ERIA Research Project Report 2025, No. 45

Exploring Carbon Market Opportunities in Brunei Darussalam: The Case of Belait Peat Swamp Forest

ERIA

And

Ministry of Primary Resources and Tourism, Brunei Darussalam

ERIA
Economic Research Institute for ASEAN and East Asia

جابتن ڤرهوتنن
FORESTRY DEPARTMENT
MINISTRY OF PRIMARY RESOURCES AND TOURISM

Exploring Carbon Market Opportunities in Brunei Darussalam:

The Case of Belait Peat Swamp Forest

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Foreword

by the Minister of Primary Resources and Tourism, Brunei Darussalam

This Final Report highlights the successful collaboration between the Ministry of Primary Resources and Tourism (MPRT), through its Forestry Department, and the Economic Research Institute for ASEAN and East Asia (ERIA). The partnership has strengthened Brunei Darussalam's National Forest Resources Inventory and assessed the potential for a credible, high-integrity forest carbon market.

Brunei Darussalam's peat swamp forests are of exceptional ecological importance and global significance, representing one of the last remaining relatively pristine peat swamp forest ecosystems in the region. These forests harbour high biodiversity, including Bornean endemic species and the Endangered alan tree, Rubroshorea albida, which is closely associated with peat swamp habitats and dominates large portions of the forest canopy, playing a key structural and ecological role in these ecosystems.

The Belait Peat Swamp Forest is a significant national asset, offering significant value both locally and globally. Its capacity for long-term carbon storage and rich biodiversity is vital for climate change mitigation and ecosystem resilience. This report is grounded in rigorous scientific analysis, validated data, and practical policy recommendations, providing a strong basis for informed decision-making.

Through this collaboration, Brunei Darussalam has enhanced its technical capacity, particularly in data sufficiency and the implementation of effective monitoring, reporting, and verification (MRV) systems. ERIA's guidance in aligning with international carbon standards has been invaluable. The report also underscores the broader benefits of forest protection and restoration, including biodiversity conservation and alignment with Brunei's commitments under the Paris Agreement and the Brunei National Climate Change Policy (BNCCP).

We express sincere appreciation to ERIA for its dedicated contributions. This collaboration marks a key milestone in Brunei Darussalam's journey toward sustainable economic diversification, in line with Brunei Vision 2035.

The findings and recommendations in this report will serve as a key reference for policy development, institutional strengthening, and regional and international cooperation. It establishes a solid platform for advancing nature-based solutions, ensuring that Brunei Darussalam's forests continue to deliver climate benefits, conserve biodiversity, and provide long- term value for current and future generations.

Dato Seri Setia Dr. Haji Abdul Manaf bin Haji Metussin
Minister of Primary Resources and Tourism
Brunei Darussalam

Foreword

by the President, Economic Research Institute for ASEAN and East Asia (ERIA)

As the world grapples with the escalating challenges of climate change, the role of Nature-based Solutions (NbS) has moved from the periphery to the centre of global climate strategy. For Brunei Darussalam – a nation endowed with pristine, carbon-dense tropical ecosystems – this shift presents a unique opportunity to lead by example. The Belait Peat Swamp Forest is not merely a national treasure; it is a global asset for carbon sequestration and biodiversity conservation.

This joint publication, Exploring Carbon Market Opportunities in Brunei Darussalam: The Case of Belait Peat Swamp Forest, marks an important milestone in the collaborative partnership between the Economic Research Institute for ASEAN and East Asia (ERIA) and the Ministry of Primary Resources and Tourism (MPRT) of Brunei Darussalam in advancing high-integrity carbon market development in the region.

The genesis of this work lies in the visionary leadership of Dato Seri Setia Dr Haji Abdul Manaf bin Haji Metussin, Minister of Primary Resources and Tourism, whose commitment to environmental stewardship and economic diversification has been exemplary. Guided by the principles of Brunei Vision 2035, His Majesty's Government has recognised that preserving the nation's natural capital is not only compatible with, but essential to, sustainable and resilient economic growth.

This book provides a rigorous, evidence-based assessment of the technical, institutional, and financial frameworks required to transform Brunei's forests into high-integrity carbon assets. Designed as a practical guide for senior policymakers and officials of the Brunei Forestry Department, it systematically navigates the complexities of carbon market development – from establishing foundational data and methodologies for a robust National Forest Resources Inventory, to analysing market economics and carbon pricing strategies that reflect the premium value of Brunei's biodiversity co-benefits. It also sets out a phased roadmap for the regulatory and institutional infrastructure needed to position Brunei as a regional leader in forest-based carbon finance.

The pilot study in the Belait Peat Swamp Forest serves as a national policy experiment. It provides a testing ground for remote sensing applications, carbon accounting methodologies, and – most critically – the institutional capacity required to govern and manage participation in voluntary carbon markets with integrity.

As Brunei Darussalam enters this pivotal phase of its climate neutrality journey, it has the potential to influence the wider ASEAN region. By establishing a credible, high-integrity framework, Brunei can demonstrate how nature-based carbon markets can generate sustainable revenue streams while supporting national development priorities and fulfilling international commitments under the Paris Agreement.

I wish to express my sincere appreciation to the team at the Brunei Forestry Department for their unwavering commitment to this project. I hope that this report will serve as a valuable resource for Brunei's policymakers, ASEAN carbon market stakeholders, and the global research community as they work towards a low-carbon, resilient, and prosperous future.

Tetsuya Watanabe

President, Economic Research Institute for ASEAN and East Asia

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This joint Ministry of Primary Resources and Tourism of Brunei Darussalam and ERIA study Exploring Carbon Market Opportunities in Brunei Darussalam: The Case of Belait Peat Swamp Forest was conceptualised and guided by the Minister Dato Seri Setia Dr. Haji Abdul Manaf bin Haji Metussin and Tetsuya Watanabe, the President of ERIA.

The study team gratefully acknowledges the contributions of Steering Committee of Forest Department of Brunei Darussalam consisting of Noralinda Haji Ibrahim (Deputy Permanent Secretary II), Reni Haji Yahya (Acting Director of Forestry), Liyana Yahya (Senior Forestry Officer), Miza Farzana Haji Awang Abdul Ghani, Nurzahidah Bakar, Nureen Farahhanis Salam Affandi, and Muhammad Arif Haji Selamat (Forestry Officers), as well as Lunima Sdn Bhd and Borhan Mohd, the National Forest Resources Inventory Consultant, for their technical inputs and support. Hiroshi Okouchi, Special Representative of ERIA in Brunei provided valuable organisational support to the study and organising the workshops.

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The study benefited from strong institutional cooperation and expert contributions across multiple countries and disciplines, reflecting a shared commitment to advancing the knowledge on forest carbon inventory and markets. This report would not have been possible without the valuable contributions of the chapter authors. Chapter 1 (Introduction: Establishing the Forest Carbon Market in Brunei) was prepared by Venkatachalam Anbumozhi and Haekal Akbar Kartasasmita (ERIA). Chapter 2 (Peat Swamp Forest Data Verification, Data Sufficiency, and Gap Analysis) was authored by Budi Indra Setiawan (IPB University, Indonesia), Cecilia Antonieta (Social Carbon, Brazil), Rudiyanto (Universiti Malaysia Terengganu, Malaysia), and Jeyanny Vijayanathan (Forest Research Institute Malaysia, Malaysia). Chapter 3 (Carbon Sequestration and Credit Calculation) was developed by A. Faroby Falatehan (IPB University, Indonesia), Stepi Hakim (Jasa Ekologi Makmur, Indonesia), Muhammad Ridwan (IPB University, Indonesia), and Arbind Chaudary (Policy Research Foundation, Nepal).

Chapter 4 (Forest Carbon Project Eligibility Assessment) was contributed by Suresh Babu (International Food Policy Research Institute, USA), Krishan Kumar Kaushal (Principal Chief Conservator of Forests, India), Jeyanny Vijayanathan (Forest Research Institute Malaysia, Malaysia), and Rishi Rabindranath (Indonesia). Chapter 5 (Ensuring Environmental Integrity of Forest Carbon Markets in Brunei: Principles of Additionality, Permanence, Leakage, and Baselines) was authored by Heinrich W. Wyes (Ministry of

Environment, Rwanda), Shivakumar Srinivas (Independent Researcher, India), and Venkatachalam Anbumozhi (ERIA). Chapter 6 (Identifying Project Feasibility and Profitability of the Belait Peat Swamp Forest) was prepared by Fortunato Costantino (Axel Carbon Capital, Italy), Basil Sharp (University of Auckland, New Zealand), and Venkatachalam Anbumozhi (ERIA). Chapter 7 (Policy and Institutional Readiness for Forest Carbon Market in Brunei) was authored by Venkatachalam Anbumozhi (ERIA) in cooperation with Sufrizul Husseini (Centre for Strategic and Policy Studies, Brunei Darussalam).

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List of Acronyms

ABG	above-ground biomass
AFOLU	Agriculture, Forestry, and Other Land Uses (AFOLU)
ALOS-PALSAR	Advanced Land Observing Satellite – Phased Array type L-band Synthetic Aperture Radar
ASEAN	Association of Southeast Asian Nations
ART-Trees	Architecture for REDD+ Transactions-the REDD+ Environmental Excellence Standard
BGB	below-ground biomass
CCB Standard	Climate, Community and Biodiversity standards
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CO_2	Carbon dioxide
CORSIA	The Carbon Offsetting and Reduction Scheme for International Aviation
CCB	climate, community & biodiversity
DOM	dead organic matter
ERIA	Economic Research Institute for ASEAN and East Asia
ESG	environmental, social, and governance
FPIC	Free, Prior and Informed Consent
FREL	Forest Reference Emission Level
GDP	gross domestic product
GHG	greenhouse gas
HFLD	High Forest, Low Deforestation
InSAR	Interferometric Synthetic Aperture Radar
IPCC	Intergovernmental Panel on Climate Change
LiDAR	Light Detection and Ranging
MRV	monitoring, reporting, and verification
Mt	metric tonne
$MtCO_2$	million tonnes of CO_2

NbS	nature-based solution
NDC	nationally determined contribution
REDD+	reducing emissions from deforestation and forest degradation
SD VISta	The Sustainable Development Verified Impact Standard
SOC	Soil organic carbon
TSX	TerraSAR-X
UAV	Unmanned Aerial Vehicle
UNFCCC	The United Nations Framework Convention on Climate Change
VCM	voluntary carbon market
VCS	verified carbon standard
VCU	Verified Carbon Unit

Executive Summary

Brunei Darussalam is entering a pivotal phase in its pursuit of sustainable development, biodiversity conservation, and economic diversification by laying the foundations for a national forest inventory and carbon market. This initiative aims to harness the ecological value of the country's largely pristine ecosystems, particularly the Belait Peat Swamp Forest, a globally significant reservoir for carbon sequestration and biodiversity. The overarching objective is to transform these forests into high-integrity carbon assets that support Brunei Vision 2035 and contribute to the country's commitments under the Paris Agreement, including a targeted 20% reduction in greenhouse gas emissions by 2030.

Accurate and verifiable data are the cornerstone of a credible carbon market. Current assessments under the National Forest Resources Inventory rely on Tier 1 methodologies of the Intergovernmental Panel on Climate Change (IPCC). While these methods are appropriate for national reporting, participation in voluntary carbon markets will require a transition to Tier 2 or Tier 3 approaches based on locally calibrated data and higher-resolution monitoring. Establishing a reliable inventory will therefore require closing key data gaps, particularly relating to below-ground biomass, deadwood, and peat soil carbon, which constitute major carbon pools in peat swamp forest ecosystems.

The generation of carbon credits depends not on total stored carbon but on additional sequestration or avoided emissions relative to a defined baseline. The Belait Peat Swamp Forest exhibits exceptionally high carbon storage, with total ecosystem carbon stocks estimated at 2,665.83 tonnes of CO_2 equivalent per hectare, including approximately 1,545.50 tonnes per hectare stored in peat soils. To monetise these assets, projects must demonstrate eligibility under recognised international frameworks such as the Verified Carbon Standard (VCS) or the Architecture for REDD+ Transactions. Key technical requirements include establishing clear geographic and temporal boundaries, quantifying greenhouse gas fluxes such as methane emissions in rewetted peatlands, and meeting the core principles of additionality, permanence, and leakage prevention. The use of standardised methodologies combined with advanced remote sensing technologies can help reduce uncertainty and support long-term monitoring.

Maintaining strong environmental integrity will be essential to attract responsible investment and secure premium prices for Brunei's carbon credits. This requires the establishment of robust baseline scenarios to ensure that emission reductions are genuine, as well as risk-management mechanisms such as buffer pools or long-term contractual arrangements to safeguard permanence against threats including fire and illegal logging. Financial modelling indicates that the project could be economically viable. Based on a moderate carbon pricing scenario, revenues are projected to reach approximately US$168 million over the project lifetime, with an initial credit issuance target of 359,006 tCO_2e by 2030.

The proposed institutional roadmap follows a phased approach. The foundation phase (2026–2027) focuses on project validation under recognised carbon standards and the securing of offtake agreements. The implementation phase (2028–2030) aims to deliver the first issuance of carbon credits. The operational phase (2031–2055) would establish a sustainable national financing mechanism supported by carbon market revenues. Realising this potential will depend on the development of a coherent regulatory framework that integrates economic, environmental, and social governance considerations, positioning Brunei as a regional leader in high-integrity carbon finance.

Chapter 1

Introduction: Establishing the Forest Carbon Market in Brunei

Brunei Darussalam is at a critical juncture in aligning environmental stewardship with the long-term diversification of its economic base. In response to global climate commitments under the Paris Agreement, the Government is exploring the establishment of a national forest carbon market anchored in a robust forest carbon inventory. This effort reflects both international climate policy trends and Brunei's strategic objective to strengthen sustainable, non-hydrocarbon growth pathways.

This chapter outlines the policy, scientific, and institutional context for developing forest carbon projects in Brunei, with particular attention to the role of voluntary carbon markets. It explains why forest-based carbon finance is relevant to Brunei's national development priorities and sets the foundation for the technical, financial, and governance assessments presented in subsequent chapters.

Recognising the high carbon density and ecological value of Brunei's forests, the Government has initiated a pilot voluntary carbon market project, with the Belait Peat Swamp Forest identified as a priority site. The pilot is designed to support methodological learning, strengthen national capacity in forest carbon accounting, and inform the development of regulatory and institutional frameworks required for future carbon market participation.

Beyond climate mitigation, this initiative supports broader national objectives, including biodiversity conservation, climate resilience, scientific capacity development, and regional leadership in high-integrity nature-based solutions. The chapter concludes by outlining the structure of the book and the key policy questions guiding each chapter.

1.1. The Role of (Belait) Peat Swamp Forest in Climate Mitigation

Peat swamp forests are amongst the most carbon-dense ecosystems on the planet. Despite covering a relatively small land area, they store massive amounts of carbon – primarily in their soils. However, these ecosystems are also fragile and prone to emitting greenhouse gases when disturbed by drainage, fire, or deforestation. The Belait Peat Swamp Forest offers both a challenge and an opportunity: while under some pressure, it still retains significant carbon storage potential and biodiversity value. With proper restoration and protection, it can become a flagship carbon sequestration project for Brunei.

The Brunei Forestry Department, with support from ERIA (Economic Research Institute for ASEAN and East Asia), has outlined a structured programme aimed at:

- Conducting data verification, methodological review, and gap analysis of the Belait Peat Swamp Forest inventory data

- Evaluating eligibility under leading carbon standards (e.g. Verra, ART-TREES)
- Quantifying carbon sequestration and credit potential
- Assessing the feasibility and profitability of carbon projects, including REDD+ schemes and voluntary markets

This initiative is not just a scientific endeavour – it is a national policy experiment designed to test the viability of natural capital monetisation while ensuring ecological integrity and community benefits.

The development of a forest carbon market in Brunei holds strategic national as well as regional significance for several reasons:

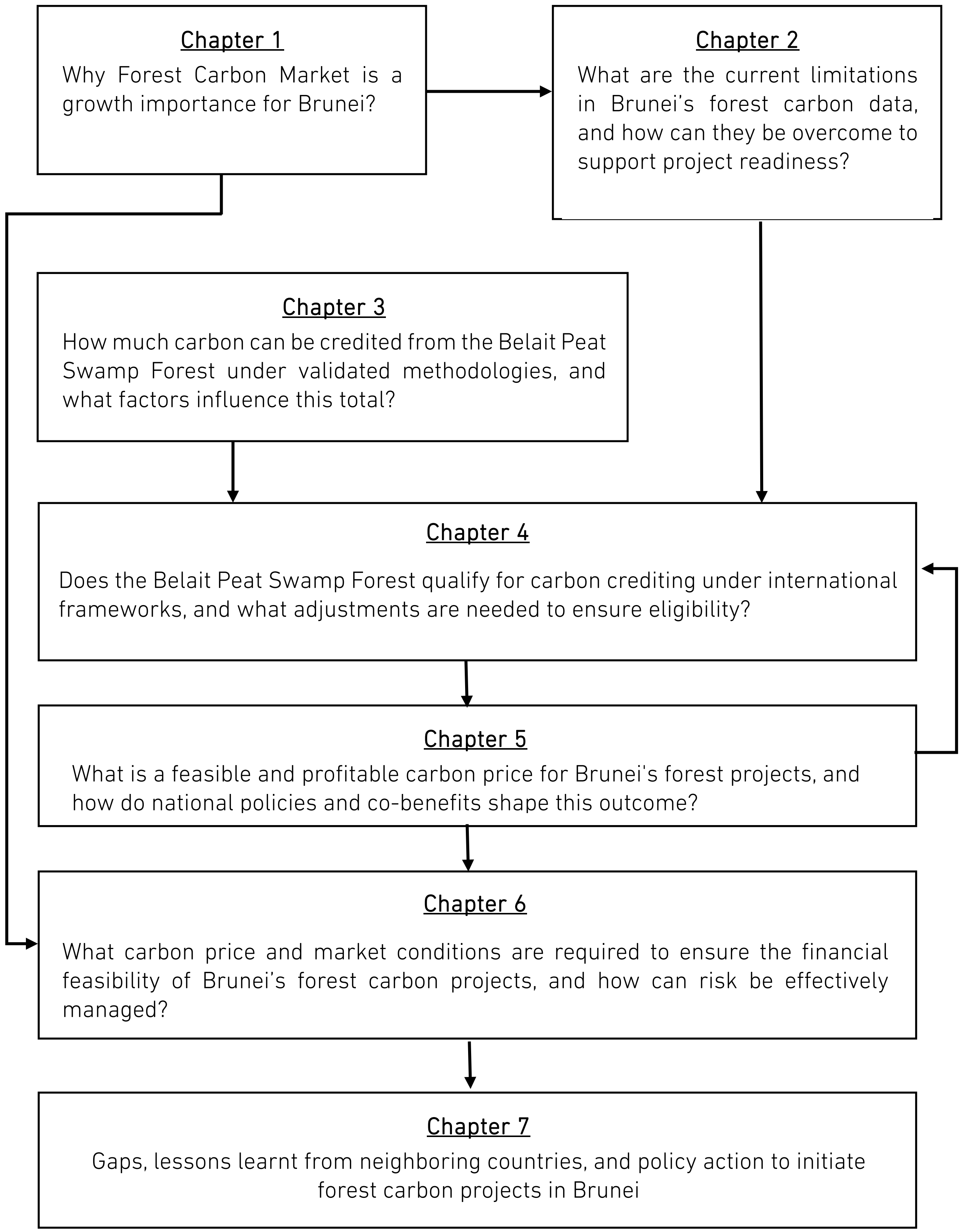
- Climate Action Leadership: It signals Brunei's active participation in global climate mitigation efforts and could contribute meaningfully to its Nationally Determined Contributions (NDCs), namely reducing GHG emissions by 20% compared to business-as-usual levels by 2030 (Climate Policy Database, n.d.).
- Economic Diversification: By enabling carbon trading and investment in ecosystem restoration, the project supports Brunei's Vision 2035, which includes goals for green growth and economic sustainability beyond hydrocarbons.
- Scientific and Technological Advancement: It promotes the development of national capabilities in remote sensing, carbon accounting, and ecological monitoring.
- Biodiversity and Co-benefits: The project offers significant opportunities for preserving unique flora and fauna and delivering social co-benefits such as employment, education, and community resilience.
- Regional Influence: As ASEAN becomes a hotspot for nature-based carbon markets, Brunei has the opportunity to position itself alongside Indonesia and Malaysia as a leader in high-integrity forest carbon finance.

1.2. Structure of the Book

This book aims to serve as a foundational reference for policymakers, researchers, carbon market developers, and environmental practitioners. The following seven chapters explore key aspects of the forest carbon market development process.

This book is organised into seven core technical chapters, each addressing a critical aspect of forest carbon market development in Brunei. The focus begins with scientific and data groundwork, moves through calculation and eligibility methodologies, and culminates in pricing strategy and financial viability analysis. Each chapter is anchored by a guiding question and delivers practical insights for policymakers, practitioners, and researchers.

Figure 1.1. Reader's Guide to Navigate the Chapters



Chapter 1: Introduction-Establishing the Forest Carbon Market in Brunei

This chapter sets the stage for the book and makes the case for investing in forest conservation in Brunei, emphasising the potential global benefits of making carbon markets work for biodiversity conservation. It provides key policy questions to guide each chapter's deeper exploration, bringing evidence to support conceptual issues, major challenges, and opportunities related to the Peat Swamp Forest.

Chapter 2: Peat Swamp Forest Data Verification, Sufficiency, and Gap Analysis

A successful forest carbon market begins with accurate and verifiable data. For Brunei, establishing a reliable carbon inventory – particularly in sensitive ecosystems such as the Belait Peat Swamp Forest, where carbon stocks are highly vulnerable to disturbance and degradation – is foundational. This chapter examines the current state of forest inventory data, including land-use classifications and carbon stock estimates, and assesses their accuracy, completeness, and consistency. Special attention is given to identifying missing datasets, such as belowground biomass, deadwood, and peat soil carbon, which are crucial in peatland contexts. The limitations of both ground-based and remote sensing techniques currently being adopted are examined. Highlighting the difficulties faced in collecting reliable data in dense, swampy terrain, successful approaches practiced in neighbouring countries with similar ecosystem characteristics are introduced. Where data gaps exist, strategies for targeted data collection and refinement are recommended, including new field measurements and technological enhancements. The chapter also introduces standardised methods for calculating carbon stocks, discusses how to reduce uncertainty in these calculations, and presents a roadmap for integrating new data into long-term monitoring frameworks.

Chapter 3: Carbon Sequestration and Credit Calculation

Generating carbon credits depends not on the total carbon stored in a forest, but on the additional sequestration or emissions avoided compared to a defined baseline. This chapter outlines the technical process of estimating how much carbon Brunei's forests – particularly the Belait Peat Swamp Forest – can realistically sequester under conservation or restoration scenarios. It introduces methodologies for defining geographic and temporal boundaries and project jurisdiction, as well as the factors shaping the crediting framework. The selection of carbon pools – ranging from aboveground tree biomass to peat soil – is discussed, along with methodologies for measuring or modelling changes in these pools. The chapter also addresses the complexities of quantifying greenhouse gas fluxes, especially methane emissions in rewetted peatlands, and compares sequestration-based approaches with avoided deforestation models. Special attention is given to setting credible baseline scenarios, drawing on examples from Indonesia, Malaysia, Nepal, and Mozambique using historical land-use data, reference sites, or predictive models. The chapter concludes by outlining the calculation of total CO_2 equivalents (tCO_2e) for the Belait Peat Swamp Forest over a defined crediting period, including deductions for risk and the use of a buffer pool, and presents a realistic estimate of carbon credit potential for Brunei's pilot site.

Chapter 4: Forest Carbon Project Eligibility Assessment

While Brunei's forests offer high carbon sequestration potential, eligibility under international carbon crediting standards requires more than ecological value – it demands demonstrable compliance with specific criteria. This chapter evaluates whether the Belait Peat Swamp Forest meets eligibility thresholds established by standards such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries), Verra's Verified Carbon Standard, and ART-TREES (Architecture for REDD+ Transactions – The REDD+ Environmental Excellence Standard). The assessment begins with a review of key international criteria, including additionality, permanence, leakage, and baseline integrity. The Belait forest is examined against these metrics, considering its ecological status, degradation history, and protection status. The chapter also explores the applicability of allometric equations and biomass models, particularly where local data may be lacking, and highlights risks posed by land-use pressures, fire, and changing climate patterns. Based on this review, the chapter outlines the structure of a Project Design Document (PDD) tailored to Brunei's pilot project, including methodology selection and monitoring plans. Legal and institutional alignment is also assessed to ensure compliance and credibility.

Chapter 5: Ensuring Environmental Integrity for Forest Carbon Markets in Brunei – Principles of Additionality, Permanence, Leakage, and Baselines

Assigning value to carbon credit requires careful balancing of project costs, market demand, and the policy environment. This chapter examines the elements influencing carbon pricing for forest-based projects in Brunei. It begins by exploring global pricing trends in both voluntary and compliance carbon markets, with comparisons to peatland projects in neighbouring Southeast Asian countries. The chapter then assesses Brunei's domestic climate policies – including NDC commitments, forest protection laws, institutional capacity, and land rights issues – to determine their influence on price feasibility. The principle of additionality is reviewed in detail, given its critical role in credit quality and pricing outcomes. The chapter also explores how biodiversity co-benefits – such as the protection of rare species and ecosystems – can be bundled with carbon credits or monetised separately through emerging biodiversity credit markets. Policy gaps and risks posed by unclear land tenure, benefit-sharing obligations, and regulatory hurdles are also addressed.

Chapter 6: Identifying Project Feasibility and Profitability of the Belait Peat Swamp Forest

Beyond ecological value, forest carbon projects must demonstrate financial sustainability. This chapter presents a comprehensive financial model simulating the economic performance of Brunei's forest carbon project under various market scenarios. Based on current conditions and development trajectories, it details all relevant project costs, including data collection, verification, certification, restoration activities, legal compliance, and monitoring systems. Revenue projections are generated using different carbon pricing assumptions, aligned with insights from Chapter 5. Financial metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period are calculated to assess viability. The model also incorporates risk adjustments, including buffer deductions and potential revenue losses from project underperformance or regulatory delays. Sensitivity analysis reveals how project viability responds to changes in price, sequestration rates, discount rates, or cost assumptions, identifying the minimum break-even price threshold and highlighting strategic interventions to enhance profitability.

Chapter 7: Policy and Institutional Readiness for Forest Carbon Markets in Brunei

Forest carbon market development in Brunei will require substantial policy redirection to increase public and private sector financial flows to the forestry sector, much of which must be mobilised through financial markets. Coherent policy and regulatory frameworks are needed to better integrate economic, environmental, social, and forest governance considerations into future investment decisions. The central question guiding this chapter is the action agenda for the Brunei Government in responding to emerging carbon market opportunities. This chapter serves as a practical guide for forest officials, academia, and carbon market operators seeking to deepen their understanding of Brunei Darussalam's vision for forest carbon markets. By optimising the values of its natural assets and aligning them with global carbon finance frameworks, the information, fact sheets, and recommendations presented can help chart a low-carbon development pathway that integrates ecological sustainability with economic growth. The Belait Peat Swamp Forest pilot project serves as a testing ground – not only for forest carbon inventory development and project design, but also for strengthening institutional capacity – laying the groundwork for scaling forest carbon market initiatives in Brunei and across the region.

Chapter 2

Peat Swamp Forest Data Verification, Data Sufficiency and Gap Analysis

2.1. Introduction

The credibility of any forest carbon market depends on the availability of accurate, verifiable, and spatially consistent data. In Brunei Darussalam, strengthening forest carbon inventory systems – particularly for peat swamp forests – is a prerequisite for credible carbon accounting, compliance with international standards, and effective participation in voluntary and compliance carbon markets.

This chapter assesses the current status of forest inventory data in Brunei, focusing on peat swamp forests due to their exceptionally high carbon storage potential and methodological complexity. It reviews existing datasets on forest types, biomass, soil carbon, and peat characteristics, and evaluates their accuracy, completeness, and consistency with international carbon accounting frameworks.

The chapter identifies critical data gaps affecting carbon stock estimation, including limited field-based measurements of peat depth, bulk density, carbon content, below-ground biomass, and dead organic matter. It also highlights constraints associated with reliance on coarse-resolution global datasets and non-local allometric models, as well as challenges in integrating fragmented datasets across institutions.

Based on this assessment, the chapter proposes methodological pathways to improve data quality and reduce uncertainty, including enhanced field sampling, higher-resolution spatial mapping, improved data verification, and alignment with higher-tier IPCC methodologies. These recommendations aim to support the development of a robust Monitoring, Reporting, and Verification (MRV) system and strengthen Brunei's readiness for forest carbon project implementation.

Peat Swamp Forests (PSFs) are vital ecosystems due to their ability to sequester carbon, support agriculture-based livelihoods, mitigate floods, and conserve biodiversity. With growing concern over climate change, PSFs are now recognised as amongst the most important ecosystems, in stark contrast to their previous perception as wastelands. An accurate inventory of tropical peatlands is essential for estimating their national extent and carbon storage capacity (Minasny et al., 2024). Such data can help predict the effects of land-use changes, wildfires, and climate change on peatlands, which can act as either carbon sinks or sources of greenhouse gases. PSFs must be assessed to determine the total carbon stocks and monitor their possible changes over time. These carbon stocks are stored in the form of:

a) Above-ground biomass (AGB): living trees, branches, leaves, and understory vegetation.

b) Below-ground biomass (BGB): roots and other subterranean plant materials.

c) Dead organic matter (DOM): deadwood, coarse woody debris, and litter layers.

d) Soil organic carbon (SOC): quantitatively the most significant carbon pool in PSFs.

The Intergovernmental Panel on Climate Change (IPCC) provides a framework for carbon stock estimation consisting of three Tiers (IPCC, 2014; IPCC, 2019) to support transparent and comparable reporting. Each Tier, as summarised in Table 2-1, reflects a different level of accuracy.

Tier 1 is the most basic method, relying on default data provided by the IPCC. It is typically used when country- and site-specific data are unavailable, for example, to estimate emissions based on global or regional averages. Tier 2 employs more specific local activity data and more accurate emission factors, either from the IPCC or national sources, providing results that are more representative than Tier 1. Tier 3 is the most precise approach, using direct measurements, simulation-based models, or facility-specific data. Countries with advanced inventory systems often apply Tier 3 to achieve the highest accuracy.

Table 2.1. Tiers of IPCC Tiers for Carbon Stocks Estimation

Tier	Data Type	Method	Accuracy	Typical Use
Tier 1	IPCC default values	Default Method (Basic Approach)	Low	Initial reporting, low-capacity countries
Tier 2	National inventory + equations	Country-Specific Method (Intermediate Approach)	Medium	National GHG inventories, REDD+
Tier 3	High-resolution RS + models	Detailed Method (Highest Approach)	High	Carbon projects, advanced MRV

Source: ERIA Study Team, 2025 adopted from IPCC (2014) and IPCC (2019).

This chapter, based on Brunei National Forest Resources Inventory (NFRI) (2025) and other secondary data, examines the land and forest types and forest diversity of Belait PSFs, as well as their biomass and carbon stocks, and the potential emissions from land use.

This chapter is also developed based on following the objectives:

1. Examine the current state of forest inventory data, including land-use classifications and carbon stock estimates, and assess their accuracy, completeness, and consistency;
2. Identify missing datasets, such as below-ground biomass, deadwood, and peat soil carbon, which are particularly important in peatland contexts;

3. Highlight the limitations of both ground-based and remote sensing techniques currently in use, as well as the challenges of collecting reliable data in dense, swampy terrain;
4. Present successful approaches implemented in neighbouring countries with similar ecosystem characteristics; and
5. Recommend methods for improving data collection and analysis, including new field measurements and technological enhancements.

This comprehensive assessment will provide a foundation for enhanced forest inventory practices, addressing critical data gaps and methodological limitations to support more accurate carbon accounting and sustainable forest management in challenging peatland environments.

2.2. Land and Forest Types in Brunei

The National Forest Resources Inventory (2024) identified three main types of forest, covering a total area of 243,713 ha, of which the Peat Swamp Forest area (PSF) is 61,659 ha. (Table 2.2).

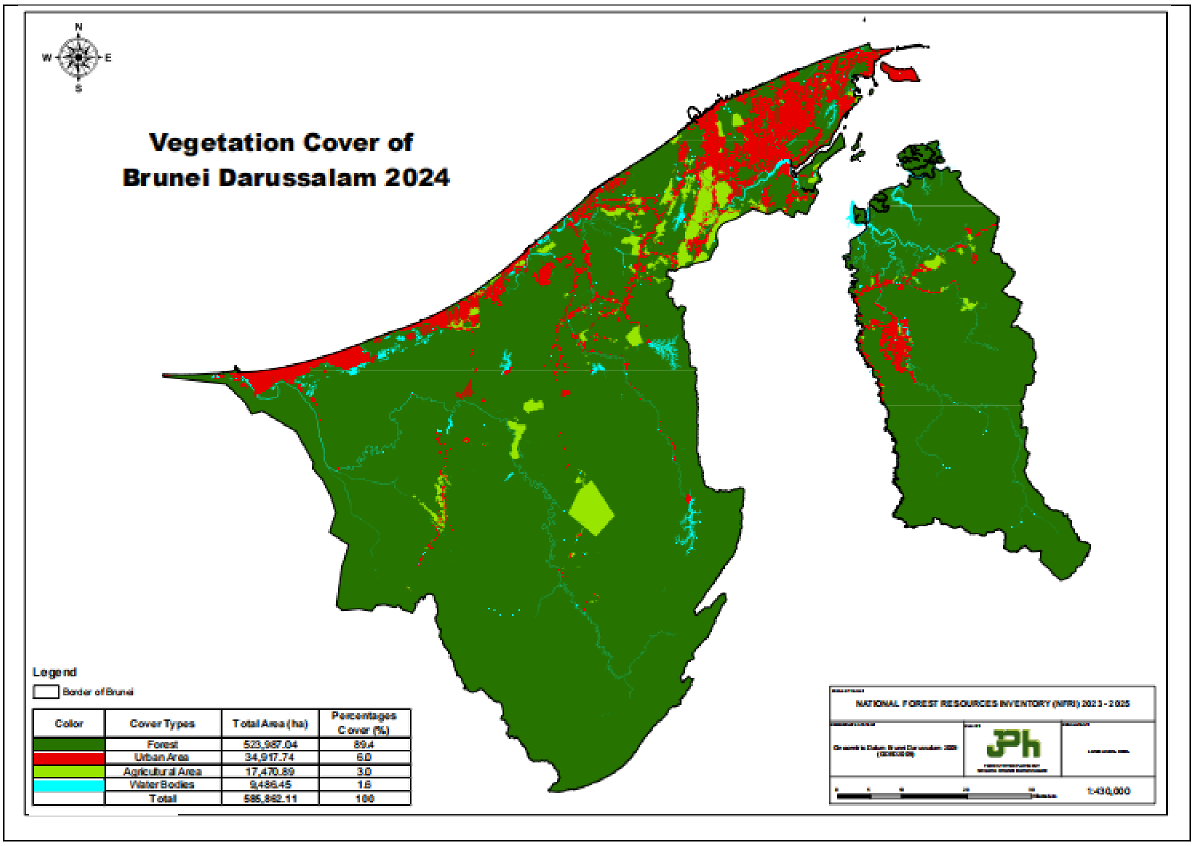
Table 2.2. Forest Types in Brunei Darussalam

No	Forest Type	Area (ha)	Percent
1	Mixed Dipterocarp Forest (MDF)	167,706	68.8%
2	Peat Swamp Forest (PSF)	61,659	25.3%
3	Mangrove Swamp Forest (MF)	14,348	5.9%
Total		243,713	100.0%

Source: NFRI, 2024.

Figure 2.1 and Table 2.3 show a detailed land cover in Brunei Darussalam based on the National Forest Resources Inventory in 2025, while Table 2.4 is based on remote sensing(RS) data (Ikbal et al., 2023) and Mangrove Region Delineation (Bunting et al., 2022). There are 12 categories, covering a total area of 585,861 ha as of 2024. The NFRI identified the PSF area as 100,026 ha, while the RS data resulted in 111,087 ha, and PEATGRIDS, a global dataset with a spatial resolution of 1 km × 1 km, indicated an effective area of 109,889 ha (Widyastuti et al., 2024). Differences in data sources and analysis methods produce different results. Therefore, a more in-depth study is needed to obtain more accurate results that are acceptable to all stakeholders.

Figure 2.1. Vegetation Cover of Brunei Darussalam



Source: NFRI, 2025.

Table 2.3. Major Forest Types Relative to Other Land Uses in Brunei by Districts in 2024

No	Forest & Land Use Types	District (ha)				Total (1), ha	Total (2), ha
		Temburong	Muara	Tutong	Belait		
1	Beach Coastal Forest (BCF)	0.00	464.83	281.95	834.82	1,581.60	Total Forested Land = 523,986.37ha (89.44%)
2	Mangrove Forest (MGF)	13,451.20	3,246.42	2,313.47	214.30	19,225.39	
3	Freshwater Swamp Forest (FSF)	0.00	0.00	1,238.50	13,650.43	14,888.93	
4	Peat Swamp Forest (PSF)	12,322.97	123.45	10,617.39	76,962.54	100,026.35	
5	Kerangas Forest (KRF)	957.66	1,082.00	2,330.74	4,912.23	9,282.63	
6	Mixed Dipterocarp Forest (MDF)	83,695.73	606.34	51,171.40	129,491.95	264,965.42	
7	Montane Forest (SMF)	6,976.87	0.00	0.00	0.00	6,976.87	
8	Plantation Forest (PF)	0.00	0.00	1,857.96	3,437.63	5,295.59	
9	Secondary Forest (SF)	5,513.17	22,119.24	40,042.83	34,068.65	101,743.89	
10	Urban Area (UR)	2,285.46	19,694.18	5,545.57	7,392.38	34,917.59	Total Non-Forested Land = 61,874.85ha (10.56%)
11	Agricultural Area (AG)	1,181.94	6,596.88	3,717.03	5,974.96	17,470.81	
12	Water Bodies (WB)	2,206.77	1,830.72	2,538.55	2,910.41	9,486.45	
Total		128,591.77	55,764.06	121,655.39	279,850.30	585,861.52	
		21.95%	9.52%	20.77%	47.77%	100.00%	

Source: NFRI, 2025.

Table 2.4. Forest and Non-Forest Areas in Brunei (in 1000 ha)

No	Land Types	Area		
		1979*	1996*	2023**
1	Mangrove Forest	18.418	18.418	12.383
2	Freshwater Swamp Forest	12.668	12.668	9.944
3	Peat Swamp Forest (PSF)	103.705	103.705	111.087
4	Heath Forest/Kerangas	7.608	6.558	8.684
5	Mixed Dipterocarp Forest	223.754	223.754	270.957
6	Montane Forest	7.196	7.196	7.373
7	Mixtures	52.671	52.671	157.192
8	Plantations	0.076	2.360	
9	Secondary/Others	42.950	20.788	
	Total	469.046	448.118	577.620

Source:
*National Forest Inventory (FAO, 2020).
**Rasterised data (Ikbal et al., 2023) and Mangrove Region Delineation (Bunting et al., 2022).

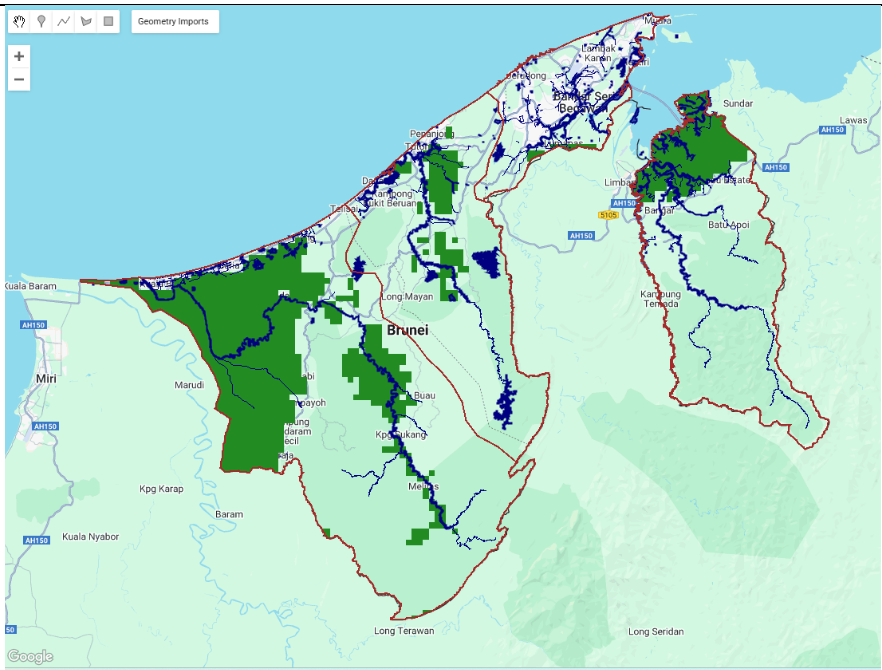
This section has established Brunei's diverse forestry types and ecosystem landscape. In the following section, it will focus on peat swamp forests (PSF), which represent the most carbon-rich ecosystem and pose unique challenges for accurate stock assessment.

2.3. Peat Swamp Forests

Different datasets provide varying estimates of the total area of Badas PSFs, reflecting differences in methodology and spatial resolution. Table 2.4 shows that the total area of Badas PSFs, based on the National Forest Resources Inventory (NFRI), is 100,026.35 thousand hectares, which is slightly lower than the estimate from the rasterised data (111.087 thousand hectares).

PEATGRIDS is a global dataset providing maps at a spatial resolution of 1 km × 1 km. According to Figure 2.2, the total area is 140.9 thousand hectares (Widyastuti et al., 2024). The larger estimate from PEATGRIDS is likely due to the inclusion of peatlands overlapping with mangrove forests, freshwater swamp forests, and heath forests (kerangas).

Figure 2.2. Spatial Distribution of Peatlands in Brunei Based on PEATGRIDS at 1 km × 1 km Spatial Resolution



Source: Widyastuti et al., 2024.

