservation. Denmark was one of the first foreign countries to allocate substantial funding between 1995 and 2010. Among them include developing a Master Plan for Protected Areas for Peninsular Malaysia. Subsequently several protected areas, including the Endau Rompin National Park, Tengku Hassanal Wildlife Reserve (formerly the Krau Wildlife Reserve), and Maliau Basin Conservation Area received significant funding that led to enhanced management practices (Danish Cooperation for Environment and Development 2001).

At the same time, non-government organisations, civil society organisations, community-based organisations, and others. have been receiving funding and support from local and international grants to conserve and advocate for the sustainable management of biodiversity and the natural environment.

WAY FORWARD

The cumulative effects of unabated extraction and exploitation of the natural environment has come to a head in Malaysia, the current practise of administering short-term, piecemeal solutions by Ministries/Agencies working in isolation, where its source of power (*punca kuasa*), being the Federal Constitution of Malaysia and its subsidiary legislations, are not equipped for sustainable environmental governance in the 21st century.

There is a need for an honest review of how Malaysia should prepare itself and chart a path forward in this century of climate crisis. This process can no longer be top-down driven, outsourced to consultants, resulting in a process that neglects the voice of IPLCs, the marginalised, the third sector, universities and research institutions. The viability and longevity of Malaysia's natural environment needs to have a place of importance in the highest law of the land.

Acknowledgements: The author expresses his sincere thanks to Dr. Sivananthan Elagupillay, Evelyn Teh, and Kiu Jia Yaw for reviewing and contributing to the Chapter. The writer also expresses his thanks to his colleagues Donovan Louis, Lai Yue, and Vivian Soon for the additionalities provided to the Chapter. Lastly, an expression of gratitude to all the conservationists, grassroot actors, and comrades in Malaysia and beyond who shaped and refined the writer's understanding on environmental governance, locally and globally.

REFERENCES

Aqil, H.M. 2024. Petrol subsidy cuts for top 15% of income earners, increased minimum wage as Malaysia unveils record US$97.8 billion Budget. *Channel News Asia*. https://www.channelnewsasia.com/asia/malaysia-budget-2025-anwar-ibrahim-petrol-subsidies-minimum-wage-4687106

Danish Cooperation for Environment and Development. 2001. *Malaysian-Danish Country Programme for Cooperation in Environment and Sustainable Development (2002-2006)*. Copenhagen: Danish Cooperation for Environment and Development.

Datuk Bandar Kuala Lumpur v *Perbadanan Pengurusan Trellises & Ors and Other Appeals*. 2023. 3 MJL 829.
Dauvergne, P., Allan, J.I., Beaudoin, S., Almroth, B.C., Clapp, J., Cowan, E., de Groot, B., Farrelly, T.M. *et al.* 2025. Competing axes of power in the global plastics treaty: Understanding the politics of progress and setbacks in negotiating a high-ambition agreement. *Marine Policy* 181: 1–9. https://doi.org/10.1016/j.marpol.2025.106820
Elagupillay, S.T. 2004. Conceptualizing protected area policy for Peninsular Malaysia: a case study of land-based protected area designation. PhD dissertation. Idaho: University of Idaho.
European Commission. n.d. EU Deforestation Regulation (EUDR). *European Commission*. https://environment.ec.europa.eu/topics/forests/deforestation/eu-deforestation-regulation-eudr_en
Free Malaysia Today. 2023, June 3. Regazetting of Kuala Langat North Forest Reserve finalised. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2023/06/03/regazetting-of-kuala-langat-north-forest-reserve-finalised
Guillaume, T., Holtkamp, A.M., Damris, M., Brümmer, B. and Kuzyakov, Y. 2016. Soil degradation in oil palm and rubber plantations under land resource scarcity. *Agriculture, Ecosystems and Environment* 232: 110–118. https://doi.org/10.1016/j.agee.2016.07.002
Ho, K.Y. 2026, April 1. NGOs fail in Bukit Cherakah degazetting lawsuit. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2026/04/01/ngos-fail-in-bukit-cherakah-degazetting-lawsuit
Hultgren, A., Carleton, T., Delgado, M., Gergel, D.R., Greenstone, M., Houser, T., Hsiang, S. *et al.* 2025. Impacts of climate change on global agriculture accounting for adaptation. *Nature* 642: 644–652. https://doi.org/10.1038/s41586-025-09085-w
Kolaja, G.J. and Hinton, D.E. 1977. Effects of DDT on eggshell quality and calcium adenosine triphosphatase. *Journal of Toxicology and Environmental Health* 3 (4): 699–704. https://doi.org/10.1080/15287397709529604
Konapala, G., Mishra, A.K., Wada, Y. and Mann, M.E. 2020. Climate change will affect global water availability through compounding changes in seasonal precipitation and evaporation. *Nature Communications* 11: 3044. https://doi.org/10.1038/s41467-020-16757-w
Lakhani, N. 2023. Record number of fossil fuel lobbyists get access to Cop28 climate talks. *The Guardian*. https://www.theguardian.com/environment/2023/dec/05/record-number-of-fossil-fuel-lobbyists-get-access-to-cop28-climate-talks
Law, Y.H. 2022a, April 14. Revenue and Power Drive Forest Area Changes. *Macaranga*. https://www.macaranga.org/revenue-and-power-drive-forest-area-changes/
Law, Y.H. 2022b, November 29. Cutting the Chini-Bera Forests for Oil Palm that can't sell. *Macaranga*. https://www.macaranga.org/cutting-the-chini-bera-forests-for-oil-palm-that-cannot-sell/
Ling, S. 2024. Sarawak tables RM15.8bil 2025 budget, largest in state history. *The Star*. https://www.thestar.com.my/news/nation/2024/11/11/sarawak-tables-rm158bil-2025-budget-largest-in-state-history
Maniam, A. 2019. Federalism and Policy Implementation: A Case Study of Malaysia's Central Forest Spine Policy. PhD dissertation. Auckland: University of Auckland.
Ministry of Energy and Natural Resource. 2019. *Sixth National Report of Malaysia to the Convention on Biological Diversity*. Putrajaya, Malaysia: Ministry of Energy and Natural Resource.
Ministry of Science, Technology and the Environment Malaysia. 1992. *An Initiative for the Greening of the World*. Putrajaya, Malaysia: Ministry of Science, Technology and the Environment Malaysia.
Ministry of Science, Technology and the Environment Malaysia. 1997. *Assessment of Biological Diversity in Malaysia*. Putrajaya, Malaysia: Ministry of Science, Technology and the Environment Malaysia.
Ministry of Science, Technology and the Environment Malaysia. 1998. *National Policy on Biological Diversity 1998*. Putrajaya, Malaysia: Ministry of Science, Technology and the Environment Malaysia.
Miwil, O. 2024. Sabah tables record RM6.421 billion 2025 Budget. *New Straits Times*. https://www.nst.com.my/news/nation/2024/11/1134917/sabah-tables-record-rm6421-billion-2025-budget
Nambiar, P. 2024. Penang tables RM940mil budget for 2025 with lowest-ever deficit. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2024/11/22/penang-tables-rm940mil-budget-for-2025-with-lowest-ever-deficit