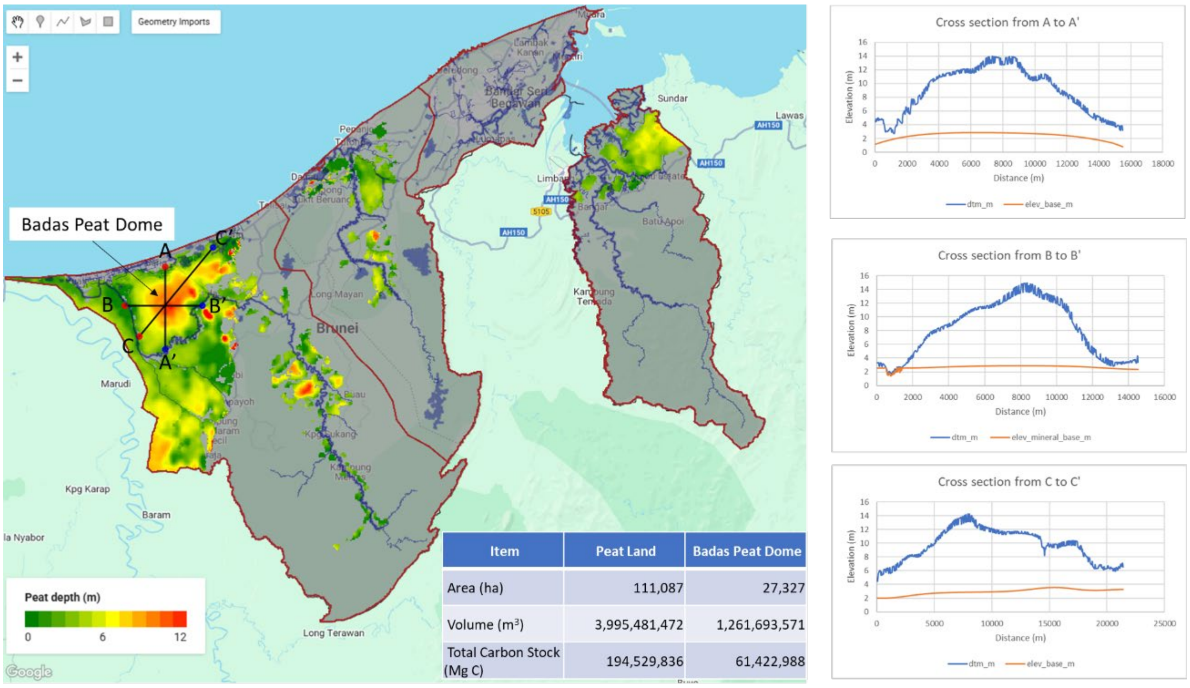
2.3.1. Peat Depth

Based on the National Forest Resources Inventory (NFRI) and PEATGRIDS data, the Badas PSFs cover between 103.7 and 140.9 thousand hectares, with the larger PEATGRIDS estimate likely including areas overlapping mangrove forests, freshwater swamp forests, and heath forests. Within this extent, the Badas peatland forms an ombrogenous peat dome with a maximum thickness of 9.7 m (Omar et al., 2022), underlain by clay and, in some areas, sand (Suhip et al., 2020). Another ombrogenous peatland, Ulu Mendaram, located in western Kuala Belait, has peat layers ranging from 1 m to 12 m.

Figure 2.3 shows peat depth mapped using the Peat Base Elevation Subtraction Model (PBESM) (Minasny et al., 2019a), where depth is the difference between land-surface elevation, derived from a digital terrain model (DTM) (Pronk et al., 2024), and peat-base elevation. Boundaries correspond to Badas and Ulu Mendaram (Ikbal et al., 2023), and interpolation uses the Kriging method at a 30-meter interval. The thickest peat layers align with previous findings, although peat depth varies spatially across both peatlands. Understanding the spatial distribution and thickness of these peatlands is critical for accurately estimating their carbon stocks, which is discussed in the following section.

Figure 2.4 illustrates a map of peat depth from PEATGRIDS at a spatial resolution of 1 km (Widyastuti et al., 2024). The map indicates depths of up to approximately 6 m; however, unrealistic values appear at the peatland edges, reaching up to a maximum of 12 m (shown in red).

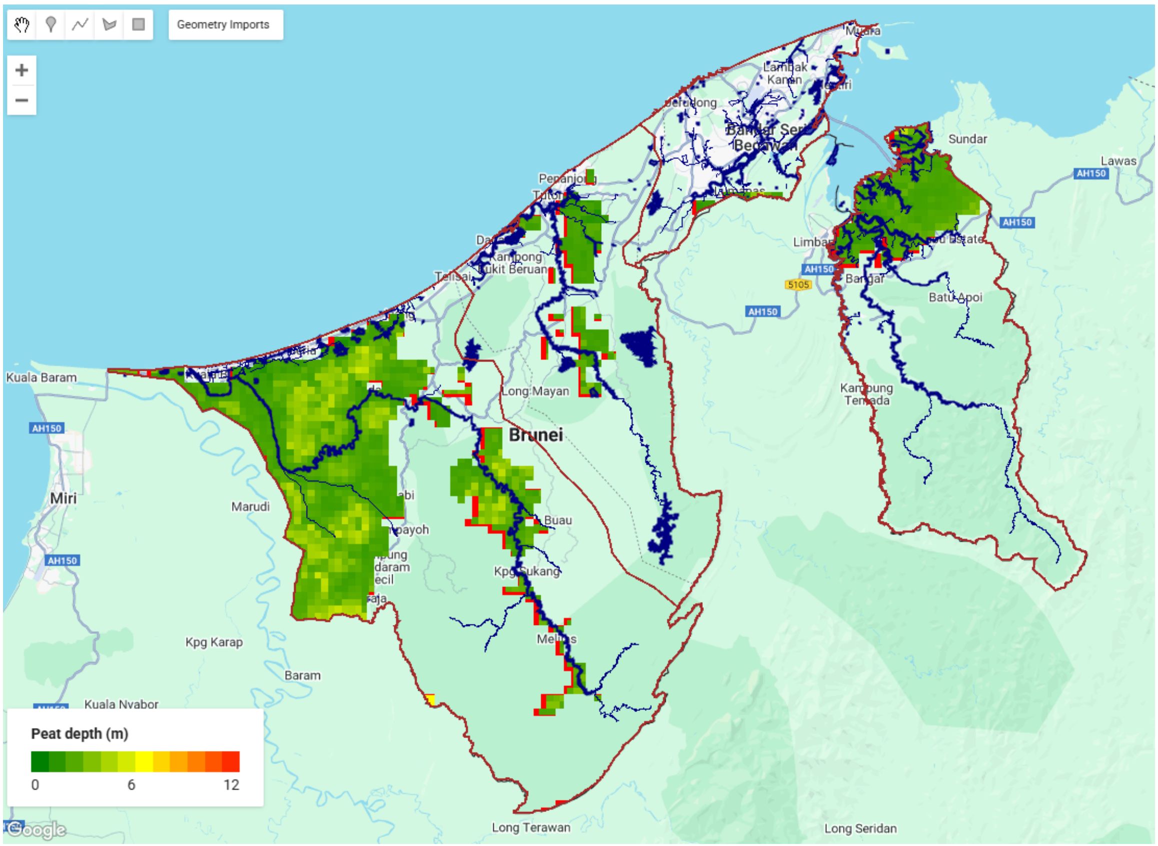
Figure 2.3. Spatial distribution of the peat depth at 30 m spatial resolution (Left), and Corresponding Peat Depth Cross-Sections (Right) along transects A–A′(Top), B–B′(Middle), and C–C′(Bottom) at the Badas Peat Dome



Item	Peat Land	Badas Peat Dome
Area (ha)	111,087	27,327
Volume (m³)	3,995,481,472	1,261,693,571
Total Carbon Stock (Mg C)	194,529,836	61,422,988

Source: ERIA Study Team, 2025.

Figure 2.4. Peat Depth Map from PEATGRIDS at a spatial resolution of 1 km



Source: Widyastuti et al., 2024

2.3.2. Peat Bulk Density

The peat bulk density (BD) commonly depends on the maturity of the peat, classified as sapric, hemic, or fibric. Sapric, which is the most mature and compacted, has the highest bulk density, followed by hemic and fibric. Based on the results from NFRI (2025), using 123 samples from various forest types across the country – including 31 samples from the peat swamp forests (PSF) of Badas, Sg. Mau, and Tg. Maya, as shown in Table 2.5– the average BD is 0.03 g/cm^3.

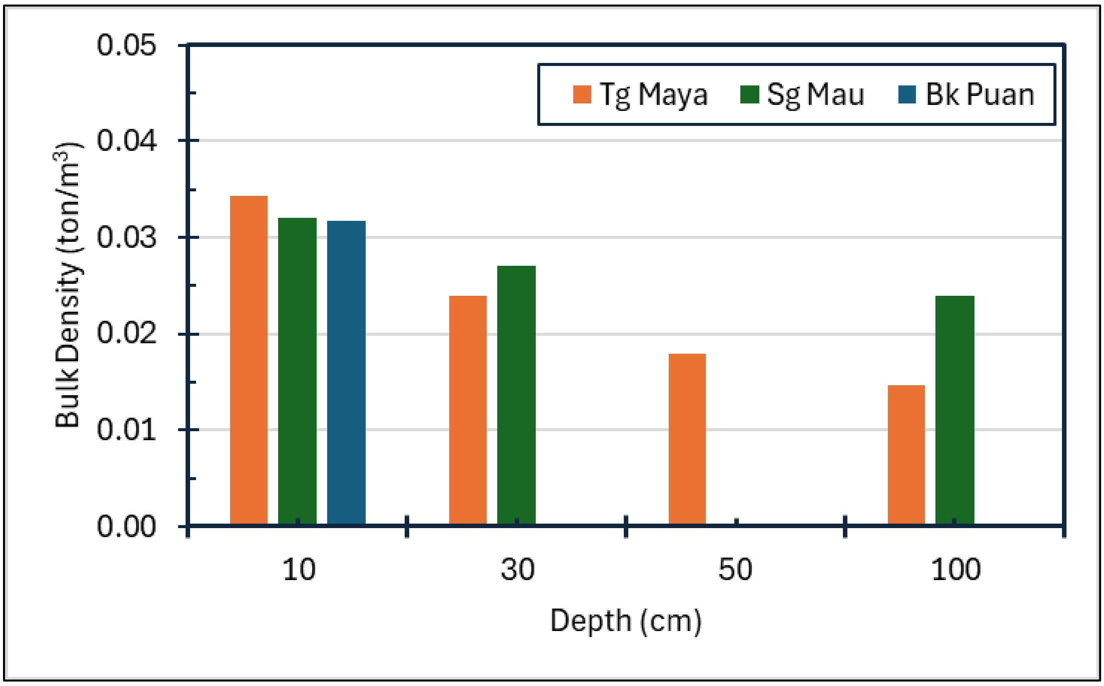
Table 2.5. Summary of Soil Bulk Densities in Different Forest Types in Brunei Darussalam

No	Forest Type	Location	Average Soil Bulk Density, g/cm^3	
			Avg BD by Location	Avg Soil BD by Forest Type
1	Mixed Dipterocarp Forest (MDF)	Bukit Patoi	0.43	0.55
2		Talingan	0.53	
3		Andulau	0.67	
4	Logged-Over Forest (LOF)	Batu Apoi	0.47	0.47
5	Plantation Forest (PLF)	Sg Ubar	0.46	0.46
6	Montane & Sub-Montane Forest (SMF)	Gunong Pagon	0.44	0.44
7	Kerangas Forest (KRF)	Bukit Patoi	0.04	0.40
8		Pak Bidang	0.77	
9	Freshwater Swamp Forest (FSF)	Labu	0.03	0.03
10	Peat Swamp Forest (PSF)	Badas, Sg Mau, Tg Maya	0.03	0.03

Source: NFRI, 2025.

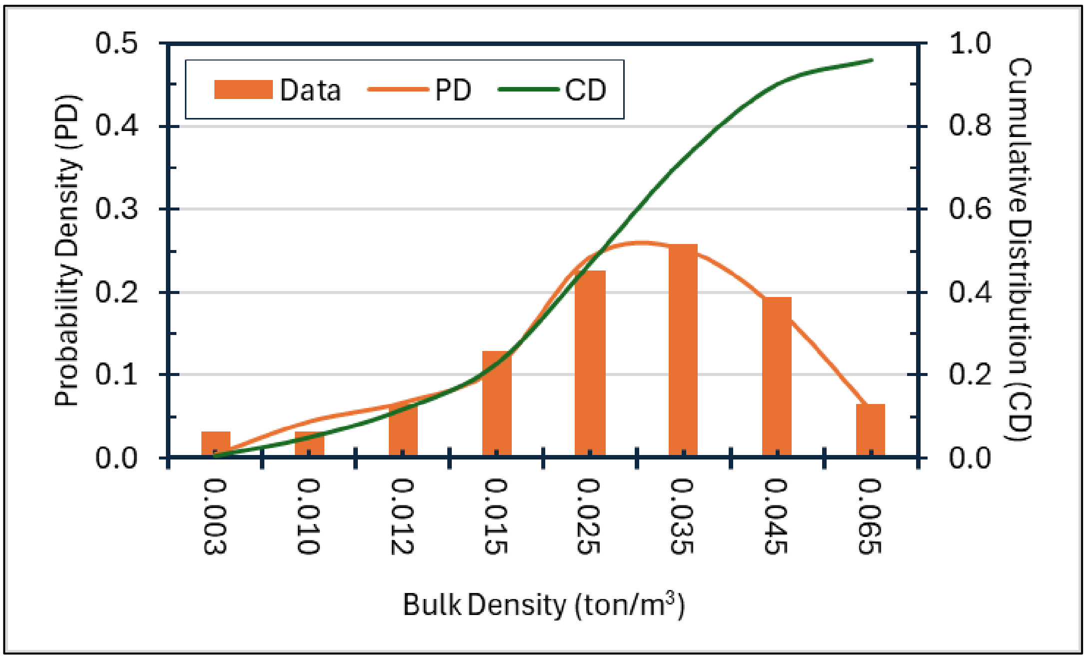
In the study by the ERIA team in Belait, the peat BD sampled from 31 points at three sites was 0.027 ± 0.013 g/cm^3. Based on the standard range for fibric peat, which is 0.10 ± 0.06 g/cm^3, both the NFRI data and the ERIA team's results are classified as fibric type. The BD decreases with depth (Figure 2.5), and its distribution is shown in Figure 2.6.

Figure 2.5. Bulk Density with Depth



Source: ERIA study team, 2025.

Figure 2.6. Bulk Density Distribution



Source: ERIA study team, 2025.

Other sources also reported that the bulk density in the Belait and Ulu Mendaram up to 140 cm-depth was 0.089 ± 0.032 g/cm^3 (Lupascu et al., 2020; Suhip et al., 2020), and along the Seria By-Pass Road in the Badas peatland it was 0.069 ± 0.016 g/cm^3 (Suhip et al., 2020). These relatively low bulk densities confirm that the peat is classified as fibric type.

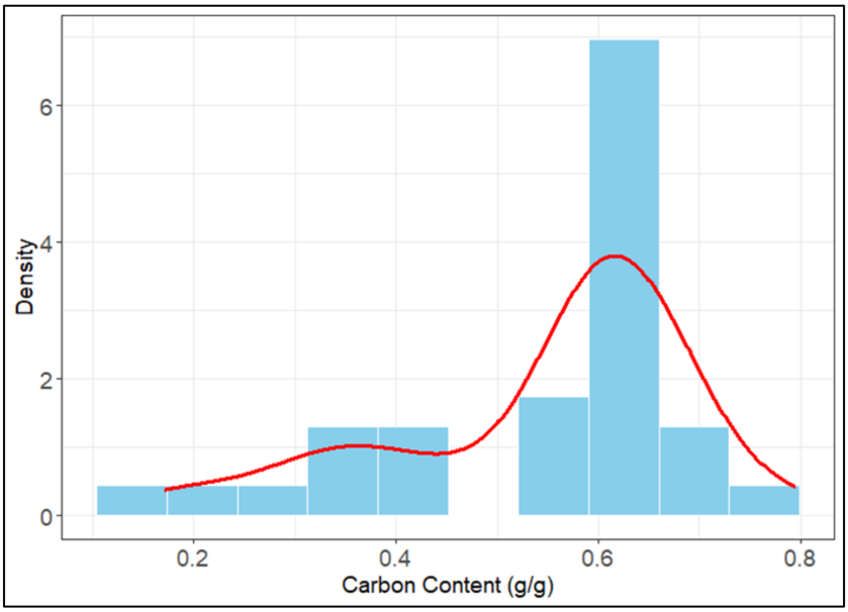
The variation in soil bulk density values, both observed and reported in the literature, reflects complex interactions amongst soil, water, vegetation, and ecosystem conditions. Appropriate considerations should be given in quantifying bulk density and peat characteristics, as they have important implications for carbon sequestration.

2.3.3. Carbon Content

In the Belait District, for peat layers up to 140 cm peat depth, carbon content decreases from 0.66 g/g near the surface to 0.38 g/g at depth, with an average of 0.60 ± 0.08 g/g (Lupascu et al., 2020).

Figure 2.7 shows the distribution of carbon content based on 33 samples collected in the Belait and Ulu Mendaram (Lupascu et al., 2020; and Suhip et al., 2020), with an overall average of 0.547 ± 0.147 g/g. These values are comparable to those reported in Indonesia (Minasny et al., 2019b) where the carbon content was (0.55 ± 0.02) g/g.

Figure 2.7. Carbon Content Distribution of the Belait and Ulu



Source: ERIA study team, 2025.

2.3.4. Carbon Stocks

The synthesis of the National Forest Resources Inventory (2025) and Continuous Forest Inventory (CFI) plot measurements indicates that the Peat Swamp Forest (PSF) in Belait has a mean carbon density of 752.5 tC/ha, derived from above-ground biomass (AGB), below-ground biomass (BGB), and necromass components. Based on a mapped PSF area of 100,026 ha, the corresponding total carbon stock is estimated at 75.27 MtC (Table 2.6).

These inventory-based results confirm that below-ground carbon pools dominate carbon storage in peat swamp forest systems, consistent with previous assessments showing that below-ground carbon stocks substantially exceed above-ground biomass carbon.

Table 2.6. Total Country's Biomass and Carbon Stock By Forest Types
(Figures in Tons)

No	Summary of Findings	AGB	Necromass+ BGB	ΣBiomass	ΣCarbon	ΣCO_2, tCO_2e
1	Mangrove Forest (MGF): 19,225.39ha	4,659,609.71	1,258,094.14	5,917,703.85	2,781,321.79	10,207,447.82
2	Peat Swamp Forest (PSF): 100,026.35ha	45,523,102.18	12,291,237.89	160,141,296.12	75,266,407.47	276,227,726.83
3	Coastal-Beach Forest (CBF): 1,581.60ha	375,789.43	70,175.59	445,965.02	209,603.60	769,235.51
4	Kerangas Forest: 9,282.63ha	3,510,568.14	1,872,807.73	5,383,375.87	2,530,186.88	9,285,784.24
5	Freshwater Swamp Forest (FSF): 14,888.93ha	4,380,427.43	1,182,715.56	5,563,142,98	2,614,677.75	9,595,864.76
6	Mixed Dipterocarp Forest (MDF): 264,965.42ha (incl. Logged-over areas)	135,747,666.90	50,600,287.28	186,347,980.67	87,583,551.18	321,431,591.24
7	Plantation Forest (Dryobalanops sp.): 5,295.59ha	589,574.98	462,252.05	1,070,644.38	503,202.85	1,846,754.40

No	Summary of Findings	AGB	Necromass+ BGB	**Σ**Biomass	**Σ**Carbon	**Σ**CO_2, tCO_2e
8	Montane & Sub-Montane Forest (SMF): 6,976.87ha	2,522,409.21	1,009,870.54	3,532,279.74	1,660,171.33	6,092,829.41
9	Secondary Forest: 101,743.89ha	35,884,174.66	10,999,704.91	46,883,879.57	22,035,427.16	80,870,011.78
	TOTAL	233,193,322.64	79,747,145.69	966,037,423.22	195,184,550.01	716,327,245.99

Source: NFRI, 2025.

Earlier NFRI assessments on the Belait Peat Swamp Forest[1] indicate a higher total carbon stock of 218.6 Mt, with a density of 3,545 t/ha, comprising 162 Mt (74%) below-ground carbon at 2,628 t/ha, and 56,5 Mt (24%) above-ground 917 t/ha. The difference between these estimates and the updated inventory-based values reflects differences in accounting boundaries, as earlier estimates incorporated deep peat soil carbon across the full peat profile, whereas Table 2-6 primarily represents biomass-related carbon pools within a plot-consistent inventory framework. The carbon stock estimation for Belait PSF based on primary and secondary data analysis is broadly aligned with other methods of estimation.

For comparison, peat carbon density in the Malaysian Peninsula is 142.9 t/ha, and in Pahang it is 204.8 t/ha. A spatially detailed study of a peat hydrological unit in Sumatra Island reported densities ranging from 116.8 t/ha to 220.2 t/ha. The peat carbon density in Belait is therefore considerably higher than in Malaysia and Indonesia.

Based on the spatial distribution of the peatland shown in Figure 2.8 the total peat volume (PV) is estimated at 3,995,481,472 m^3, with a Carbon Content (0.547 ± 0.147) g/g and a bulk density of (0.089 ± 0.032) Mg/m^3.

Overall, these measurements highlight the exceptionally high carbon storage potential of Brunei's peatlands, underscoring their importance for climate mitigation and conservation efforts.

The Carbon Stock (CS) is calculated as follows.

$$\text{CS} = 3{,}995{,}481{,}472 \times 0.547 \times 0.089 = 194{,}529{,}836\ \text{Mg} \quad (1)$$

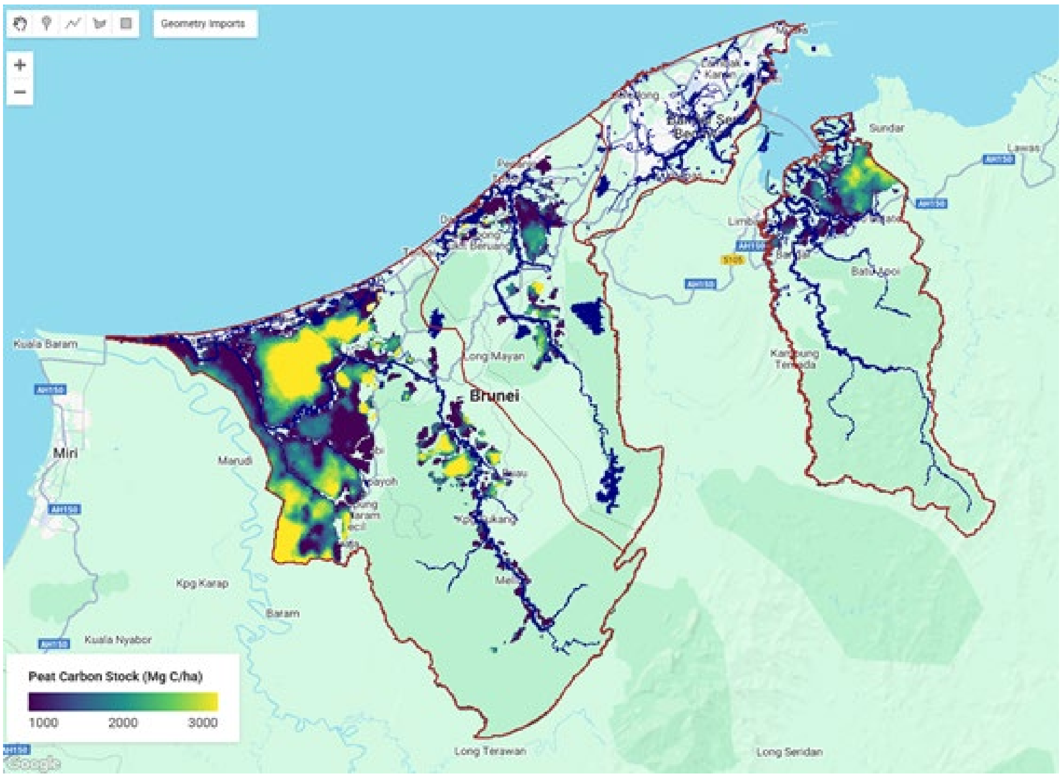
With an uncertainty,

$$\Delta\text{CS} = \left(\frac{0.147}{0.547}\right)^2 + \left(\frac{0.032}{0.089}\right)^2 \times \text{CS} \approx 87{,}288{,}874\ \text{Mg} \quad (2)$$

Thus, the total carbon stock (Figure 2.8) is estimated at 194.5±87.2 Mt, with an areal density of 1,751 t/ha. These values are consistent with estimates from the recent PEATGRIDS, a global map at 1 km × 1 km resolution (Figure 2.9), which reports a peatland area of 140.9 thousand hectares, a total carbon stock of 241.0 Mt, and a density of 1,710 Mg/ha (Widyastuti et al., 2024).

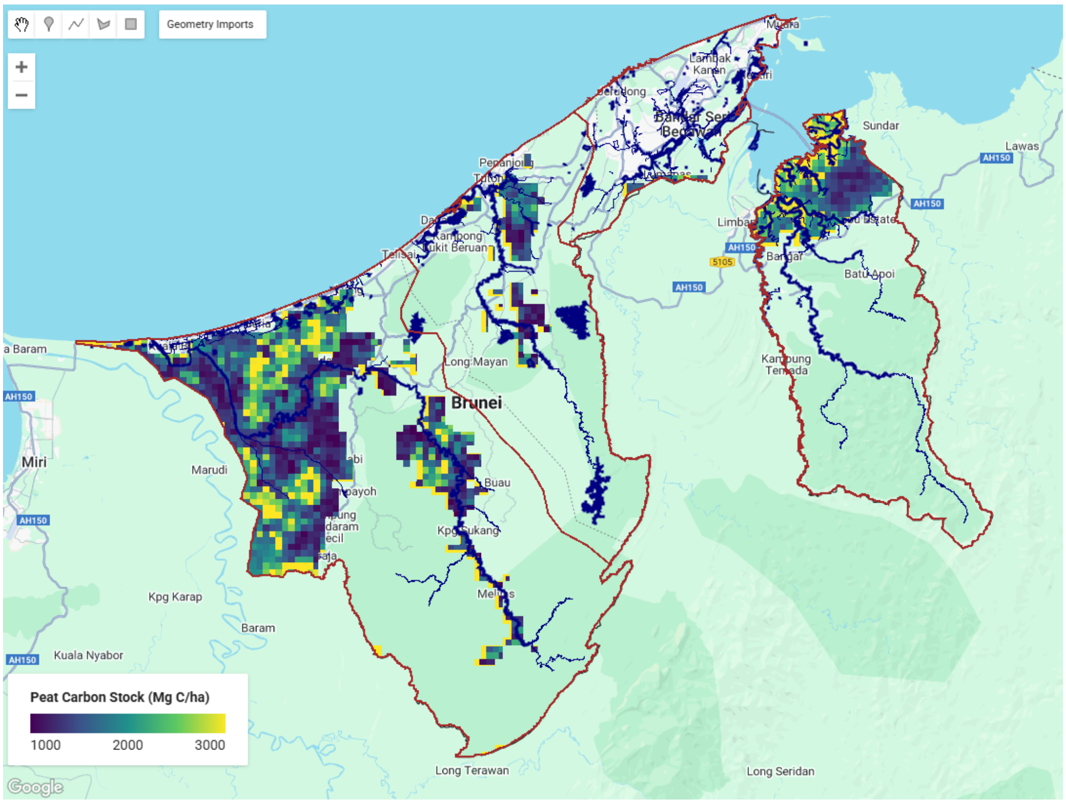
[1] Report on Carbon Stock in the Peat Swamp Forest of Brunei Darussalam dated 29 June 2024.

Figure 2.8. Peat Carbon Stock Density at a Spatial Resolution of 30 m



Source: ERIA study team, 2025.

Figure 2.9. Peat Carbon Stock Density (Mg C/ha) from PEATGRIDS at a Spatial Resolution of 1 km



Source: Widyastuti et al., 2024.

While peat swamp forests dominate carbon storage, understanding the complete national carbon picture requires examining the soil characteristics and carbon densities of Brunei's other major forest types.

2.4. Estimation of the Biomass and Carbon Density

Table 2.7 presents the Above Ground (AG) biomass and carbon density at Badas, Sg. Mau, and Maya that are based on the calculation results and estimates by Istomo (2006) and Ujang et al. (2012), as shown below. Badas has the highest biomass and carbon content compared to the other two locations. Overall, in Belait PSF, the carbon content is 222.35 tC/ha based on sample data, while the Istomo (2006) model estimates 242.46 tC/ha, and the Ujang et al. (2012) model estimates 356.72 tC/ha.

Model Istomo (2006):

$$AGB=0.0145\ D^3-0.4659\ D^2+30.64\ D-263.32;\ BGB=0.201\ AGB;\ D=DBH\ (cm) \quad (2\text{-}3)$$

Ujang et al (2012):

$$AGB=0.087\ D^{2.47}\ (kg);\ D=DBH\ (cm) \quad (2\text{-}4)$$

Table 2.7. ABG Biomass and Carbon, and Compared with Two Other Methods

Plots	Data (2024)				Istomo (2006)				Ujang et al (2012)			
	Biomass (t/ha)			Carbon (tC/ha)	Biomass (t/ha)			Carbon (tC/ha)	Biomass (t/ha)			Carbon (tC/ha)
	AG	BG	Total	Total	AG	BG	Total	Total	AG	BG	Total	Total
1. Badas	502.6	101.0	603.6	283.70	488.7	98.2	586.9	275.85	690.1	138.7	828.8	389.53
2. Sg. Mau	385.6	77.5	463.1	217.65	376.8	75.7	452.5	212.69	601.4	120.9	722.2	339.46
3. Sg. Maya	293.5	59.0	352.5	165.70	423.1	85.1	508.2	238.85	604.4	121.5	725.9	341.18
Average				222.35				242.46				356.72

$AGB=0.0145\ D^3-0.4659\ D^2+30.64\ D-263.32;\ BGB=0.201\ AGB;\ D=DBH\ (cm)$ (Istomo, 2006)

$AGC=0.087\ D^{2.47}\ (kg);\ D=DBH\ (cm)$ (Ujang et al, 2012)

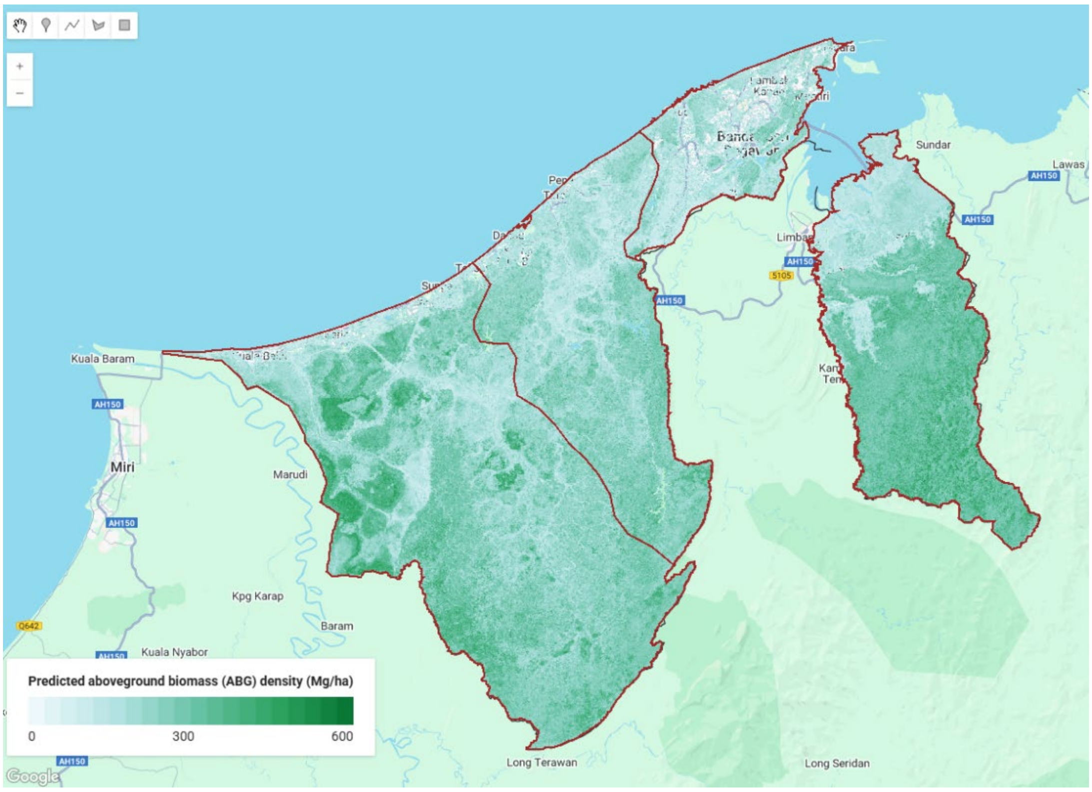
Source: ERIA study team, 2025.

2.4.1. Spatial Distribution of the Biomass and Carbon Density

Following the previous estimates of above-ground biomass (AGB), which were derived from sampling data and considering the natural variability in tree species and sizes across spatial distributions, an alternative approach was applied using Remote Sensing.

Based on Remote Sensing data in 2024 with a resolution of 100 m, the distribution of carbon content was obtained as presented in Figure 2.10 and Table 2.8. The total carbon content was only 58,580 MtC with a density value of 92.06 tC/ha, which was much lower than the previous calculation. The peatland itself contained 11,605 MtC (19.8%) with a density value of 104.5 tC/ha.

Figure 2.10. Above-Ground Biomass Density at 100-m Spatial Resolution for 2024



Source: ERIA study team, 2025.

Regarding above-ground biomass, Table 2.8 presents AG carbon stocks and densities for different forest types in 2024, totalling 58.6 Mt and 119.5 Mg/ha. Mixed Dipterocarps forests contributed 55.3% of the total carbon stock, while PSFs accounted for 19.8%, with a carbon density of 104.5 Mg/ha. Montane forests contributed only 1.7% of the total stock but exhibited the highest carbon density of 137.9 Mg/ha.

Table 2.8. AG Carbon Stock and Density Amongst the Forest Types (2024)

Class	Forest Types	Carbon Stock (Mt)*	Percentage	Area (ha)	Carbon Density (Mg/ha)
1	Mangrove Forest	0.694	1.2	12,383	56.1
2	Freshwater Swamp Forest	0.808	1.4	9,944	81.3
3	Peat Swamp Forest	11.605	19.8	111,087	104.5
4	Heath forest (Kerangas)	0.859	1.5	8,684	98.9
5	Mixed Dipterocarps	32.373	55.3	270,957	119.5
6	Montane Forest	1.016	1.7	7,373	137.9
7	Non-Forest	11.225	19.2	157,192	71.4
	Total/Average	58.584	100.0	577,620	92.06

Source: ERIA study team, 2025.
Note: *Calculated using Carbon Fraction 0.47, the IPCC Default Value.

Extending the analysis over time, Table 2.9 presents above-ground (AG) biomass and carbon stocks from 2019 to 2024, along with their temporal changes. Although there was a slight decrease from 2021 to 2022, overall AG biomass and carbon stocks showed a positive increasing trend over the period.

Table 2.9. AG Biomass and Carbon and their Changes (2019–2024)

Year	Biomass (Mt)	Carbon (Mt)	Changes (Mt)
2019	112.162	52.716	
2020	116.505	54.757	2.041
2021	117.460	55.206	0.448
2022	116.831	54.910	- 0.295
2023	124.966	58.734	3.823
2024	125.024	58.761	0.027

Source: ERIA study team, 2025.

Above-ground carbon represents only part of the total ecosystem storage. Below-ground biomass, particularly root systems, contributes significantly to overall carbon accounting in tropical forest ecosystems.

2.4.2. Below-Ground Carbon Stocks

Below-ground (BG) biomass refers to roots and other living biomass below the soil surface. In tropical forests, the root-to-shoot ratio typically ranges from 0.20 to 0.30, with the IPCC default value set at 0.24 (IPCC, 2014). Table 2.10 below presents BG biomass and carbon stocks, along with their temporal changes, which exhibit trends similar to those observed for the AB biomass and carbon stocks mentioned previously.

Beyond static carbon stocks, understanding temporal dynamics through emission quantification is crucial for monitoring forest carbon balance and informing climate mitigation strategies.

Table 2.10. Below Ground Biomass and Carbon in their Changes (2019–2024)

Year	Biomass (Mt)	Carbon (Mt)	Changes (Mt)
2019	26.918	12.651	
2020	27.961	13.141	0.489
2021	28.190	13.249	0.107
2022	28.039	13.178	- 0.070
2023	29.992	14.096	0.917
2024	30.005	14.102	0.006

Source: ERIA study team, 2025.

2.5. Carbon Emissions

The IPCC estimates annual carbon emissions (tons/year) using the following equation:

$$\text{Carbon Emission} = \text{Activity} \times \text{Emission Factor} \qquad (5)$$

where Activity refers to the magnitude of the human activity causing emissions (e.g. land-use area, fuel consumption, biomass burned), expressed in hectares, and Emission Factor is the amount of carbon emitted per unit of activity (e.g. tons/ha/year).

Using supporting data and references from multiple sources, Table 2.11 presents key land-use activities and associated carbon emissions from 2019 to 2024. Emissions peaked at 174,644 Mg in 2019, after which they increased gradually at an average rate of 3,410.4 Mg/year between 2020 and 2024.

Table 2.11. Land Use/Activity and Carbon Emission (2020–2024)

Land Use/Activities	2019	2020	2021	2022	2023	2024
	Area (ha)					
1. New Deforested Land		0.00	0.00	0.00	33	62
2. Degraded tropical moist forests (TMF)	9,938	9,964	9,986	10,031	10,043	10,050
3. Forest Regrowth	2,694	3,048	3,683	3,871	3,868	3,871
4. Conversion to a water body	673	675	678	678	679	680
5. Other land cover	2,366	2,309	2,163	2,112	2,111	2,108
6. Forest fires	229	248	0	0	0	0
Land Use/Activities	Annual Emission (Mg)					
• New Deforested Land		0	0	0	6,003	11,278
• Degraded TMF	60,869	61,029	61,163	61,439	61,512	61,555
• Forest Regrowth	-29,524	-33,403	-40,362	-42,422	-42,389	-42,422
• Conversion to a water body	17,752	17,804	17,884	17,884	17,910	17,936
• Other land cover	14,492	14,142	13,248	12,936	12,930	12,911
• Forest fires	106,256	115,072	0	0	0	0
Total		174,644	51,933	49,836	55,965	61,258

Source: ERIA study team adopted from Vancutsem et al., 2021; Ikbal et al., 2023; FAO, 2010b; Giglio et al., 2015; IPCC, 2014; IPCC, 2019; Sasmito et al., 2019.

Despite several recent efforts to assess Brunei's forest carbon pools, significant limitations hinder the development of a robust and verifiable carbon inventory, particularly for peatland areas.

a) Ungrounded Spatial Data for Forest Types: The available map of forest ecosystem types exists only in image format without georeferencing. This restricts its use in spatial analyses, preventing the accurate delineation of forest boundaries and accurate carbon pool estimation. Georeferencing and vectorisation are urgently needed.

b) Incomplete Peat Soil Carbon Observations: Field-based measurements of peat depth with geographic coordinates, bulk density, and carbon content are sparse or non-existent across much of Brunei. Existing values are localised (e.g. Badas), limiting their generalisability.

c) Use of Coarse Resolution Global Datasets: While datasets like PEATGRIDS offer broad-scale insights, their 1 km resolution lacks the spatial granularity necessary for sub-national or project-scale carbon accounting in Brunei's heterogeneous peatlands.

d) Non-local Allometric Models for AGB: AGB in PSFs is estimated using allometric models developed outside Brunei (e.g. Basuki et al., 2009). These models may not fully capture local forest structure variability. Moreover, existing data are concentrated in Badas, leaving other PSF regions unassessed.

e) Limited Temporal Coverage: Most biomass estimates reflect a single point in time. The absence of multi-year data makes it difficult to analyse trends or detect forest degradation and regrowth over time.

f) Lack of Integration Across Datasets: Existing biomass, soil, and remote sensing datasets are fragmented across institutions and remain unpublished or inaccessible, making it difficult to harmonise data for comprehensive national carbon stock estimation.

Current carbon assessments face substantial methodological and data constraints. Identifying these limitations is essential before proposing solutions for more robust inventory systems.

2.6. Critical Data Gaps

Addressing key data gaps is essential for Brunei to advance forest inventory and carbon project readiness and meet Monitoring, Reporting, and Verification (MRV) standards.

Key Gaps

a) Direct AGB Measurements – Current estimates rely heavily on models and remote sensing with limited ground-truthing. Expanding field plots across diverse forest types and regions is critical.

b) Belowground Biomass (BGB) – No datasets exist for root biomass in Brunei's forests, even though BGB represents a significant share of total biomass, particularly in peatlands.

c) Deadwood and Litter Pools – These carbon pools, required for IPCC Tier 2+ methodologies, have not been systematically surveyed in Brunei.

d) Peat Soil Carbon Profiles and Maps – Comprehensive mapping of peat depth, bulk density, and carbon content with GPS-referenced data is lacking. Existing studies are localised and fragmented.

e) Long-Term Monitoring Data – Current carbon stock estimates are static. There are no permanent sample plots or time-series datasets to track fluxes, degradation, or restoration.

Implications

The above-mentioned data gaps limit Brunei's capacity to:

a) Produce accurate, comprehensive carbon stock estimates across all pools.

b) Apply higher-tier IPCC methodologies for credible accounting.
IPCC Tier 1 uses global default emission factors, Tier 2 applies country-specific data, and Tier 3 employs advanced inventory systems and models, with higher tiers reducing uncertainty and enabling more credible forest carbon accounting.

c) Demonstrate additionality, permanence, and reduced uncertainty in carbon projects.

d) Fulfil MRV requirements under REDD+, UNFCCC, and voluntary market mechanisms.

e) Support evidence-based decision-making for forest management and climate finance.

Beyond general limitations, specific data gaps create critical barriers to advancing Brunei's carbon accounting capabilities and meeting international reporting standards for climate commitments.

2.7. Land-Use Additionality in Brunei's Peat Carbon Context

Brunei Darussalam stands out for exceptionally high remaining forest cover and virtually no historical deforestation. One analysis notes Brunei 'has maintained one of the highest proportions of forest cover to total land area' in Southeast Asia (ForestIndustries.EU, 2011), and the country's annual deforestation rate has been essentially negligible (ForestIndustries.EU, 2011). At the same time, about 90,900 hectares (≈15.6% of the country) are peat swamp forest (Forestry Department Brunei Darussalam, n.d.-a), concentrated largely in the Belait District. These peatlands hold enormous carbon – often hundreds of tonnes of carbon per hectare – almost entirely belowground. This makes every hectare of peat critically important: even small-scale drainage, logging, or fire can release disproportionately large emissions. Indeed, tropical peat swamp forests are amongst the Earth's richest carbon stores (Massachusetts Institute of Technology, 2020).