Padmanaba, M. and D. Sheil. 2014. Spread of the invasive alien species *Piper aduncum* via logging roads in Borneo. *Tropical Conservation Science* 7(1): 35-44. https://doi.org/10.1177/194008291400700108

Rigden, A., Golden, C., Chan, D. and Huybers, P. 2024. Climate change linked to drought in Southern Madagascar. *npj Climate and Atmospheric Science* 7: 41. https://doi.org/10.1038/s41612-024-00583-8

Lee, S.T.T. 2021, October 13. Fate of Malaysian forests stripped of protection points to conservation stakes. *Mongabay*. https://news.mongabay.com/2021/10/fate-of-malaysian-forests-stripped-of-protection-points-to-conservation-stakes/

Sears, L., Caparelli, J., Lee, C., Pan, D., Strandberg, G., Vuu, L. and Cynthia Lin Lawell, C.Y. 2018. Jevons' paradox and efficient irrigation technology. *Sustainability* 10(5): 1590. https://doi.org/10.3390/su10051590

The Malaysian Reserve. 2024. Johor tables state budget 2025 with surplus of RM5.12m. *The Malaysian Reserve*. https://themalaysianreserve.com/2024/11/21/johor-tables-state-budget-2025-with-surplus-of-rm5-12m/

The Sun. 2024. Selangor govt tables RM3b state budget for 2025. *The Sun Malaysia*. https://thesun.my/news/malaysia-news/selangor-govt-tables-rm3b-state-budget-for-2025-pj13292962/

United States Environmental Protection Agency. 2026, August 24. DDT - A Brief History and Status. *United States Environmental Protection Agency*. https://www.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status

van den Berg, H., Amwele, H.R., Brooke, B.D., Fortelius, L.E., Jain, T., Karunaratne, S.H.P.P., Munyinda, N.S. *et al.* 2025. DDT: last mile in the global phase-out of its use for disease vector control? *The Lancet Planetary Health* 9 (8): 101283. https://doi.org/10.1016/j.lanplh.2025.06.007

State of Nature Conservation in Malaysia 2025, 993–1004
doi: 10.62613/sonc2025.v3anc24

CHAPTER 24

Financing biodiversity conservation in Malaysia

GOPALASAMY REUBEN CLEMENTS[1]*, TAJANG JINGGUT[2], DEVJIT ROY CHOWDHURY[1], JAMES PILKINGTON[1], TANG KEAN SENG[3] and CHUN SHENG GOH[4]

Abstract: Global biodiversity conservation is constrained by persistent financing shortfalls, with an estimated USD 700 billion annually required to halt biodiversity loss by 2030. For upper-middle-income countries such as Malaysia, securing adequate conservation funding presents distinct challenges due to declining access to concessional international assistance and continued reliance on limited public expenditure. Although the Malaysian Federal government has launched several initiatives to support local conservation efforts, they remain insufficient to meet national conservation needs. Here, we: 1) examine the landscape of conservation finance in Malaysia; 2) highlight institutional and implementation barriers; and 3) propose recommendations to strengthen enabling conditions for conservation investment. Ultimately, conservation finance should function as a complement to public expenditure and mobilising private, philanthropic, and blended capital will be critical to sustaining Malaysia's biodiversity and ecosystem services in the context of economic transition.

INTRODUCTION

Prior to the current economic slowdown brought about by multiple geopolitical crisis (e.g., United States–China trade war, the Russia–Ukraine conflict, and the United States–Iran standoff), global conservation efforts were already constrained by capital shortages. To halt global biodiversity decline by 2030, experts estimated around USD 700 billion would be needed every year to close financing gaps (Duetz *et al.* 2020). At the resumed COP16 negotiations in 2025, governments adopted the first global strategy to finance biodiversity, marking a significant step toward closing this funding gap. This agreement, reached under the Convention on Biological Diversity (CBD), sets a framework for mobilising financial resources to implement the Kunming-Montreal Global Biodiversity Framework (GBF); Target 19 specifically aims to mobilise USD 200 billion worth of conservation finance annually for biodiversity by 2030. Conservation finance can be broadly defined as strategies, means, tools or activities that are used to generate capital to fund the conservation of nature and biodiversity for the general benefit of nature and society (Clark 2012), and is usually refers as non-donor based or innovative financing. Despite being one of the world's 17 megadiverse countries, Malaysia still faces significant challenges in securing adequate conservation finance. Since Malaysia became an upper-middle-income country in 1996, obtaining sufficient conservation financing from abroad has become even more challenging. Malaysia previously received financial aid from multilateral organisations, but it can no longer rely on international finance for its development. Notably, Malaysia is no longer a net recipient of official development assistance (Afandi *et al.* 2024). The public sector is the primary source for environment-related expenses, but budget allocations for conservation efforts have remained low, below 1% of the GDP (Afandi *et al.* 2024).