Brunei's peat regions also face elevated risk: for example, Belait's peat swamps are recognised fire hotspots (especially during dry El Niño periods), and large peat fires there are extremely difficult to extinguish once ignited (Said, Shams, Zahran, and Yap, 2018). Together, these facts mean that Brunei's land-use context is one of high-carbon stock and high sensitivity, despite very little net forest loss to date.

Additionality as a Land-Use Counterfactual

In carbon accounting, additionality is fundamentally a land-use counterfactual question: what would the land-use trajectory and emissions have been in the absence of the project (OffsetGuide, n.d.). In practice, that means establishing a credible baseline scenario for Brunei's forests. Here, Brunei's high-forest-cover/low-deforestation (HFLD) status poses a dilemma. A naively observed baseline (essentially zero forest loss) would yield almost no credits, but it would ignore any real future pressures.

On the other hand, arbitrarily inflating the baseline without evidence would over-credit. In short, a 'zero baseline' would fail to account for genuine non-zero threats (e.g. infrastructure or fire risk), while an 'inflated baseline' would assume implausible conversion. The solution is a middle ground: baselines that are spatially stratified and risk-allocated, higher than zero where credible pressures exist, but still conservative overall, and that explicitly incorporate peatland drainage and fire dynamics. In other words, Brunei's additionality framework must predict a plausible without-project future – one that is neither complacent nor speculative. This tension underscores that additionality is not a fixed assumption but a modelled counterfactual requiring strong justification.

Data Mapping Strengths and Baseline Gaps

Fortunately, Brunei has outstanding data on its forests and carbon stocks. The country is 'one of the world's best-mapped' on land cover and biomass: it has invested in extensive LiDAR and terrestrial laser scanning surveys, integrates spaceborne LiDAR (NASA GEDI) and other satellite data, and is undertaking a new National Forest Resources Inventory (2023–2025) to align with global standards. Field studies confirm Brunei's peat forests are old-growth with exceptionally high biomass – roughly 470–560 tonnes per hectare in study plots (Forestry Department of Brunei Darussalam, 2024). Moreover, hybrid mapping approaches are correcting known biases: for example, raw GEDI estimates were found to underestimate Brunei's forest carbon by ~75% without local calibration (Forestry Department of Brunei Darussalam, 2024).

In short, transparent land stratification and precise emission factors can be built from Brunei's data. However, it is important to recognise what these data do not provide: they quantify current stocks and measure changes, but they do not by themselves specify the counterfactual scenario. The inventory tells us what and where the forest is today, but not how land use would have evolved without a project. Thus, the greatest gap is not lack of mapping or carbon data per se, but the lack of a standardised protocol to translate these data into land-use baselines and additionality claims. In this sense, the mapping and carbon inventory are assets – as noted, 'Brunei's peat swamps are one of a kind and hold high biomass and carbon stock' – but they must be paired with rules and procedures (e.g. on how to allocate risk and define degraded land) to form a credible baseline (Forestry Department of Brunei Darussalam, 2024).

Implications for Baseline Design

In summary, Chapter 2's gap analysis finds that Brunei's real challenge is methodological: how to turn rich forest data into rigorous counterfactuals. The solution will be addressed in Chapter 5. There, we propose a formal land-use additionality framework tailored for Brunei's HFLD context. Key elements will include stratified baselines (different rates of assumed loss or degradation in different zones, reflecting proximity to roads or settlements), spatial risk allocation (using maps of infrastructure, drainage, or fire risk to weight baselines), and explicit peatland rules (e.g. enhanced emissions factors or risk metrics for drained peat). We will also recommend project eligibility screening (to ensure crediting only applies to areas with genuine land-use threats or degradation, not already-protected or planned restorations) and preventive additionality pathways, such as requiring projects to incorporate land-use planning or zoning safeguards (no-conversion buffers, fire-prone development setbacks, maintenance of water table) that lock in avoided emissions. Together, these measures – which build directly on the data gaps identified here – will help ensure that Brunei's forest-carbon baselines are neither unrealistically conservative nor inflated, but are auditable, data-driven, and aligned with Brunei's unique high-carbon peat landscape.

In effect, Chapter 2's inventory and stratification work will dovetail into Chapter 5's design of auditable, GIS-based baseline protocols that uphold additionality in Brunei.

2.8. Estimation Methodology and Data Verification Procedures

Traditionally, peat carbon deposits were estimated using default values and coarse-scale maps, which contributed to high levels of uncertainty. Improving the accuracy and spatial consistency of peat carbon stocks requires the use of appropriate methodologies to generate higher-resolution maps and to better estimate peat depth and carbon density. The following steps are recommended:

2.8.1. Peat Depth Mapping

Figure 2.10 and Figure 2.11 present the overall workflow for updating peat depth mapping and estimating peat carbon stocks. The workflow integrates remote sensing-derived elevation models, digital soil mapping, and spatial analysis techniques. Peat carbon stock is calculated using a pixel-wise dot product of carbon content, bulk density, peat depth, and pixel area.

Two alternative approaches are proposed for mapping peat depth, depending on the availability and density of field-observed peat depth data:

1. Digital Soil Mapping (DSM) Framework

   When point-based observations of peat depth are available, spatial prediction models such as regression kriging, random forest, or other machine learning approaches can be applied to estimate peat depth continuously across the landscape (Figure 2-10). Covariates may include topographic indices, vegetation indices, soil types, land cover, and proximity to rivers or water bodies.

2. Elevation-Difference Method

   When high-resolution elevation data (e.g. Digital Surface Model, DSM and Canopy Height Model (CHM)) are available, peat depth can be estimated by calculating the vertical distance between the peat surface (Digital Terrain Model, DTM) and the estimated mineral soil base (Figure 2-11):

$$DTM_{\text{peat surface}} = DSM - CHM \quad (6)$$

$$\text{Peat Depth} = DTM_{\text{peat surface}} - \text{Mineral Base Elevation} \quad (7)$$

Figure 2.11. The Method with Peat Depth Data

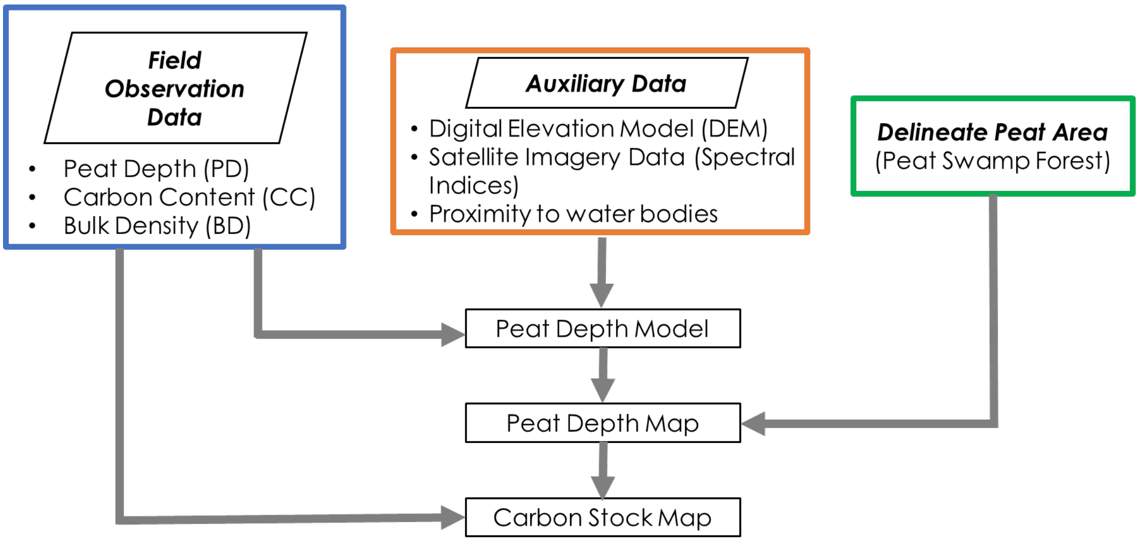
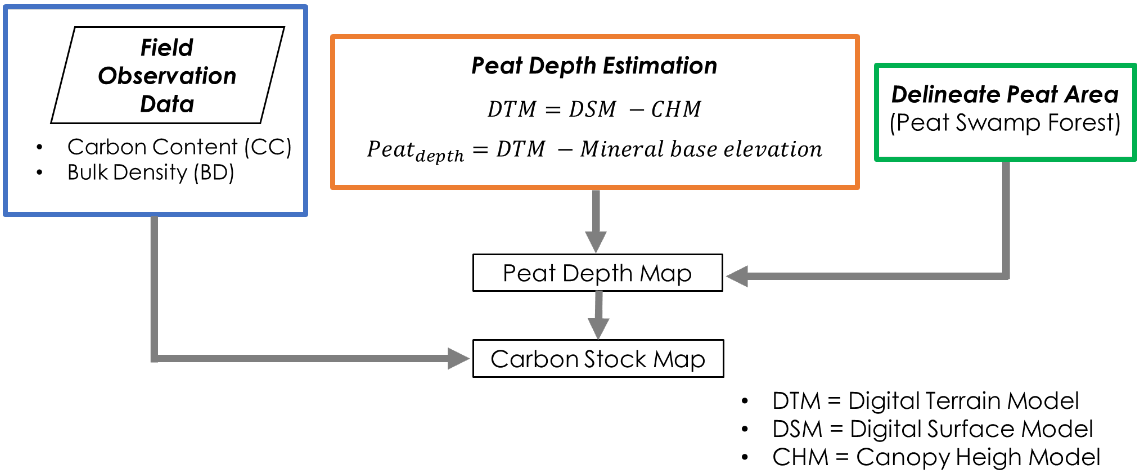


Figure 2.12. The Method with Limited Peat Depth Observation



Source: ERIA study team, 2025.

Field Surveys

The field observations include:

a) Geographical coordinates at each observation point (Figure 2.11).

b) Peat depth measurements.

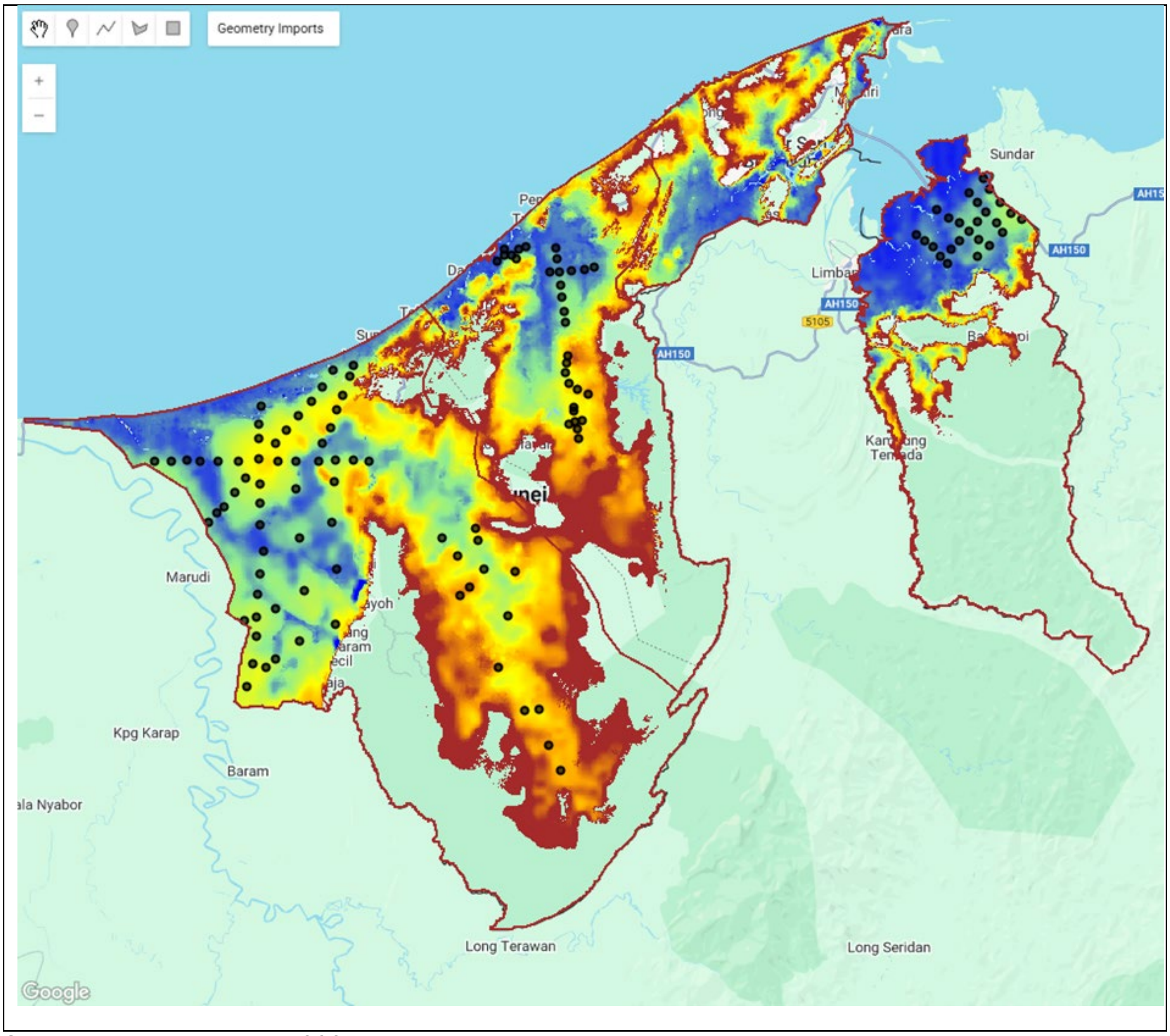
c) Peat bulk density recorded at five depth intervals:

- 0–15 cm
- 15–30 cm
- 30–60 cm
- 60–100 cm
- >100 cm

Peat carbon content measured at the same five depth intervals.

In peat mapping, field surveys demand substantial resources, including surveyors, transportation logistics, accommodations, specialised equipment (such as a peat auger, GPS, and a ring sampler), and laboratory analyses. These requirements often present constraints. Moreover, the accuracy of the mapping methods is directly influenced by the number of field observations, highlighting a clear trade-off between cost and recovery.

Figure 2.13. Recommended Sampling Points



Source: ERIA study team, 2025

2.8.2. Data Acquisition

The most critical aspect of data reporting is sampling. It is necessary to determine the sample size for the given area to ensure it represents the distribution of carbon stocks. This also requires consideration of spatial heterogeneity, peat depth, topography, desired precision, and the resource availability, such as labour, funding, tools, and logistics.

a) For a 1 ha (10,000 m^2) plot, at least one sample is recommended, provided that the homogeneity of the plot is first confirmed, particularly when the area is large.
b) To facilitate this process, forest stratification should be carried out, whereby the forest is divided into several types or strata.
c) A statistical calculation can also be used to determine the optimal sample size. This method can be applied depending on the resources available to conduct the work.

The formula for calculating the optimal sample size is given below:

$$n = \left(\frac{Z\,\sigma}{E}\right)^2 \quad (8)$$

<u>where:</u>
n = required sample size
z = z-value (e.g. 1.96 for 95% confidence)
σ = standard deviation of carbon stock (e.g. 10)
E = desired margin of error (e.g. 2)

<u>Substituting the values:</u>
$n = (1.96^2 \times 10^2) / 2^2 = 96.04$

Thus, for a 10,000 m^2 (1 ha) area, at least 96 samples are required. However, in practice, the required number of samples may vary depending on manpower, funding, and other logistical considerations.

Another important challenge is the timing of sampling. Peat bogs undergo seasonal variations, influenced by hydrological conditions. Ideally, sampling should be carried out during the dry season, when accessibility is better and sufficient samples can be collected without complications. However, if the site is safe and accessible, conducting sampling in both dry and wet seasons over a time series can provide more refined data and improve the accuracy of carbon stock estimates.

2.8.3. Data Analysis

Data analysis for peat carbon stock estimation requires special consideration. In Malaysia, peat samples are oven-dried at 65-70^{0}C until they reach a constant weight for bulk density measurement (Jeyanny et al., 2021), instead of conventional 105^{0}C for 48 hours used for mineral soils. This adjustment is necessary because peat is an organic material and drying at higher temperatures lead to decomposition of organic matter, resulting in erroneous bulk density values and, consequently, inaccurate carbon stock calculations.

2.8.4. Data Verification

Data verification ensures that peat carbon assessments are reliable and representative. Accurate sampling requires distinguishing peat types, confirming organic content thresholds, and validating remote sensing results with ground-truthing to minimise errors in bulk density, carbon stock, and emission estimates.

a) Sampling requires knowledge of peat characteristics as peat can differ with peat types (sapric/hemic/fibric) and peat description, whereby only material which has a minimum thickness of 50 cm within the upper 100 cm depth, has a minimum 12% organic carbon content, and has a loss of ignition (LOI) more than 65% (Paramananthan, 2016).
b) Thus, one who samples should know the differences between peat and mineral soils to differentiate between organic clay and muck, which may have lower LOI.

Any sampling using remote sensing technology needs to be verified with ground truthing data. Thus, based on the remote sensing data, some of the common statistical analyses that can be done are correlation analysis, regression analysis, or geostatistical methods such as Kriging.

2.8.5. Emission Uncertainties

Emission uncertainties arise from multiple interacting factors affecting peat carbon sequestration. These include biotic and abiotic variables, peatland management practices, vegetation dynamics, and climate-driven events. Understanding these uncertainties is essential for improving the accuracy of carbon flux estimates and policy recommendations.

Having identified key constraints and gaps, we now present comprehensive methodological recommendations to enhance data collection accuracy, spatial resolution, and analytical rigor.

2.9. Towards Enhanced Methodology for Peat Swamp Forest Carbon Estimation

This assessment of Brunei's peat swamp forest carbon stocks reveals significant methodological inconsistencies and data limitations that affect inventory accuracy. The existing methodology reported in the National Forest Resources Inventory (2024) is generally appropriate for national-level inventory purposes (Tier 1). However, its application for more advanced uses – such as carbon credit issuance in voluntary or compliance carbon markets – would likely require further methodological refinement, improved data resolution, and enhanced consistency.

Regional comparisons highlight substantial variations in carbon density estimates, reflecting differences in assessment tiers and data collection approaches. These findings underscore the need for more robust and standardised carbon accounting systems, while the recommendations outline practical pathways toward improving methodological rigor and comparability across assessments.

2.9.1. Conclusions

When compared regionally, carbon density values reported in Sumatra, Indonesia (Tier 3) and Malaysia (Tier 2) are much smaller, ranging between 116.8 tC/ha and 225.8 tC/ha. This suggests that more representative and locally calibrated data can substantially improve the accuracy of carbon assessments. Similarly, carbon loss through emissions, based on the National Forest Resources Inventory (NFRI), varied annually between 0.449 tC/ha and 0.504 tC/ha during the fire-free period of 2022–2024. These values are somewhat higher than those reported in Malaysia, which range between 0.39 tC/ha and 3.48 tC/ha. Overall, such differences reflect the varying tiers of methodology employed, alongside differences in data collection and analysis procedures. These findings emphasise the need for robust, standardised, and context-specific approaches to reduce uncertainty in carbon accounting, summarised as follows:

a) Given the high biodiversity index and the critical role of the Belait Peat Swamp Forest in maintaining ecosystem health and resilience, the choice of methodological approach is crucial, as it strongly influences the accuracy and representativeness of the information captured regarding ecosystem composition and carbon dynamics.
b) As summarised in Table 2-12 below, the total carbon stocks in Belait Peat Swamp Forest (PSF) based on the NFRI (Tier 1) and our Evaluation (Tier 2) produced similar values, which are 218.6 MtC and 220.2 MtC, respectively.
c) The evaluation results showed the average carbon density was lower, at around 56% of the NFRI, which is 3.545 tC/ha. This is because the 2024 National Forest Resources Inventory Report (NFRI) used the average peat thickness in calculating the peat volume, which generally tends to yield overestimated results.
d) Carbon density in both Sumatra (Tier 3) and Malaysia (Tier 2) shows closer values ranging from 116.8 tC/ha to 225.8 tC/ha. These are much smaller than those in the NFRI and Evaluation, showing that the use of more representative data can improve accuracy.
e) Carbon loss through emissions, based on the NFRI, varies each year, ranging from 0.449 tC/ha to 0.504 tC/ha during the normal period without fires between 2022 and 2024. These values are higher than those in Malaysia, which range from 0.39 tC/ha to 3.48 tC/ha.

The above differences occur because each uses a different Tier, and there may also be differences in data collection methods and analysis methods.

2.9.2. Recommendations

Specific recommendations to obtain more precise estimates of the carbon stocks are as below:

a) Sampling Design: A more rigorous approach, such as stratified random sampling based on biophysical characteristics (e.g. peat depth, tree species composition), could have enhanced the representativeness of the data. This would have allowed for a more precise estimation of forest parameters and their variability across different peat swamp types.
b) Measurement Techniques: Accurate measurement of peat depth and tree diameter is crucial for understanding the carbon stock and forest structure. The use of standardised measurement protocols and calibrated instruments is essential to ensure data consistency and reliability. Additionally, given the dynamic nature of peatlands, repeated measurements over time could provide valuable information on forest growth rates and peat accretion or degradation.
c) Species Identification: Accurate species identification is fundamental for understanding biodiversity and ecological processes. The use of expert taxonomists or molecular techniques can improve accuracy, especially for challenging or rare taxa. This is particularly important for PSFs, which often harbour unique and endangered species. Since different species have varying rooting strategies and leaf litter characteristics, they may influence carbon estimation differently.
d) Carbon Stock Estimation: Estimating carbon stocks in peatlands requires careful consideration of both above-ground and below-ground components. In the NFRI process, BGB was measured using a root-to-shoot ratio. While the inventory may include aboveground biomass, the belowground carbon stored in peat, root systems, and soil should also be quantified. This can be achieved using appropriate sampling techniques and allometric equations.
e) Data Analysis and Quality Control: Robust data analysis and quality control procedures are essential to ensure data accuracy and reliability. This includes checking for outliers, assessing data consistency, and using appropriate statistical methods to analyse and interpret the data. Regular data audits can also help to identify and address potential errors or inconsistencies.
f) It is also advisable to utilise remote sensing methods, as applied in Sumatra and Malaysia, supported by suitable ground truthing.

Implementing these recommendations on forest inventory will strengthen Brunei's capacity for accurate carbon accounting, enhance climate reporting credibility, and support evidence-based forest management decisions. Success requires coordinated efforts across institutions, sustained funding commitments, and systematic application of improved methodologies to achieve internationally recognised standards for carbon stock assessment.

Table 2.12 Fact Sheets Comparing the Peat Swamp Forests in Brunei, Indonesia, and Malaysia

Domains	Parameters	Unit	Belait PSF Assessment, 2024			Belait PSF with Spatial Data			Sumatra Island with Spatial Data			Malaysia	
			Value	Note		Value	Note		Merang	Buring	Kepahyang	Peninsular	Pahang
	Land	ha	576,500	100.0%	Brunei								
	Forest	ha	415,657	72.1%	AcoFo, 2023								
	Peat SF	ha	243,713	58.6%									
	Barks	m^3	72,000,000										
	Carbon Stock	t/ha	143.95										
	Total Carbon	t/ha	198.74										
	1. Mixed	ha	167,706	68.8%	Arroyo, 2005	454,151	78.6%	Ikbal et al., 2023					
	2. Peat	ha	61,659	25.3%		111,086	19.2%						
	3. Mangrove	ha	14,348	5.9%		12,383	2.1%	Bunting et al., 2022					
	Total		243,713	100%		577,620	100%						
Below Ground Peat	1.Area	ha	4,000		**Badas PSF**								
	2.Volume				Survey, 2024								
	Min	m^3/ha	35,708										
	Max	m^3/ha	58,833										
	Ave	m^3/ha	47,271										
	3.Depth												
	Min	m	3.57						1.3	0.8	0.4	0.8	
	Max	m	5.88						12.9	13.2	11.4	7.45	
	Ave	m	4.38										
	4. Biomass												
	Min	m^3	142,833,200										
	Max	m^3	235,333,600										
	Ave	m^3	165,065,340										
	5. Carbon Content	%	0.60			0.547			0.50	0.50	0.50		
	Min	m^3	85,699,920										
	Max	m^3	141,200,160										
	Ave	m^3	99,039,204										
	6. Carbon Density												
	Min	t/m^3	0.074										
	Max	t/m^3	0.153										
	Ave	t/m^3	0.117			0.089	0.032						
	7. Carbon Stock												
	Min	ton	10,026,891										
	Max	ton	16,520,419										
	Ave	ton	11,587,587										
	SOC	tC/ha	60	0.10	m-depth								
	SOC	tC/ha	2,628	4.38	m-depth								
Below Ground Peat	Area	ha	61,659		**Belait PSF**	111,086			36,040	45,850	27,530	600,000	
	Peat Volume	m^3	2,700,664,200			3,995,481,472	Figure 5		440,400,000	451,600,000	233,600,000		
	Peat Carbon	ton	162,039,852			194,529,836			220,200,000	225,800,000	116,800,000	142,896,000	
	Carbon per Area	t/ha	2,628			1,751			6,110	4,925	4,243	238	37.62
Above Ground Vegetation	Area	ha	61,659		**Belait PSF**	111,086							
	Biomass	ton	113,033,760	2.077	1,833	24,692,934	2,024						
	Carbon	ton	56,516,880	0.5		11,605,679	0.47						
	Carbon per Area	t/ha	917			104							167.2
Below Ground Veg. Roots	Area				**Belait PSF**	111,086							
	Biomass					30,005,959	2,024						
	Carbon					14,102,801	0.47						
	Carbon per Area			0.50		127							
Carbon Stock	Per Area	tC/ha	3,545			1,983			220.2	225.8	116.8	142.9	204.8
	Total	Mt	218.6			220.2			6,110	4,925	4.243	238.2	41.7
Annual Emission	2022	tC/ha				0.449						0.39	3.48
	2023	tC/ha				0.504							
	2024	tC/ha				0.551							

Source: ERIA study team, 2025.

This chapter demonstrates that Brunei Darussalam's peat swamp forests represent an exceptionally significant carbon reservoir, but current forest carbon inventory systems face substantial methodological and data limitations. While existing estimates provide an initial indication of carbon stocks, reliance on coarse-resolution datasets, limited field measurements, and non-local models introduces high uncertainty, particularly for peat soil carbon and below-ground pools.

Comparative analysis with regional studies highlights that differences in carbon density estimates are largely driven by methodological choices, data resolution, and IPCC Tier levels applied. The use of simplified assumptions, such as average peat depth, risks systematic overestimation and reduces the credibility of carbon accounting for market-based applications. At present, Brunei's forest carbon data are adequate for exploratory analysis but insufficient for high-integrity carbon crediting under international standards.

Table 2.13 Data Availability and Gap Analysis Matrix

Data Type	Available	Partial	Gap	Priority
Field Plot Data	✓			High
Satellite Imagery	✓			High
Peat Depth Surveys		✓		High
Carbon Stock Data		✓		Critical
Biomass Allometry			✓	Medium
Water Table Monitoring			✓	High
Historical Deforestation	✓			Medium
Community Boundaries		✓		Low
Emissions Factors			✓	Critical

Data Available   Partial/Outdated   Data Gap

Source: ERIA study team, 2025.

Table 2.13 summarises the data availability and gap analysis of Belait peat swamp forest. Addressing these gaps limitations is essential not only for carbon market participation but also for strengthening national forest management, climate reporting, and long-term monitoring of ecosystem change.

To enhance the accuracy, credibility, and policy relevance of forest carbon accounting in Brunei Darussalam, the following actions are recommended:

1. Strengthen field-based data collection by establishing permanent sample plots across peat swamp and non-peat forest types, with systematic measurement of above-ground biomass, peat depth, bulk density, carbon content, and dead organic matter.
2. Develop high-resolution spatial datasets for peatlands using a combination of field observations, digital soil mapping, and elevation-based modelling to replace reliance on coarse global datasets.
3. Transition progressively from Tier 1 to Tier 2 and Tier 3 IPCC methodologies by generating locally calibrated emission factors and allometric models tailored to Brunei's forest ecosystems.
4. Improve data integration and institutional coordination by consolidating forest, soil, and remote sensing datasets into a centralised, accessible national forest carbon database.
5. Establish a long-term Monitoring, Reporting, and Verification (MRV) framework aligned with Verra/REDD+ and voluntary carbon market requirements, including protocols for uncertainty management and independent verification.
6. Invest in national technical capacity through targeted training, partnerships with research institutions, and sustained funding to support repeated measurements and methodological refinement over time.

Implementing these recommendations will reduce uncertainty, strengthen environmental integrity, and position Brunei to participate credibly in forest carbon markets while supporting broader climate and biodiversity objectives.

Chapter 3
Carbon Sequestration and Credit Calculation

3.1. Introduction

Carbon accounting – sequestration and credit estimation choices underpin the credibility, eligibility, and value of participation in carbon markets. Decisions on how emissions reductions and removals are measured, reported, and verified affect market acceptance, buyer confidence, and Brunei's reputational risk. While these processes are technical, many involve clear policy choices, including baseline selection, treatment of uncertainty, and long-term permanence obligations. This chapter outlines the key methodological options relevant to forest-based carbon activities and clarifies where government decisions are required, linking technical approaches directly to their policy and market implications.

While Brunei Darussalam's forests (e.g. Belait peat swamp) hold substantial potential for climate mitigation, ecological value alone does not guarantee eligibility for participation in international carbon markets. Forest carbon projects must comply with rigorous technical, legal, and governance requirements established under multilateral frameworks and voluntary standards. This chapter assesses whether the Belait Peat Swamp Forest meets these eligibility criteria and identifies the adjustments required to ensure credibility, environmental integrity, and market acceptance.

It evaluates the Belait Peat Swamp Forest's eligibility by examining forest conditions, historical land-use dynamics, data availability, institutional arrangements, and exposure to environmental and market risks. It also considers the applicability of existing carbon accounting methodologies, including the use of non-local allometric models and proxy datasets where local data are limited.

The chapter further draws on comparative case studies from the region to identify practical lessons, common pitfalls, and design choices relevant to Brunei's context. By doing so, it provides a structured basis for determining whether the Belait Peat Swamp Forest can generate high-integrity carbon credits and what policy, technical, and institutional actions are required to move from conceptual readiness to project implementation.

Ideally, a carbon trading scheme should provide economic incentives for the efficient and effective reduction of emissions, while simultaneously serving as part of a sustainable conservation financing portfolio, such as carbon finance from REDD and voluntary carbon market, payments for environmental services, and similar mechanisms. According to the Conservation Finance Alliance, conservation finance or biodiversity finance is defined as 'mechanisms and strategies that generate, manage and deploy financial resources and align incentives to achieve nature conservation outcomes' (Conservation Finance Alliance, n.d.). The potential for financing through carbon trading presents an opportunity to develop innovative and sustainable approaches. Brunei has launched the Brunei National Climate Change Policy (BNCCP), which outlines ten key strategies to guide the country toward becoming a low-carbon and climate-resilient nation. As part of this policy, Brunei plans to implement a carbon pricing mechanism to serve as a tool for reducing greenhouse gas emissions.

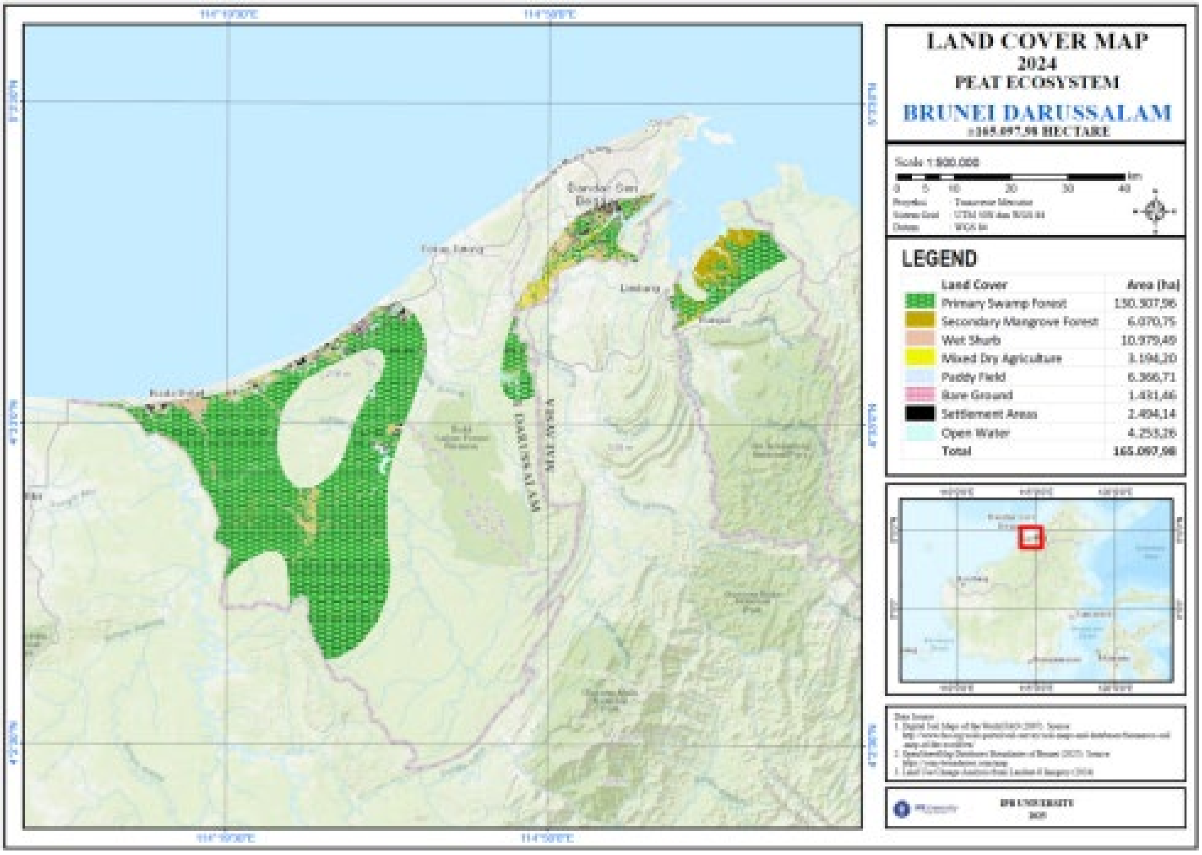
Carbon pricing refers to the process of assigning a monetary value to greenhouse gas emissions, typically expressed as a cost per metric ton of carbon dioxide equivalent (tCO_2e). This economic tool is designed to internalise the environmental and social costs of carbon emissions, thereby encouraging emitters to reduce emissions and invest in cleaner technologies.

The concept of carbon pricing arises from the economic principle of internalising externalities – costs or benefits not reflected in market prices. Greenhouse gas emissions contribute significantly to climate change, but their true environmental and social costs, such as health impacts, biodiversity loss, and damage to infrastructure from extreme weather events, are not directly borne by the polluters (Stern, 2007). Carbon pricing aims to correct this market failure by attaching a cost to emissions, thereby incentivising emitters to reduce their carbon footprint and encouraging investment in cleaner technologies (UNFCCC, n.d.).

Brunei Darussalam is currently in the early stages of establishing a carbon market mechanism and international emission trading pathways leveraging the nature-based solutions available within its jurisdiction. Initially focusing on the forestry sector, this initiative aims to implement a pilot project that will generate credits through a voluntary carbon market in preparation for the forthcoming application of the carbon pricing framework. In line with these objectives, the acquisition of accurate baseline data on the country's existing carbon stock is essential. This baseline data will serve as a key foundation for assessing the feasibility of implementing forest carbon projects within Brunei Darussalam.

In this context, the Government of Brunei Darussalam is preparing a National Forest Inventory, with a primary focus on carbon stock assessment in the Belait Peat Swamp Forest, which has been designated as a pilot project area. This inventory will update previous data, and the Forest Management Plan will subsequently be reviewed, validated, and enhanced for multipurpose use by the Brunei Forestry Department. Brunei has exotic natural beauty. The country's total land area is approximately 165,000 hectares, with around 78% consisting of primary peatland and 4% being secondary mangrove areas. Peatland and mangrove ecosystems are highly attractive for global carbon-related businesses. Given this type of land cover, the most crucial aspect in the context of climate change is protecting peatlands and mangroves from deforestation and forest degradation threats (Figure 3.1).

Figure 3.1. Land Cover Brunei Darussalam, 2024



Source: ERIA study team, 2025.

In carbon stock accounting, it is crucial to incorporate emission reductions from various ecosystems, including peat swamp forests. Peat swamp forest ecosystems and peat soil management play a critical role in sequestering atmospheric carbon and storing it over long periods within both aboveground biomass and deep peat layers. In line with the development and climate mitigation strategy of the Government of Brunei Darussalam, this study compares carbon stock estimations against a 30-year baseline, providing long-term insights into how changes in peat swamp ecosystems influence carbon dynamics and greenhouse gas emissions. Therefore, the estimation of biomass and carbon is vital for conservation purposes and has become a central issue of global environmental concern.

This chapter is designed to achieve the following objectives:

1. To analyse the land cover changes and suitability potential for additional carbon credit generation through avoided deforestation and degradation activities, from ongoing or failed projects.
2. To analyse potential emissions coming from deforestation, degradation, and peat composition and propose mitigation options.
3. To identify key factors influencing project profitability.
4. To evaluate the economic value of carbon over the next 30 years, based on projected emission reductions and carbon market valuations.

3.2. Carbon Sequestration and Carbon Credit Programmes

3.2.1. Carbon Sequestration

The Intergovernmental Panel on Climate Change (IPCC) in 2018 identified carbon sequestration technologies as one of the key strategies to limit carbon dioxide emissions (IPCC, 2018). Carbon sequestration refers to the process of capturing, securing, and storing CO_2 from the atmosphere, stabilising it in either solid or dissolved forms (CLEAR Center, 2019). Naturally, the oceans and forests play a crucial role in this process, each absorbing approximately 25% of carbon dioxide emitted by human activities every year. Additionally, soils, grasslands, and geological formations act as natural carbon sinks. Beyond natural systems, carbon can also be captured directly from industrial sources through technologies like direct air capture and engineered molecules (CLEAR Center, n.d.). These approaches are essential for mitigating the impacts of global warming, ocean acidification, and broader climate change.

To support carbon sequestration initiatives, carbon credit programmes have been introduced as market-based solutions. Carbon credits allow entities to offset their carbon emissions by purchasing credits representing verified emissions reductions achieved by another party (Thompson and Miranda, 2021). Each carbon credit is equivalent to one metric ton of carbon dioxide emissions (Ollendyke, 2023). For instance, an airline might buy credits from an agricultural company that adopts carbon-friendly land management practices. This mutually beneficial arrangement enables buyers to meet their emissions goals cost-effectively while providing sellers with financial resources to expand environmental projects. Organisations aiming to sell carbon credits can select from various sequestration techniques. Despite projections estimating the carbon credit market could reach US$50 billion by 2030, questions about the system's credibility remain (Blaufelder et al., 2021). Critics argue that carbon credit programmes may allow companies to continue emitting greenhouse gases while creating a misleading environmentally friendly image (Thompson and Miranda, 2021).

As carbon emissions continue to degrade ecosystems and human well-being, researchers have explored a range of strategies to mitigate their effects and restore the environment. Many of these approaches are compatible with carbon crediting programmes. Engineered solutions, such as on-site carbon capture at power plants, are under development as ways to reduce emissions, though they are often costly and complex to deploy at scale (Herzog and Golomb, 2004). These technological options, while valuable, face limitations in accessibility and affordability, particularly for developing economies.

In response, Nature-based Solutions (NbS) have gained increasing attention as a flexible and cost-effective alternative. NbS work by enhancing and leveraging existing natural ecosystems to mitigate climate impacts while delivering additional environmental and social benefits. Activities such as reforestation, mangrove restoration, and wetland conservation not only sequester carbon but also support biodiversity, improve water quality, and strengthen community livelihoods (Soanes et al., 2023). Compared to engineered solutions, NbS are typically more adaptable to diverse landscapes and can be integrated more easily into local land-use practices.

Consequently, the combined use of technological innovations and Nature-based Solutions offers a comprehensive pathway for addressing climate change, particularly by enabling significant emission reductions across sectors.

The effective implementation of REDD+ (Reducing Emissions from Deforestation and Forest Degradation) at the national level is highly dependent on its success at the sub-national level, where provinces and districts serve as key governance units for coordinating emission reductions and aligning with global deforestation-free supply chain commitments (Boyd et al., 2018). The jurisdictional approach (JA) is widely favored at this level at the sub-national level, such as provinces and districts, due to the proximity of local governments to land users and their authority over land-use decisions. In large, diverse countries like Indonesia, implementing JA nationally would be costly and less responsive to local conditions. Sub-national governments, being closer to farmers and communities, are better positioned to manage land use effectively (Stickler et al., 2014). JA also promotes collaboration amongst stakeholders, enhances accountability, and supports comprehensive landscape management. It shifts carbon accounting from isolated projects to entire jurisdictions, helping to mitigate risks like displacement and reversals while encouraging private sector engagement and long-term sustainable land-use planning.

In the context of Brunei Darussalam, the jurisdictional approach aligns closely with the country's climate governance framework, particularly the Directive on Mandatory Reporting on Greenhouse Gases issued under the authority of the Prime Minister's Office Brunei Darussalam and implemented by the Department of Environment, Parks and Recreation (JASTRe). This approach fosters collaboration amongst government agencies, private sector entities, and local stakeholders, thereby enhancing transparency and accountability across sectors in line with national reporting obligations and international climate transparency standards (Government of Brunei Darussalam, 2020). By shifting carbon accounting from isolated project initiatives to a framework that covers entire jurisdictions, Brunei can better manage risks such as emissions displacement and reversal. It also supports integrated landscape management by integrating land-use planning across sectors and spatial scales. This approach reduces regulatory uncertainty and aligns public and private incentives, thereby encouraging sustained private sector engagement in long-term and environmentally responsible land-use planning. Collectively, these governance and investment dynamics constitute essential components for achieving Brunei Darussalam's national climate targets and for ensuring credible and consistent implementation of its commitments under the Paris Agreement.

In Indonesia, East Kalimantan Province exemplifies this approach. This province was selected in 2011 for the Forest Carbon Partnership Facility (FCPF) Carbon Fund as Indonesia's first jurisdictional REDD+ programme. Covering 12.7 million hectares – 54%

of which remains forested – the programme addresses deforestation through governance reforms, corporate and community engagement, and sustainable land management. It includes four main components: forest and land governance, improved supervision, reducing degradation in licensed areas, and promoting sustainable alternatives. Initially, REDD+ was not well understood in Indonesia, prompting the establishment of a REDD+ Working Group in East Kalimantan in 2010. However, due to limited influence, the Provincial Council on Climate Change was formed in 2011, chaired by the Governor and composed of stakeholders from NGOs, government agencies, and academia. This council plays a crucial role in harmonising national and provincial climate policies, ensuring coordinated and effective REDD+ implementation.

At least five elements are required in developing the Emissions Reduction programme for East Kalimantan. These elements are also required for the foundation of the REDD+ programme. The elements are as follows: a) Safeguards, b) Benefit-sharing mechanism, c) Carbon Accounting (MRV), d) Emission Reduction (ER) title, and e) Programme Design. Each element was led by a team chaired by the specialist(s). The role of each team can be seen in Table 3.1.

The Emission Reduction (ER) Program in East Kalimantan aims to achieve gross emission reductions of 86.3 million tCO_2eq over 5 years (2020–2024), with nearly half expected from reduced deforestation in estate crop areas. These reductions are recorded in the National Registry System, managed alongside the national MRV system by the Ministry of Environment. The programme covers the entire East Kalimantan Province, including seven districts, three cities, 103 sub-districts, and 1,038 villages (BPS, 2020), extending beyond state forest areas. Developed through a participatory process, the programme involved consultations with the Government of Indonesia and development partners, followed by stakeholder workshops and focus group discussions. The ER-Program Idea Note (ER-PIN) was approved in 2016, and East Kalimantan was selected for the Carbon Fund pipeline. The Emission Reduction Program Document (ERPD), developed between July 2017 and June 2019, underwent extensive stakeholder engagement and technical input.

Table 3.1. Elements in the ER Programme

Team	Role	Output
Safeguards	To ensure the programme addresses environmental and social risks towards proposed ER activities	SESA; ESMF; ESMP;IPPF; RFP
Benefit Sharing Plan (BSP)	To ensure the benefits received by beneficiaries	BSP
Measurement, Reporting, Verification (MRV): • Carbon Accounting • Non-Carbon Accounting	To calculate the emissions reduction achieved by the programme in period of implementation year To ensure no double accounting in the programme area	Carbon Calculation in ton CO2eq per year
Carbon Title (Lawyer)	To ensure no overlap of the Carbon right	Legal framework for ER Title
Programme Design	To develop and design programme activities in relation to reduce emissions	-

Note:
SESA = Social Environmental Safeguards Assessment; ESMF = Environmental and Social Management Framework; ESMP = Environmental and Social Management Plan; IPPF = Indigenous People Policy Framework; RFP = Resettlement framework Policy; BSP = Benefit Sharing Plan.
Source: ERIA study team, 2025.

The ERPD development included consultations with key sectors and stakeholders to define priority areas and address drivers of deforestation and degradation. Focus group discussions in November 2017 helped shape the programme's activities and benefit-sharing mechanisms. The World Bank conducted three rounds of reviews in 2018, offering technical guidance and requesting additional data, particularly on carbon accounting and Reduced Impact Logging in secondary forests. Despite data limitations, the East Kalimantan team submitted the ERPD for the first Technical Advisory Panel (TAP) assessment in June 2018. The TAP review highlighted areas for improvement, including refining forest degradation definitions, recalculating baseline emissions, and enhancing safeguards and emission rights (ER titles). These recommendations were incorporated into subsequent drafts. By late 2018, the revised ERPD was submitted to the World Bank and reviewed by Carbon Fund country members. After further revisions and clarifications, the final draft was presented at the 19th Carbon Fund meeting in February 2019 and conditionally accepted. The Government of Indonesia addressed the conditions, and the 9th draft was approved on 28 June 2019. This approval led to the negotiation and signing of the Emission Reduction Payment Agreement (ERPA) during COP UNFCCC 25 in December 2019. The ER Programme's first reporting period (June 2019–December 2020) verified 35 million tCO_2eq in emission reductions, with 22 million purchased under ERPA. An advance payment of US$20.9 million was made in November 2022 to test the benefit-sharing mechanism, with the remaining US$89.1 million scheduled for distribution before the programme concludes on 31 December 2025.

3.2.2. Carbon Pricing Under Paris Agreements

Carbon credit programmes have the potential to play a pivotal role in incentivising both types of initiatives by providing financial returns for verified emissions reductions. Although concerns over market integrity and effectiveness persist, the establishment of transparent, accountable, and environmentally rigorous carbon markets will be essential for ensuring that carbon credit systems contribute meaningfully to global emissions reduction goals while supporting sustainable development and ecosystem restoration.

The Paris Agreement introduced a transformative framework for international climate cooperation, notably through Article 6, which facilitates both market-based and non-market-based mechanisms to help countries achieve their Nationally Determined Contributions (NDC). Article 6.2 establishes the groundwork for countries to trade emission reductions with each other through Internationally Transferred Mitigation Outcomes (ITMOs). This mechanism allows nations with lower-cost abatement opportunities – such as those rich in forest carbon stocks – to sell emissions reductions to countries facing higher marginal abatement costs. To ensure environmental integrity and maintain international mitigation credibility, the system mandates transparency, robust accounting rules, and safeguards against double counting (UNFCCC, 2015).

Table 3.2. Carbon Pricing Mechanism under Article 6

Article	Mechanism Type	Description	Key Features
6.2	Market-based (ITMOs)	Allows bilateral or multilateral transfer of emission reductions between countries, known as ITMOs.	- Based on country-to-country cooperation. - Requires robust accounting and reporting. - Must avoid double counting.
6.4	UN-supervised Global Market	Establishes a centralised carbon crediting mechanism, functioning under UNFCCC oversight,	- Successor to Clean Development Mechanism (CDM).

Article	Mechanism Type	Description	Key Features
		and open to public and private entities.	- Generates certified emission reductions (CERs). - Includes sustainable development co-benefits.
6.8	Non-market approaches	Supports voluntary cooperation on climate action outside of carbon markets, including finance, technology transfer, and capacity building.	- Focuses on adaptation, resilience, and holistic development. - No trading or sale of emissions units involved.

Source: World Bank, 2023.

In addition to Article 6.2, Article 6.4 creates a centralised, UNFCCC-supervised global carbon market, envisioned as the successor to the Kyoto Protocol's Clean Development Mechanism (CDM). This mechanism permits both public and private actors to implement emission reduction projects in host countries, generating certified carbon credits that can be sold internationally. A distinguishing aspect of Article 6.4 is its explicit requirement for projects to support not only climate mitigation but also broader sustainable development goals. For countries endowed with extensive forest resources, such as Brunei, this provision presents an opportunity to monetise conservation and reforestation initiatives by generating high-integrity, tradable carbon credits (UNFCCC, 2015; World Bank, 2023).

Meanwhile, Article 6.8 introduces a framework for non-market approaches, emphasising voluntary cooperation in areas such as climate finance, technology transfer, and capacity building. This pathway is particularly relevant for developing countries that may not yet be prepared to engage in carbon markets but wish to participate in collaborative climate actions. Non-market mechanisms also recognise the importance of holistic adaptation and mitigation measures that, while not easily tradable, are vital for achieving long-term climate resilience, social equity, and sustainable development outcomes (UNFCCC, 2015).

Collectively, the three components of Article 6 create a flexible yet rigorous framework for scaling up global climate action through both market-based and non-market-based pathways. These mechanisms enable countries to engage in carbon pricing systems that either generate financial flows through carbon markets or support structural transformation and institutional strengthening. For nations with substantial natural carbon sinks and nature-based solutions – like forest ecosystems – Article 6 represents a strategic entry point into the global carbon economy, provided that supportive institutional, legal, and policy infrastructures are in place to operationalise these mechanisms effectively.

Within this context, carbon pricing emerges as a pivotal solution for mitigating greenhouse gas emissions and promoting sustainable land management. By assigning financial value to the carbon sequestration services provided by forests, carbon pricing mechanisms create economic incentives for conservation and sustainable forest use. Initiatives such as REDD+, voluntary carbon markets, and compliance-based trading schemes enable forest stakeholders to generate revenue while contributing to global climate goals. Recognising forests as essential assets in the global carbon economy ensures that emission reduction targets are achieved more cost-effectively, while simultaneously promoting biodiversity, protecting livelihoods, and integrating natural climate solutions into broader economic and policy frameworks.

3.2.3. Carbon Pricing Approaches in the Forest Sector

The forest sector occupies a pivotal position in the global climate policy landscape due to its dual role as a major carbon sink and a source of emissions through deforestation and degradation. As a result, it has become central to emerging carbon pricing mechanisms designed to mitigate climate change. Forest-based carbon pricing is increasingly being implemented through both market-based mechanisms (compliance and voluntary markets) and non-market incentives such as results-based financing. Result-Based Financing (RBF) is a fund or financing that is only provided after the recipient, for example a government, organisation, or community, has succeeded in achieving previously agreed results, such as reducing carbon emissions, increasing forest cover, or conserving biodiversity. According to the World Bank, results-based financing includes a range of financing mechanisms where financing is linked and provided after the delivery of pre-agreed and verified results (GPRBA, n.d.). The evolution of forest carbon pricing reflects broader trends in global carbon governance, particularly under frameworks such as REDD+ and Article 6 of the Paris Agreement.

a. REDD+: Foundations of Forest Carbon Pricing

The emergence of REDD+ (Reducing Emissions from Deforestation and Forest Degradation, and the role of conservation, sustainable forest management, and enhancement of forest carbon stocks) represents a pivotal advancement in climate finance within the forest sector. Developed under the UNFCCC, REDD+ is structured as a three-phase mechanism – readiness, implementation, and results-based payments – linking forest conservation to performance-based incentives for verified emission reductions (UNFCCC, 2011).

Recognising that deforestation and forest degradation contribute approximately 10–15% of global greenhouse gas emissions, particularly in tropical regions (IPCC, 2014), REDD+ integrates climate mitigation objectives with broader socio-economic development goals. Supported by multilateral initiatives such as the Forest Carbon Partnership Facility and the UN-REDD Programme, REDD+ has evolved from a readiness-focused framework toward results-based finance and increasing interaction with carbon market mechanisms under the Paris Agreement (UNFCCC, 2015).

Despite persistent challenges related to permanence, leakage, and land tenure (Angelsen et al., 2018), REDD+ has driven significant innovations in satellite-based monitoring, carbon accounting, and forest reference emission level setting, strengthening its position as one of the most promising frameworks for aligning large-scale forest conservation with international climate finance.

Nepal's REDD+ framework was developed during the readiness phase (2008–2015) with support from the FCPF, establishing key elements such as national strategies, safeguards, community engagement, and a forest monitoring system. The Emission Reductions Program Document (ERPD), approved in 2019, targets the Terai Arc Landscape and addresses deforestation drivers like unsustainable fuelwood use and illegal logging (MoFE, 2018; FCPF, 2019). Instead of carbon taxes or trading systems, Nepal utilises results-based carbon finance, with the World Bank's Carbon Fund committing to purchase up to 9 million tons of CO_2 equivalent at US$5 per ton, potentially yielding US$45 million over 5 years (Chaudhary and Babu, 2025; World Bank, 2021). This mechanism relies on rigorous MRV systems supported by tools like SERVIR-Himalaya and GIS. Insights from pilot projects (2009–2013) shaped Nepal's National REDD+ Strategy (2018–2030) and led to the 2020 Emission Reductions Purchase Agreement (ERPA). Key drivers behind Nepal's REDD+ adoption include its community forestry institutions, high forest cover, lack of a domestic carbon market, and support from partners like the UN-REDD Program and donors such as Norway and Finland. Despite ongoing challenges in equitable benefit-sharing and MRV transparency, Nepal's REDD+ approach offers a replicable model for other forest-rich, low-income nations.

b. Compliance Market Integration of Forest Carbon

The integration of forest carbon credit into compliance carbon markets provides companies with greater flexibility in meeting emission reduction targets while reducing overall compliance costs. These markets, established through mechanisms like emissions trading systems (ETS) or carbon taxes, allow regulated entities to use verified carbon offsets – such as those from forestry projects – within set limits. Notable examples include programmes like California's Cap-and-Trade and New Zealand's ETS, which incorporate forest-based offsets under strict protocols to ensure permanence, transparency, and environmental integrity. At the international level, Article 6.4 of the Paris Agreement aims to expand the role of forest carbon credits in global compliance markets, though operational rules are still being finalised to address concerns like double counting and corresponding adjustments. Despite their potential, forestry offsets remain controversial due to risks of undermining direct emission reductions and uncertainties around long-term carbon storage. As a result, many systems impose usage caps and apply discount factors. Nevertheless, when rigorously designed and monitored, forest carbon credits can channel essential funding into conservation and reforestation, with future improvements in monitoring, accounting, and standardisation expected to enhance their credibility and alignment with national climate goals.

In developed economies, forest carbon pricing is integrated into broader ETS, supported by sophisticated MRV mechanisms and robust regulatory frameworks. Several developed countries have integrated forestry into their national or subnational ETS, recognising forests as a key component of their carbon pricing strategies. New Zealand is a leading example, having incorporated forestry into its ETS since its inception in 2008. Landowners can earn New Zealand Units (NZUs) by increasing forest carbon stocks through afforestation or sustainable forest management, underpinned by the Climate Change Response Act 2002 (Ministry for the Environment, 2021).

California, a U.S. state with one of the most advanced subnational carbon markets, includes forest offset protocols within its Cap-and-Trade Program, allowing regulated entities to use credits generated from forest conservation and improved management projects (California Air Resources Board, n.d.). South Korea has developed forestry-based offset methodologies that are eligible for compliance in its carbon market under the Korea Offset Program, even though forestry is not yet directly integrated into its ETS (ICAP, 2023). Similarly, Switzerland permits the use of domestic and international forest-based offsets to meet part of its compliance obligations under its ETS, though subject to stringent eligibility criteria (ICAP, n.d.). In the European Union (EU), forest carbon is not directly priced in the EU ETS yet, but some countries like Finland and Sweden are looking into including land use, land-use change, and forestry (LULUCF) in additional climate policies and voluntary carbon programmes related to ETS frameworks.

c. Voluntary Carbon Markets and Private Sector Leadership

The voluntary carbon market (VCM) has emerged as a vital mechanism for channelling private sector finance into climate mitigation, particularly in the forest sector, which offers significant carbon sequestration potential. Unlike compliance markets governed by legal mandates, the VCM allows corporations, institutions, and individuals to voluntarily purchase carbon credits from certified projects that reduce or remove greenhouse gas emissions. Forest-based initiatives – such as afforestation, reforestation, avoided deforestation, improved forest management, and agroforestry – have become especially prominent, accounting for over 40% of global credits issued in recent years. These projects not only offer cost-effective carbon abatement but also deliver co-benefits like biodiversity conservation, watershed protection, and rural development, aligning with ESG and SDG goals.

To ensure credibility, the VCM relies on independent standards like Verra's Verified Carbon Standard (VCS) and the Gold Standard, which provide rigorous methodologies and emphasise social and environmental integrity. Corporate interest has surged, with major firms like Microsoft, Amazon, and Unilever investing in high-quality forest credits, pushing the market's value beyond US$2 billion in 2022. However, challenges such as additionality, permanence, and over-crediting persist, prompting the establishment of initiatives like the Integrity Council for the Voluntary Carbon Market (ICVCM) and the Voluntary Carbon Markets Integrity Initiative (VCMI) to enhance transparency and trust. As Article 6.4 of the Paris Agreement evolves, integrating voluntary credits into national accounting systems could further legitimise the VCM and strengthen its role in global climate policy.

d. Public Forest Ownership and Implications for Forest Carbon Pricing

In jurisdictions where forest land is predominantly publicly owned, the state plays a central role in governing, managing, and monetising forest carbon, creating both opportunities and challenges for applying carbon pricing mechanisms such as REDD+, jurisdictional crediting, and participation in compliance and voluntary carbon markets. Public ownership enables governments to implement large-scale emission reduction strategies, set national reference levels, and receive results-based payments, aligning forest-sector actions with national climate goals under the Paris Agreement, particularly through Articles 6.2 and 6.4.

In voluntary markets, the state or a designated public entity often acts as the project developer or authorising body, certifying projects under standards like Verra's VCS or the Gold Standard. However, this concentration of authority raises governance concerns, including carbon rights, revenue transparency, and potential conflicts of interest. Moreover, even in publicly owned forests, indigenous and local communities often hold customary rights, making it essential to uphold principles such as Free, Prior, and Informed Consent (FPIC), benefit-sharing, and inclusive stakeholder engagement. While public ownership offers advantages in centralised decision-making and jurisdictional coordination, it requires strong institutional capacity to ensure transparency, accountability, and social legitimacy. When effectively governed, public forest ownership can support a high-integrity, nationally coordinated approach to forest-based carbon finance that contributes meaningfully to global climate mitigation efforts.

e. Project-Based Mechanisms

Project-based mechanisms have become a cornerstone of carbon pricing strategies in the forest sector by enabling the measurement, certification, and verification of carbon benefits from specific interventions such as afforestation, reforestation, and improved forest management (IFM), which then generate tradable carbon credits for voluntary or, in some cases, compliance markets. These approaches not only incentivise forest conservation and restoration but also integrate nature-based solutions into broader climate mitigation efforts. Afforestation and reforestation sequester atmospheric carbon by establishing or restoring tree cover, while IFM enhances carbon storage in existing forests through sustainable practices like reduced-impact logging and fire prevention.

Most forest carbon projects are certified under voluntary market standards such as Verra's Verified Carbon Standard (VCS), the Gold Standard, and ART-TREES, each offering rigorous methodologies and safeguards to ensure environmental integrity and social co-benefits. VCS emphasises measurable and durable carbon outcomes with third-party validation and risk buffers, while the Gold Standard prioritises sustainable development impacts aligned with the SDGs. ART-TREES, meanwhile, supports jurisdictional-scale REDD+ efforts by aligning carbon accounting with national systems and satellite monitoring. Together, these standards form the operational backbone of forest carbon markets, with their effectiveness hinging on credible certification, transparent governance, and adaptability to evolving climate policies and scientific advancements.

3.2.4. Factors of Carbon Price Determination

The determination of carbon prices – whether in compliance or voluntary markets – depends on a range of environmental, economic, and policy-based factors. Central to this valuation is the carbon sequestration potential, typically measured in tons of carbon dioxide equivalents per hectare per year (tCO_2e/ha/year). This potential varies significantly across project types and ecosystems. For example, afforestation and reforestation projects in tropical zones can sequester over 10 tCO_2e/ha/year, while grassland restoration may sequester less than 2 tCO_2e/ha/year (Griscom et al., 2017). As such, sequestration potential serves as a foundational metric for estimating the supply of credits and, ultimately, the baseline for price formation.

Beyond ecological performance, carbon prices are also shaped by the cost structure of carbon project development. These include upfront costs such as feasibility assessments, stakeholder consultations, and project design document (PDD) preparation. Additionally, transaction and MRV costs introduce significant variation, particularly in remote or technically challenging project areas. MRV costs can represent up to 20–30% of total project costs in community-based forest management or improved cookstove initiatives. As the carbon market matures, efforts to standardise digital MRV systems may reduce such costs and improve price stability (Broekhoff et al., 2019).

In Tanzania, total costs per carbon credit – including implementation (US$4.5–12.2), transaction (US$0.21–1.46), and institutional costs (US$0.06–0.11) – amount to approximately US$4.8 to 13.8 per tCO_2 (Merger et al., 2012).

Furthermore, risk adjustments play a critical role in carbon price modeling. To deal with the possibility of credits not lasting or not being delivered, many standards – like Verra's Verified Carbon Standard – ask for a permanence buffer, which means setting aside a portion of credits (usually 10–20%) to protect against losses from things like fires, pest problems, or illegal logging. Similarly, some buyers impose non-delivery penalties, which reduce the value of credits in high-risk regions. For example, Nepal's Terai Arc Landscape REDD+ programme allocates 23% of total emission reductions – about 7.9 $MtCO_2e$ – as buffer credits. This risk adjustment ensures credit integrity against non-permanence threats like fires or illegal logging (MoFE, 2020). Policy and political risks also influence carbon prices: countries with unstable regulatory frameworks or weak governance may experience reduced buyer confidence, leading to price discounts or higher buffer requirements. Conversely, jurisdictions with robust national frameworks and legal recognition of carbon rights often see higher project valuations (World Bank, 2023).

Lastly, carbon pricing increasingly incorporates socio-economic co-benefits into project valuation. Projects that contribute to biodiversity conservation, indigenous land rights, poverty reduction, or gender equity may attract price premiums in voluntary carbon markets (Goldstein et al., 2018). A notable example is the Alto Mayo REDD+ Project in Peru, implemented by Conservation International in collaboration with local communities and the Peruvian government. This project protects over 182,000 hectares of tropical forest and has generated verified emissions reductions while simultaneously delivering socio-economic benefits. It supports sustainable coffee farming, empowers women through training programmes, enhances indigenous land rights, and promotes environmental education. These co-benefits have increased the project's credibility and attractiveness in the voluntary carbon market, allowing it to command premium prices for its carbon credits due to its alignment with multiple Sustainable Development Goals (Conservation International, 2021). This illustrates how carbon projects that integrate social and environmental objectives can maximise both climate and development outcomes.

Another aspect of carbon pricing depends on the assessment institutions, such as Gold Standard, Fairatmos, and the Indonesian Carbon Exchange (ICX), which determine its elements. These elements can help buyers make informed decisions about which carbon credits to purchase. By supporting high-quality projects, companies and individuals can offset their emissions and contribute to efforts to combat climate change. Those elements are based on the institution it; they can be seen in Table 3.3.

Table 3.3. Elements that can Influence Carbon Prices based on the Institution

No	Institution		
	Gold Standard	Fairatmos	ICX
1	Value of beyond-carbon benefits Projects like clean cookstoves offer direct health and social benefits, making them more valuable than large-scale wind farms that mainly reduce emissions.	Project Quality High-quality projects produce more valuable credits. Quality depends on: o Whether the emission reduction wouldn't happen without the project (additionality). o Whether emissions aren't just shifted elsewhere (leakage).	Ecological value of the project: For example, the presence of rare species or unique ecosystems can increase the project's worth.

No	Institution		
	Gold Standard	Fairatmos	ICX
		o Social and environmental benefits	
2	Size and location of the project Small projects often have high social impact but lower carbon volumes and higher costs. Remote or conflict-prone areas also raise project costs and prices.	Project Vintage o Vintage refers to the year the emission reduction happened. o Newer credits often cost more due to updated standards. o Older credits can still be valuable if verified properly	Financial backing: The more investors are interested, the higher the potential price of the carbon credits.
3	Project vintage Older credits can still be valuable if verified properly. Avoiding them may unfairly penalise early project developers.	Market Demand o The more companies want to offset emissions, the higher the demand. o High demand for quality credits can push prices up.	Project location: A project with reicher biodiversity may be priced higher than another.
4	Differences in emission reduction methodologies Prices can vary within the same project type and this can often be related to the methodology used for the project.	Co-benefits Additional benefits such as conservation of biodiversity and community development	
5	Quality of the project High-quality projects – those with strong community involvement, transparency, and third-party verification – are priced higher.		
6	Economies of scale and good communications		

No	Institution		
	Gold Standard	Fairatmos	ICX
	Bulk purchases may get discounts. Projects with strong visuals and narratives (photos, impact stories) attract premium buyers.		
7.	Transparency in pricing Because carbon prices aren't always disclosed, platforms like Ecosystem Marketplace help track trends. More transparency can boost trust and funding.		

Source: ERIA study team, 2025.

Below are some examples of carbon pricing in Indonesia and Malaysia, as shown in Table 3.4. These differences may arise from differing approaches to carbon valuation. For example, in determining the social cost of carbon, restoration and deforestation are considered, as well as the hybrid REDD+ model, which combines conservation, restoration, and institutional strengthening. Meanwhile, in Indonesia, there is a buyer from Switzerland, named Mercuria. Mercuria's pricing strategy considers premium project quality, meeting the Verra (VCS) or Gold Standard, and achieving a net-zero goal with a voluntary market. The price from this institution is higher in Indonesia than in the domestic carbon market in Indonesia.

Table 3.4. Carbon Price Reference from Indonesia dan Malaysia

Country	Carbon Price (USD/tCO_2e)	Mechanisms	Market Status
Indonesia	6 – 9.5	IDXCarbon, SRN-PPI	Active
Indonesia	30 – 45	Mercuria, Switzerland (buyer)	Not Active
Malaysia	10.5 – 11	Bursa Carbon Exchange (BCX)	Active
Malaysia	23 – 64	Social Cost of Carbon	Not Active

Source: ERIA study team, 2025.

The carbon market and the social cost of carbon represent two distinct approaches, while private sector actors such as Mercuria play a commercial role in implementing carbon-related strategies. Understanding the differences between these concepts is essential for shaping effective climate policies and promoting sustainable development.

A carbon market is a trading system where governments, companies, and organisations buy and sell carbon credits. These credits represent either the right to emit a certain amount of greenhouse gases or the offset of emissions through verified environmental actions such as reforestation or renewable energy projects. The purpose of carbon markets is to regulate emissions and encourage reductions through market-based mechanisms. Prices are determined by supply and demand and are influenced by policy frameworks and economic conditions. Examples of carbon markets include the European Union Emissions Trading System and the Voluntary Carbon Market (World Bank, 2023).

In contrast, the social cost of carbon is an economic estimate of the long-term damage caused by emitting one additional ton of carbon dioxide into the atmosphere. It accounts for impacts on public health, agriculture, infrastructure, and ecosystems. This value is used to inform climate policy, carbon pricing, and cost-benefit analyses, and is calculated using integrated assessment models rather than market dynamics (Molocchi and Mela, 2024). Meanwhile, Mercuria Energy Group is a global commodities trading company that actively participates in carbon markets. Unlike the previous two concepts, Mercuria is a private sector entity that trades carbon credits, invests in low-carbon projects, and offers offset solutions. Its role is commercial, aiming to support the energy transition while generating profit, and it is one of the key players shaping both voluntary and compliance-based carbon markets (Mercuria Energy Group Ltd, 2025).

3.2. Proposed Model for Brunei Forest Carbon Pricing

Brunei Darussalam has increasingly recognised the critical role of forest carbon initiatives in its national climate strategy. Given that forests cover approximately 72.1% of the country's land area, much of which comprises tropical rainforest ecosystems, the nation possesses substantial natural carbon sinks capable of sequestering significant amounts of atmospheric CO_2 (AFoCO, 2023). These forested landscapes are not only biodiversity reservoirs but also serve as vital buffers against climate-induced ecosystem degradation.

Brunei Darussalam has one of the highest per capita rates of fossil fuel consumption globally, estimated at approximately 103,268 kilowatt-hours per person in 2021, with fossil fuels comprising nearly 100% of the national energy mix (CEIC, 2024). This intensive reliance contributes to elevated per capita CO_2 emissions, placing Brunei amongst the world's highest emitters on a per-person basis (IEA, 2023). Introducing a carbon pricing mechanism could help internalise these environmental costs, promote energy diversification, and align national development with global climate goals.

In alignment with its NDC under the Paris Agreement, Brunei has initiated a suite of forest-based mitigation actions with a strong emphasis on carbon sequestration through reforestation and afforestation programmes. A flagship initiative is the government's commitment to plant 500,000 new trees by 2035, which is designed to both restore degraded lands and enhance the country's carbon absorption capacity (AFoCO, 2023). This initiative is integrated into Brunei's Low Emissions Development Strategy and reflects a shift toward nature-based solutions as a cost-effective, scalable approach to emissions mitigation.

These projects focused on forest carbon development are supported by the establishment of MRV frameworks, which are currently in developmental stages but aim to incorporate satellite imagery and geospatial analysis tools. Although Brunei does not yet participate in international carbon credit markets such as REDD+ or voluntary carbon standards like Verra, these foundational activities indicate potential readiness for future engagement. Forest carbon initiatives are viewed not only as environmental imperatives, but also as strategic development investments that co-deliver climate resilience, ecosystem services, and green economy transitions. Moreover, Brunei's participation in regional initiatives – such as the ASEAN Working Group on Forests and Climate Change – demonstrates its intent to build institutional and technical capacity for long-term forest carbon governance. These cooperative frameworks could serve as platforms for accessing international finance mechanisms and integrating Brunei into broader jurisdictional carbon accounting systems.

Table 3.5. Contextual Summary of Brunei's Carbon Profile

Key Context	Implication
High forest cover (72.1%)	Significant carbon sequestration potential
High per capita CO_2 emissions	Due to fossil fuel-based economy and limited diversification
No existing carbon tax or ETS	Relies on voluntary and results-based forest carbon projects
Ongoing forest mitigation efforts	500,000-tree reforestation target by 2035; development of MRV systems and forest-based mitigation strategies.
Small, export-dependent economy	Needs pricing model that avoids disruption but ensures climate finance access
High-income status (GDP per capita > US$30,000)	Indicates fiscal capacity for implementing carbon pricing; supports absorptive capacity for green reform.

Source: ERIA study team, 2025.

Brunei's carbon profile, as given in Table 3-5, presents a unique context for setting up a carbon pricing system. The country has strong carbon sequestration potential, though its high per capita CO_2 emissions stem from a fossil fuel-reliant economy. The absence of a carbon tax or ETS means current efforts depend on voluntary and results-based forest carbon initiatives. Brunei's active reforestation targets and monitoring systems indicate readiness for structured mitigation. As a small, export-driven, and high-income economy, Brunei must adopt a carbon pricing model that safeguards economic stability while leveraging its fiscal capacity to access international climate finance and support green reforms.

As outlined in Table 3-6, Brunei Darussalam has limitations in terms of carbon pricing readiness, particularly in its reliance on voluntary reforestation efforts and nascent MRV systems. With 72.1% forest cover, Brunei holds substantial carbon sequestration potential, yet it currently lacks both a carbon tax and an ETS, placing it in a pre-market phase similar to REDD+ pilot countries that are still building foundational infrastructure for future carbon market participation (IMF, 2023).

In contrast, Indonesia has made significant progress in establishing a national carbon pricing framework. Through Presidential Regulation No. 98 of 2021 [2], the country introduced a phased carbon tax and laid the legal foundation for carbon trading. Indonesia also operates a national registry system (SRN-PPI) to track and verify emission reductions. With its vast tropical forests, Indonesia has the potential to reduce up to 247 million tonnes of CO_2 annually and generate as much as 1,283 million tonnes of carbon credits by 2030 (PwC, 2024). However, challenges remain in strengthening MRV systems, clarifying international trading rules, and improving transparency across sectors.

Malaysia presents a more decentralised approach, with notable advancements at the subnational level, particularly in Sarawak. The state has introduced legal definitions for carbon credits and forest carbon activities under the Forest Ordinance 2015 and the Forest Carbon Activity Rules 2022. While Malaysia does not yet have a national carbon tax or ETS, its engagement in voluntary carbon markets and REDD+ initiatives reflects growing interest in market-based climate solutions. Compared to Brunei, Malaysia has taken more concrete steps toward enabling carbon trading, though national harmonisation is still needed to support a unified framework (ASEAN Centre for Energy, 2024).

Despite having one of the highest per capita CO_2 emissions globally – primarily due to its fossil fuel-dependent economy – Brunei has no formal carbon pricing in place. This mismatch between emissions intensity and regulatory response underscores a

[2] This regulation has been replaced by the New Presidential Regulation No. 110 of 2025, which effectively lifts the ban on international carbon trading, allowing carbon units from Indonesian projects to be sold to foreign buyers under certain conditions.

significant policy gap. Although the country has initiated forest-based mitigation, including a national target to plant 500,000 trees by 2035, it has not yet linked these efforts to carbon credit markets. Its current market access and institutional capacity are found to be limited to moderate, consistent with early-stage carbon pricing environments.

However, Brunei's high-income status (GDP per capita > US$30,000) suggests a unique opportunity for the introduction of a carbon price without major economic disruption. A potential carbon price in the range of US$5–10 per ton of CO_2 is appropriate in the initial phase – aligned with rates offered in international results-based financing schemes [e.g. FCPF, LEAF (Lowering Emissions by Accelerating Forest Finance) Coalition]. This price range is not only practical and realistic but also sufficient to encourage efforts to reduce emissions from forests, improve monitoring systems, and signal the importance of carbon in local policies.

Brunei's fiscal capacity and political stability provide a foundation for progressing toward a hybrid carbon pricing model. Brunei can gradually establish a credible, nationally appropriate carbon pricing architecture by starting with voluntary forest offsets at modest price levels and then moving toward more formal mechanisms – such as a carbon tax or ETS with forest offsets.

Table 3.6 compares carbon pricing readiness and project eligibility across four country categories: developed, developing, least developed, and Brunei Darussalam. Developed countries have established carbon markets, advanced MRV systems, and strong legal frameworks, with higher carbon prices and robust institutional capacity. Developing and least developed countries are still evolving, with mixed MRV systems, limited market access, and lower carbon prices, relying heavily on donor support and partnerships.

Brunei Darussalam does not yet have a formal carbon market but shows potential for voluntary reforestation and REDD+ initiatives. Its MRV systems and legal frameworks are emerging, with institutional capacity gradually growing through regional support. This comparison highlights how readiness and project feasibility are shaped by development level, institutional strength, and access to global carbon markets.

Table 3.6. Comparative Matrix of Carbon Price Readiness and Project Eligibility Criteria

	Developed Economies	Developing Economies	Least Developed Economies	Brunei Darussalam
Key Tools & Mechanisms	Cap-and-Trade (California), NZ ETS	PES (Costa Rica), Voluntary Market (Colombia)	REDD+ Pilots (Nepal, Mozambique)	Voluntary Reforestation; No formal market yet; potential REDD+ pilots
MRV Systems	High-tech, automated (e.g. satellite, blockchain)	Moderate, mixed methods (GIS, field surveys)	Basic, community-based with satellite aid	Emerging MRV (satellite + GIS planned)
Legal Framework	Strong, long-standing	Evolving	Emerging or pilot-level	Emerging; initial reporting mandates introduced
Market Access	Fully integrated, compliance markets	Regional & voluntary markets	Limited or donor-dependent	Very limited; not yet linked to carbon credit markets
Carbon Price Range (US$/t$CO_2$)	\$15–\$50	\$5–\$20	< \$10 (mainly donor-negotiated)	No established price; potential in \$5–\$10 range
Institutional Capacity	High	Medium	Low	Low to medium; building capacity via national agencies
Support Mechanisms	National climate policy frameworks	International donors, public-private partnerships	FCPF [3], UN-REDD[4], ISFL[5]	National reforestation targets; ASEAN & AFoCO support

Source: ERIA study team, 2025.

[3] A global partnership that supports developing countries in their efforts to reduce emissions from deforestation and forest degradation through results-based financing.
[4] This initiative is a collaborative effort by the United Nations to assist countries in developing and implementing REDD+ strategies and safeguards.
[5] Promotes integrated land-use programmes to reduce emissions while enhancing livelihoods and sustainable development.

Meanwhile, a detailed comparison between Southeast Asian countries – Indonesia, Malaysia, and Brunei Darussalam – is presented in Table 3-7. As Southeast Asian nations respond to the global call for climate action, Indonesia, Malaysia, and Brunei Darussalam are emerging as key players in the development of carbon pricing frameworks and market-based climate solutions. Each country possesses unique strengths and challenges in its approach to carbon market readiness, shaped by legal structures, institutional capacity, and forest-based mitigation potential. Understanding these differences is essential for designing effective climate policies and identifying opportunities for regional collaboration.

Indonesia has made significant progress in establishing a national carbon pricing framework. Through Presidential Regulation No. 98 of 2021, the country introduced a phased carbon tax and laid the legal foundation for carbon trading. Indonesia also operates a national registry system (SRN-PPI) to track and verify emission reductions. With its vast tropical forests, Indonesia has the potential to reduce up to 247 million tonnes of CO_2 annually and generate as much as 1,283 million tonnes of carbon credits by 2030. However, challenges remain in strengthening MRV systems, clarifying international trading rules, and improving transparency across sectors.

Malaysia presents a more decentralised approach, with notable advancements at the subnational level, particularly in Sarawak. The state has introduced legal definitions for carbon credits and forest carbon activities under the Forest Ordinance 2015 and the Forest Carbon Activity Rules 2022. While Malaysia does not yet have a national carbon tax or emissions trading system, its engagement in voluntary carbon markets and REDD+ initiatives reflects growing interest in market-based climate solutions.

Brunei Darussalam, by contrast, remains in a pre-market phase. Despite having 72.1% forest cover and substantial carbon sequestration potential, Brunei currently lacks both a carbon tax and an emissions trading system. Its efforts rely primarily on voluntary reforestation and emerging MRV systems, as outlined in its National Climate Change Policy and supported by regional workshops and technical studies. Detailed information can be seen in Table 3.7.

Table 3.7. Comparative Matrix of Carbon Price Readiness for Indonesia, Malaysia and Brunei Darussalam

Criteria	Indonesia	Malaysia	Brunei Darussalam
Key Tools and Mechanisms	Presidential Regulation No. 98/2021; SRN-PPI registry; Carbon tax (phased)	Bursa Carbon Exchange (BCX); Forest Carbon Activity Rules (Sarawak); under study federal[1)]	Voluntary Reforestation; No formal market yet; potential REDD+ pilots

Criteria	Indonesia	Malaysia	Brunei Darussalam
MRV Systems	SRN-PPI platform; MRV framework under development; needs international alignment[2]	MRV guidelines in Sarawak; national MRV system under review; capacity-building ongoing[1]	Emerging MRV (satellite + GIS planned)
Legal Framework	National-level regulation for carbon pricing and trading; REDD+ integrated	Legal definitions at state level (Sarawak); federal framework still evolving[3]	Emerging; initial reporting mandates introduced
Market Access	Domestic and international (Article 6 readiness in progress); voluntary market active	Voluntary market via BCX; international access under study; Article 6 not yet operational[1][3]	Very limited; not yet linked to carbon credit markets
Carbon Price Range (USD/tCO_2)	Estimated below \$5/tCO_2 in domestic market; varies in voluntary credits[2]	BCX prices range from \$6–\$15/tCO_2 depending on project type and standard[1]	No established price; potential in \$5–\$10 range
Institutional Capacity	Strong national coordination; multi-sectoral involvement; technical gaps remain	Decentralised; Sarawak leads; federal coordination improving through inter-agency efforts[1]	Low to medium; building capacity via national agencies
Support Mechanisms	Government incentives; donor support; private sector engagement increasing	Capacity-building programmes; PMI collaboration; policy studies and workshops[1]	National reforestation targets; ASEAN & AFoCO support

Source: ERIA study team, 2025 with References: (1) Malaysia's Carbon Pricing Journey – PMI Global Forum; (2) Indonesia Carbon Market White Paper – PwC; (3) Carbon Credits Framework Comparison – Bird & Bird.

The three-phase approach is strategically designed to align with Brunei Darussalam's national circumstances and international carbon pricing practices. Phase I, focusing on voluntary domestic forest offset development, allows the country to build essential technical infrastructure, such as MRV systems and registry platforms, while fostering stakeholder engagement and market readiness without regulatory pressure (World Bank, 2021). Phase II introduces results-based international finance mechanisms like REDD+, enabling Brunei to monetise verified emission reductions and attract climate finance while continuing to strengthen governance frameworks and institutional capacity (MoFE, 2018). Phase III proposes a gradual transition to a compliance-based pricing system – such as a carbon tax or emissions trading scheme (ETS) – using forest offsets as a cost-effective flexibility instrument. This ensures policy credibility and environmental integrity while minimising economic disruption and aligning with global carbon pricing standards (CPLC, 2017; PMR and ICAP, 2021).

Phase I (2025–2028): Voluntary Forest-Based Carbon Offset Market

The first phase emphasises the establishment of a domestic voluntary carbon offset framework, initially focused on forestry and land use. Key components include the development of a national carbon registry based on international standards (e.g. Verra, Gold Standard) adapted to Brunei's regulatory context. The phase supports jurisdictional and community-level carbon projects, such as reforestation, afforestation, and mangrove ecosystem restoration. A carbon price range of US$5–10 per ton of CO_2 is proposed, benchmarked to rates in similar donor-driven initiatives such as the FCPF and ISFL. To ensure transparency and trust, Brunei needs to create a complete MRV system that uses satellite technology (like SERVIR-type platforms) along with data collected from the community. This low-risk entry phase builds foundational infrastructure and confidence in the environmental integrity of Brunei's carbon credits.

Phase II (2028–2030): Results-Based Payment Agreements

The second phase entails monetising verified emissions reductions through results-based financing arrangements with international climate finance institutions. Brunei should pursue agreements with entities such as the World Bank's Carbon Fund or the LEAF Coalition, enabling the sale of VERs from forest conservation activities. Pricing should remain within the range of US$5–7 per ton of CO_2, consistent with precedent set by forest-carbon programmes in countries like Nepal and Mozambique. This model bypasses the administrative burdens of a full domestic compliance system while reinforcing forest governance and generating predictable climate finance for ecosystem-based mitigation. The revenue stream from this phase can also be reinvested into forest management, MRV enhancement, and stakeholder benefit-sharing mechanisms.

Phase III (Post-2030): National Carbon Pricing Framework

The final phase envisions the implementation of a domestic compliance-based carbon pricing mechanism, aligned with Brunei's development trajectory and international obligations under the Paris Agreement. Two policy options are proposed:

1. Carbon Tax with Forest Offset Integration:
   Introduce a gradually escalating carbon tax (starting at US$10/t$CO_2$), with a provision allowing emitters to use domestic forest offsets to meet 20–30% of their liability. This hybrid design provides both a market signal and a cost-containment mechanism.
2. Pilot Emissions Trading System:
   Launch a sector-specific ETS (e.g. for energy or heavy industry), establishing an emissions cap, tradable allowances, and offset eligibility from certified forest carbon projects. MRV systems established in earlier phases would support credit validation and market oversight.

This phase would institutionalise carbon pricing within national policy, create demand for domestic carbon assets, and enable future market linkage with regional platforms (e.g. ASEAN), while promoting decarbonisation of Brunei's fossil-intensive economy.

Table 3.8. Forest Carbon Credit Mechanisms and Price Discovery

Phase	Mechanism	Timeline	Price Range ($/t$CO_2$)	Primary requirements
Phase 1	Voluntary Forest Offset Registry	2025–2028	$5–10	Institutional capacity building, MRV development
Phase 2	Results-Based Finance (FCPF, LEAF)	2028–2030	$5–7	Monetisation of forest carbon through donors
Phase 3	Carbon Tax or ETS with Forest Offsets	Post-2030	$10+	Long-term compliance pricing, green fiscal reform

Source: ERIA study team, 2025.