[1] Zoological Society of London, Regent's Park, London NW1 4RY, United Kingdom.
[2] Nature Based Solutions, Kuala Lumpur, Malaysia.
[3] Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798.
[4] Institute of Asian Studies, Universiti Brunei Darussalam, Gadong BE1410, Brunei Darussalam.
***Corresponding author: reuben.clements@zsl.org**

To allow us to better understand the conservation finance ecosystem, the Conservation Finance Alliance has collated a list of at least 30 known mechanisms (Meyers *et al.* 2020); these can be categorised into seven core operational areas (Table 1): A) return -based investments; B) economic instruments; C) grants and other transfers; D) business and markets; E) public financial management; F) risk management; G) financial efficiency. In this review, we: 1) provide examples of how some of these mechanisms under each category have been used to finance conservation in Malaysia; 2) discuss challenges facing their implementation; and 3) provide recommendations to overcome them.

Table 1. A taxonomy of conservation finance mechanisms according to the Conservation Finance Alliance.

Category	**Subcategories / Mechanisms**
A. Return-Based Investments	• Microfinance • Peer-to-peer (P2P) Investing and Crowdfunding • Angel Investing, Incubators and Venture Capital • Private Equity • Debt: Leasing, Bank Loans, Notes, Trade Finance • Capital Markets • Sustainable Investment Strategies
B. Economic Instruments	• Environmentally Related Taxes • Fees and Charges • Tradable Resource Use Permits • Fines and Penalties • Compensation and Offsets • Deposit-refund Schemes • Environmentally Motivated Subsidies
C. Grants & Other Transfers	• Official Development Assistance (ODA) • Private and Corporate Philanthropy • Remittances • Conservation Trust Funds / Environmental Funds
D. Business & Markets	• Supply Chain Resilience • Conservation Businesses • Corporate Social Responsibility and Sustainability • Voluntary Offsets
E. Public Financial Management	• Public Fiscal Planning, Budgeting and Disbursement • Fiscal Transfer • Government Grants • Reforming Harmful Subsidies • Earmarking Revenues for Nature
F. Risk Management	• Insurance Products • Pay for Success • Blended Finance
G. Financial Efficiency	• Management Effectiveness • Public-Private Partnerships (PPPs) • Integrated Accounting • Mainstreaming Biodiversity in Development

A. Return-based investments

Debt instruments such as bonds are examples of return-based investments that can help mobilise large-scale upfront capital for conservation activities such as restoration, corridor protection and watershed management (Hjort-Falsted *et al.* 2026). They take three broad forms: 1) Use-of-proceeds green or sustainability bonds ring-fence proceeds for eligible projects; 2) Sustainability-linked bonds leave proceeds unrestricted but tie the coupon (interest) to the issuer's performance against sustainability targets; and 3) Outcome bonds link investor returns to conservation outcomes based on independently verified results. Safeguards can be embedded through eligible project criteria, environmental and social risk management, Key Performance Indicators (KPIs), sustainability performance targets, and outcome verification arrangements, depending on the structure in place. This follows ICMA's Practitioner's Guide for Sustainable Bonds for Nature, which introduced the option for thematic bonds aligned with the Green Bond Principles, and whose proceeds are used exclusively for nature-related projects, to carry the secondary designation "Nature Bond" (ICMA 2025).

Malaysia is well placed to issue such instruments because it already has a strong sustainable debt market. The Securities Commission Malaysia launched its Sustainable and Responsible Investment (SRI) Sukuk Framework in 2014 (Securities Commission Malaysia 2014), and Tadau Energy issued the world's first green sukuk in 2017. The Government of Malaysia followed with the world's first sovereign US dollar sustainability sukuk in 2021, and the Securities Commission introduced an SRI-Linked Sukuk Framework for performance -linked issuance in 2022 (Securities Commission Malaysia 2022). Issuers can also align with the ASEAN Green, Social and Sustainability Bond Standards. Additional issuance costs for thematic bonds, including framework development, external review, monitoring and reporting, remain a barrier. The SRI Sukuk and Bond Grant Scheme help offset external review costs, while eligible issuance expenses may qualify for tax treatment (UNDP 2024). A nature-themed sukuk or bond for conservation would therefore build on familiar rails rather than start from scratch.

In practice, sovereign and sub-national issuances could finance shared ecological infrastructure such as forest corridors, with proceeds tied to verified conservation outcomes and with safeguards such as Free, Prior and Informed Consent (FPIC) and equitable benefit -sharing written into the bond framework. Regional precedent exists. Indonesia issued the world's first publicly offered sovereign blue bond in 2023, raising about USD 150 million in line with ICMA principles, with proceeds directed to marine biodiversity conservation, mangrove rehabilitation, coastal protection and sustainable fisheries (UNDP 2023). At the species level, the World Bank's 2022 Wildlife Conservation Bond, also known as the rhino bond, paid investors a success coupon tied to verified growth in black rhino populations in South Africa (World Bank 2022; Figure 1). Its 2024 Amazon Reforestation-Linked Outcome Bond applied a similar outcome-linked logic to carbon removal units generated through reforestation, with the project expected to restore thousands of hectares (World Bank 2024).

For Malaysia, the priority is to use its exsiting sukuk and sustainable bond architecture to move beyond do-no-harm safeguards and finance measurable gains in habitat connectivity, species recovery and ecosystem resilience. Indeed, there have been efforts to design a nature-themed bond that is similar to the rhino bond to support the conservation of the Malayan tiger.