3.4. Calculate the Number of Carbon Credits in Belait Peat Swamp Forest Area

3.4.1. Carbon Sequestration

In calculating carbon sequestration, several stages are required in order to derive the economic value of carbon. The following steps describe the carbon sequestration analysis used to estimate emission reduction potential:

(1) Land cover analysis

A land cover analysis is conducted to identify land cover types at the project site based on the classification system specified in the Forest Reference Level (FRL) 2022 document.

(2) Calculation of land cover area

The area of each land cover class is calculated, and the proportion of each class relative to the total area is determined.

(3) Pre-assessment

A pre-assessment is carried out by establishing a minimum of five plots for each land cover class. From these plots, the average carbon stock per hectare is estimated to determine the minimum number of plots required for the study area.

(4) Emission Factor (EF) calculation

Emission Factors for each land cover class are calculated to obtain detailed Tier 3 data. These emission factors are derived following the main assessment, which is conducted separately for each land cover class.

(5) Determination of the base year

The base year is defined as the starting year for determining the emission reference period. Typically, this is set 5–10 years prior to project implementation. In the FRL document, the project base year is defined as 16 years prior to project commencement.

(6) Calculation of reference period emissions

Emissions during the reference period are calculated over a span of 5–10 years. These reference period emissions are used to estimate projected emissions (baseline).

(7) Baseline calculation

The baseline is calculated based on reference period emission data. The average emissions during the reference period are used to project future emissions over the project lifetime, for example baseline emissions for 2030, 2040, 2050, and so forth.

(8) Mitigation action emission analysis

Once the baseline emissions are established, emissions under mitigation actions are calculated. In the context of mitigation actions such as tree planting or carbon sequestration activities, this step estimates the potential future emission removals over the project duration.

(9) Calculation of emission reduction potential (ER)

Emission reduction potential is calculated as:

ER = Baseline emissions – Mitigation action emissions.

(10) Validation and verification

After estimating the emission reduction potential, validation and verification are conducted by recognised emission reduction standard bodies, such as Verra, Gold Standard, the Clean Development Mechanism (CDM), the National Registry System (SRN), or other relevant standards.

(11) Issuance of Emission Reduction Certificates

Emission Reduction Certificates (SPE) or Verified Carbon Units (VCUs) are issued by the standard-setting bodies upon successful validation and verification.

(12) Carbon trading

Carbon trading is conducted using officially issued SPEs or VCUs that have been certified by the respective standard bodies.

3.4.1.1. Forest Reference Level (FRL/FREL) Analysis Technique

A Forest Reference Level (FRL) or Forest Reference Emission Level (FREL) is a benchmark used to assess a country's performance in reducing greenhouse gas (GHG) emissions and/or increasing removals from the forest sector under the REDD+ mechanism of the United Nations Framework Convention on Climate Change (UNFCCC). In simple terms, FRL/FREL represents the 'business-as-usual' level of emissions or removals from forests that would occur without additional mitigation actions. Actual emissions or removals achieved through REDD+ activities are then compared against this benchmark (Arens et al., 2010).

There are several critical functions of FRL/FREL, such as:

1. Benchmark for performance measurement

It allows comparison between actual emissions/removals and the reference level to determine emission reductions.

2. Basis for results-based payments (RBP)

Verified emission reductions below the FREL/FRL can be eligible for international climate finance.

3. Ensures transparency and environmental integrity

Prevents overestimation of emission reductions and double counting.

4. Supports national climate commitments

FRL/FREL is aligned with Nationally Determined Contributions (NDCs) and national MRV systems.

Meanwhile, the procedures for determining the Forest Reference Level (FRL) based on the Forest Reference Level Document of Republic of Indonesia (2022), consist of the following steps:

1. Determination of the reference period

The reference period is defined as the historical timeframe used to calculate average emissions and removals, which serves as the basis for establishing the FRL.

2. Land cover change analysis for generating activity data

An analysis of land cover change is conducted to generate activity data, including transitions between forest and non-forest categories, which form the basis for emission and removal calculations.

3. Emission calculation from peat decomposition

Emissions resulting from peat decomposition are calculated to account for greenhouse gas emissions associated with peatland drainage and degradation.

4. Emission calculation from deforestation and forest degradation

Emissions from deforestation and forest degradation are estimated based on changes in forest area and associated with carbon stock losses.

5. Emission calculation from peat fires

Emissions generated by peat fires are calculated to capture greenhouse gas releases caused by biomass and peat combustion.

6. Removal calculation from enhancement of forest carbon stocks

Removals are estimated from activities that enhance forest carbon stocks, such as forest restoration, rehabilitation, and sustainable forest management practices.

7. Reference level calculation

The Forest Reference Level is calculated by integrating emissions and removals from all relevant sources and sinks during the reference period.

8. Uncertainty calculation

An uncertainty analysis is conducted to assess the reliability of activity data and emission factors, ensuring transparency and consistency with IPCC methodological guidance.

This study compares carbon counts to a 30-year baseline and provides a long-term picture of how changes in the forest ecosystem are affecting the carbon cycle. Some factors to consider in this analysis include:

1. Changes in carbon stocks in forest biomass and soil over time.
2. Rates of deforestation or degradation over the 30-year period could lead to carbon release.
3. Restoration and new vegetation growth could increase carbon stocks.
4. Climate change that may affect carbon uptake and release rates.

5. Human activities such as land conversion for settlement or agriculture that could have significant impacts.

A common method is to compare baseline carbon stocks with current conditions using historical data and ecosystem models. If there is an increase in carbon stocks, it can indicate the effectiveness of forest conservation and restoration. Conversely, if there is a decrease, there may be negative impacts such as deforestation or environmental change.

To implement climate change mitigation, Brunei needs to develop a Forest Reference Emission Level (FREL) document. By creating a FREL document, Brunei can assess past forest conditions and predict future forest conditions. Brunei's forest and land conditions share geographic similarities with Indonesia, allowing Brunei to adopt Indonesia's FREL approach.

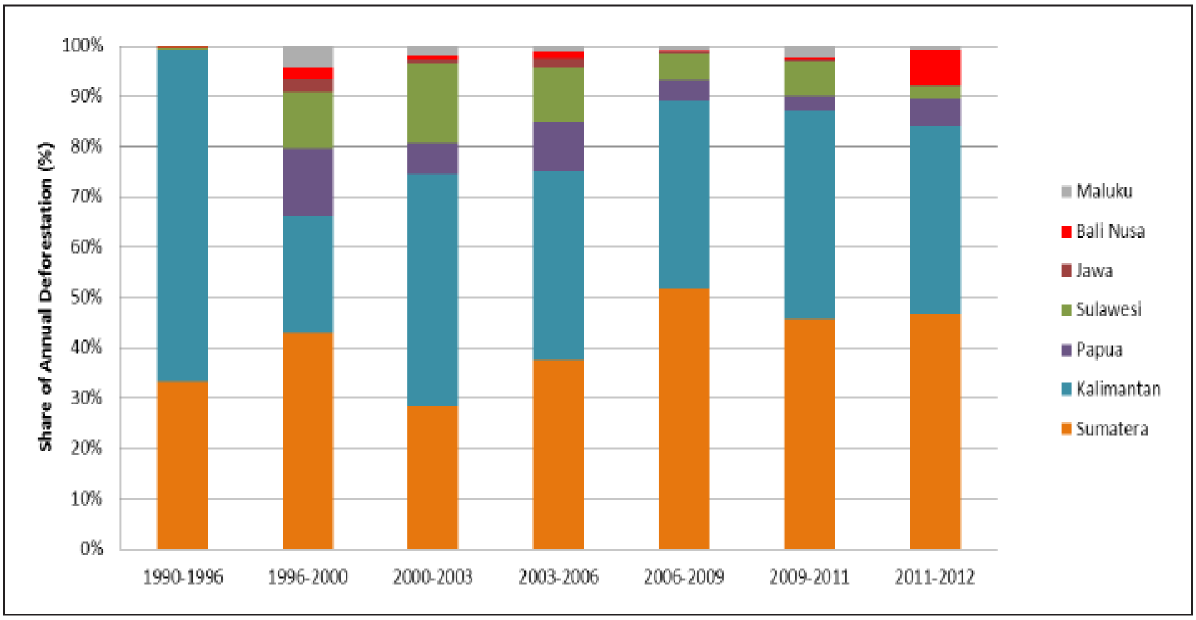
Indonesia submitted its national FREL document to the UNFCCC in 2016 and its 2nd Forest Reference Level (FRL) in 2022. These documents serve as key references, especially for determining emission reference periods.

- In the 2016 Indonesian FREL document, the reference period used was 1990–2012, divided into sub-periods:
  - 1990–1996, 1996–2000, 2000–2003, 2003–2006, 2006–2009, 2009–2011, and 2011–2012.
  - This timeframe covers deforestation, forest degradation, and peat decomposition, using the same reference period (see Figures 4.2, 4.3, and 4.4).

Indonesia's Forest Reference Emission Level (FREL) framework encompasses three main sources of emissions, such as deforestation, forest degradation and peat decomposition. While Indonesia's FREL framework includes three primary sources of emissions, it is important to note that not all of these categories may be applicable to Brunei Darussalam's Forest inventory. The relevance of each emission source depends on Brunei's specific ecological characteristics, land-use history, and forest types. For instance, if Brunei's peatlands remain largely intact and undisturbed, peat decomposition may contribute minimally to national emissions. Similarly, the extent and nature of forest degradation must be assessed based on localised data and definitions. Therefore, Brunei's FREL development should be tailored to reflect its unique forest dynamics, ensuring that emission sources are accurately represented and aligned with national mitigation priorities.

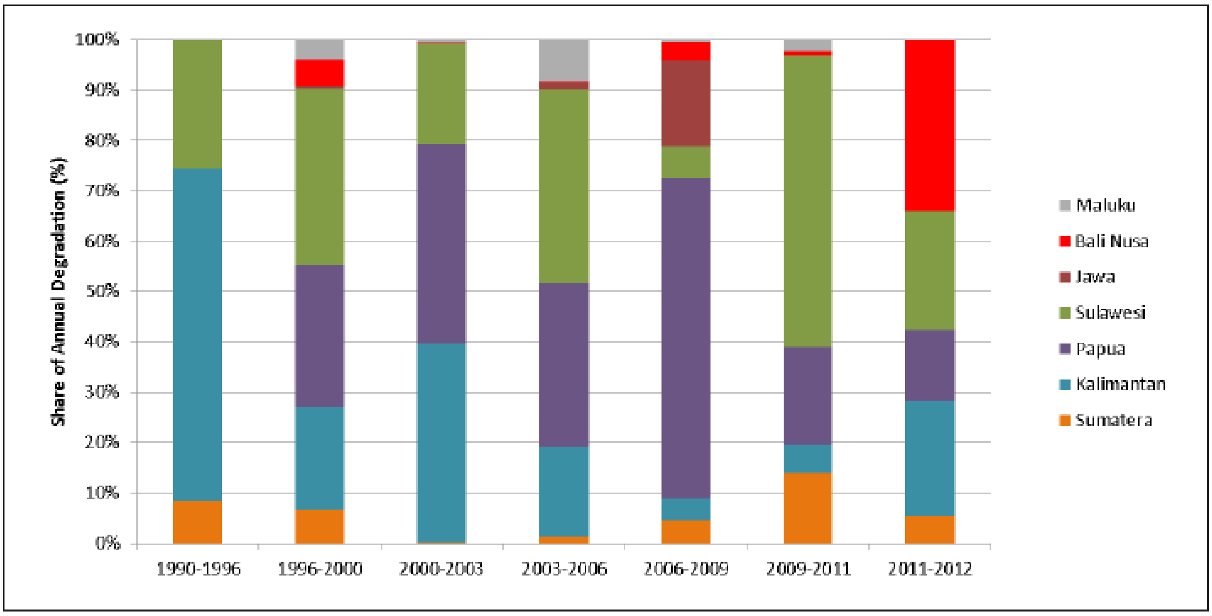
Since these emission sources follow a consistent reference period (1990–2012), Indonesia's national policies are aligned with site-level activities.

Figure 3.2. Average Deforestation Proportion across Indonesia's Seven Largest Islands



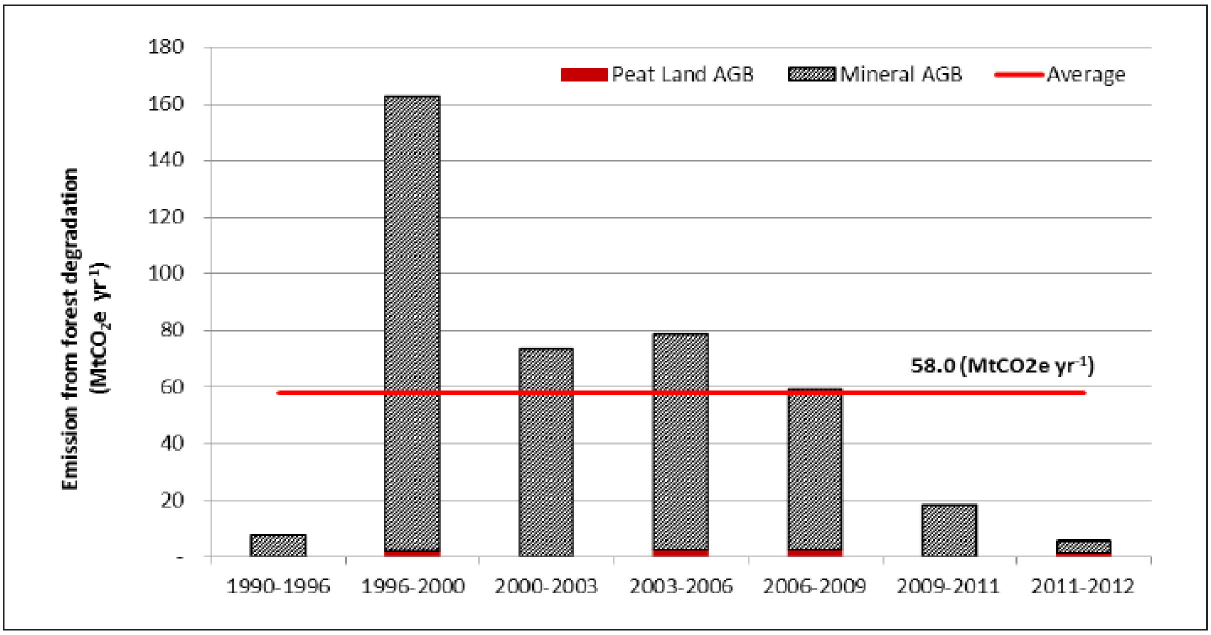
Source: MoEF, 2016.

Figure 3.3. Average Forest Degradation Proportion across Indonesia's Seven Largest Islands



Source: MoEF, 2016.

Figure 3.4. Average Peat Decomposition Proportion across Indonesia's Seven Largest Island



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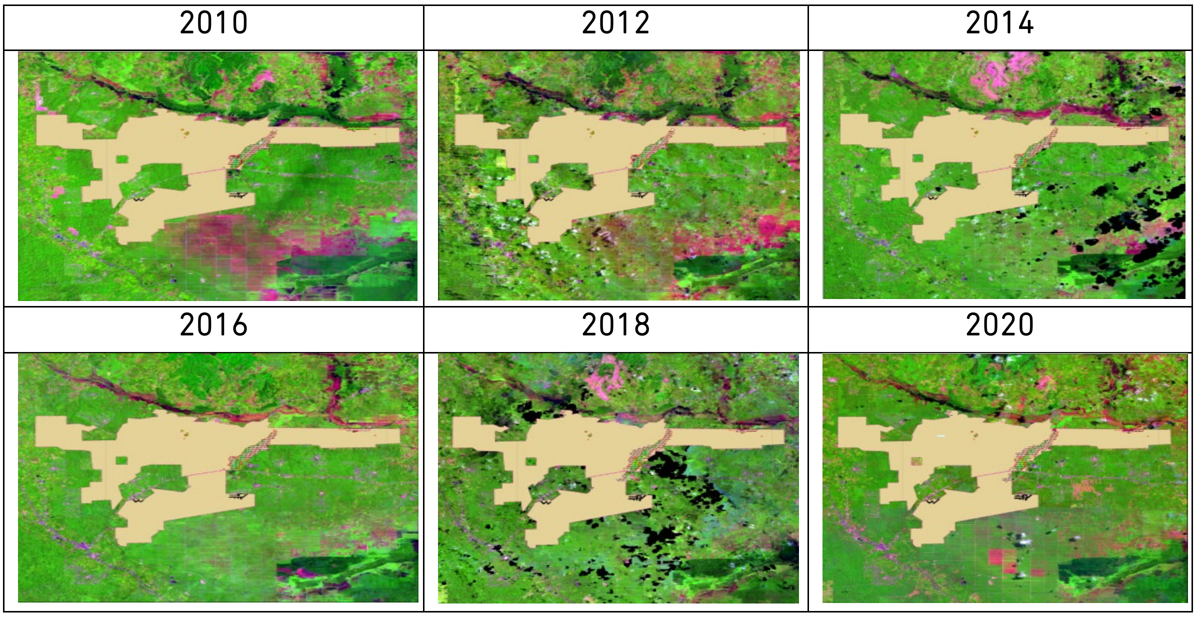
Source: MoEF, 2016.

In the 2022 2nd FRL document, Indonesia updated its emission reference period to 2006–2020. This means that for future emission reduction projects, studies should refer to the latest FRL document (2022). The illustration of land cover changes in the study area can be seen in Figure 3.5.

Brunei needs to prepare a FREL document that can serve as a baseline analysis. The reference period can be set similarly to Indonesia's 14-year timeframe or at a minimum of the last 10 years. Using this reference period, Brunei can develop mitigation action plans, including land rehabilitation efforts in deforested areas.

Figure 3.5. Illustration of Land Cover Changes from 2010 to 2024



Source: ERIA study team, 2025.

3.4.1.2. Above Ground Biomass (AGB) Calculation Technique

Biomass calculations for litter, seedlings, and understory plants are conducted in the laboratory using:

- Oven-dry weight parameters, following SNI 7724:2019.
- C-organic parameter, using the gravimetric method.

AGB data for saplings, poles, and trees are also measured following SNI 7724:2019.

In addition to mangrove areas, Brunei's forest areas also contain peatlands and mineral soils. Several allometric formulas can be used for mineral and peat soils, such as those in Table 3.9.

Table 3.9. Several Allometric Formulas for Mineral and Peat Soils

No	Subject	Formula	Reference
1	Dipterocarpaceae/ meranti / Tanah Mineral	$B= p * 0{,}18D^{2{,}50}$	Hardiansyah and Ridwan, 2012
2	Pohon Bercabang / Tanah Mineral	$B= 0{,}11 * p * D^{2{,}62}$	Ketterings, 2001
3	Hutan Tropis	$B= Exp(-1{,}499 + 2{,}148(\ln D) + 0{,}207(\ln D)^3 – 0{,}0281(\ln D)^3) * p$	Chave et al. (2005)
4	Lahan Gambut	$B = p * 0{,}19 * D^{2{,}37}$	Murdiyarso, et al, 2004

No	Subject	Formula	Reference
5	Hutan dipterokarpa primer	$B = 0{,}0112(D)^{2{,}6878}$	Siregar dan Dharmawan, 2011
6	Hutan gambut primer	$B = 0{,}040\ (DxpxH)^{1{,}524}$	Dharmawan, Saharjo, Supriyanto, Arifin, Siregar, 2013
7	Hutan gambut sekunder	$B = 0{,}1066\ (D^2)^{1{,}243}$	Jaya et al., 2007
8	Sonneratia spp.	$W = 0.258\ DBH^{\ 2.287}$	Kusmana et al, 2018

Source: ERIA study team, 2025.

The biomass value in stakes, poles and trees for each type of land cover is then converted using the following formula:

Wood Carbon = % carbon x B

Description:

% carbon = percentage of organic carbon

B = tree biomass in tons/ha.

In SNI 7724:2019, the percentage of carbon in wood, litter and dead wood is stated as 47%. For this calculation example, we use the percentage of carbon in wood as stated in SNI 7724:2019, which is 47%.

3.4.1.3. Below Ground Biomass (BGB) Calculation Technique

To determine the potential biomass and carbon in the roots, there are two ways, namely destructive and allometric. In a study conducted by Hardiansyah and Ridwan, 2011, for mineral soil, the potential for tree root carbon (BGB) is 24.57%. The study location is divided into wetlands. In this study, the BGB calculation was carried out using the allometric method developed by Hairiah and Rahayu (2007) as listed in Table 3.10.

Table 3.10. Root Shoot Ratio (NPA) in Several Land Types

No	Type of Land	Ratio Tree and Root
1	Dry Land	4 : 1
2	Wet Land	10 : 1
3	Poor Soil	1 : 1

Source: Hairiah and Rahayu, 2007.

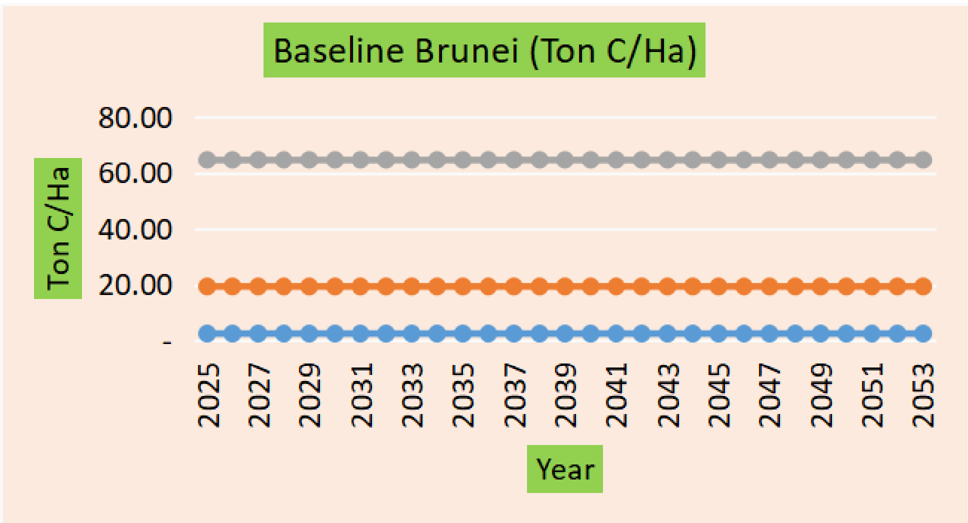
Pond cover and secondary mangrove forests are included in the type of wetlands so that in this study the allometric formula for calculating BGB uses a ratio of 10:1. For secondary dryland forest land cover, a ratio of 4:1 is used.

3.4.1.4. Brunei Baseline Projection on Deforested Areas

To determine the baseline conditions in the next 30 years in Brunei (i.e., by 2054), it is necessary to analyse the conditions of the reference period at least 10 years ago. From the conditions of the reference period 10 years ago, it is then projected for the next 30 years with the condition that there is no intervention of mitigation intervention.

The results of the land cover analysis in Brunei by the IPB Team in 2025 show that there are three classes of non-forested areas, namely bare land, shrub and mixed dry agriculture. Based on the Indonesia Reference Level 2022, the carbon stock (biomass) for wet shrub is 19.34 tons of biomass/ha, bare ground is 2.40 tons of biomass/ha and Mixed Dry Agriculture is 64.64 tons of biomass/ha. If there is no intervention, then in the next 30 years, the vegetation conditions in hectares will be relatively constant (Figure 3.6).

Figure 3.6. Illustration of Baseline Conditions in Bare Ground, Shrub and Mixed Dry Agriculture Areas



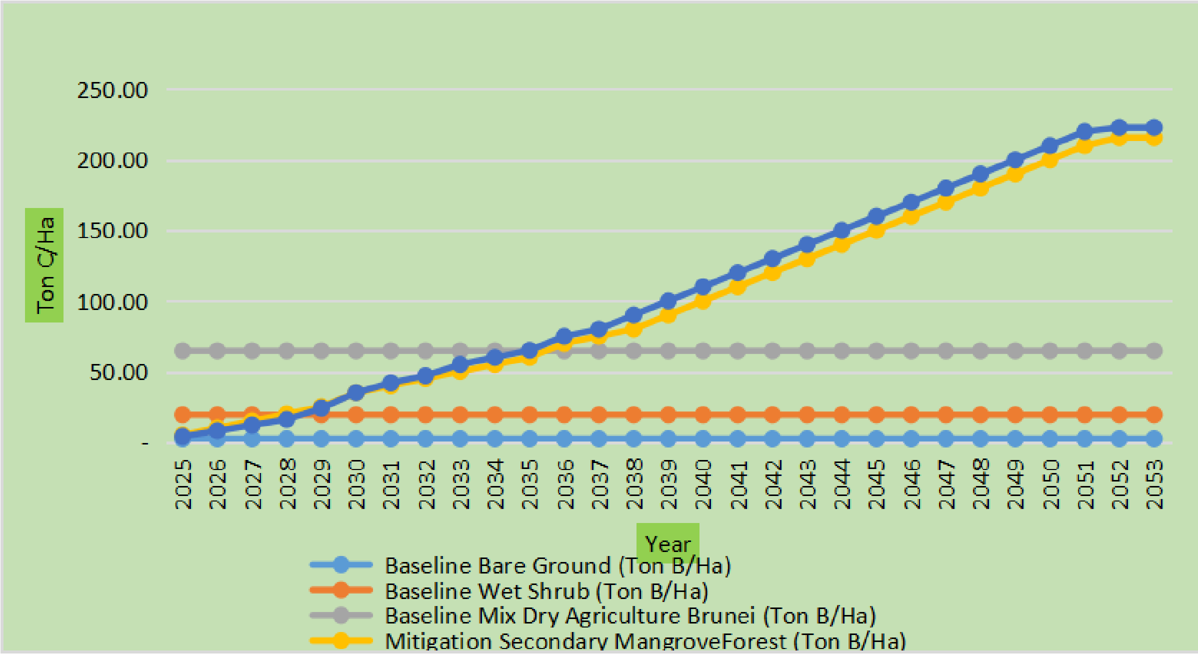
Source: ERIA study team, 2025.

3.4.1.5. Potential for Increasing Emission Absorption with Sequestration Activities

Identifying of activities carried out and calculating the potential emissions that will occur are used to determine the potential for emission absorption in an area.

Activities carried out in deforested areas include land rehabilitation. It is estimated that in the next 30 years, the condition of empty land can change into Secondary Swamp Forest or Secondary Dry Land Forest. By changing the condition of open areas into Secondary Swamp Forest or Secondary Dry Land Forest, there will be an increase in carbon stock for each hectare and then quantified into an area with a large mitigation action (Figure 3-7).

Figure 3.7. Illustration of Land Rehabilitation Mitigation Actions for Hectares



Source: ERIA study team, 2025.

3.4.2. Economic Value of Carbon

The determination of carbon pricing for a specific area depends on various factors, including government policies, market dynamics, and environmental characteristics. Here are some key approaches:

- Carbon Market – The price of carbon is determined through trading mechanisms where carbon credits are bought and sold based on supply and demand.
- Carbon Tax – Governments set a fixed price per ton of carbon emissions, which influences the carbon price within a given area.
- Economic Valuation of Carbon – Carbon pricing is calculated based on the economic and environmental impact of emissions, as well as the benefits of conservation.
- Carbon Credit Quality – The price may vary depending on the quality of projects generating carbon credits, such as their effectiveness in reducing emissions and additional social benefits.

The carbon determination carried out in this study uses the economic value of carbon. This approach falls under economic valuation of carbon, where the price of carbon is determined based on the economic value provided by the carbon stock in forest ecosystems. In many studies, the carbon price is often derived from global carbon market prices or values set by institutions such as the World Bank Group.

According to information from the Department of Forestry Brunei Darussalam, in this region there are no activities related to projects specifically designed that do not have specific projects to increase carbon sequestration in mangrove areas, so carbon pricing is usually based on the economic value of natural carbon stored in the ecosystem. Some approaches that can be used include:

- Voluntary Market Price - Carbon prices are determined based on transactions in the voluntary market, where companies or individuals buy carbon credits to offset their emissions.
- Mandatory Market Price - If there is government regulation, carbon prices can be set based on national or international policies related to carbon trading.
- Carbon Storage Estimation - Carbon prices are calculated based on the amount of carbon stored in mangrove ecosystems, usually through allometric methods and sediment analysis.

Brunei Darussalam has collaborated with the Indonesia Climate Exchange (ICX) to establish a regional carbon market covering the Borneo region. This collaboration involves Dynamic Technologies Brunei Darussalam, which collaborates with ICX to develop a credible and inclusive carbon trading platform. The main objective of this initiative is to harmonise carbon trading standards and improve technology interoperability in the ASEAN green economy ecosystem

Therefore, in terms of pricing, the price that will be applied in this analysis is the price that will be applied to carbon in East Kalimantan, one of the regions of Indonesia that is close to Brunei Darussalam. This price is based on the wishes of a number of large companies from Europe who are interested in buying carbon from East Kalimantan at a price of US$30-45 per ton.

Meanwhile, according to Ahyar et al 2024, who conducted a study on carbon stocks in the Kawae Block Protected Forest Area, Indonesia. This study used the voluntary carbon certificate purchase price standard of US$7.

But in this case, this study used the Voluntary Forest Offset Registry as mentioned in the previous chapter, where this price will be implemented in 2025–2028 (Phase 1). The price is US$10.

3.4.3. Mitigation Action Calculation

3.4.3.1. Calculate the number of carbon credits that can be generated based on the estimated sequestration

The area of Brunei is around 165 thousand hectares and interestingly around 78% of Brunei Darussalam's area is primary peatland and around 4% is secondary mangrove area. Peatland and mangrove are very attractive for the world's carbon business. From this type of land cover, the most important thing in the context of climate change is to protect peat and mangrove areas from the threat of deforestation and forest degradation.

In addition to the potential for mitigation actions preventing deforestation and land degradation, mitigation actions through sequestration also need to be carried out. In mitigation actions through the potential for emission absorption, it is necessary to know the areas with shrub land cover, open land and mixed agriculture.

Based on satellite image analysis in 2024, the area of bare ground was 110.76 ha, mixed dry agriculture was 2.537.99 ha and wet shrub was 5,952.7 ha (Table 3.11).

Table 3.11. Land cover change Belait Peat Ecosystem, Brunei Darussalam, 2014 and 2024

No	Land Cover	Area (ha)	
		2014	2024
1	Primary Swamp Forest	101,097.60	99,471.21
2	Secondary Mangrove Forest	984.84	457.04
3	Wet Shrub	6,941.25	5,952.57
4	Mixed Dry Agriculture	1,697.59	2,537.99
5	Paddy Field	414.55	1,740.68
6	Bare Ground	211.35	110.76
7	Settlement Areas	1,371.77	1,649.93
8	Open Water	758.43	1,557.19
	Total	113,477.37	113,477.37

Source: ERIA study team, 2025.

Meanwhile, according to NFRI (2025) research in Brunei Darussalam, it was found about 27 types of plants in peat swamp forest (PSF) area of SG Mau Belait District. Dominant types are alan, medang tabak and tulang ular. The diameter of the trees found ranged from 10 – 82.8 cm with an average diameter of 30.58 cm (Table 3.12).

Table 3.12. Species Composition in Peat Swamp Forest (PSF) Area of SG Mau Belait District

No	Species	Count	Rel density %	Basal Area, m^2 total	Mean DBH, cm	Mean Height, m	BA share %
1	Alan	139	37.16	34.04	54.6	43.71	85.59
2	Medang Tabak	46	12.29	1.42	18.7	18.35	3.56
3	Tulang Ular	31	8.28	0.36	12.0	13.84	0.91
4	Kayu Malam	27	7.21	0.00			0.00

No	Species	Count	Rel density %	Basal Area, m^2 total	Mean DBH, cm	Mean Height, m	BA share %
5	Ubah Merah	24	6.41	0.63	17.3	15.47	1.59
6	Menjalin	22	5.88	0.65	18.9	18.91	1.65
7	Mempening	17	4.54	0.19	11.9	13.88	0.49
8	Pinsi	15	4.01	0.32	15.5	15.59	0.80
9	Ubah	13	3.47	0.39	22.7	17.75	0.97
10	Uba Merah	8	2.10	0.00			0.00
11	Nyatoh	7	1.87	0.12	14.2	16.86	0.30
12	Eleocarpus	4	1.06	0.10	17.2	16.28	0.26
13	Barun	4	1.06	0.06	14.1	14.47	0.16
14	Ecalinacae	2	0.53	0.10	25.8	18.50	0.26
15	Tampoi Hutan	2	0.53	0.00			0.00
16	Kulim Panas Paya	2	0.53	0.00			0.00
17	Gerongang	1	0.26	0.24	55.5	38.00	0.61
18	Platea	1	0.26	0.12	39.3		0.31
19	Uba	1	0.26	0.06	27.0	16.00	0.14
20	Ubah	1	0.26	0.02	15.6	16.00	0.05
21	Nyatoh Ketiau	1	0.26	0.02	15.3	13.90	0.04
22	Perious	1	0.26	0.01	13.2	12.00	0.03
23	Semundu	1	0.26	0.01	10.9	15.20	0.02
24	Medang Ketup	1	0.26	0.01	10.8	10.00	0.02
25	Mempening	1	0.26	0.01	10.8	13.00	0.02
26	Rambutan	1	0.26	0.01	10.0	14.70	0.02
27	Sterculia	1	0.26	0.00			0.00

Source: NFRI, 2025.

Thus, mitigation actions through land rehabilitation activities can be carried out in these three land cover categories. According to Raihan et al. (2021), forest carbon stocks in Malaysia range from 144 - 198 tons of carbon per hectare. The results of the study by Saatchi et al. 2011, forest carbon stocks are between 164 to 196 tons of carbon per hectare. The results of the FAO state that forest carbon stocks in Malaysia vary between 89 to 276 tons of carbon per hectare. The results of a study by Besar et al, 2020, forest carbon stocks in Sabah, Malaysia are around 249.90 + 61.44 tons of carbon per hectare.

If rehabilitation activities are carried out into secondary mineral soil forests and secondary mangrove forests, there will be major sequestration. Mitigation activities in wet shrub areas can be rehabilitated into secondary mangrove or peat forests. Sequestration activities on bare ground and mixed dry agriculture can turn into secondary mineral soil forests. Comparison of carbon stocks in the Brunei Darussalam area for sequestration mitigation actions in the form of changes from non-forest to forest (Table 3.13).

Table 3.13. Carbon Stock in Kalimantan

No	Land Cover	Carbon Stock (ton Biomass/ha)
1	Wet Shrub	19.34
2	Mixed Dry Agriculture	64.64
3	Bare Ground	2.40
4	Secondary Mangrove Forest	155.74
5	Secondary Swamp Forest	215.71
6	Secondary Dry Land Forest	222.91

Source: FRL of Republic of Indonesia, 2022.

Many tropical forest lands are changing, but how these changes may affect deforestation rates remains unclear (Pacheco and Meyer 2022). Preventing deforestation is an effective strategy to reduce the impacts of climate change. In addition to preventing deforestation and forest degradation, other activities in efforts to reduce the impacts of climate change are through land rehabilitation.

If there is no intervention or mitigation action and assuming no change in land cover, then in 2055 the potential carbon stock in wet shrub, mixed dry agriculture and bare ground areas is around 481,575.34 tons of carbon (Table 3.14).

Table 3.14. Carbon Stock Potential

No	Land Cover	Carbon Stock (ton Biomass/ ha)	Area (ha)	Biomass (Ton)	Carbon (Ton C)	Emission (Ton CO_2e)
1	Wet Shurb	19.34	5,952.57	115,122.69	54,107.67	198,394.78
2	Mixed Dry Agriculture	64.64	2,537.99	164,055.58	77,106.12	282,722.45
3	Bare Ground	2.40	110.76	265.83	124.94	458.11
	Total			279,444.10	131,338.73	481,575.34

Source: ERIA study team, 2025.

3.4.3.2. Potential Mitigation Actions for Rehabilitation

Potential mitigation actions for sequestration include changing the land cover of wet shrubs, mixed dry agriculture and bare ground into secondary swamp forest. While mitigation actions are carried out on the three non-forest land covers for 30 years, then the area can absorb emissions (CO_2e) of around 3,197,456.78 tons of CO_2e (Table 3.15).

When compared to the mangrove area, the carbon stock in this area is relatively the same as the carbon stock in Malaysia, namely around Kuala Selangor Nature Park (KSNP) with a carbon stock in the mangrove area of around 121.82 tons C/ha or 259.19 tons biomass/ha and degraded mangroves in Sungai Haji Dorani (SHD) with a carbon stock of around 48.17 tons C/ha (Hong et al., 2017). According to Hong et al., if this value is converted into biomass, it will produce a biomass of 102.89 tons/ha.

Carbon stock data in mangroves based on the results of Hong's study are relatively the same as the FRL Indonesia except for the degraded areas in the SHD region, Malaysia. If it is assumed that the wet shrub area can be rehabilitated to reach conditions like in Malaysia, namely the SHD or KSNP area, then in the next 30 years the carbon stock will range from 564,169.52 to 4,904,247.07 tons of CO_2e.

If we compare with Mohd Borhan's research in Belait District, Brunei, 2025, during National Forest Resources Inventory (NFRI) activity, the potential carbon stock is 195.03 ton C/ha, this value is higher than carbon stock in Kuala Selangor Nature Park, Malaysia, 121.82 ton C/ha, and in Kalimantan Indonesia, around 155.75 ton C/ha.

If it is assumed that all wet shrub areas in Brunei can be rehabilitated and reach conditions like those in Belait District, then in the next 30 years the potential for emission absorption will reach around 2.47 million tons of biomass. The sequestration assumptions use FRL, 2022 values (Table 3.15).

Table 3.15. Emission Sequestration Potential in 30 Years

No	Land Cover	Carbon Stock (ton Biomass/ ha)	Area (ha)	Biomass (Ton)	Carbon (Ton C)	Ton CO_2e
1	Secondary Swamp Forest	215.71	5,952.57	1,284,028.77	603,493.52	2,212,809.59
2	Secondary Dry Land Forest	215.71	2,537.99	547,469.51	257,310.67	943,472.45
3	Secondary Dry Land Forest	215.71	110.76	23,892.50	11,229.48	41,174.75
	Total			1,855,390.78	872,033.67	3,197,456.78

Source: ERIA study team, 2025.

According to Hardiansyah (2011) and Hardiansyah and Ridwan (2012), the primary forest carbon potential in this study was 242.42 tons C/ha. In the study of Rahayu et al. (2005) in Nunukan, East Kalimantan Province, the carbon value in primary forests was 230.1 tons/ha. Based on the results of the study by Hardiansyah (2011) conducted in the PT area. SBK obtained the primary forest carbon potential of 229.33 tons C/ha. According to Lasco (2002), the carbon potential in primary forests in Indonesia is between 254-390 tons C/ha.

The sequestration potential in Intensive Silviculture System (SILIN) activities in Central Kalimantan after 25 years was 250.51 tons C/ha. Meanwhile, emission absorption (sequestration) in forests with the Indonesian Selective Cutting and Planting System (TPTI) for 25 years is around 115.41 tons of C/ha (Hardiansyah, 2011; Hardiansyah and Ridwan, 2012).

Thus, to effectively contribute to climate change mitigation, it is preferable to prioritise the cultivation of commercially valuable tree species, as these species not only offer higher economic returns but also demonstrate a greater capacity for carbon sequestration and emissions absorption. The potential emission reduction in the Belait Peat Ecosystem area if utilising secondary forest potential in 30 years is 2,715,881.45 tons of CO_2e as shown in Table 3.16.

Table 3.16. Decrease of Emission from Emission Sequestration Potential in 30 Years

No	Land Cover	Baseline (Ton CO_2e)	Mitigation Action (Ton CO_2e)	Emission Reduction (Ton CO_2e)
1	Secondary Swamp Forest	198,394.78	2,212,809.59	(2,014,414.81)
2	Secondary Dry Land Forest	282,722.45	943,472.45	(660,750.00)
3	Secondary Dry Land Forest	458.11	41,174.75	(40,716.63)
	Total	481,575.34	3,197,456.78	(2,715,881.45)

Source: ERIA study team, 2025.

Furthermore, if it is assumed that land rehabilitation activities are carried out in Wet Shrub, Mixed Dry Agriculture and Bare Ground areas by changing them to peat swamp forest (PSF) carbon conditions as per Mohd's study in 2025, there will be a much greater potential for emission absorption. The CO_2e emission absorption value can reach 6,150,574.72 tons over the next 30 years (Table 3.17).

Table 3.17. Alternative Value of Emission Sequestration Potential in 30 Years

Land Cover	Carbon Stock (ton Biomass/ ha)	Area (ha)	Biomass (Ton)	Carbon (Ton C)	Ton CO_2e
Peat Swamp Forest	414.94	5,952.57	2,469,936.40	1,160,870.11	4,256,523.74
Secondary Dry Land Forest	414.94	2,537.99	1,053,103.24	494,958.52	1,814,847.92

Land Cover	Carbon Stock (ton Biomass/ ha)	Area (ha)	Biomass (Ton)	Carbon (Ton C)	Ton CO_2e
Secondary Dry Land Forest	414.94	110.76	45,959.22	21,600.83	79,203.06
Total			3,568,998.87	1,677,429.47	6,150,574.72

Source: Assumptions of carbon stocks of PSF and secondary dry land forest using NFRI's values, 2025.

Using data from NFRI 2025 about carbon stock potential value for 2025 and assuming that emissions absorption over 30 years can reach the PSF condition, the absorption potential will be very high in the next 30 years. In the next 30 years, the potential emission reduction could reach 5.67 million tons of CO_2e (Table 3.18).

Table 3.18. Alternative Calculation of Potential Emission Reductions

No	Land Cover	Baseline (Ton CO_2e)	Mitigation Action (Ton CO_2e)	Emission Reduction (Ton CO_2e)
1	Peat Swamp Forest	198,394.78	4,256,523.74	(4,058,128.96)
2	Secondary Dry Land Forest	282,722.45	1,814,847.92	(1,532,125.48)
3	Secondary Dry Land Forest	458.11	79,203.06	(78,744.94)
	Total	481,575.34	6,150,574.72	(5,668,999.38)

Source: ERIA study team using processed data taking into account carbon stock assumptions according to the results of NFRI, 2025.

3.4.3.3. Estimated Carbon Credits from Belait

Based on secondary data analysis and applying carbon stock assumptions from Mohd (2025), it is estimated that if land currently classified as wet shrub, mixed dry agriculture, and bare ground were fully rehabilitated and allowed to grow optimally, the potential emission sequestration could reach approximately 5,668,999.38 tons of CO_2e.

The main limitation of this study lies in its reliance on secondary (Tier 1) data. To improve the accuracy of the estimates, more detailed, site-specific data are required, particularly regarding the growth characteristics of the plant species selected for land rehabilitation into forest ecosystems. Specifically, information on the average annual increment (AAI/MAI) for each planted species is necessary to refine carbon sequestration estimates.

3.4.3.4. Economic Value of Carbon

Net sequestration potential refers to the ability of an ecosystem or system to absorb and store carbon from the atmosphere net of emissions. It is often used in the context of climate change mitigation and environmental conservation. Mangrove ecosystems have high carbon sequestration potential due to their ability to store carbon in sediments for thousands of years.

The economic value of carbon is analysed from the reduction in carbon emissions that occurred over 30 years in Brunei. The economic value of carbon is defined as the value of each unit of greenhouse gas emissions generated from human and economic activities. In this mitigation activity, the change in land cover from wet shrub to secondary swamp forest / secondary mangrove forest while bare ground and mixed dry agriculture can become secondary dryland forest. The highest reduction with mitigation is from wet shrub cover to secondary swamp forest with an emission reduction value of 2,014,414.81 tons of CO_2e or around 74.18%. while for bare ground and mixed dry agriculture can become secondary dryland forest reducing emissions by 701,466.63 tons of CO_2e or around 25.81%.

This analysis uses the delta of the emission reduction plan between the current time and the next 30 years (baseline) with a carbon price per ton of US$10/ ton CO_2e. Based on the analysis results, the economic value of carbon from emission reduction is US$13,579,407.25, of which 72.42% comes from secondary swamp forest. This emission reduction value is used compared to several other studies that emphasise the economic value of carbon at a static point (only a certain year or at that time) because it reflects the real impact of climate change mitigation efforts.

Table 3.19. Economic Value of Carbon based on Emission Reduction between now and Baseline at a Carbon price of US$10

No	Land Cover	Decreasing of Emission (Ton CO_2e)	Percentage (%)	Economic Value of Carbon (US$)
1	Secondary Swamp Forest	2,014,414.81	74.17%	10,072,074.05
2	Secondary Dry Land Forest	660,750.00	24.33%	3,303,750.00
3	Secondary Dry Land Forest	40,716.63	1.50%	203,583.15
	Total	2,715,881.45	100.00%	13,579,407.25

Source: ERIA study team, 2025.

Currently, activities in the area, such as restoration, have not been carried out much, so that in conducting an analysis to compare existing activities to get a better price is rather difficult. But some things that can be done to get a better price are: (1) the quality of the project to reduce emissions, (2) the type of ecosystem, (3) greater social benefits received by the community, (4) the reputation of the buyer (companies with a good reputation in the field of sustainability tend to buy at a higher prices) (5) the target market, preferably the international market and (6) volume and risk, where large projects with low risk tend to attract premium prices.

Therefore, if decarbonisation activities in Brunei Darussalam want to obtain better carbon prices, it is recommended that the Government of Brunei Darussalam can implement the following strategies:

1. Brunei Darussalam is well-positioned to engage in high-value carbon markets, supported by its strong environmental assets and emerging climate policy framework. The Brunei National Climate Change Policy (BNCCP) outlines a clear commitment to emissions reduction and forest conservation, yet the country has not established a formal carbon trading system. With its pristine rainforests, extensive mangrove ecosystems, and low deforestation rates, Brunei holds significant potential for nature-based carbon projects such as REDD+, reforestation, and coastal restoration.
2. Socially, Brunei benefits from a stable welfare system and high living standards, though community participation in environmental initiatives remains limited and could be enhanced through inclusive, benefit-sharing mechanisms.
3. To maximise the value of carbon credits, Brunei should pursue a dual-track strategy. First, channelling revenue toward community-based programmes, including conservation training, green livelihood development, and performance-based incentives, would ensure local engagement and equitable benefit distribution. Second, investing in institutional and ecological infrastructure, such as national MRV systems, legal frameworks, and biodiversity research, would strengthen project credibility and attract premium buyers.
4. Brunei can expand market access through international cooperation under Article 6 of the Paris Agreement. Transparent governance, ecosystem prioritisation, and alignment with global sustainability standards will be key to unlocking Brunei's full potential in the carbon economy.

This approach helps ensure that policies and investments contribute to global emission reductions. Here are some of the main reasons:

a. Assessing Policy Effectiveness - The emission delta shows how much carbon reduction is achieved through policies such as carbon taxes, carbon trading, or investment in clean energy.
b. Calculating the Economic Value of Carbon - The economic value of carbon is often calculated based on the amount of carbon that has been successfully reduced, not just the total emissions.
c. Supporting Net-Zero Targets - Many countries and companies set net-zero emissions targets, which means they must reduce emissions to reach balance with the carbon absorbed.
d. Investment Optimisation - Companies and governments use emission reduction data to determine the most effective investment strategies in low-carbon technologies.

3.5. Advancing Methodology on Carbon Credit Calculation

3.5.1. Conclusion

Carbon sequestration and carbon credit programmes are essential strategies to address climate change. Carbon sequestration can be achieved through both technological approaches and nature-based solutions such as reforestation and mangrove restoration. These efforts not only capture carbon emissions but also provide additional benefits for biodiversity, ecosystems, and local communities. At the same time, carbon credit programmes allow companies or countries to offset their emissions by supporting verified projects that reduce or absorb carbon elsewhere.

The success of these programmes depends on clear regulations, transparent monitoring systems, and active stakeholder participation. Experiences from Indonesia, Malaysia, and Brunei highlight the importance of strong institutions and results-based financing to ensure sustainable forest management. With these foundations, carbon pricing can serve as an effective tool to reduce emissions while promoting green and sustainable development.

Brunei Darussalam, with 72.1% forest cover and substantial carbon sequestration potential, has increasingly prioritised forest-based mitigation within its climate strategy, targeting the planting of 500,000 trees by 2035 and developing MRV systems. Despite having one of the world's highest per capita CO_2 emissions due to its fossil fuel-reliant economy and lacking a carbon tax or ETS, Brunei is laying groundwork through voluntary and results-based forest carbon initiatives. While its carbon pricing readiness structurally resembles least developed countries, its high-income status and fiscal capacity position it uniquely to adopt a phased, hybrid carbon pricing model – beginning with voluntary forest offsets at modest prices and advancing toward formal mechanisms – balancing environmental imperatives with economic resilience and regional cooperation.

Given Brunei Darussalam's high forest cover, elevated per capita emissions, and absence from existing carbon markets, a phased hybrid carbon pricing strategy centred on forest offsets is recommended to progressively build capacity and align with global standards. Phase I (2025–2028) establishes a voluntary domestic forest-based offset market with MRV and registry systems, offering US$5–10/t$CO_2$ to build infrastructure and investor confidence. Phase II (2028–2030) leverages international results-based finance, monetising verified emission reductions via programmes like the LEAF Coalition at US$5–7/t$CO_2$ while reinforcing forest governance. Phase III (post-2030) introduces a national compliance-based carbon pricing framework, either through a carbon tax with forest offset provisions or a pilot ETS for key sectors, institutionalising carbon pricing while safeguarding economic stability and enabling regional market integration.

Brunei Darussalam possesses significant potential for carbon sequestration through land rehabilitation, particularly in wet shrub, mixed dry agriculture, and bare ground areas, which collectively cover around 8,600 hectares. Current carbon stocks in these non-forest areas are relatively low, but through mitigation actions converting them into secondary swamp forest, secondary mangrove, or secondary dryland forest, substantial emission absorption can be achieved. Over a 30-year period, in Belait Peat Ecosystem, these interventions could sequester up to 3,197,456.78 tons of CO_2e, with wet shrub areas contributing the highest share. If restored to conditions comparable to mangrove ecosystems in Malaysia, the sequestration capacity would be even greater, reflecting the critical role of land-use change and forest restoration in Brunei's climate strategy.

Economically, this carbon sequestration potential translates into a considerable financial value. Using a carbon price of US$10 per ton CO_2e, the total economic value of avoided emissions reaches US$13,579,407.25 over 30 years. Most of this value (around 74.17%) comes from converting wet shrub to secondary swamp forests. This valuation underscores the importance of targeted land rehabilitation not only for emission reductions but also for generating tangible economic returns, supporting climate policy effectiveness, net-zero targets, and optimal investment decisions in nature-based solutions.

Factors that impact carbon price are the quality of the project to reduce emissions, the type of ecosystem, greater social benefits received by the community, the reputation of the buyer, the target market and volume and risk, where large projects with low risk tend to attract premium prices.

3.5.2. Recommendation

According to the conclusion of this analysis, there are some recommendations to fully optimise the environmental and economic benefits of its mitigation efforts, Brunei Darussalam should:

1. Prioritise the establishment of a credible national carbon registry and MRV system to improve market access and investor confidence.
2. Focus land rehabilitation activities on wet shrub, mixed dry agriculture, and bare ground areas using high-value commercial tree species to maximise sequestration.
3. Engage with international results-based finance schemes while advocating for higher carbon pricing in line with ASEAN or regional standards.
4. Gradually implement a compliance-based carbon pricing policy post-2030, integrating domestic forest offsets as cost-control instruments.
5. Based on differences of economic value of carbon, it is crucial for Brunei to:
    a. Align its carbon price target with regional market trends.
    b. Encourage participation in both voluntary and compliance carbon markets.
    c. Strategically negotiate higher carbon credit prices based on the country's high sequestration potential.

Chapter 4

Forest Carbon Project Eligibility Assessment

4.1. UNFCCC Guidelines for the Carbon Markets and Global Carbon Credit Programme

The global carbon market, governed by Article 6.A of the UNFCCC, provides an essential framework for international collaboration and carbon credits trading, enabling countries to advance climate action through transparent and credible emission reductions.

ASEAN countries, including Brunei, are developing strategies to reduce carbon emissions and designing interventions supported by sustainable incentives. Brunei is working to meet its Nationally Determined Contribution (NDC) commitments by prioritising the conservation of old-growth forests. These ecosystems form a central part of the country's climate strategy. Over time, Brunei has strengthened its forest protection efforts, with a particular focus on peat swamp forests to safeguard significant carbon stocks and critical biodiversity.

The decision to focus on the Belait Peat Swamp Forest is deliberate, as it remains one of Brunei's most intact and ecologically important carbon sinks. Through this focus, Brunei seeks to access opportunities in international carbon credit schemes while advancing its environmental objectives. For the Belait PSF to gain recognition in these markets, it must meet strict and evolving criteria for forest carbon projects, reflecting ongoing advances in science and best practices. Frameworks such as the Clean Development Mechanism, REDD+, and standards including the Verified Carbon Standard and Gold Standard each require robust evidence of environmental gains, long-term carbon storage, thorough monitoring, and quantifiable emission reductions. By fulfilling these requirements, Brunei's forestry projects can serve as credible sources of carbon credits on the global stage.

4.1.1. Context of Carbon Cycle and Credit Programme

The carbon cycle is central to life on Earth, moving carbon continuously between the atmosphere, living things, oceans, and the Earth's crust. Through photosynthesis, plants absorb carbon dioxide and release oxygen, while respiration and decomposition return carbon to the air. The oceans act as both a sink and a source of carbon, exchanging it with the atmosphere. Over longer timescales, geological processes store carbon deep underground, which can re-enter the cycle through natural events or human activities as fossil fuel combustion. Today, this balance is disrupted as human activities, especially fossil fuel burning and deforestation, release more carbon dioxide than natural systems can absorb. This growing imbalance increases greenhouse gases, drives global warming, and leads to problems like rising sea levels, extreme weather, and loss of biodiversity. The UNFCCC's Paris Agreement aims to limit warming and reduce emissions.

Effective climate action means better management of the carbon cycle, alongside other mitigation and adaptation measures. It becomes inevitable that conserving and restoring carbon-rich landscapes, such as forests and peatlands, is critical. In Brunei, where forests cover most of the country, initiatives like the Belait Peat Swamp project are vital for protecting valuable carbon stores, regulating water flow, and supporting rich biodiversity.

To make a real impact, carbon projects need to follow strict international standards such as CDM (Clean Development Mechanism), REDD+, VCS (Verified Carbon Standard), JNR (Jurisdictional and Nested REDD+), and Gold Standard. These frameworks provide the rules for measuring carbon benefits and ensuring environmental and community safeguards, aligning projects with evolving carbon market expectations. Beyond carbon storage, they also support biodiversity, protect endangered species, and empower local communities. Together, these efforts reinforce Brunei's national climate strategies and help build a stronger, more resilient economy and environment. The research problem and the related research questions on the eligibility of the Belait PSF are presented below.

4.1.2. Challenges in Forest Carbon Project Eligibility

- The absence of verified carbon data for Brunei's forests limits the country's participation in voluntary carbon markets.
- There is a need to assess the eligibility of the Belait forest under recognised forest carbon crediting standards.

4.1.3. Research Objectives

- Evaluate the Belait Peat Swamp Forest against key forest carbon standards and frameworks such as REDD+, the Clean Development Mechanism, and leading voluntary standards to determine its eligibility for forest carbon programmes.
- Identify the challenges and opportunities unique to developing forest carbon projects in Brunei, considering local socio-economic, ecological, and stakeholder factors to ensure long-term success.
- Develop a robust project framework, including scientific methodologies for accurate carbon measurement, credit calculation, and clear procedures for reporting, verification, and ongoing monitoring.
- Assess trends in the carbon market and analyse price dynamics to ensure that marketing Brunei's carbon credits remains both viable and economically sound.

The Chapter is organised as follows. Section 4.2 presents a conceptual framework for analysing the eligibility criteria for carbon financing. Section 4.3 and 4.4 review international standards and frameworks for assessing project eligibility. Section 4.5 evaluates the eligibility of the proposed project, while Section 4.6 discusses case studies from Malaysia, India, and Indonesia. The final sections provide concluding remarks.

4.2. Conceptual Framework for Analysing Eligibility Criteria for Forest Carbon Financing

Figure 4.1. Conceptual Framework for Analysing Eligibility Criteria for Carbon Financing

Note: UNFCCC – United Nations Framework Convention on Climate Change; CDM – Clean Development Mechanism; VCS – Verified Carbon Standard; REDD+ – Reducing Emissions from Deforestation and Forest Degradation, plus the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks; NGO – Non-Governmental Organization; CER – Certified Emission Reduction; VCU – Verified Carbon Unit
Source: ERIA study team, 2025.

Figure 4.1 presents the conceptual framework for identifying the stages involved in evaluating the eligibility of carbon financing projects. The process begins with defining initial goals and identifying critical stakeholders responsible for initiating and planning the assessment. This is followed by determining data requirements and addressing gaps to forest, soils, biomass, and other related fields through field studies and remote sensing.

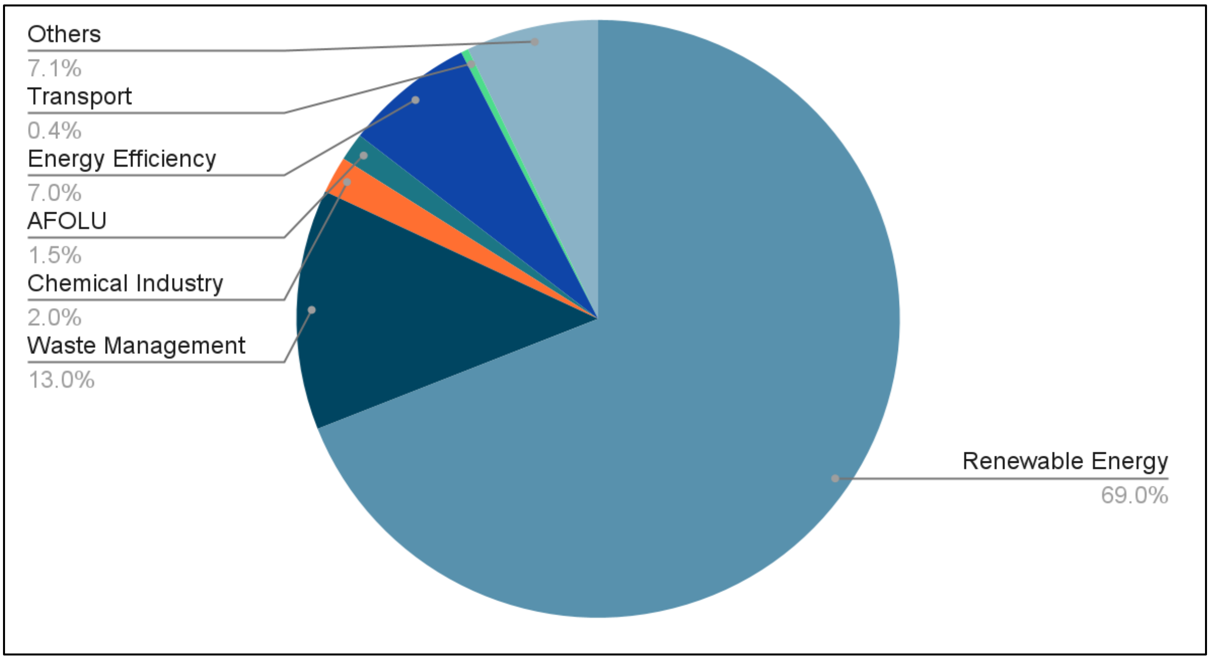
4.3. Standards

4.3.1. Forest Carbon Market and Global Standards

4.3.1.1. Clean Development Mechanism (CDM)

The CDM, created under the 1997 Kyoto Protocol, allowed developed countries to fund emission-reduction projects in developing nations and earn Certified Emission Reductions (CERs). It supported more than 8,000 projects in 111 countries and generated over 2 billion CERs. However, benefits were concentrated in a few countries, and falling CER prices along with reduced European demand raised concerns about its climate impact and financial sustainability. Criticism also grew over negative community effects and weak incentives. These issues led to its replacement under the Paris Agreement by a new market system with stronger standards, broader participation, and greater transparency. Despite shortcomings, the CDM was a milestone in climate action, pioneering the global carbon market and shaping today's more inclusive approaches.

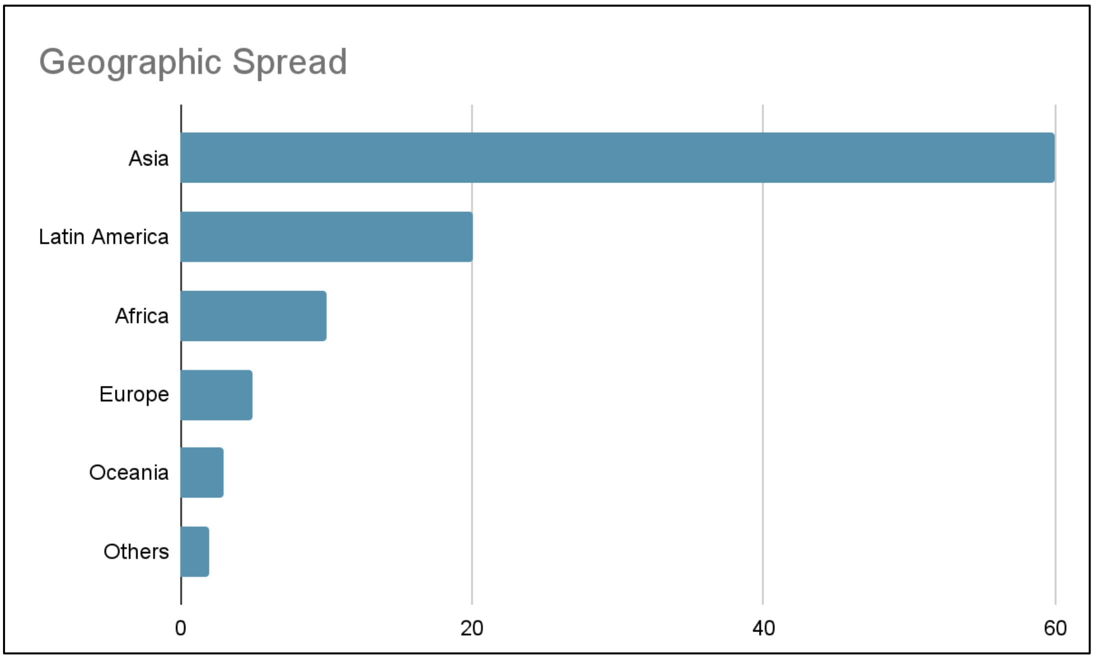
Figure 4.2. Sectoral Distribution of CDM Project at Global Level



Source: ERIA study team, 2025.

The CDM portfolio is dominated by renewable energy projects, which account for 69% of all initiatives, primarily wind and hydropower. Waste management represents 13%, focusing on landfill gas capture and methane reduction, while chemical industry projects are 2%, targeting the destruction potent industrial gases such as HFC-23 (trifluoromethane), N_2O (nitrous oxide), PFCs (perfluorocarbon), and so on. Agriculture, Forestry, and Other Land Use, including afforestation and peatland restoration, comprises only 1.5%, largely due to verification challenges. Energy efficiency contributes 7%, and transport is the smallest sector at 0.4%, likely because of complex measurement and monitoring issues.

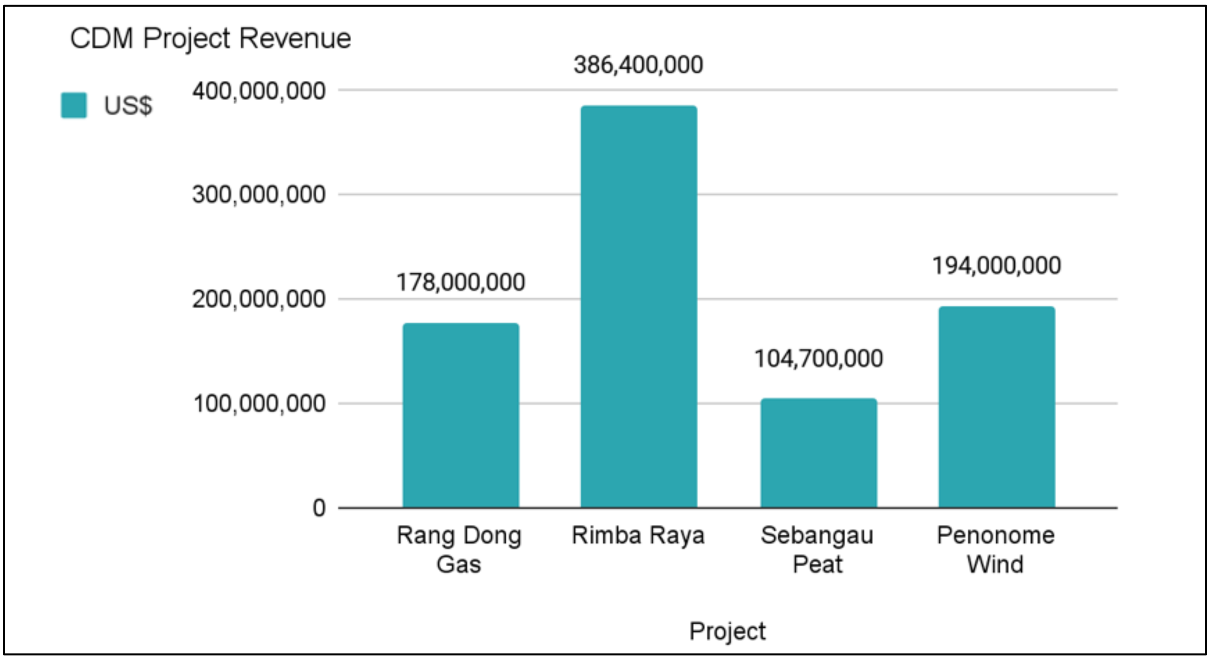
Figure 4.3. CDM Geographic Spread under Agriculture and Forestry



Source: ERIA study team, 2025.

Agriculture and forestry make up about 1.5% of CDM projects, with Asia leading at roughly a 60% share, reflecting extensive afforestation and peatland restoration efforts, particularly in Indonesia and China. Latin America (20%) follows with strong community-led forest initiatives, while Africa (10%) contributes through agroforestry. Europe (5%) and Oceania (3%) play smaller roles, mostly in peatland and afforestation projects. This distribution reflects regional ecological priorities and capacities for land-based climate solutions.

Figure 4.4. Notable CDM Project Revenue in US$

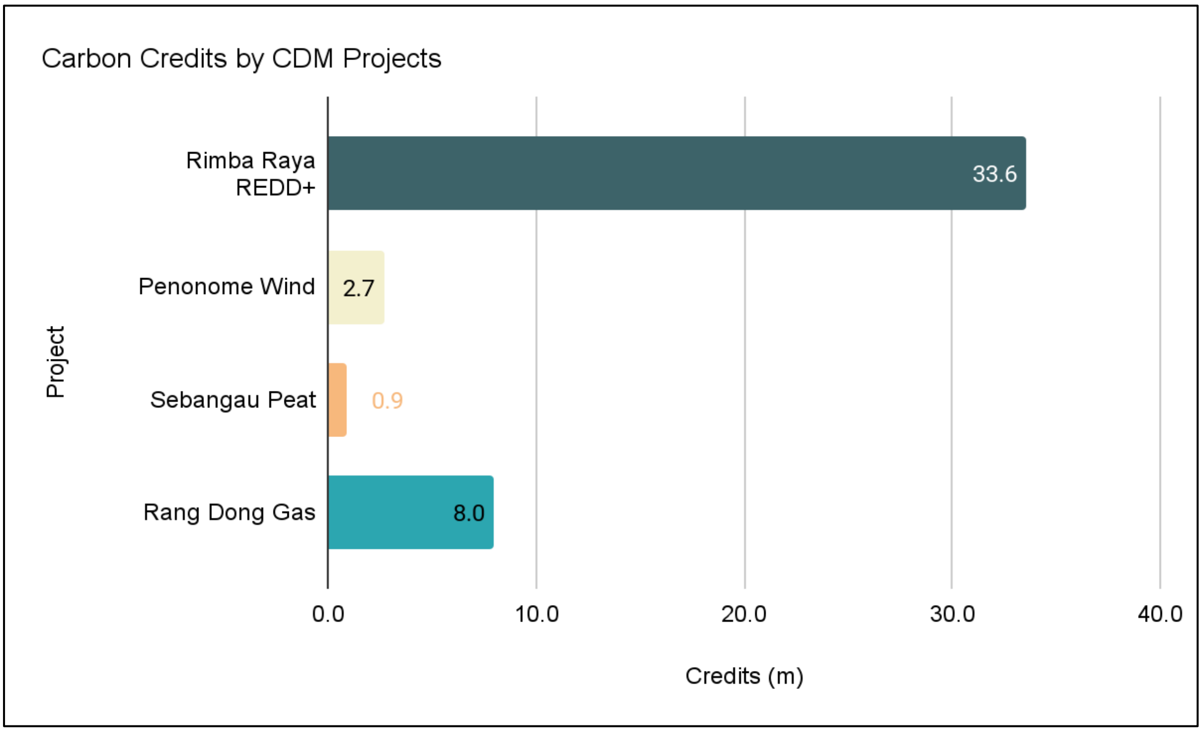


Note:
The price used is the average of the highest and lowest market prices of carbon credit

- Rang Dong Gas Recovery (Viet Nam)
  Rang Dong Gas Recovery reduces methane emissions by capturing and using gas from offshore oil fields instead of burning it. Officially recognised by CDM in 2006, it had already reduced over 4.49 million tonnes of CO_2 by 2005 and continued verified emission cuts through 2011.
  The project-built gas recovery systems and a pipeline to bring gas onshore, but as equipment ages, risks increase, and monitoring has become less reliable since CDM oversight ended. Community involvement and benefit-sharing were minimal. To stay effective, Rang Dong should modernise equipment, upgrade monitoring, follow international standards, schedule third-party audits, and direct part of carbon revenues into community programmes to improve trust and fairness.
- Rimba Raya REDD+ (Indonesia)
  The Rimba Raya REDD+ project protects 47,000 hectares of peat swamp and has issued over 33 million carbon credits, supporting conservation, health, water, and local businesses in 14 villages. Reporting on fund distribution to communities is limited, and economic stability relies heavily on carbon sales. Some reforestation uses non-native trees, risking biodiversity. The project should provide village-level funding reports, engage communities on spending, promote alternative incomes like ecotourism and agroforestry, and use only native species in restoration.
- Sebangau Peat Rewetting (Indonesia)
  The Sebangau Peat Rewetting Project restored drained peatland by building over 400 dams to prevent fires and subsidence, while supporting reforestation and local training. Early results were promising, but challenges remain, including deteriorating dams, continued fire risk, and limited local economic benefits or involvement. The project should pay and train local residents to maintain and monitor dams, adapt dam designs for community use, hold regular meetings with villagers, and link restoration to income opportunities such as sustainable fisheries or floating gardens.
- Penonomé Wind Farm (Panama)
  The Penonomé Wind Farm, with 108 turbines generating 270 MW, provides up to 7% of Panama's electricity and reduces carbon emissions by 450,000 tonnes annually. Since 2014, it has lessened reliance on fossil fuels and stabilised the grid. However, the project could improve monitoring and reporting of environmental impacts, particularly on local wildlife. Community engagement has declined since construction, and there are risks of the technology becoming outdated as energy demands evolve.

Source: ERIA study team, 2025.

Figure 4.5. Carbon Credits by CDM Projects



Source: ERIA study team, 2025.

Table 4.1. Key Metrics for Notable CDM Projects

Metric/Project	Rang Dong Gas Recovery (Vietnam)	Rimba Raya REDD+ (Indonesia)	Sebangau Peat Rewetting (Indonesia)	Penonomé Wind Farm (Panama)
Project Period	2001–2011	2013–2024 (license revoked)	2004–2038	2012–2022 (CDM); 2022–present
Project Area	Block 15-2, Offshore Vietnam	64,000 ha (47,237 ha carbon area)	568,700 ha (Sebangau National Park)	46,000 acres
Total CERs/ VCUs Issued	8.856 million CERs	33.6 million VCUs	910,387 CERs	4.0 million CERs
Annual Reduction	677,000 tCO_2e/yr	4.5 million tCO_2e/yr	Not specified (low volume overall)	400,000 tCO_2e/yr
Revenue Generated	$17.8 million (avg. $4/CER)	$386.4 million (est. $11.5/VCU)	Unclear (low CER volume)	$184 million (est. $11.5/CER)
Key Partners	JVPC, ConocoPhillips, PetroVietnam	InfiniteEARTH, local communities	WWF Indonesia, National Park Office	Unión Eólica Panameña, InterEnergy

Metric/Project	Rang Dong Gas Recovery (Vietnam)	Rimba Raya REDD+ (Indonesia)	Sebangau Peat Rewetting (Indonesia)	Penonomé Wind Farm (Panama)
Infrastructure	Three offshore platforms, pipeline	Community, health, solar, water projects	434 dams, advanced satellite MRV	108 turbines, 270 MW
Technology Transfer	Gas processing, pipelines	Community programmes, solar, water	Hydrology, fire monitoring	Wind turbine tech, grid integration
Local Employment	Gas plant operations staff	Community jobs, local programmes	Community MRV, dam construction	Nearly 500 jobs created
Community Programmes	Minimal	Education, health, clean water	Community nurseries, training	Some local investment
Biodiversity Impact	Methane reduction, offshore risk	105,000 orangutans, 55 mammals	Peatland restoration, fire risk	Bird/wildlife impact unclear
Challenges & Status	Aging infrastructure, low community benefit	License revoked, legal dispute	Maintenance, community buy-in	Ongoing operational and environmental monitoring
MRV	CDM, needs upgrade post-CDM	VCS, CCB, SD VISta; needs more	TET-1 satellite, community MRV	CDM, environmental monitoring needed
Climate Contribution	Gas to energy, emission reduction	Peat carbon, avoided deforestation	Fire reduction, peat carbon	5–7% of Panama's electricity

CDM = Clean Development Mechanism; MW = Megawatt; VCS = Verified Carbon Standard; CCB = Climate, Community & Biodiversity Standards; SD VISta = Sustainable Development Verified Impact Standard; MRV = Measurement, Reporting, and Verification.

Source: ERIA study team from Alexeew et al.(2010); Olsen and Fenhann (2008); Schneider, Kollmuss, and Lazarus (2015); Schneider et al.(2015); UNFCCC (n.d.-a); UNFCCC (n.d.-b); World Bank, 2024.

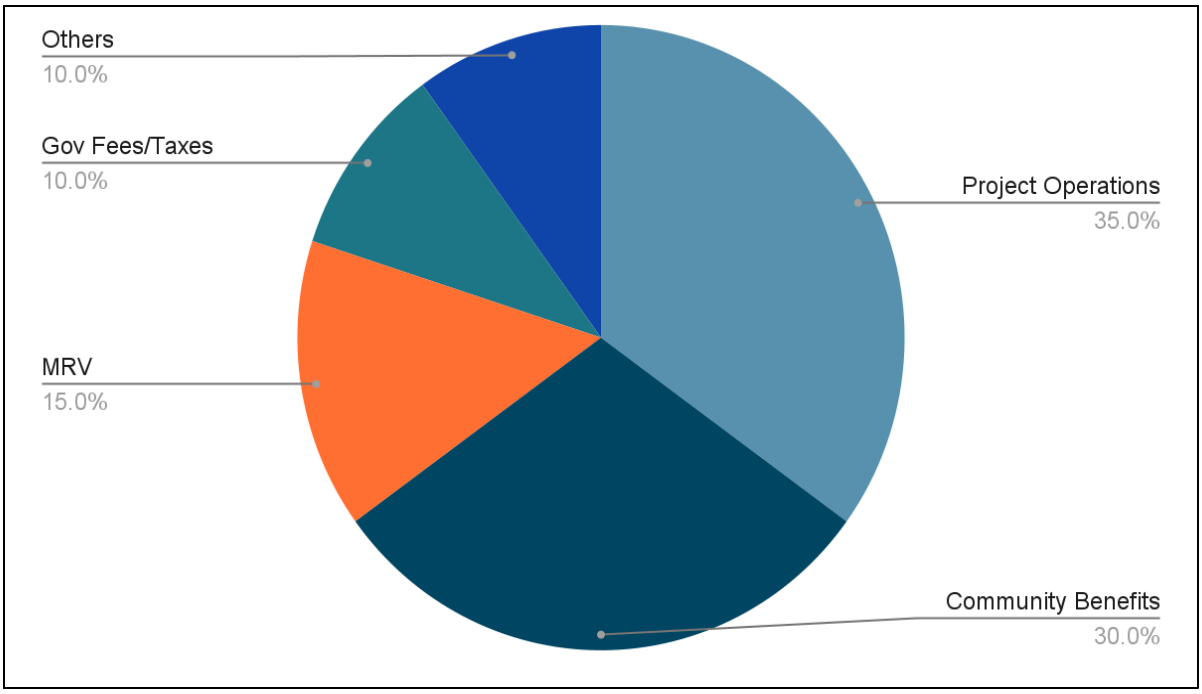
4.3.1.2. Reducing Emissions from Deforestation and Forest Degradation (REDD+)

REDD+, or Reducing Emissions from Deforestation and Forest Degradation, is an international framework under the UNFCCC that rewards developing countries for protecting forests and managing them sustainably. The core idea is to pay countries that reduce deforestation, enhance forest carbon storage, and promote conservation, recognising that forest protection is critical for addressing global greenhouse gas emissions.

Originating in 2005 and officially adopted in 2010, REDD+ targets not only emission reductions but also supports biodiversity and the livelihoods of local communities through a results-based finance system. Countries progress through phases, starting with strategy development and monitoring, and then receive payments, typically $8 to $15 per tonne of CO_2 reduced, only after independently verified results.

While REDD+ faces challenges, such as ensuring permanent emission reductions, avoiding double counting, and preventing deforestation from simply shifting elsewhere, recent improvements under the Paris Agreement promote more rigorous national accounting and allow for larger scale climate financing. Today, most REDD+ projects are in tropical regions, particularly the Amazon, Southeast Asia, and Central Africa, making it a vital link between climate finance and the long-term protection of the world's most important forests. When properly implemented, REDD+ will deliver measurable emissions cuts, conserves biodiversity, and advances the rights and wellbeing of forest communities.

Figure 4.6. Revenue Allocation for REDD+ Projects



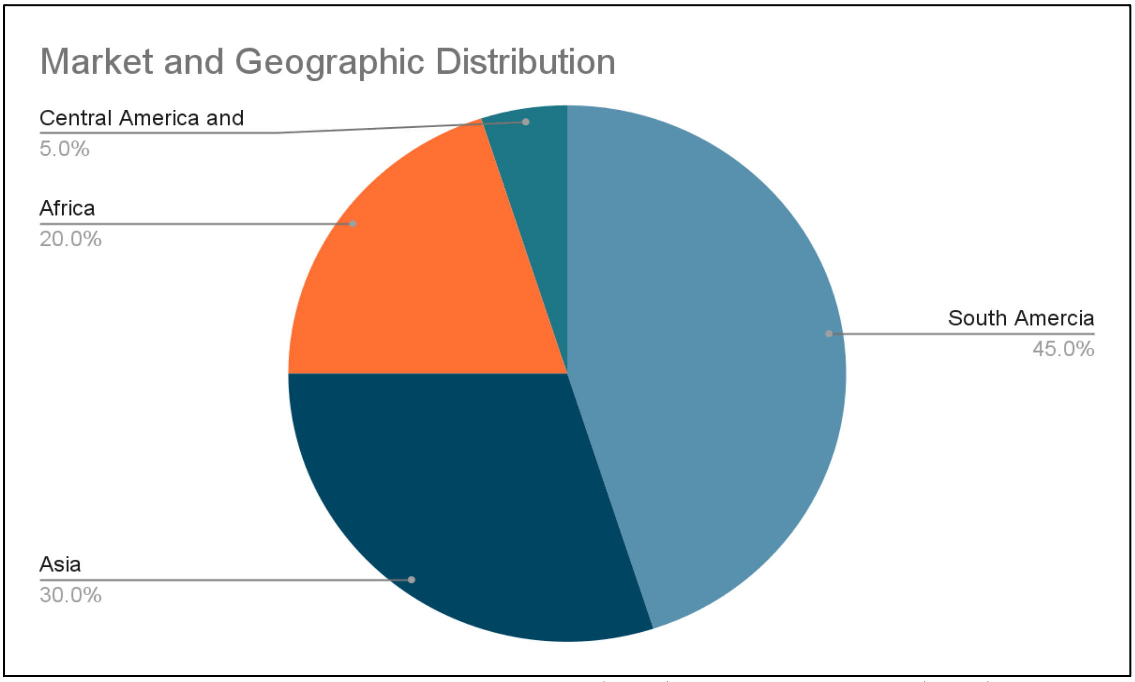
Source: ERIA study team, 2025.

Volatility of REDD+

REDD+ quickly gained international support as a leading nature-based solution (NbS) to climate change, attracting billions in funding from donors like Norway and inspiring over 50 countries to launch national programmes and hundreds of projects. However, enthusiasm has waned as price volatility and credibility concerns have emerged.

REDD+ carbon credit prices have fluctuated from as low as $2 to as high as $15 per tonne, complicating long-term planning and making private investment less attractive. Oversupply and doubts about the actual impact of credits have further undermined confidence, particularly after studies suggested that many credits may not reflect real emission reductions. On top of technical concerns, integrating local projects into national tracking systems has proven complex, often leading to disputes over emission reduction ownership and slowing progress in countries with limited capacity. Some donors have withdrawn, frustrated by slow results and issues such as leakage or non-permanence, where gains in one area are offset by losses elsewhere. While these challenges have not ended REDD+, they have forced a shift toward improved national coordination and more reliable carbon accounting under the Paris Agreement. Today, REDD+ is recognised as a long-term effort requiring careful planning, transparency, and trust between local and national actors to deliver both climate and community benefits effectively.

Figure 4.7. REDD+ Market and Geographic Distribution



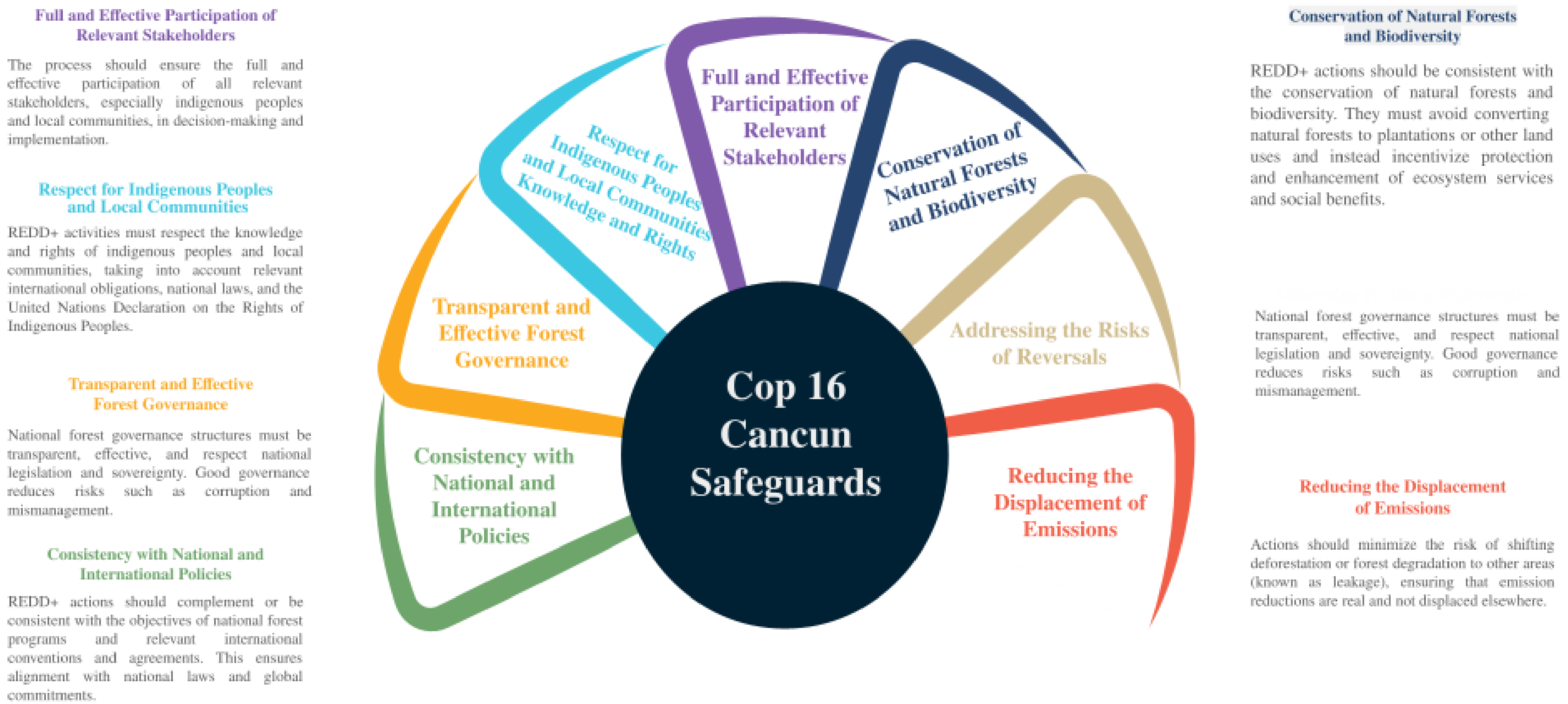
Source: ERIA study team compiled from Boer et al. (2023); UN-REDD Program (2024); UN-REDD Programme (2018); OPIS (2025); REDD+ Project Database (2024); ART (2025).