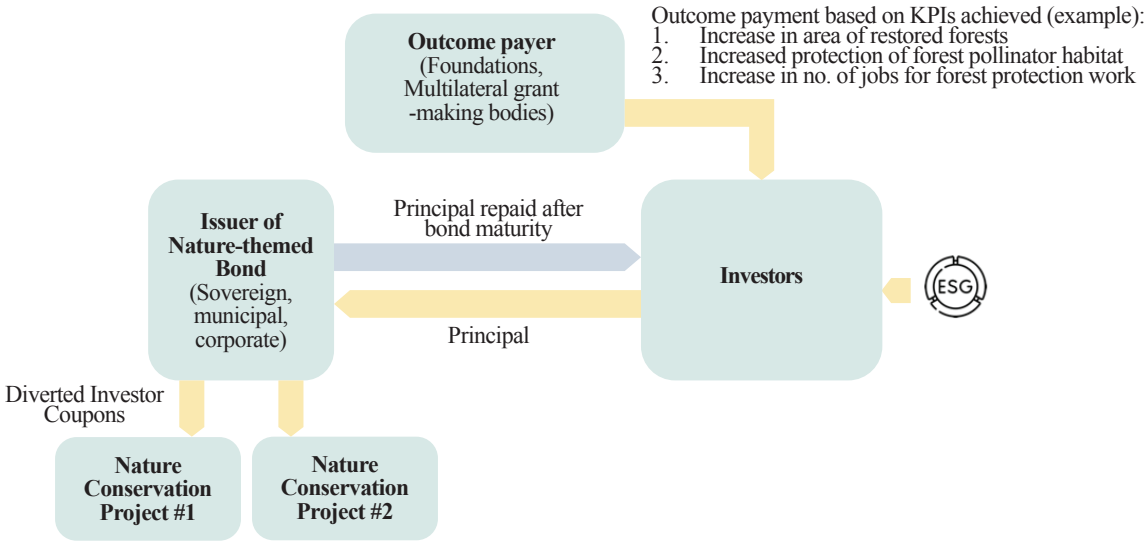


Figure 1. Structure of nature-themed bond modelled after World Bank's rhino bond.

B. Economic instruments

Under this model, NGOs and private companies could pay governments fees to lease concessions of protected areas in which they obtain management rights, and commit to funding and ensuring protection and restoration of the area while utilising it to generate income. The most established example of this is tourism concessions (Ramli *et al.* 2024), where governments grant a private resort operator a fixed-term concession to operate accommodation, food and beverages, as well as other tourism activities in a protected area. Marketing protected areas as a prime eco-tourism asset is essential for the success of tourism concessions because this would attract the best and most experienced operators that can not only maximise ecotourism potential but also deliver on conservation promises committed to the protected area. Additionally, these trusted operators would work with local communities to create opportunities such as nature guides that prioritise and enhance local livelihoods. Not only would the tourism concession generate tangible financial revenue for the protected area, the protected area management can then focus on achieving conservation goals rather than managing and running tourism programmes or assets. Although these concessions can take have alternative financial structures such as profit sharing or additional fees or licensing requirements.

In Sabah, the Sugud Islands marine conservation area offers an example of a successful tourism concession in Malaysia (Teh *et al.* 2008). The approximately 462 km^2 archipelago in the Sulu Sea, which includes the three islands of Lankayan, Billean and Tegapil, is established as a Category II conservation area under the IUCN Protected Area Management Category. Reef Guardian was officially appointed as the management company responsible for conservation activities. Reef Guardian leases the islands of Lankayan, Billean, and Tegapil from the Sabah Wildlife Department for 30 years for a fee of RM 60,000 per year. Reef Guardian then sub-leases the Sugud Islands to Lankayan Island Dive Resort (LIDR) for RM 35,000 annually. Reef Guardian generates revenue by charging a conservation fee of RM 20 per visitor per night and uses this revenue to fund management and conservation programmes. Additional funds to balance expenses are subsidised annually by private investors, which include the owners of LIDR. This demonstrates that tourism is a valuable tool to achieve a self-financing status whereas conservation fees can cover annual operating costs. Financial risks are further mitigated by maintaining a resilient financial structure that is not entirely dependent on tourism by obtain funds from other means such as conservation grant and private investors.

C. Grants and other transfers

Grants are arguably the most popular and competitive source of conservation finance for Non-Governmental Organisations (NGOs) to achieve biodiversity conservation outcomes. Common sources in Malaysia include private and corporate philanthropy (e.g. foundations, CSR/ESG donations), official development assistance (e.g. United Kingdom Partnering for Accelerated Climate Transitions [UKPACT]), and conservation trust funds such as the National Conservation Trust Fund for Natural Resources in 2014 by the Ministry of Natural Resources and Environmental Sustainability (NRES 2026).

In Terengganu, for example, the local NGO Rimba (rimba.ngo) obtained funds from Rainforest Trust to help the state government create the 30,000-hectare Kenyir State Park (Figure 2). Subsequently, foundations such as Yayasan Sime Darby (YSD) donated RM1.5 million to the Terengganu State Park Management Council to support improved management and protection of this park. After Rimba's closure in 2020, one of the conservation organisations it incubated, Nature Based Solutions (NBS), obtained support from UKPACT to assist the state in exploring the feasibility of a voluntary carbon project to finance the long-term protection of the same park under the project known as Kenyir for Life (nbsmalaysia.com). While grants are typically short-term or even one-off sponsorships, this type of funding is often used by NGOs to plug funding gaps in their respective programmes. However, grants may not provide enough long-term funds to help NGOs achieve all the conservation goals intended by the NGOs. Nevertheless, such catalytic or bridge funding is vital to "buy" some time to develop longer-term financing solutions.



Figure 2. A grant from Rainforest Trust helped the NGO Rimba support the Terengganu state government in the establishment of the 30,000-hectare Kenyir State Park.

D. Business and markets

A market-based conservation finance instrument that has been widely used globally is the carbon credits or carbon finance (Goh *et al*. 2023). Such credits are often sold to buyers who either have to offset their impacts on climate voluntarily or due to regulations (e.g., carbon taxes). Carbon credit projects (Figure 3) generate revenue streams by monetising avoided deforestation or ecosystem restoration outcomes, which can then be reinvested into conservation, community livelihoods, and cross-border governance systems. Malaysia's Voluntary Carbon Market (VCM) was launched in 2022, and carbon credits were issued from the Kuamut Rainforest Conservation Project in Sabah. This example demonstrates how large, contiguous forest areas can generate sustained financing through carbon markets while embedding safeguards such as community engagement, benefit-sharing, and transparent Monitoring, Reporting and Verification (MRV) systems.

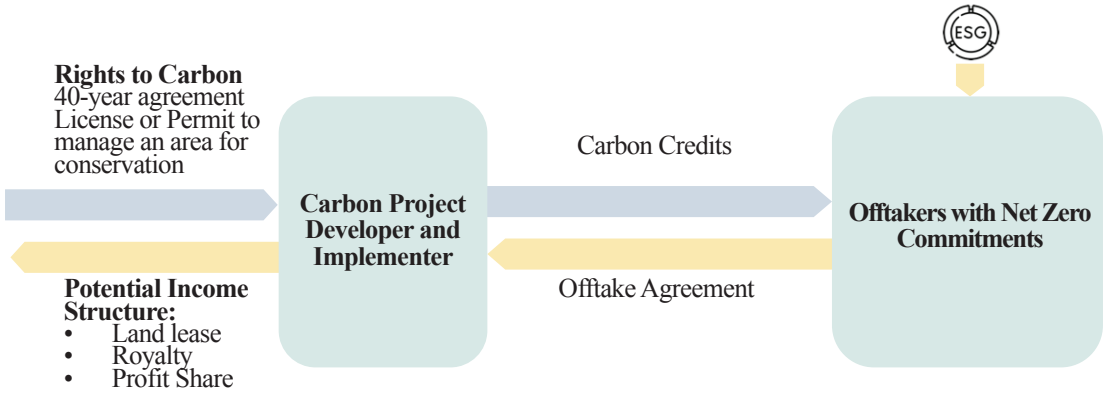


Figure 3. Structure of a voluntary carbon credit project.

Biodiversity or nature credits represent an emerging carbon finance by valuing species conservation, habitat integrity, and ecosystem services beyond carbon sequestration (Treweek 2024). Such credits are typically sold to compliance buyers who are seeking to offset their localised ecological impacts on biodiversity due to regulations, or to voluntary buyers simply interested in creating ESG impact (Figure 4). Unlike carbon accounting which uses a globally fungible emission metric (tCO_2), each unit of biodiversity credit is quantified through unique combination of metrics tailored to the ecosystem of interest or government regulations (Biodiversity Credit Alliance 2024). For instance, the metrics used to assess structural integrity or indicator species occupancy are not transferable between a coral reef and a tropical rainforest. This inherent non-fungibility and ecological complexity make the development of compliance offset markets both operationally demanding and politically contested (Carter *et al*. 2026). Despite this, offset markets are now the largest single source of nature-based solutions finance (UNEP 2026), and functional offset markets exist for wetlands in the United States, and, more recently, in England, where it delivers 10% biodiversity net gain (BNG) across c. 150 habitat sub-types.

Nevertheless, biodiversity credits remained a promising alternative to mobilise voluntary funding toward robust, evidence-based nature contributions. Manuell (2023) reported that $8 million has been pledged to develop biodiversity credit schemes in 2023, while the Bloomlabs (2025) database has documented more than $5 million in completed transactions globally; according to data, buyers are highly diverse, spanning sectors such as manufacturing, healthcare, real estate, infrastructure, luxury goods, technology, food products, among others. Promisingly, Small-Medium Enterprises (SMEs) constitutes about 80% of buyers, suggesting that lowering the ticket size of nature investments could help aggregate private funding from smaller market players, though some big companies have also been directly or indirectly involved (e.g., Microsoft, Air New Zealand).

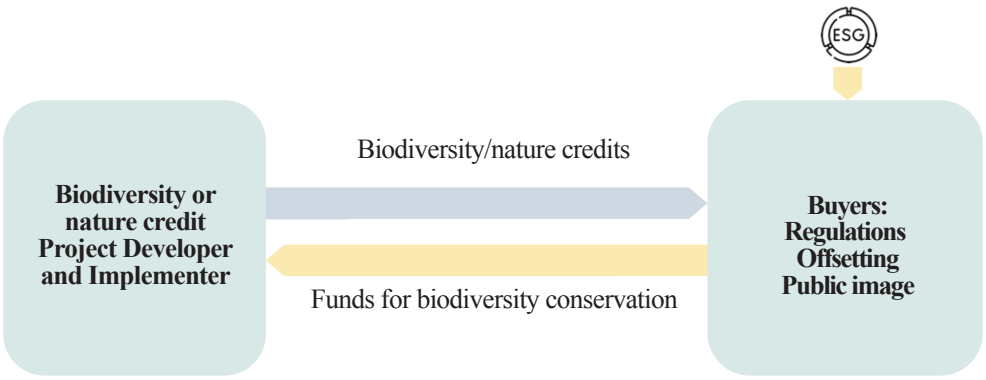


Figure 4. Structure of a biodiversity/nature credit project.

In Malaysia, biodiversity credits could incentivise conservation of high-value habitats and species corridors that are not fully captured by carbon metrics. Structurally, biodiversity credits can be linked to a "flexible basket" of site-appropriate indicators (e.g., habitat quality, endangered megafauna occupancy rates) and stacked/bundled with carbon credits or tourism revenues, while embedding safeguards such as FPIC, tenure recognition, and equitable benefit-sharing to ensure local communities access financial flows. Proving voluntary markets may lead to compliance markets being feasible over time. Although not yet widely implemented in ASEAN, early global discussions and pilot schemes highlight their potential to direct finance toward conservation outcomes where carbon revenues alone are insufficient, particularly in ecosystems with exceptional ecological value but lower carbon density.

E. Public Fiscal Management

In 2019, the federal government of Malaysia laudably implemented Ecological Fiscal Transfers (EFT) to reduce state governments' level of dependency on natural resources and exploitative activities that lead to biodiversity loss, as well as incentivise biodiversity conservation actions (i.e., Target 17 of National Policy on Biological Diversity 2022 – 2030; NRES 2022). The rationale behind the EFT programme is that state governments derive a disproportionate amount of their state revenue from premiums and royalties collected from extractive activities such as logging and mining which leads to biodiversity loss. The initial budget in 2019 was RM 70 million, and while the budget increased to RM 150 million in 2023, threats to Malaysia's biodiversity show little signs of abatement. As such, foundations, corporate or even individual sources of philanthropy are now having to play a bigger role in conservation financing. As Malaysia transitions into a developed country, innovative approaches to augment funding and financing for conservation from non-government sources are urgently needed.