REDD+ projects primarily focus on tropical and subtropical regions, where deforestation and forest degradation are most severe. South America leads with around 45% of global REDD+ initiatives, concentrated in the Amazon basin due to high deforestation pressures and extensive intact forest landscapes. Asia accounts for roughly 30%, driven by projects in Indonesia and Malaysia emphasising peatland conservation and forest protection. Africa hosts about 20% of REDD+ activities, particularly in the Congo Basin, targeting community forest management and agroforestry. The remaining 5% is spread across Central America and Pacific Island nations, representing smaller-scale yet critical conservation efforts. This geographic distribution underscores REDD+'s role in safeguarding biodiversity hotspots, supporting indigenous rights, and local community rights, and mitigating climate change by promoting forest conservation and sustainable management, even as pressures from rising populations and food demand increase, without directly linking to agricultural expansion. The REDD+ framework is implemented in three phases:

Figure 4.8. The REDD+ Framework Implementation Phases

Source: ERIA study team compiled from Angelsen et al. (2009); UN-REDD Programme (2021); UNFCCC (2023).

Figure 4.9. Cancun Safeguards – REDD+



Source: ERIA study team compiled from UNFCCC (2010); UN-REDD Programme (2016); UN-REDD Programme (2015); Lofts et al. (2021); Walcott (n.d.); Climate Focus (2015); Amazon Fund (2015); State of Tocantins Secretariat (2024).

Table 4.2. Notable REDD+ Projects

Project	People Reached	Main Co-benefits Provided
Surui Forest Carbon Project (Brazil)	~1,000	Sustainable income, education, health services, support for traditional livelihoods
Rimba Raya REDD+ Project (Indonesia)	~2,500	Education, health services, jobs, microfinance, clean water, solar energy
Kasigau Corridor REDD+ Project (Kenya)	116,000 (largest reach)	Education (26,000+ scholarships), health services, jobs, clean water, economic development
Mai Ndombe REDD+ Project (Rep. of Congo)	28,000	Education (10 schools), health clinics, agriculture support, clean water, vocational training

Source: ERIA study team, 2025.

- Surui Forest Carbon Project (Brazil)

  The Surui Forest Carbon Project, launched in 2009 by the Paiter-Surui tribe in the Brazilian Amazon, was the first Indigenous-led REDD+ initiative certified under both the Verified Carbon Standard and Climate, Community & Biodiversity Alliance. Covering 248,000 hectares, the project significantly reduced deforestation between 2009 and 2014 while generating sustainable income through activities such as medicinal plant harvesting and agroforestry.

  However, a gold rush in 2014 led to illegal land clearing, overwhelming the tribe and resulting in the project's suspension by 2018. Transparency challenges also arose, with limited data on carbon credits issued, revenue distribution, and monitoring costs. Moving forward, the project should adopt participatory and satellite-based monitoring, enhance financial transparency through public reporting, and strengthen ecological and social impact assessments to build resilience, trust, and long-term sustainability.

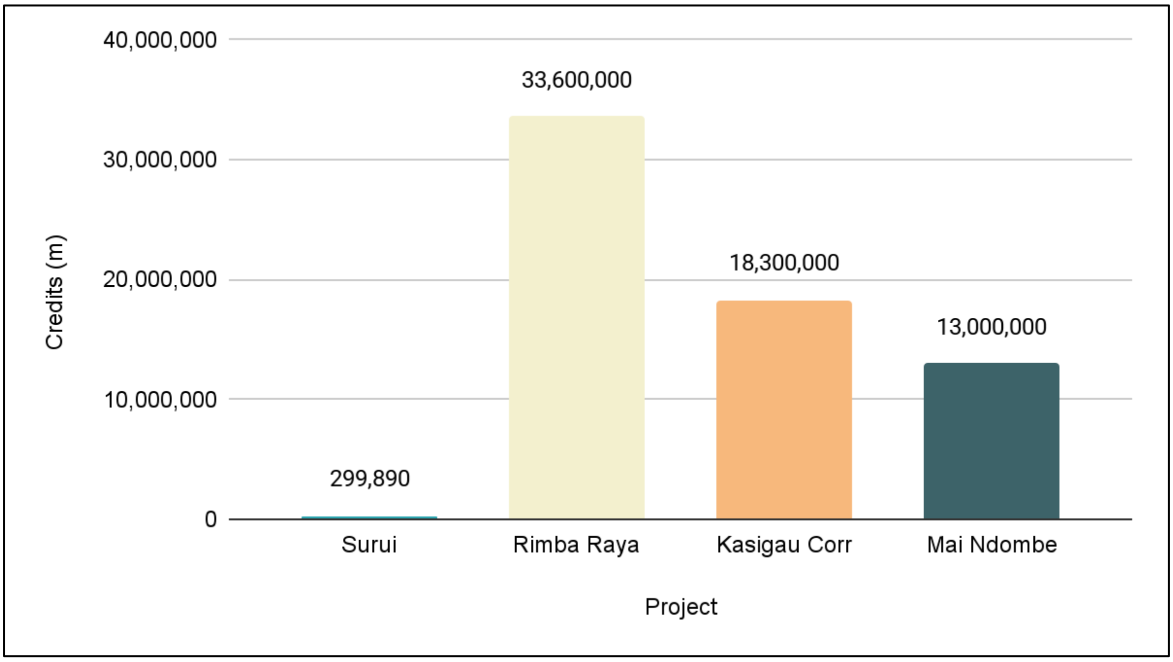
- Kasigau Corridor REDD+ Project (Kenya)

  The Kasigau Corridor REDD+ Project is located in southeastern Kenya, spans 200,000 hectares between Tsavo East and Tsavo West National Parks. The project was managed by Wildlife Works, aiming at halting deforestation, conserving biodiversity, and supporting local communities through carbon finance. Since its inception, Kasigau has helped avoid approximately 18.3 million tonnes of carbon emissions and protected a critical wildlife corridor for over 11,000 elephants. The project is also recognised for its education programmes, providing over $1.2 million in bursaries and enabling more than 26,000 students to remain in school. Forest rangers employ an innovative mobile monitoring app, allowing real-time reporting of illegal activities and ecosystem changes. However, the project lacks transparency regarding the number of credits issued and clear details on spending for rangers, schools, or reforestation. Limited data exists on household incomes, health, or food security, and biodiversity, which is not regularly published. To enhance trust and effectiveness, Kasigau would benefit from annual reports detailing credit issuance, financial allocations, and specific community benefits, along with improved wildlife monitoring and measurement of local social outcomes, solidifying its position as a leading African REDD+ project.

- Mai Ndombe REDD+ Project (Democratic Republic of Congo)

  The Mai Ndombe REDD+ Project in the DRC protects over 380,000 hectares of valuable forest, aiming to balance environmental conservation with community development. Certified under major carbon and biodiversity standards, the project has issued over 13 million Verified Carbon Units and supported local communities through the construction of schools, health centers, and clean water systems. Its theory-of-change approach links everyday activities, such as forest patrols, with broader goals of reduced deforestation and improved living standards. However, challenges remain, including limited transparency regarding carbon revenue generation, allocation, and the extent of benefits reaching communities. Data on biodiversity outcomes and restoration costs is also sparse. To enhance credibility, Mai Ndombe should publish detailed financial reports, implement a community benefit tracking system, strengthen forest and drought monitoring using new technologies, and collaborate with researchers to provide comprehensive biodiversity reporting.

Figure 4.10. VCUs Issued by Project



Source: ERIA study team compiled from Verra (2022) and Forest Trends (2019).

Table 4.3. Comparative Table of Key Metrics for Leading REDD+ Forest Carbon Projects

Metric/ Project	Surui Forest Carbon Project (Brazil)	Rimba Raya REDD+ (Indonesia)	Kasigau Corridor REDD+ (Kenya)	Mai Ndombe REDD+ (DRC)
Project Period	2009–2018 (suspended)	2013–2024 (license issued)	2011–present	2011–present
Project Area	248,000 ha (TISS); 31,994 ha core area	64,000 ha (47,237 ha carbon area)	200,000 ha	300,000–380,000 ha
Total VCUs Issued	299,895 VCUs	33.6 million VCUs	~18.3 million VCUs	13+ million VCUs
Annual Emission Reduction	~30,000 tCO_2e/year (2009–2014)	~4.5 million tCO_2e/year (avg)	~1.5–2 million tCO_2e/year (est.)	~1–2 million tCO_2e/year (avg)
Estimated Lifetime Emissions Avoided	7.4 million tCO_2e (projected)	130 million tCO_2e	18.3 million tCO_2e	>100 million tCO_2e (30-year est.)
Revenue Generated	Not publicly disclosed	$386.4 million (est. $11.5/VCU avg.)	$150–200 million+ (est.)	$100+ million (est.)
Certification	VCS, CCB Gold	VCS, CCB Gold, SD VISta	VCS, CCB Gold	VCS, CCB Gold
Community Impact	1,000+ Indigenous beneficiaries; 6 sustainable income programmes	2,500 households, 14 villages; education, health, clean water, solar, micro-enterprises	116,000 people; 26,000+ scholarships, jobs, clean water, health	50,000+ people; schools, clinics, water, agriculture, training
Biodiversity Impact	Maintained core Amazon forest; medicinal plants, traditional knowledge	105,000 orangutans, 55 threatened mammals, >300 species	11,000 elephants, wildlife corridor,	Bonobos, forest elephants, wetlands, high

Metric/ Project	Surui Forest Carbon Project (Brazil)	Rimba Raya REDD+ (Indonesia)	Kasigau Corridor REDD+ (Kenya)	Mai Ndombe REDD+ (DRC)
			savannah/forest	conservation priority
Forest Cover Change	Prevented 12,218 ha loss (target); 90% reduction (2009–2014)	Maintained/increased forest; 76% cover	Clear reduction, corridor protected	299,645 ha better managed for biodiversity
Infrastructure / Interventions	Community MRV, sustainable income programmes	Community, health, solar, water, fire prevention	Mobile ranger app, scholarships, water projects, sustainable charcoal	Schools, clinics, wells, patrols, tree nurseries, satellite internet
MRV / Monitoring	Needs participatory/satellite MRV	Satellite, hydrological, not public	Mobile ranger app, not public	Satellite, field monitoring, not fully public
Status / Challenges	Illegal mining, project suspension	Land tenure, regulatory risk, transparency	Revenue allocation, biodiversity monitoring	Revenue transparency, biodiversity & social monitoring

Source: ERIA study team. compiled from Angelsen et al. (2018); Duchelle et al. (2017); Duchelle et al. (2018); Oldekop et al. (2019); Oldekop et al. (2016); Sunderlin et al. (2014); Verra (2024); Wildlife Works (2021).

4.3.1.3. Verified Carbon Standard (VCS)

The Verified Carbon Standard (VCS), is one of the most widely used voluntary carbon crediting programmes globally and is managed by Verra, a non-profit organisation based in Washington, D.C. Since its launch in 2005, VCS has issued over 1.3 billion Verified Carbon Units and now certifies approximately 60% of all REDD+ projects worldwide, making it a cornerstone of the voluntary carbon market.

VCS was launched to address a gap left by programmes such as the Clean Development Mechanism (CDM), which primarily served countries with binding climate targets under agreements like the Kyoto Protocol. It provides science-based, transparent, and flexible standards applicable across multiple sectors, particularly for projects such as forest conservation and peatland restoration, which previously fell outside conventional carbon crediting frameworks.

The primary goal of VCS is to support real, verified emission reductions and removals, enabling companies, organisations, and individuals to voluntarily offset their emissions or invest in climate solutions beyond regulated government-regulated markets. The VCS approval process is structured, beginning with detailed project descriptions, followed by independent validation, ongoing monitoring, and final issuance of credits, each representing one metric tonne of carbon dioxide equivalent kept out of the atmosphere. Every project and credit is tracked in a public registry, promoting transparency, trust, and preventing double counting. VCS has played a key role in advancing nature-based solutions such as REDD+, providing an accessible pathway to carbon finance for projects and countries without binding climate commitments.

Challenges remain, particularly regarding the quality and impact of some credits illustrated by lessons from the Rimba Raya Case Study-which has prompted Verra to tighten its rules and align more closely with global frameworks under the Paris Agreement. In summary, the Verified Carbon Standard remains a flexible and rigorous platform for expanding climate finance, particularly for forest- and land-based projects, and its importance is set to grow as the market expands and demand for credible, trustworthy carbon credits increases.

Market Dominance and Recent Downturn

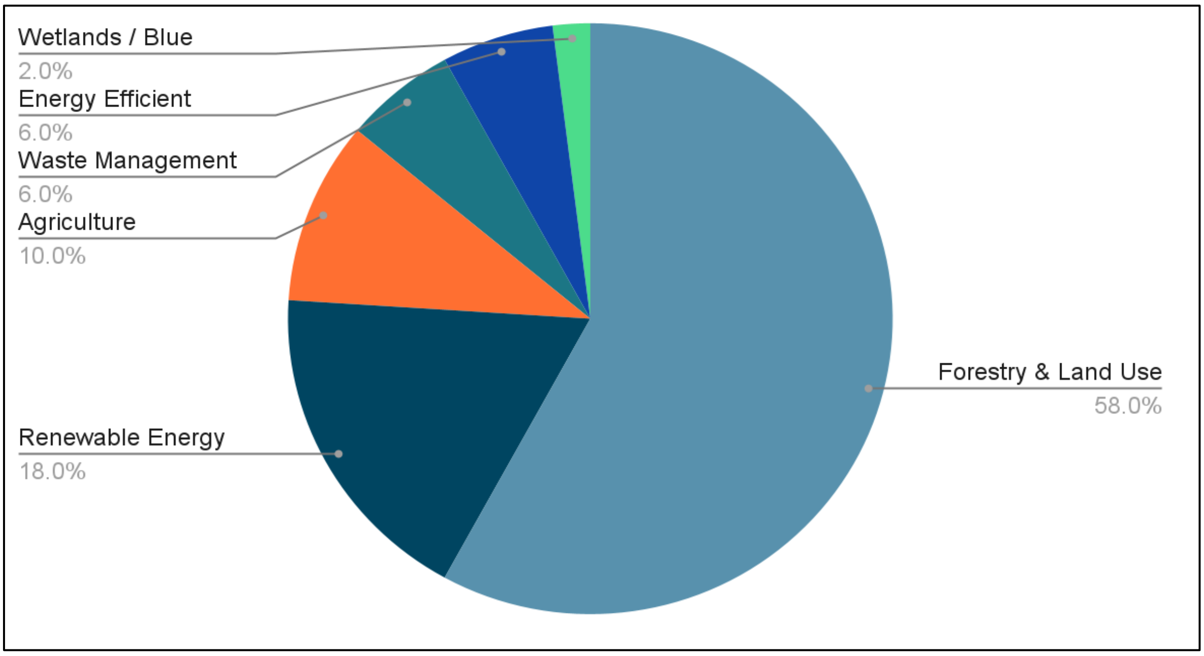
Since 2010, the Verified Carbon Standard has been the dominant player in the voluntary carbon markets, particularly for REDD+ and other nature-based projects. By 2013, VCS, often combined with CCB standards – accounted for at least half of the project market share and up to 70% when paired with CCB, attracting significant investment to forest conservation in high-risk areas. This rapid growth also led to increased scrutiny. In 2023, global media investigations raised serious concerns about several VCS-certified rainforest projects, highlighting inflated baseline deforestation rates that overstated the actual emission reductions. Although not all projects were implicated, the credibility of forest-related credits was called into question. The situation intensified in 2024 when some Amazon projects faced allegations involving land tenure violations and illegal logging, highlighting gaps in social safeguards, land rights clarity, and local oversight. The situation intensified in 2024 when some Amazon projects faced allegations of land tenure violations and illegal logging, exposing gaps in social safeguards, unclear land rights, and weak local oversight. These controversies damaged the reputation of the voluntary carbon market and underscored the need for stronger governance, transparency, and meaningful community engagement.

In response, Verra revised its methodologies to make baselines more realistic, introduced new transparency measures across project cycles, and began aligning VCS standards with the Core Carbon Principles of the Integrity Council for the Voluntary Carbon Market. Nonetheless, market preferences are moving away from avoidance-based credits and toward projects that verifiably remove carbon from the atmosphere, such as reforestation and ecosystem restoration, as well as jurisdictional and nested approaches tied to national or regional monitoring systems. These shifts demand larger scale, independently verified, and more reliable emission reductions. Despite its recent controversies, VCS remains a major certifier for forest-based projects but now carries the burden of restoring credibility and proving that its credits represent lasting climate benefits rather than inflated claims. Its future will depend on whether it can convincingly demonstrate transparency, integrity, and scientific rigor in the increasingly sceptical carbon market.

Figure 4.11. Key Requirements of VCS Projects

Source: ERIA study team, 2025.

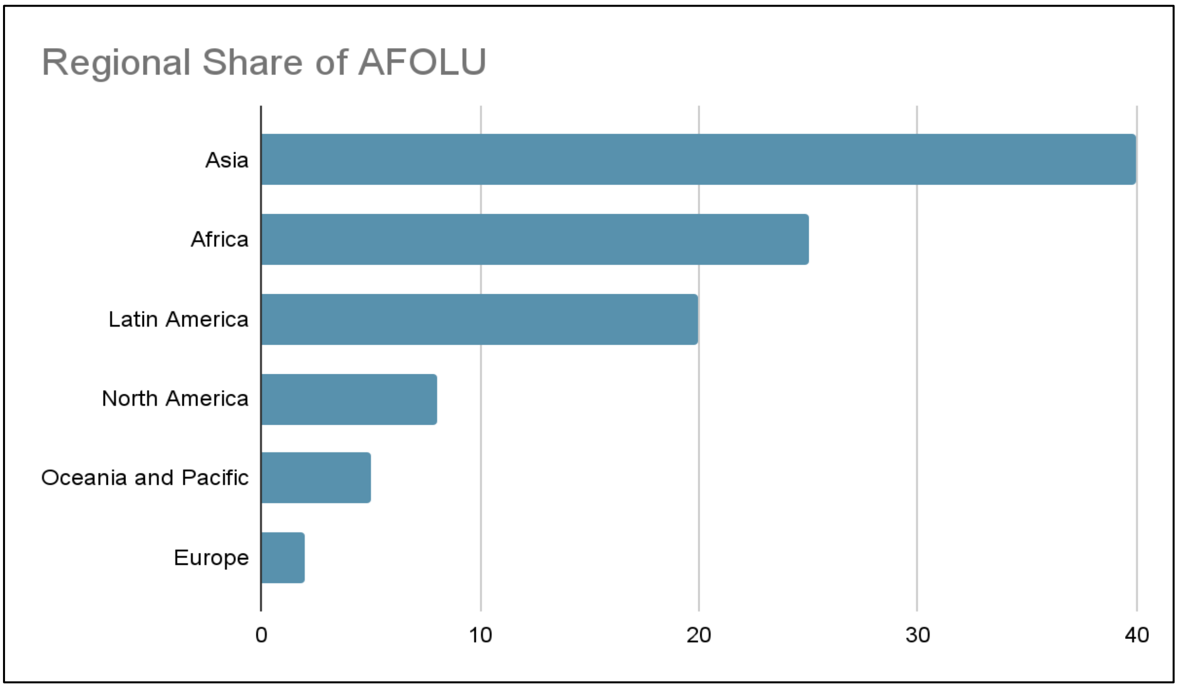
Figure 4.12. VCS Portfolio



Source: **ERIA study team** compiled from Verra (2025) and (2026).

Forestry and land use projects dominate the portfolio at 58%, driven by REDD+, afforestation, and peatland conservation, which deliver both climate and biodiversity gains. Renewable energy contributes 18%, centred on wind, hydro, solar, and biomass. Agriculture accounts for 10%, targeting methane and nitrous oxide reductions through improved livestock and sustainable practices. Waste management and energy efficiency each represent 6%, aiming at methane capture and emission reductions. Wetlands and blue carbon projects remain just 2% of the total but offer exceptionally high carbon density and critical ecological benefits. This heavy tilt toward forestry reflects an overreliance on a single category, leaving the portfolio vulnerable to credibility concerns and market shifts.

Figure 4.13. Regional Share of Agriculture and Land Use (AFOLU) Projects under VCS



Source: ERIA study team, 2025.

VCS AFOLU projects are concentrated in regions with rich natural ecosystems. Asia leads with about 40%, driven largely by Indonesia's REDD+ and peatland projects. Africa holds 25%, focused on forest conservation in countries such as Kenya and the DRC. Latin America contributes around 20%, anchored by major rainforest initiatives in Peru, Colombia, and Brazil. North America accounts for 8%, emphasising reforestation and wetland restoration in the U.S. Oceania and the Pacific represent 5%, including blue carbon and dryland reforestation efforts. reflecting minimal forestry engagement. Europe makes up less than 2%, reflecting minimal forestry engagement. This distribution highlights the VCS's reliance on biodiversity-rich regions, offering significant potential for large-scale climate impact but also exposing the system to high risks from political instability, weak land tenure systems, and the long-term uncertainties of forest permanence.

Notable VCS Projects:

- Rimba Raya REDD+ (Indonesia) - Information provided in section 4.3.1.1 Clean Development Mechanism (CDM)
- Mai Ndombe REDD+ (Democratic Republic of Congo)

  Certified under VCS version 3.4 and CCB Gold, the Mai Ndombe project covers 300,000 hectares of tropical forest. In 2021, it issued 13.3 million carbon credits and reported avoiding an estimated 7.7 million tonnes of CO_2. Alongside carbon outcomes, the project financed ten schools and health clinics, backed sustainable agriculture, expanded clean water access, and invested in local capacity-building, framed within a theory-of-change model. However, the scale of credit issuance underscores the need for close scrutiny of baselines, permanence, and the durability of both climate and community benefits. Despite its scale and development claims, the Mai Ndombe projects lacks transparency in critical areas. It does not disclose annual credit issuance or costs associated linked to restoration, monitoring, or community programmes. No per hectare cost data are publicly available. Biodiversity outcomes are reported only in broad terms, while socio-economic impacts are presented qualitatively rather than measured through systematic surveys.

- Conservation Coast (Guatemala)

  This landscape-level REDD+ initiative, certified under VCS and CCB Gold for biodiversity, unites more than a thousand landowners across 54,157 hectares of tropical rainforest. It plays a key role in the Mesoamerican Biological Corridor while supporting local communities through sustainable agriculture, generating local jobs, and wildlife conservation.

  While Conservation Coast has issued millions of carbon credits, it does not systematically disclose data on annual issuance, project costs, revenue flows to communities, restoration expenses, biodiversity outcomes, or detailed socio-economic impacts. Community benefits are highlighted, but remain qualitative, with no systematic surveys to quantify results. These gaps limit independent assessment and raise questions about the project's overall credibility and accountability.

- Katingan Mentaya Project (Indonesia)

  The Katingan Mentaya Project safeguards 157,000 hectares of peat swamp, certified under VCS, CCB Gold, and SD VISta. It reports sequestering more than 7.5 million tonnes of CO_2 annually and features strong local engagement, quarterly data updates, and the SIRETA (Carbon Registry and Transaction Information System or Sistem Informasi Registri dan Transaksi Karbon) monitoring database. The project is noted for its nature-based investment readiness, community education programmes, livelihood support, and peatland ecosystem restoration.

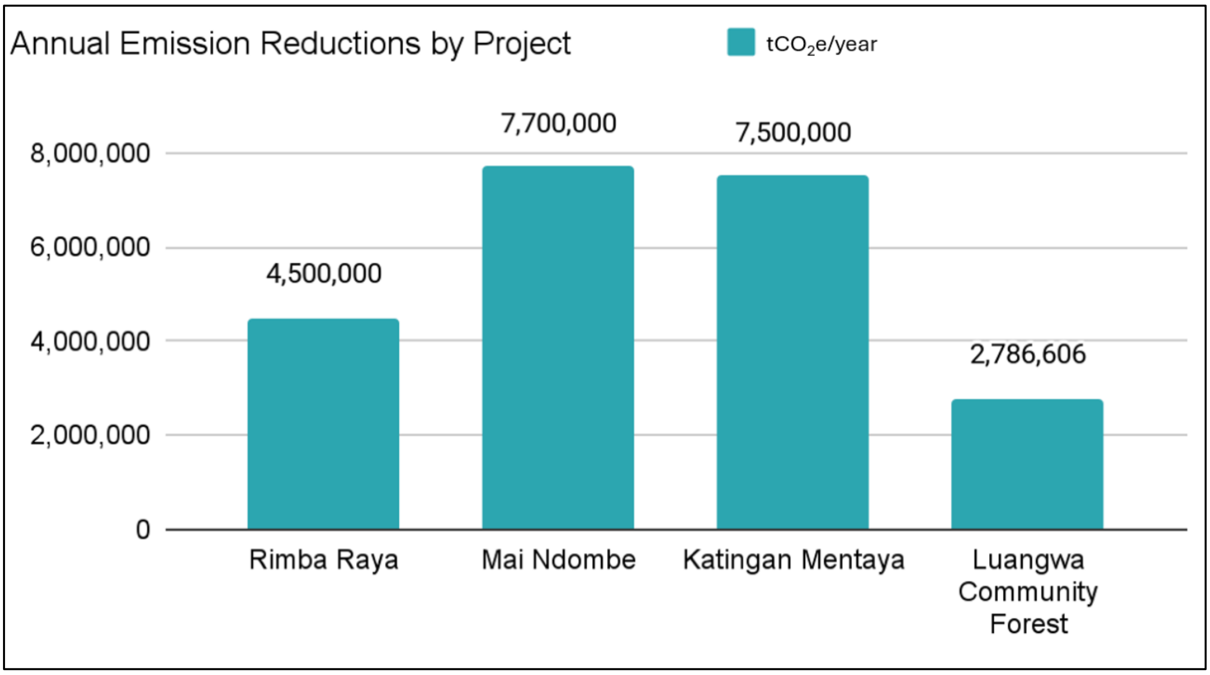
  However, as with other large-scale initiatives, the credibility of long-term carbon sequestration depends on continued transparency and independent verification. Significant gaps remain in cost transparency, revenue-sharing mechanisms, restoration expenditure tracking, quantitative biodiversity metrics, and public reporting of socio-economic outcomes. While local engagement is strong, community members still lack clear information on how carbon revenues are allocated and spent. Unless these gaps are addressed, the project's standing in global carbon markets will remain vulnerable to scrutiny and scepticism.

- **Luangwa Community Forests (Zambia)**

  The Luangwa Community Forests initiative is Africa's largest community-led REDD+ project, spanning more than 1,036,636 hectares and certified under VCS and CCB Gold. Since its first verification in 2018, it has reported preventing an average of 1.37 million tonnes of CO_2 emissions annually. The project supports 36,000 households through poverty reduction measures, wildlife corridor protection, clean water access, and local enterprise development, all audited under rigorous VCS and CCB protocols.

  However, as with other large-scale REDD+ efforts, the credibility of its outcomes depends on transparent reporting of revenue flows, long-term socio-economic impacts, and the permanence of avoided deforestation. Yet the project does not disclose year-by-year carbon issuance, project costs, per-hectare restoration expenditure, biodiversity monitoring data, or detailed breakdowns of revenue sharing. Although audited, the findings are not made public, which restricts accountability and limits opportunities for replication. Without stronger disclosure, the project risks eroding trust and weakening its credibility in global carbon markets.

Figure 4.14. Annual Emission Reductions by Project



Source: ERIA study team compiled from InfineEARTH (2016); WBSCD (2023); Permian Global (2025); Widlife Works (2025).

Comparative Information across Notable VCS Projects

Table 4.4. Comparative Information across Notable VCS Projects

Project Name	Area (ha)	Start Year	Credits Issued (VCUs)	Annual Reduction (tCO_2e)	Main Biodiversity Feature	Community Beneficiaries	Key Community Benefits
Rimba Raya	64,000	2013	33.6 million	~4.5 million	Orangutans, 100+ species	2,500 households	Health, clean water, solar, jobs
Mai Ndombe	300,000	2011	13.3 million	7.7 million (2021), ~1–2 million avg	Bonobos, elephants	50,000+ people	Schools, clinics, agriculture, water
Conservation Coast	54,157	2012	Millions (exact N/A)	N/A	Mesoamerican Biological Corridor	100 communities	Jobs, education, health
Katingan Mentaya	157,000	2010	N/A	>7.5 million	Peatland ecosystems, diverse species	34,000 people	Education, livelihoods, health
Luangwa Community Forests	1,036,636	2018	N/A	~1.37 million avg	Wildlife corridors	36,000 households	Poverty reduction, clean water, local jobs

Source: ERIA study team, 2025.

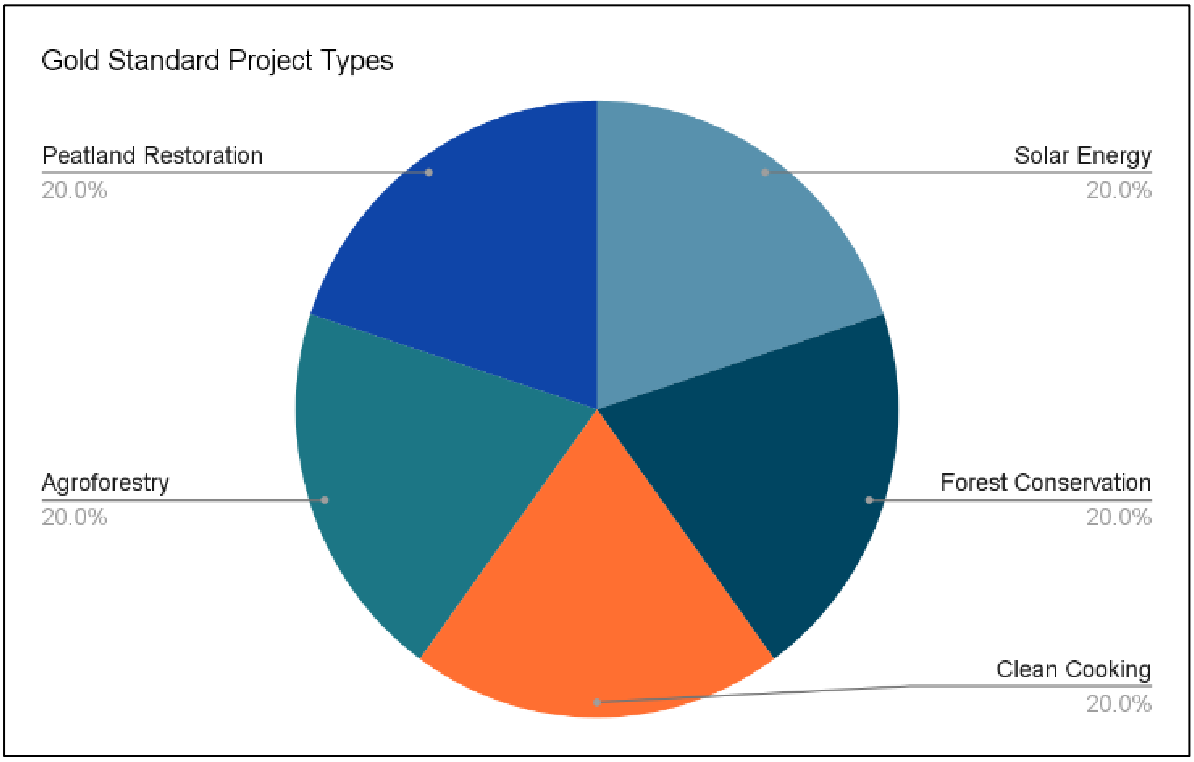
Many leading forest carbon projects, including Rimba Raya, Mai Ndombe, Conservation Coast, Katingan Mentaya, and Luangwa Forests, face persistent transparency gaps, including missing data on project costs, annual credit issuance, revenue sharing mechanisms, and measurable biodiversity or community impacts. These omissions make it difficult to assess the actual effectiveness and equity of the projects, leaving their climate and development claims open to question. More broadly, they point to systemic weaknesses in VCS governance and oversight, where disclosure standards remain uneven and accountability mechanisms insufficient to ensure credibility across the portfolio. Addressing these gaps will require mandatory disclosure of financial flows, independent auditing, and standardised metrics for biodiversity and socio-economic outcomes.

4.3.1.4. Gold Standard

The Gold Standard was launched in 2003 by the Worldwide Fund for Nature (WWF) and other international NGOs in response to concerns that many early carbon market mechanisms, particularly under the CDM, were failing to deliver social and environmental benefits at the local level. Although the CDM succeeded in mobilising emission reduction projects, critics argued that many of them prioritised cost-efficiency over sustainable development and often lacked meaningful community engagement.

To address these shortcomings, the Gold Standard introduced stricter requirements for stakeholder participation, sustainable development co-benefits, and measurable social and environmental outcomes alongside carbon reductions. Its core idea was that carbon projects should not only cut greenhouse gas emissions but also advance broader sustainable development goals. Positioned as a quality label for climate initiatives, the standard requires all certified projects to demonstrate contributions to at least three Sustainable Development Goals (SDGs), pushing developers to go beyond carbon and invest in co-benefits such as health, education, gender equality, and biodiversity. Unlike some standards that operated solely in the voluntary market, the Gold Standard was designed to certify both CDM projects and independent voluntary efforts. This flexibility gave it a broader scope and enabled support for diverse project types, including renewable energy, efficient cookstoves, clean water access, and reforestation. Over time, this dual role strengthened its credibility amongst both public institutions and private sector actors seeking high-quality offsets. As a result, the Gold Standard increasingly came to be seen as a benchmark for projects that deliver benefits well beyond carbon reductions.

Figure 4.15. Gold Standard Projects Types



Source: ERIA study team compiled from Gold standard (2020); Gold Standard Foundation (2025).

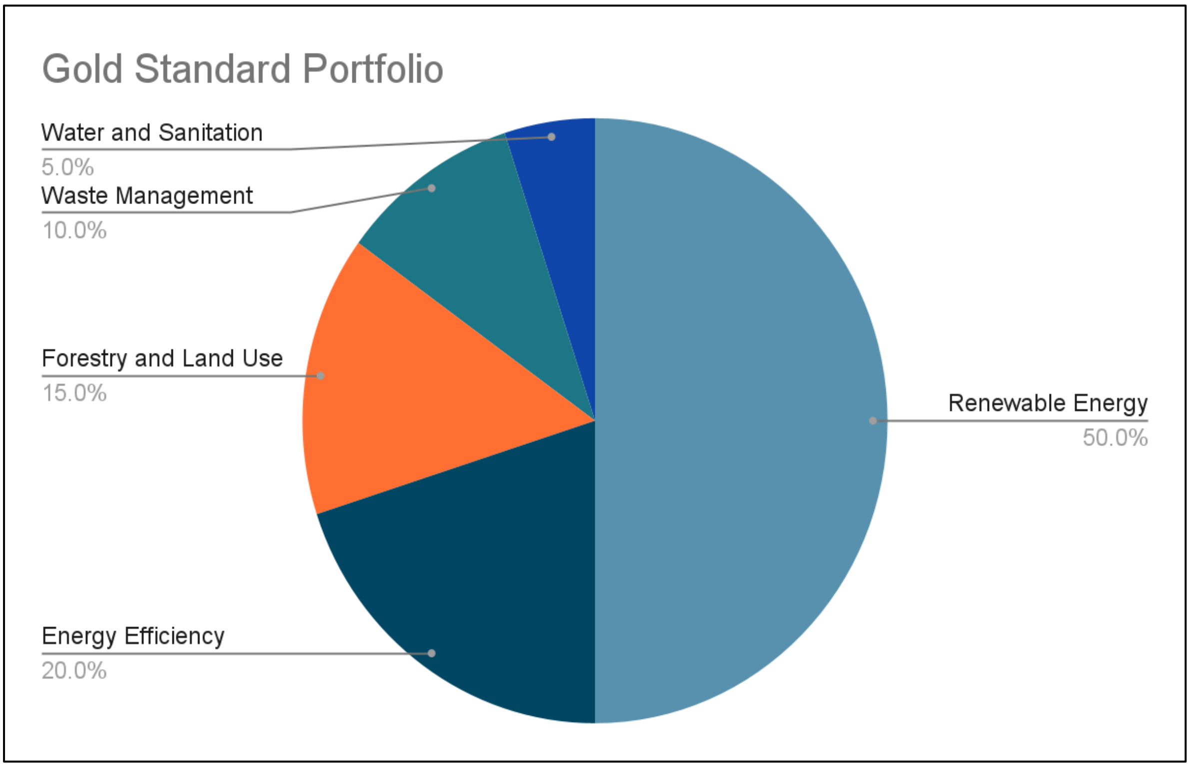
This diversification strategy reduces portfolio risk while maximising co-benefits across different sectors such as energy access, forest, agricultural productivity, and ecosystem restoration. A balanced distribution not only spreads impact but also enables cross-sector learning, where innovations in one field – such as community engagement models in forestry or monitoring techniques in agriculture, can be adapted and applied else. This cross-pollination strengthens both climate mitigation outcomes and long-term development gains, making projects more resilient and scalable.

In 2017, the Gold Standard introduced the 'Gold Standard for the Global Goals,' marking a significant expansion of its mandate. The update moved beyond carbon accounting to certify a wider spectrum of environmental and social impacts, fully aligning with the UN Sustainable Development Goals (SDGs). By introducing new methodologies and quantification tools such as such as water conservation, employment generation, and public health improvements. This shift positioned the Gold Standard as a comprehensive sustainability certification system rather than a carbon-focused standard alone.

The Gold Standard is governed by the Gold Standard Foundation, headquartered in Geneva, Switzerland with oversight provided by an independent Technical Advisory Committee made up of experts in climate science, development, and market integrity. While transparency is emphasised through a public registry that documents all certified projects and issued credits, the system still relies on self-reported project data, leaving questions about the depth of independent verification and the accessibility of impact information for local stakeholders.

In today's carbon market landscape, the Gold Standard is regarded as one of the more integrity-focused frameworks, particularly appealing to organisations that want their climate action to align with ethical and development priorities. Its emphasis on transparency, measurable outcomes, and long-term community benefits distinguishes it from many other standards, though its effectiveness ultimately depends on rigorous verification and consistent disclosure practices.

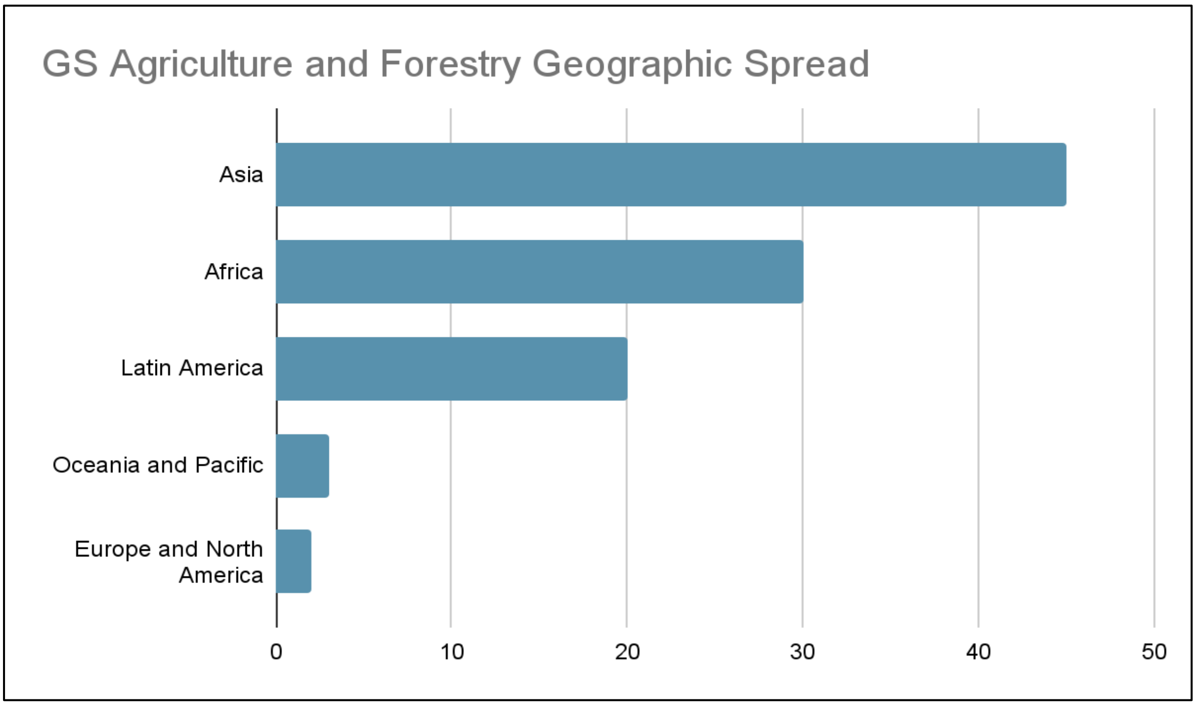
Figure 4.16. Gold Standard Portfolio



Source: ERIA study team, 2025.

The Gold Standard portfolio emphasises on projects that link climate action with sustainable development. About 50% focus on renewable energy like wind, solar, and biomass, serving both grid-connected and off-grid communities. Energy efficiency accounts for 20%, including clean cookstoves and industrial upgrades that cut emissions and improve health. Forestry and land use projects make up 15%, enhancing carbon sinks and biodiversity through reforestation and peatland restoration. Waste management projects, at 10%, capturing methane while supporting sanitation and local energy. Water and sanitation account for the remaining 5%, improving access, reducing methane, and delivering health outcomes. This diversification strengthens the portfolio's credibility by reducing risk while maximising measurable co-benefits across sectors.

Figure 4.17. GS Agriculture and Forestry Geographic Spread



Source: **ERIA study team** compiled from Gold Standard Foundation (2020); Gold Standard Foundation (2025); UNDP (2024).