F. Risk management

Payment-for-success or payment-for-performance mechanisms are a form of outcomes-based finance that is highly suited for Malaysia's landscapes because they link finance directly to verified outcomes (e.g., reduced deforestation rates, restored hectares, improved watershed services; Brokhaus *et al.* 2017). In Malaysia's forests, such mechanisms can incentivise coordinated action between countries by tying disbursements to jointly agreed indicators and shared MRV systems, thereby strengthening accountability and policy alignment. Indonesia provides strong regional examples, where results-based payments for emission reductions and ecosystem services have been used to reward subnational jurisdictions and communities for forest conservation outcomes. For example, NRES's Malaysia Forest Fund's Forest Conservation Certificates (FCC) developed under the REDD+ Finance Framework, is a non-market financing instrument that channels private sector funding into verified forest conservation, restoration, and sustainable forest management initiatives

across Malaysia (https://myforestfund.com.my). FCC projects undergo third-party verification and are registered through a transparent public registry, helping companies demonstrate measurable environmental and biodiversity contributions. Importantly, companies and individuals that contribute through FCCs are eligible for income tax deductions of up to 10% of their aggregate income under Section 44(11C) of the *Income Tax Act 1967*, subject to applicable conditions and approval limits.

Lestari Capital's Rimba Collective (https://rimbacollective.com), is another highly relevant instrument to finance landscape conservation in Malaysia. It exemplifies a private sector-driven, performance-based financing model that links corporate supply chain commitments to measurable forest Ecosystem Service Outcomes (Figure 5). By pooling funding from companies and disbursing payments based on verified results (e.g., through avoided deforestation or improved forest management), it demonstrates how long-term, results-based finance can be mobilised at landscape scale. This approach, which has been implemented in several Ecosystem Restoration sites in Indonesia, is particularly applicable to transboundary clusters, where commodity-driven deforestation pressures (e.g., palm oil, rubber) operate across borders, as it aligns incentives between producers, buyers, and conservation actors. Importantly, the model also incorporates safeguards, including community engagement and benefit-sharing, making it a relevant mechanism for ensuring that NbS financing in transboundary landscapes remains both outcome-driven and socially inclusive.

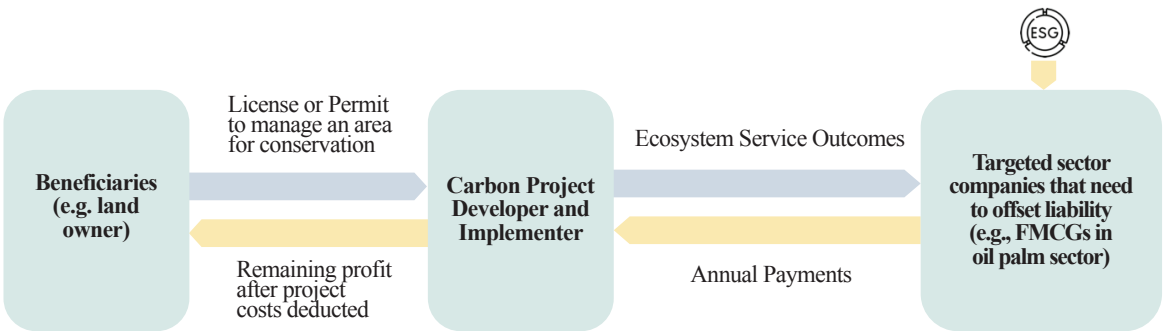


Figure 5. Diagram detailing the structure of a payment-for-performance project by the Rimba Collective.

G. Financial Efficiency

Stretching every conservation ringgit further requires integrating conservation into broader economic planning, adopting integrated environmental accounting, and forming Public-Private Partnerships (PPPs) that optimise management effectiveness. For example, the Ulu Segama –Malua (USM) Forest Management Initiative in Sabah provides a good example of improving financial efficiency by combining government-led forest management with private-sector investment, international partnerships and payments for ecosystem services. Covering approximately 241,000 hectares, the initiative brings together the Sabah Forestry Department and Yayasan Sabah to manage and rehabilitate degraded forest reserves while securing biodiversity and ecosystem services. Recognising that forest rehabilitation and silviculture activities alone cost at least RM7.15 million annually, the initiative has leveraged partnerships with international NGOs, philanthropic foundations, development partners and private companies, including Sime Darby Plantation, WWF and other conservation organisations, to share implementation costs and mobilise additional resources.

CHALLENGES

Conservation practitioners must recognise that Malaysia is not a homogeneous landscape, but a politically and historically layered terrain shaped by contested land rights, state authority, and past development interventions. This is especially important in regions rely on land-based exploitation for economic development, where conservation finance enters landscapes that have already been transformed by logging, plantation expansion, mining, infrastructure development, and state-led territorial planning (Goh and Potter 2023).

This historical background matters because conservation finance carries global assumptions about markets, contracts, and incentives. However, forests in Malaysia are not merely ecological assets; they are embedded in contested land regimes, Native Customary Rights (NCR) claims, state land ordinances, and long histories of extractive development. Forest governance is constitutionally a state matter, and debates over autonomy, revenue control, and Federal-State relations remain politically charged (Goh *et al*. 2023). Many State governments have seen successive waves of promises, from logging royalties to plantations to conservation schemes, deliver limited or uneven benefits. Conservation finance, especially carbon finance, can therefore be interpreted not as an abstract finance instrument, but as another claim on land and labour, evaluated through past disappointments as much as future possibilities.

Furthermore, conservation finance must operate within landscapes where conservation and agriculture cannot be neatly separated (Meijaard *et al.* 2023). In many tropical landscapes, biodiversity persists within mosaics of forest fragments, oil palm, smallholder agriculture, agroforestry, and village lands. Wildlife may use these mixed landscapes, while local communities depend on them for livelihoods, food security, and income. This creates a difficult policy space. Conservation finance mechanisms may therefore have no choice but to account for the wider agricultural matrix, where human-wildlife interactions, habitat connectivity, and livelihood vulnerabilities are often most visible. This makes an already complicated conservation finance landscape even more difficult to navigate.

Carbon markets, which are representative frontier of conservation finance, have recently been called out for their limitations in financing biodiversity conservation (Zeng *et al*. 2026). In Malaysia, carbon markets have presented several interrelated challenges. First, the rise of "carbon cowboys" (Goh *et al.* 2023). The absence of clearly defined carbon rights in state law, combined with evolving national positions on voluntary and Article 6 markets, has created a grey regulatory space. This has enabled intermediaries, often lightly capitalised and operating on speculative offtake models, to approach state agencies or communities with ambitious revenue projections and compressed timelines. When such deals unravel, the damage extends beyond individual projects. Failed negotiations have reinforced official scepticism, prompted tighter political controls, and framed carbon markets as another externally driven extractive frontier, just that this time under a green banner.

Second, unrealistic expectations among right holders. Expectations are frequently attributed to misinformation, but they are better understood as historically produced. Carbon revenues are often compared, implicitly or explicitly, to earlier resource rents. Per-ton prices or headline project values circulate without context, fuelling beliefs that carbon will finally compensate for decades of dispossession. In reality, most nature-based projects require years of upfront work, including baseline setting, validation, verification, before credits are issued, and net revenues are often modest once costs and buffers are deducted. Carbon literacy takes time: experience in Malaysia suggests that meaningful understanding requires years, not workshops. When expectations collide with delayed or lower-than-expected returns, trust erodes rapidly.

Third, escalating transaction costs. Carbon project development is costly everywhere, but particularly so in landscapes with Indigenous Peoples and Local Communities. Negotiations must navigate overlapping NCR claims, politically sensitive benefit-sharing expectations, and heightened scrutiny from civil society and media. Legal reviews and community engagement take time, yet early-stage grant funding for Project Design Document (PDD) development remains scarce. Private pre-financing is often the only option, but demands for large shares of future credits are politically and socially difficult to accept. The result is a stalemate: high upfront costs, limited patient capital, and negotiations that stall before implementation.

Fourth, poor direct linkages to conservation outcomes. Projects are designed to meet investor expectations of financial returns that may compromise or dilute biodiversity objectives in pursuit of maximising shareholder values. Claims around benefits, on closer assessment, may not match reality, and projects may lead to a net loss rather than a net gain from biodiversity, as in RLU Rubber's controversial sustainability bond, hailed at the time as a landmark green finance transaction (Mighty Earth 2020).

Finally, there is the broader problem of institutional patience. Many mechanisms require long project cycles, stable policy support, careful safeguards, and repeated trust -building. Yet state-level political priorities, donor cycles, corporate ESG interests, and market prices can all shift quickly. This creates a mismatch between the slow work of conservation governance and the faster expectations of finance. Without careful design, conservation finance may reproduce the same frontier logic that has shaped earlier phases of land exploitation in Malaysia: rapid entry, high expectations, uneven local participation, and disappointment when promised benefits do not materialise.

In addition to the five practical challenges mentioned above, conservation finance faces a legitimacy challenge when it is perceived as disconnected from local development needs. In Malaysia, land-use change has often been justified through promises of roads, employment, public revenue, rural services, and modernisation (Goh and Potter 2023). Conservation finance must therefore compete not only with extractive revenues, but also with the political language of development. Why should resources be allocated to conservation? Can it support credible local development pathways without repeating the uneven outcomes of earlier land-based development models? These are the fundamental questions remain to be carefully answered.

RECOMMENDATIONS

The limited success of conservation finance mechanisms in Malaysia should not be read as evidence that they are inherently unsuitable. Rather, they reveal the limits of importing market instruments without engaging deeply with state political economies, land struggles, financial incentives and institutional histories, or what are often termed "enabling conditions". Conservation finance in Malaysia is less a technical challenge than a governance test. Its future will depend not on prices or methodologies alone, but on whether it can be embedded patiently and transparently within the co-distinctive social and political realities of Malaysia's state governments, creating the enabling conditions for conservation finance mechanisms to deliver.

Based on our experience, we provide eight recommendations to help maximise the success of future conservation finance mechanisms in Malaysia:

1. Obtain political and other stakeholder alignment before project development as conservation projects without explicit state-level political backing rarely progress;
2. Identify and assess incentives for local actors for and against change; use spatial data analysis to determine where efforts are most likely to succeed; broadly assess feasibility at an early stage not just in financial or biophysical terms but also political and social feasibility;
3. Set a clear deadline for reaching contractual closure as institutional fatigue could set in if time frames are not treated as a hard boundary;
4. Simplify state-relevant benefits as decision-makers want to see clear links to State priorities (e.g., revenue stability, employment, forest management capacity, and political legitimacy);
5. Use politically comparable conservation finance projects for peer learning. For example, project located in other countries resonate less than experiences from jurisdictions facing similar sovereignty, land, and governance challenges (i.e., study visits to Sabah's Kuamut project to understand VCM projects could be useful);
6. Spend more time cultivating trust than expertise; building capacity alone is insufficient and project success usually depends on trusted local intermediaries who can bridge state governance and technical jargon;
7. Make projects publicly visible as visibility creates accountability through formal resolutions, transparent timelines, or open reporting in the politicised environments of State governments; consider third party verification of claims such as the Malaysia Forest Fund's Forest Conservation Certificates or the Tiger Conservation Coalition's Tiger Impact Certificates;
8. Design conservation finance with wider landscape dynamics in mind. Future mechanisms may benefit from complementarity and compatibility – in other words, integrating different financing mechanisms to synergistically address biodiversity conservation, agriculture, and rural livelihoods.

CONCLUSION

Scaling conservation finance in Malaysia will ultimately require increased and sustained investment from both public and private sources. The finance mechanisms that we have highlighted are promising long-term sources of conservation finance for Malaysia, especially when nature-aligned disclosures (e.g. Taskforce on Nature-related Financial Disclosures) are becoming a potential demand driver within the private sector, especially with International Financial Reporting Standards expanding the scope of disclosures to nature risks. To strengthen the accessibility and effectiveness of conservation finance, we still need to strengthen enabling conditions for private sector engagement in conservation, as well as translate Malaysia's policy commitments into operational guidance and financing frameworks that can be applied consistently across the country. Ultimately, conservation financing mechanisms are key to support the long-term sustainability of both conservation and social outcomes in Malaysia.

REFERENCES

Afandi, A., Clements, R. and Zaikariah, Z. 2024. *Shaping a nature-positive economy in Malaysia*. Policy brief. Kuala Lumpur: Institute of Strategic & International Studies (ISIS) Malaysia.

Biodiversity Credit Alliance. 2024. *Definition of a Biodiversity Credit*. Issue paper. https://www.biodiversitycreditalliance.org/wp-content/uploads/2024/05/Definition-of-a-Biodiversity-Credit-Rev-220524.pdf

Bloomlabs. 2025. Voluntary biodiversity market database. https://bloomlabs.earth/
Brockhaus, M., Korhonen-Kurki, K., Sehring, J., Di Gregorio, M., Assembe-Mvondo, S., Babon, A. *et al*. 2017. REDD+, transformational change and the promise of performance-based payments: a qualitative comparative analysis. *Climate Policy* 17(6): 708–730.
Carter, H., Thompson, B.S., Bull, J.W., Dickman, A., Jones, J.P., Shrikanth, S. and zu Ermgassen, S.O. 2026. Demystifying biodiversity finance. *Nature Reviews Biodiversity*: 1–14. https://doi.org/10.1038/s44358-026-00155-z
Clark, S. 2012. *A Field Guide to Conservation Finance*. New Jersey: Island Press.
Deutz, A., Heal, G.M., Niu, R., Swanson, E., Townshend, T., Zhu, L. *et al*. 2020. *Financing nature: Closing the global biodiversity financing gap*. Chicago: The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability. 256 pp.
Goh, C.S., Clements, G.R. and Putz, F.E. 2023. Missing the forest for the carbon: Five familiar lessons being learned again in Malaysia. *Malayan Nature Journal* 75(2): 353–362.
Hjort-Falsted, T., Aarøe, A. and Böhme, J. 2026. *Cross-market Integration of Biodiversity Outcomes into More Mature Financial Instruments*. White Paper. Upstream Partners P/S. https://planetaryresponsibility.org/wp-content/uploads/Whitepaper.pdf
ICMA (International Capital Market Association). 2025. *Sustainable bonds for nature: A practitioner's guide*. Zurich: ICMA.
Manuell, R. 2023, May 24. Developed biodiversity market schemes have seen $8 mln pledged for credits - report. *Carbon Pulse*. https://carbon-pulse.com/204564/
Meijaard, E., Unus, N., Ariffin, T., Dennis, R., Ancrenaz, M., Wich, S., Wunder, S. *et al.* 2023. Apes and agriculture. *Frontiers in Conservation Science* 4: 1225911. https://doi.org/10.3389/fcosc.2023.1225911
Meyers, D., Bohorquez, J., Cumming, T., Emerton, L., Heuvel, O.v.d., Riva, M., and Victurine, R. 2020. *Conservation finance: A framework*. Washington, DC.: Conservation Finance Alliance.
Mighty Earth. 2020. Complicit: An Investigation into Deforestation at Michelin's Royal Lestari Utama Project in Sumatra, Indonesia https://www.mightyearth.org/wp-content/uploads/Mighty_Earth_MichelinReport8Oct2020FINAL.pdf
NRES. 2022. *National Policy on Biological Diversity 2022-2030*. Kuala Lumpur: Ministry of Natural Resources and Environmental Sustainability, Malaysia. 116 pp.
NRES. 2026. *National Conservation Trust Fund for Natural Resources*. Ministry of Natural Resources and Environmental Sustainability, Malaysia. https://www.nres.gov.my/en-my/Core/Biodiversity/Pages/nctf.aspx.
Ramli, M. F., Marzuki, A. and Badarulzaman, N. 2024. The impact of destination social responsibility on sustainable development in coastal marine tourism destinations. In *Sustainable Tourism, Part A: Balancing Conservation and Progress in a Dynamic Industry*, D. Sharma, H. Abdullah and P. Singh (Eds.). Leeds: Emerald.
Securities Commission Malaysia. 2014. *Sustainable and responsible investment (SRI) sukuk framework*. Kuala Lumpur: Securities Commission Malaysia.
Securities Commission Malaysia. 2022. *SRI-linked sukuk framework*. Kuala Lumpur: Securities Commission Malaysia.
Teh, L.C., Teh, L.S. and Chung, F.C. 2008. A private management approach to coral reef conservation in Sabah, Malaysia. *Biodiversity and Conservation* 17(13): 3061–3077.
Treweek, J. 2024. Biodiversity and nature credit markets: opportunities and challenges for landowners and land managers. In *Improving standards and certification in agri-food supply chains*, Manning, L. (Ed.), pp. 163–194. Burleigh Dodds Series in Agricultural Science, Vol. 148. Cambridge: Burleigh Dodds Science Publishing.
UNDP (United Nations Development Programme). 2023. *Indonesia launches the world's first publicly offered sovereign blue bond*. Jakarta: UNDP Indonesia.
UNDP (United Nations Development Programme). 2024. *Opportunities to advance thematic bonds and sukuk in Indonesia: A knowledge brief*. Jakarta: UNDP Indonesia.
UNEP (United Nations Environment Programme). 2026. *UNEP's State of Finance for Nature 2026: Nature in the Red: Powering the Trillion Dollar Nature Transition Economy*. https://www.unep.org/en/publications/report/state-finance-nature-2026
World Bank. 2022. *Wildlife conservation bond*. Washington, DC: World Bank.
World Bank. 2024. *Amazon reforestation-linked outcome bond*. Washington, DC: World Bank.
Zeng, Y., Lamba, A., Teo, H.C. and Koh, L.P. 2026. Limitations of carbon markets for biodiversity conservation. *Nature Reviews Biodiversity*: 1–10.

Sponsored by















State of Nature Conservation in Malaysia 2025
© 2026 Malaysian Nature Society
Published by Malaysian Nature Society
JKR 641, Jalan Kelantan, Bukit Persekutuan,
50480 Kuala Lumpur, Malaysia.