Gold Standard's agriculture and forestry projects are concentrated in regions where social needs and carbon potential are greatest. Asia leads with 45%, driven by initiatives in Indonesia and India that advance agroforestry and community management. Africa follows with 30%, emphasising on reforestation and sustainable practices that benefit women and communities, mainly in Kenya, Tanzania, and Uganda. Latin America contributes 20%, with community-led conservation in Peru and Guatemala. Oceania and the Pacific represent 3%, mainly through small-scale forestry and renewable energy, while Europe and North America each have less than 2%. All projects are bound by 12 safeguards designed to ensure lasting social and environmental impact. This distribution highlights Gold Standard's focus on equity and its strategy of targeting regions with both high climate vulnerability and strong community development needs.

Figure 4.18. Safeguard Design to Ensure Lasting Social and Environment Impacts

Source: ERIA study team, 2025.

Its certification process includes:

i. Stakeholder consultation: Ensuring local communities give informed consent
ii. Validation: An independent third-party reviewer assesses the project against 12 safeguards, including gender equity and biodiversity protection measures.
iii. Performance review: post-implementation audits verify outcomes and compliance.

Key Requirements for gold standard certification:

a) Contribution to at least three of the 17 SDGs
b) Stakeholder consultation during project planning, with documented transparently
c) Benefit sharing with at least 33% of the project revenues directed to participating local communities
d) A clear monitoring and reporting plan for both emission reduction and SDG contributions.
e) Assurance that projects do not harm local ecosystems or communities
f) Compliance with one of the approved methodologies provided by gold standard

Notable Projects under Gold Standard:

- Barefoot College Solar Project (India)

  The Barefoot College Solar Project, certified under Gold Standard, has trained over 3,500 rural women as 'Solar Mamas' to install solar home systems, reaching over 2.5 million people in 93 countries. The project initiative has cut kerosene use, improved indoor air quality, expanded access to education, and increased women's incomes. It has generated an estimated $46 million from carbon credits, but annual emission reduction data and revenue distribution details remain undisclosed, raising concerns about accountability and transparency.

  Installation costs range from $100–$150 per household, but detailed community level maintenance expenses and financial breakdowns are not disclosed. Monitoring relies on local logbooks and occasional third-party audits, yet full verification processes are not transparent. Partners include the Indian Ministry of External Affairs, Credit Suisse, and Apple, with the model replicated internationally.

- Kasigau Corridor REDD+ (Kenya)

  This conservation project, certified by Gold Standard, Verified Carbon Standard, and CCB Gold, and independently validated by bodies such as AENOR, protects approximately 200,000 hectares of dryland forest in partnership with thirteen community ranches.

The area hosts more than 370 animal species, including more than 50 large mammals and 300 birds, and has provided $1.2 million in scholarships reaching more than 26,000 students. However, the project does not publish annual data on credits issued or provide a financial breakdown for conservation, monitoring, or community programmes. Revenues are managed through community trusts, but allocations to ranches or families remain unclear. Rangers use a mobile app for real-time monitoring, yet the full details on verification process is not publicly undisclosed, limiting transparency and accountability.

- BioLite Clean Cookstoves (East Africa)

  The BioLite Clean Cookstoves project, certified under the Gold Standard and audited by GS-approved bodies, distributes efficient stoves across East Africa, reducing particulate and carbon monoxide emissions. The initiative has delivered measurable improvements in household health, lowered fuel consumption, empowered women, and enhanced climate resilience. Field trials and emissions testing support these outcomes, and the project has generated approximately US$69 million from carbon credits. However, annual emission reduction data and detailed revenue allocation to local communities are not publicly disclosed, limiting transparency and accountability.

- Bhoomi Kaushal Agroforestry Project (India)

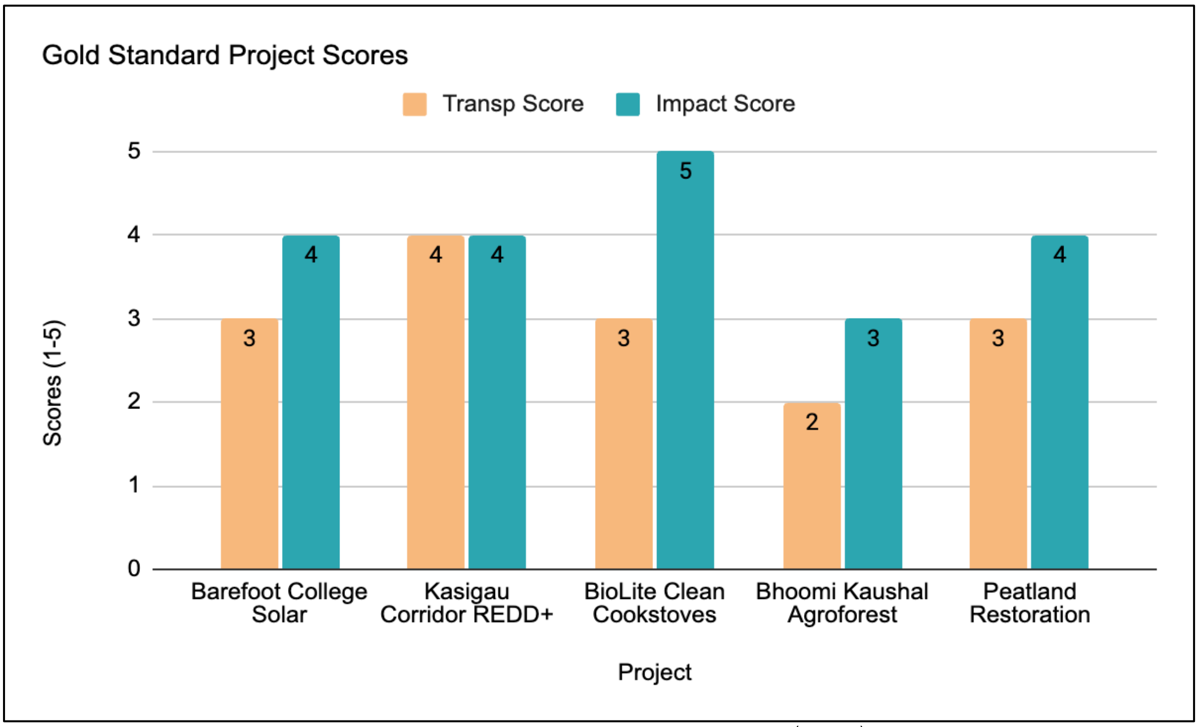
  This project is certified under Gold Standard for agroforestry and land management, and audited by accredited VVBs, supports smallholder farmers through tree planting programmes that enhance biodiversity, soil quality, and climate resilience. The initiative has generated an estimated US$28.75 million from carbon credits and covers several thousand hectares. Planting and maintenance costs are approximately US$500 per hectare.

- Peatland Restoration in Central Kalimantan (Indonesia)

  This project, certified under Gold Standard for peatland restoration and audited by accredited validation bodies, covers over 40,000 hectares of degraded peatland rehabilitated through canal blocking and rewetting. These efforts have reduced carbon emissions, mitigated flood risks, and preserved native biodiversity with active community involvement. Estimated revenue from carbon sales is approximately US$40,250,000. Restoration targets around 5000 hectares per year, with an estimated costs of US$500 per hectare.

  Early data indicate that water tables have risen by 20-30 centimetres, and biodiversity surveys report increased sightings of peatland species. Some residents have experienced income gains through fisheries and agroforestry, though systematic socio-economic data collection remains limited, constraining transparency and accountability.

Figure 4.19. Gold Standard Project Scores



Source: **ERIA study team** compiled from Gold Standard Foundation (2025); Gold Standard Foundation (2020); Gold Standard Foundation (2022).

The transparency assessment highlights significant data disclosure challenges across all projects, with scores ranging from 2-4 on a 5-point scale Most projects do not provide comprehensive annual VER issuance data, detailed cost breakdowns, and systematic assessments of community impacts. The Kasigau Corridor REDD+ demonstrates the highest transparency, benefiting from CCB Gold certification, which mandates extensive social and biodiversity monitoring.

4.3.1.5. Jurisdictional and Nested REDD+ (JNR)

The Jurisdictional and Nested REDD+ (JNR) framework, developed by Verra, enables governments and regions to manage large-scale forest carbon programmes by integrating project-level activities into a broader system. It allows countries or provinces a way to claim carbon credits for genuine reduction in deforestation through shared baselines and coordinated monitoring, preventing double counting and leakage.

JNR also aligns individual projects with regional targets, linking community action to national policy and climate finance. Since its launch, JNR has been adopted in multiple forested nations and is particularly important for meeting the Paris Agreement's requirements for transparent, reliable carbon accounting at both the national and local levels. However, the framework still relies on accurate reporting from project developers and governments, meaning gaps in monitoring, verification, or data disclosure could undermine overall credibility. It serves as a key bridge from isolated projects to integrated, government-led climate strategies.

4.3.1.6 Climate, Community & Biodiversity (CCB) Standards

The Climate, Community & Biodiversity Standards, developed by the Climate, Community & Biodiversity Alliance in the mid-2000s, assess land-based carbon projects not only for climate benefits but also for their contributions to communities and biodiversity. Used alongside carbon certification standards like VCS, the CCB Standards do not issue credits themselves but serve as a quality label, highlighting projects with exceptional co-benefits.

Projects applying the CCB Standards must demonstrate meaningful contributions to biodiversity conservation, support local communities, and effective stakeholders' engagement. Evaluation indicates detailed assessments of potential social and environmental risks, mitigation plans, and the benefits expected over time. Projects exceeding minimum requirements – such as in species protection or community empowerment – can earn Gold Level recognition.

Over the years, the CCB Standards have been widely adopted, particularly in forestry and land use projects where social and environmental impacts are closely intertwined. They are frequently used to boost buyer confidence and secure premium prices for credits. While not a crediting system themselves, the CCB Standards remain a trusted benchmark for identifying high-integrity projects that deliver meaningful benefits beyond carbon reductions.

4.3.1.7. ART-TREES

The Architecture for REDD+ Transactions is a recent initiative aimed at supporting jurisdictional-scale efforts to reduce deforestation and forest degradation. Its crediting framework, TREES (The REDD+ Environmental Excellence Standard), provides a robust, transparent, and credible system for countries and large subnational jurisdictions to access results-based finance for forest protection.

ART-TREES was developed to meet the demand for a high-integrity system suitable for both voluntary buyers and compliance markets, including those aligned with the Paris Agreement. It addresses limitations of earlier REDD+ mechanisms by using standardised baselines, conservative accounting, robust environmental and social safeguards, and independent verification.

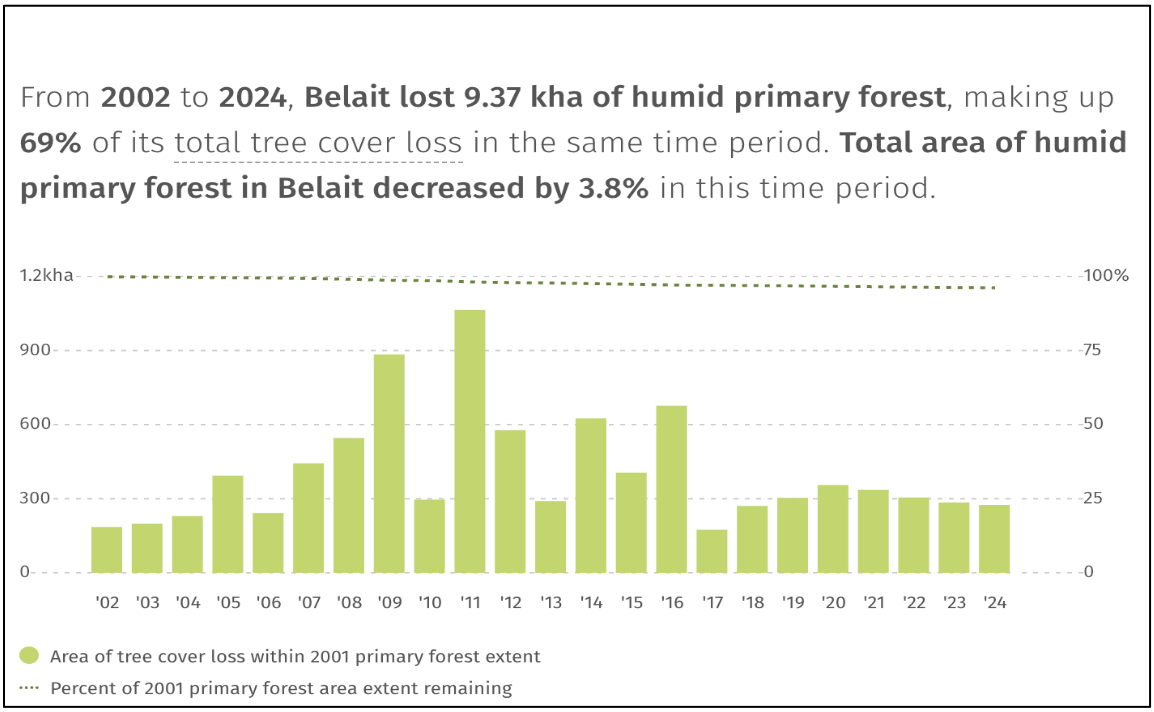
A core feature of ART-TREES is that it allows crediting only at the jurisdictional level, promoting systemic approaches that address the underlying drivers of deforestation, including land-use policy, governance, and enforcement. By targeting large-scale transformation, ART-TREES has gained support from major donor governments, development banks, and corporate buyers seeking for high-impact forest credits.

ART-TREES is currently implemented in countries including Guyana, Ghana, and Ecuador, amongst the first to receive credits for national-scale forest emission reductions. The standard continues to gain traction as a credible platform for governments linking their REDD+ results to international carbon finance.

4.4. Belait Peat Swamp Forest Information

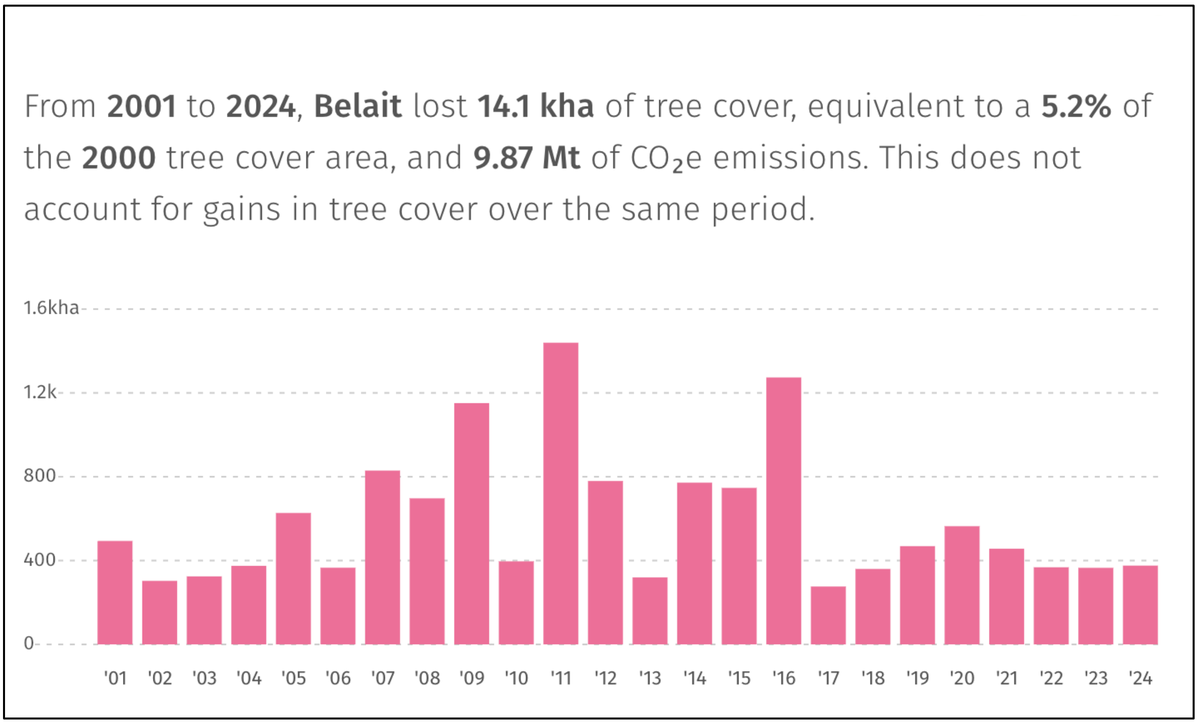
The Belait Peat Swamp Forest is the largest and most ecologically significant peatland in Brunei Darussalam, spanning estimated to be 77,000 hectares in the Belait District on the island of Borneo. It forms a key part of the coastal peat swamp ecosystem that extends into neighbouring Sarawak, Malaysia, and is valued for its unique landscape and high conservation importance. The forest features waterlogged peat soils – up to 20 meters thick – formed over thousands of years from partially decomposed plant material, making it a globally significant natural carbon sink.

Figure 4.20. Primary Forest Loss in Belait, Brunei



Source: ERIA study team compiled from Global Forest Watch (2024); Nusantara Atlas (2025).

Figure 4.21. Tree Cover Loss in Belait, Brunei



Source: ERIA study team compiled from Global Forest Watch (2024); Exploralysis (2026).

4.4.1. Forest Loss Trends in Belait District

The Belait Peat Swamp Forest, covering 77,000 hectares in Brunei, is a nationally and globally significant peatland, renowned for its deep carbon-rich soils and diverse habitats. Over the past two decades, the forest has lost more than 9,000 hectares of primary forest and 14,000 hectares of total tree cover, representing nearly 70% of total forest loss and almost ten million tonnes of carbon emissions, with peaks in 2011 and 2016. This decline underscores the forest's vulnerability and the urgent need for conservation, particularly as these losses mostly affect primary ecosystems.

Although well suited for dynamic carbon initiatives like REDD+ and voluntary markets, the forest faces threats from development, fragmentation, and drainage, which could rapidly convert this carbon sink into a major emissions source. Restoration, rigorous monitoring, water management, and community-based conservation are essential to maintain its ecological and climate functions. With effective management and science-driven policies, Belait can serve as a regional model for climate action.

The Belait forest is a biodiversity hotspot, supporting rare and endangered species such as Storm's stork and the Sunda pangolin, while providing critical ecosystem services including water regulation, flood mitigation, and fire resilience. Its deep peat stores up to 3,264 tonnes of carbon per hectare per meter and functions as a powerful carbon sink when left undisturbed and saturated (Forestry Department, Brunei Darussalam, 2024, p. 3).

However, the forest faces threats from development, fragmentation, and drainage, which could rapidly convert this carbon sink into a major emissions source. Restoration, rigorous monitoring, water management, and community-based conservation are essential to maintain its ecological and climate functions. With effective management and science-backed policies, Belait can serve as a regional model for climate action.

4.4.2. National Forest Resources Inventory 2023-2025: Data of Brunei Darussalam

This survey was conducted and managed by Lunima Sdn Bhd in collaboration with the Forestry Department in May 2023. The primary objectives of the survey include several key areas, such as baseline data collection, alignment with international standards, data updates, and climate impact assessments.

Table 4.5. Structure, Types, Coverage, and Biomass of Brunei's Forests

Feature/Type	Area or Value	Key Details/Description
Total Forest Area	488,000 ha (84% of land area)	Very high forest cover; globally significant for conservation
Primary Forest	263,000 ha (2020)	Pristine and biodiverse; highest carbon storage
Planted Forest	5,260 ha (2020)	Minimal; mostly for restoration rather than timber production
Protected Forest	19,000 ha (5%)	Officially designated for conservation
Peat Swamp Forest	90,884 ha (15.6% of land area)	Thick peat domes, high carbon content; Belait region is the major type
Belait Peat Swamp Forest	>90,000 ha	Largest peat swamp forest; key for carbon storage and biodiversity
Mangrove Forest	18,418 ha	Coastal and estuarine; provides erosion control and wildlife habitat
Heath (Kerangas) Forest	<1% of forest area	Nutrient-poor, sandy soils; supports unique plant species
Freshwater Swamp Forest	Not specified	Periodically flooded; supports water-tolerant species
Montane Forest	Not specified	Found at higher elevations; cooler, with unique flora
Mixed Dipterocarp Forest	~41% of forest area	Rich in hardwoods; forms the landscape backbone
Secondary Forest	Not specified	Regenerated after disturbance; contains a mix of species

Table 4.5. *Continued*

Feature/Parameter	Value/Notes	Description
Landscape Topography	Flat, 5–10 m above sea level	Raised peat domes with deep peat layers
Zonation	Dome edges: mixed swamp	Center: pure Shorea albida ('Alan') stands
Canopy Height	25–40 m (mature stands)	Closed canopy with sparse understory
Forest Floor	Organic, acidic, waterlogged	Conditions inhibit growth of herbs and ground plants
Aboveground Biomass	470–560 t/ha (Belait)	Higher than the regional average
Belowground Carbon Stock	~3,264 t/ha (Belait)	Extremely carbon rich
Peat Carbon Stock	21,425–35,308 tC/ha (Belait)	Significant long-term carbon storage
Dominant Species	Shorea albida, Gonystylus bancanus, Dactylocladus stenostachys	Key species shaping forest structure
Annual Tree Cover Loss	646 ha (2024)	Exceptionally low loss, indicating strong stewardship
CO_2 Emissions from Loss	416,000 tonnes (2024)	Highlights the climate importance of every hectare

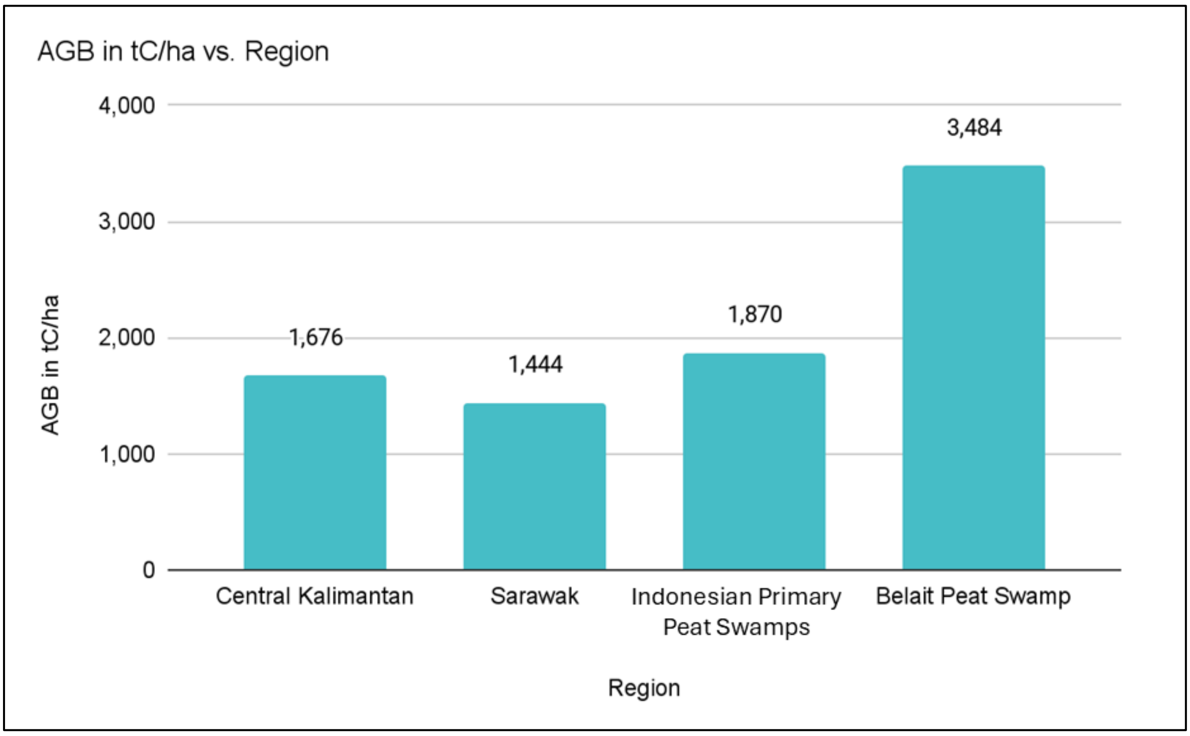
Source: ERIA study team, 2025.

Table 4.6. Challenges and Outlook for Belait Peat Swamp Forest

Challenges/ Outlook	Details
Regeneration Challenges	Low light, waterlogging, occasional drought, and slow seedling establishment
Conservation Outlook	Emphasis on protecting and restoring natural forests, expanding protected areas, maintaining low annual forest loss, and safeguarding biodiversity and climate benefits

Source: ERIA study team, 2025.

Figure 4.22. AGB in tC/Ha vs. Region



Source: ERIA study team, 2025.

Brunei's peat swamp forests have exceptionally high above-ground biomass, ranging from 470 to 560 tons per hectare, well above the regional tropical rainforest average of 350 tons per hectare. Carbon storage in Southeast Asian peat swamps varies widely, but the Belait Peat Swamp in Brunei stands out with an estimated 2,665.83 tonnes of CO_2 equivalent per hectare, including 455 tonnes of carbon above ground and a remarkable 1,545.50 tonnes below ground, thanks to its deep, undisturbed peat. The soil itself contains between 21,425 and 35,308 cubic meters of peat per hectare, reinforcing Brunei's role as a vital carbon sink. As of 2020, forest area in Brunei covers 380,000 hectares or about 72% of the country's land, with primary forests accounting for 263,000 hectares, or 69% of total forest area. These figures underscore the critical importance of protecting Brunei's high-carbon peatlands to prevent significant carbon emissions and strengthen climate resilience.

4.4.3. Pools Measurement

Measuring carbon pools in peat swamp forests is much like balancing a bank account, where photosynthesis serves as the main carbon deposit and respiration acts as the withdrawal. Peat swamps complicate this balance because waterlogged soils slow decomposition and change how carbon is stored and released. Researchers use portable photosynthesis systems to measure carbon uptake at the leaf level, while photosynthesis–irradiance curves help determine how light conditions affect carbon capture in the shaded forest canopy.

At a larger scale, eddy covariance towers track the net flow of carbon between the forest and atmosphere, showing how much carbon is fixed by plants and how that changes with light and seasonal variations. Respiration measurements rely on soil chambers that capture carbon dioxide released from both plant roots and soil microbes, with root exclusion techniques used to distinguish between these two sources. Monitoring environmental factors such as soil temperature, moisture, and water table depth is critical, as they strongly influence the rate of respiration and determine whether more carbon is stored or lost.

Ideally, researchers establish permanent plots for monthly soil sampling across different areas of the forest and combine this with advanced sensor systems to gain a comprehensive understanding of carbon dynamics. Brunei's peat swamps are particularly significant, with above-ground biomass ranging from 470 to 560 tons per hectare – well above the regional average – and peat layers storing 21,425 to 35,308 cubic meters of carbon per hectare. This high carbon content, verified using tools such as LiDAR and InSAR alongside machine learning techniques, underscores why these forests are critical for climate regulation and for supporting effective carbon market projects.

Table 4.7. Brunei Forest Carbon Framework

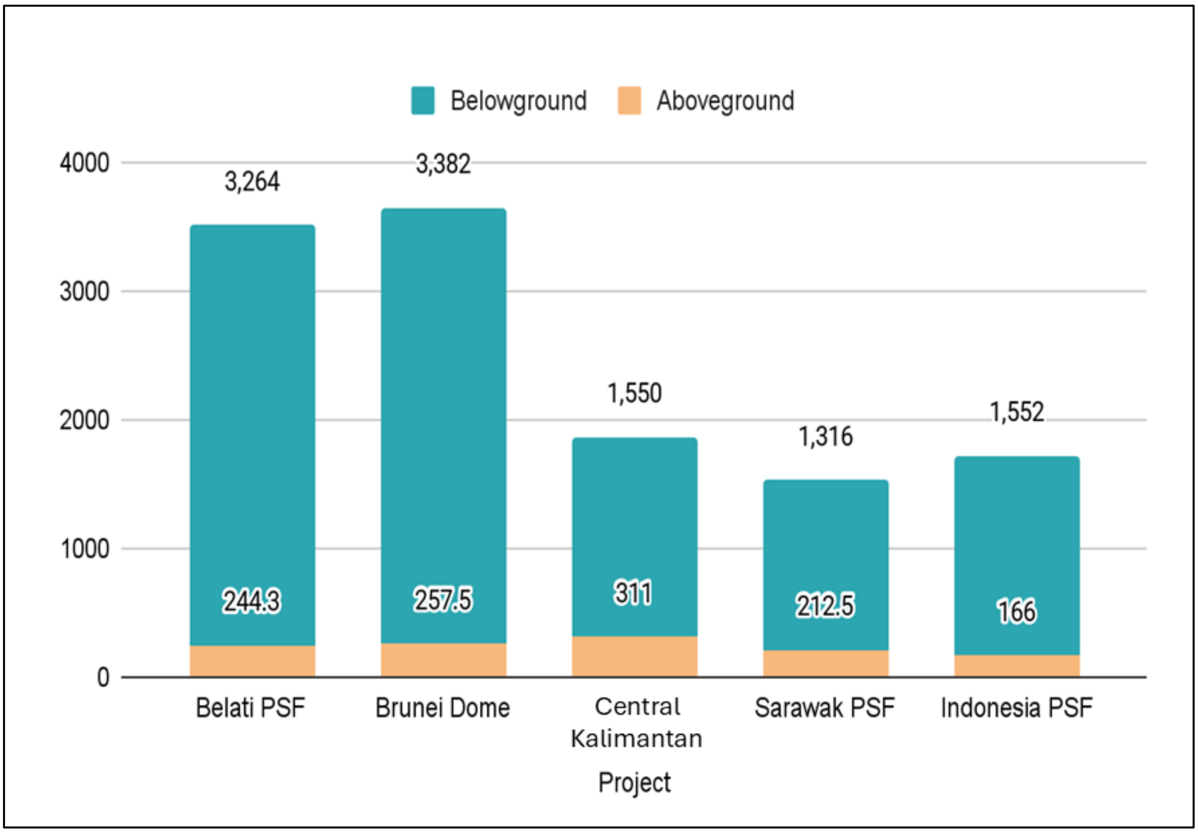
Parameter	Value/Classification	Significance
Primary Forest Type	Broadleaved Humid (100%)	Represents tropical rainforest ecosystem
Carbon Fraction	47% (IPCC default)	International standard for converting biomass to carbon
Biomass Conversion and Expansion Factor (1990–2020)	1.30 (consistent)	Indicates stable forest structure
Forest Categories	Natural, Plantation, Other Planted	Supports comprehensive carbon accounting
Reporting Frequency	Every 5 years	Enables regular monitoring and updates

Source: FAO, 2020.

The Table highlights key components of Brunei's Forest Carbon Framework, demonstrating its alignment with international standards and commitment to accurate carbon accounting. Brunei's forests are entirely classified as broadleaved humid tropical rainforests, notable for their high biodiversity and carbon storage capacity. Using the

IPCC default carbon fraction of 47% ensures consistency in carbon stock calculations. A stable Biomass Conversion and Expansion Factor (BCEF) of 1.30 from 1990 to 2020 indicates a consistent forest structure over time. Including natural, plantation, and other planted forests provides a comprehensive view of carbon stocks. Moreover, the five-year reporting cycle enables regular monitoring and transparency in forest carbon assessments.

Figure 4.23. Carbon Stocks: Belait vs. Regional PSF



Source: ERIA study team, 2025.

Recent studies from Brunei's National Forest Resources Inventory indicate that the Belait Peat Swamp Forest has exceptional carbon storage, with total ecosystem carbon stocks reaching 2,665.83 tonnes CO_2 equivalent per hectare. This includes 455 tonnes per hectare in aboveground biomass and an impressive 1,545.50 tonnes per hectare in the peat soil belowground. Compared to other Southeast Asian peat swamps, Belait's carbon density shows carbon stocks relatively comparable to Central Kalimantan–storing 1,676 tonnes per hectare, those in Sarawak 1,444 tonnes, and Indonesian primary peat swamps average 1,870 tonnes per hectare. Brunei's peat deposits are also amongst the deepest and most carbon-rich in the region, with soil carbon stocks ranging from 21,425 to 35,308 cubic meters per hectare. These numbers highlight the global importance of conserving Belait's intact peatlands.

4.4.4. Quantifying Carbon Fluxes

Quantifying carbon fluxes in the Belait Peat Swamp Forest is essential for accurately assessing its role in Brunei's emerging carbon pricing mechanism. Carbon fluxes represent the actual movement of carbon between the forest ecosystem and the atmosphere, providing insight into whether the forest acts as a net carbon sink or source.

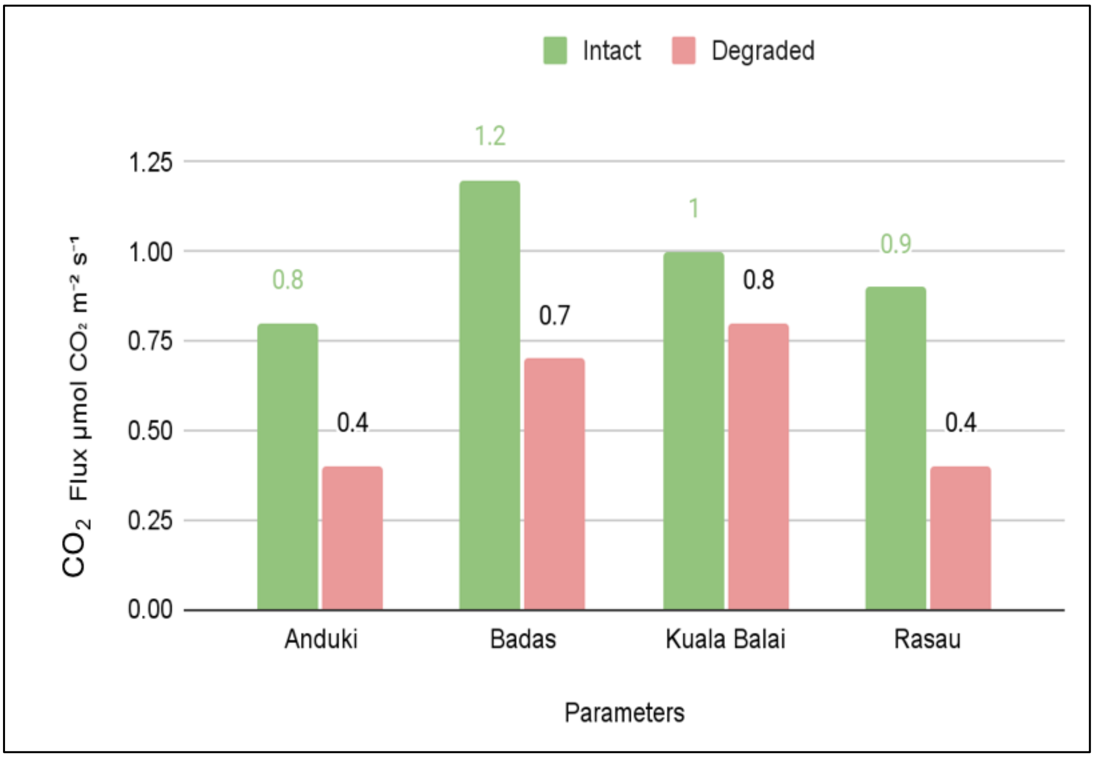
The key metric in this context is net ecosystem exchange (NEE), which balances carbon uptake through photosynthesis against carbon release via respiration and decomposition. In tropical peat swamp forests, this balance is particularly complex because waterlogged conditions slow decomposition and promote long-term carbon storage in deep peat layers.

Vertical and Horizontal Fluxes Measurement

Measuring carbon in peat swamp forests requires tracking both vertical and horizontal fluxes to fully understand carbon movement. Vertical fluxes are monitored using eddy covariance towers, which provide real-time data on carbon dioxide and methane exchange between the forest and atmosphere. In undrained peat swamps like Belait, annual CO_2 emissions typically range from 11 to 13 megagrams per hectare, with methane contributing about 0.5 to 0.6 megagrams.

Horizontal fluxes account for the carbon transported out of the ecosystem by water, mostly as dissolved or particulate organic carbon flowing through streams and drainage channels. Monthly water sampling at these drainage points generally shows carbon export of approximately 1.7 megagrams of CO_2 equivalent per hectare per year. By measuring both these gas exchanges and water-mediated exports, researchers get a complete and accurate picture of carbon dynamics across the entire peat swamp forest.

Figure 4.24. CO_2 Flux Comparison



Source: ERIA study team, 2025.

Site-specific data reveal further variability, with Badas recording the highest CO_2 flux rates for intact areas at 1.2 μmol CO_2 m^{-2} s^{-1}, and Anduki the lowest at 0.8 μmol CO_2 m^{-2} s^{-1} (Low Ying Si et al., 2022). Notably, intact peat swamp forests consistently release more CO_2 than degraded sites, indicating that forest clearance and disturbance accelerate decomposition and increase carbon emissions. This pattern provides experimental evidence that maintaining forest integrity is crucial for regulating carbon dynamics. Rather than implying that damaged sites are 'bad,' these results highlight that healthy forests have a higher capacity for carbon exchange and ecosystem 'breathing'.

4.4.5. The Badas Peat Dome

It is the largest peat deposit in Brunei, featuring a dome structure characteristic of tropical peat formations. In 2009 a survey using LiDAR – which measures the time taken for emitted lights to travel to the ground and back – revealed that the dome's topography includes having sand ridges at the surface, reaching elevations around 15 meters above sea level. The directional pattern of these ridges suggests they may be remnants of ancient dune deposits.

Having a peat dome in a forest carbon project offers significant advantages as well as notable challenges. Peat domes act as powerful carbon sinks, storing large amounts of carbon due to slow decomposition in their waterlogged soils. Protecting them helps prevent substantial CO_2 releases and supports rare plant and animal species, making them highly valuable for both climate and biodiversity objectives. Their natural water retention also reduces the risk of flooding and fires. Rewetting drained peat domes can dramatically cut annual CO_2 emissions, and although methane emissions may temporarily rise, the long-term climate benefits remain positive.

On the other hand, peat domes are highly sensitive and costly to manage. Draining or disturbing them rapidly triggers large carbon releases through oxidation and fires, and even partial drainage may destabilise the entire system. Restoring and protecting a peat dome requires careful water management and significant investment, while rewetting efforts can cause temporary spikes in methane emissions. Long-term carbon monitoring is complex, and managers must also contend with the slow vegetation recovery and the risk of peat subsidence.

Remote Sensing Technology

LiDAR has been central to mapping Brunei's Badas peat swamp, enabling precise measurement of peat depth, canopy height, and biomass with minimal error. GEDI satellite data helps extend these measurements but can underestimate biomass, so Brunei researchers combine GEDI, airborne LiDAR, and field data with machine learning for much greater accuracy. Models such as support vector machines provide rapid and reliably biomass estimates, supporting both carbon accounting and conservation efforts. Satellite tools like SRTM and Sentinel-2 are used to monitor forest changes and detect disturbances, while LiDAR-derived terrain data helps assess peat volume and identify risks. This integrated, technology-driven approach has made Brunei a leader in effective peatland monitoring across Southeast Asia.

4.4.6. Strategic Recommendations on Monitoring, Reporting and Verification (MRV)

Table 4.8. Strategic Recommendations on Monitoring, Reporting, and Verification (MRV)

Strategy	Why It Matters	Global Lesson	Key Components
Hybrid Remote Sensing Approach	Enables accurate, auditable, year-round forest monitoring by combining multiple satellite sources with ground data	Rimba Raya and Katingan Mentaya reduced undetected clearings by integrating free Landsat/Sentinel imagery with high-resolution commercial imagery, improving audit acceptance	Annual Landsat/Sentinel-2 wall-to-wall mapping High-resolution imagery for validation Radar integration (ALOS PALSAR, TerraSAR-X) Permanent ground plots with biennial field cycles

Strategy	Why It Matters	Global Lesson	Key Components
			LiDAR/UAV canopy mapping
Peat-Specific Carbon Monitoring	Most carbon is underground; precise peat measurement prevents major crediting errors and future disputes	Sebangau and Rimba Raya gained auditor trust by performing deep coring and direct carbon analysis rather than relying on defaults	Full-profile peat coring to mineral base Standardised bulk density sampling Direct carbon analyser measurements Water-table loggers & subsidence rods Integrated weather station data
Advanced Flux Measurement Systems	Direct flux data (CO_2 and CH_4) validate reductions and enhance market confidence	Eddy towers in Sarobetsu (Japan) and Indonesian peat sites provided definitive emissions data, winning higher buyer trust	Eddy covariance towers for continuous flux data Soil chamber networks for ground validation NASA FIRMS hotspot integration IoT soil-moisture/temperature sensors LoRa communications for remote data links
Tiered Methodology Framework	Conservative, site-specific methods reduce credibility risk and protect against future credit reversals	Katingan and Rimba Raya adopted local emission factors and allometries, successfully enduring auditor scrutiny and changing rules	Develop Brunei-specific emission factors Site-specific allometric equations Conservative baseline assumptions Adopt VM0007 REDD+ modules Prepare for upcoming 2024 peatland methodologies
Community-Based MRV	Engaging locals improves data quality, reduces	Rimba Raya and Katingan demonstrated that	Community carbon measurement training

Strategy	Why It Matters	Global Lesson	Key Components
Capacity Building	costs, and ensures long-term community support	trained community monitors prevent vandalism, resolve conflicts, and impress auditors	Local fire-patrol and reporting teams Integration of traditional land-use knowledge Technical training for forestry staff University/regional research partnerships Robust data-management protocols for transparency and continuity

Source: ERIA study team, 2025.

4.4.7. Risk Involved

Historically, forests in Southeast Asia have been at high risk of fires due to the dry soil in which they occur. Major forest fire events in the region include incidents in 1982-1983, 1987, 1991, 1994, 1997-1998, and more recently in 2013 and 2015. In Brunei Darussalam, particularly in the Belait district, forest fire occurrences are increasing, especially during prolonged dry periods. With approximately 80% of Brunei's forests located in Belait, including extensive peatland forests, the risk of fire is significantly heightened.

The main causes of forest fires in Brunei include natural factors, such as prolonged dry periods – particularly during El nino seasons, when ocean temperatures rise – and human activities, such as land clearance by burning. The characteristics of Brunei's peatlands, with their carbon rich soils allow fires to smolder underground, making them difficult to detect and extinguish. Forest fires have multiple impacts on Brunei's environment, economy, and public health. They destroy habitats of endangered birds in the swamp forests, incur high costs for firefighting operations such as helicopter water-bombing and release smoke into the atmosphere causing respiratory health issues.

Table 4.9. Risk Category and Explanation

Risk Category	Explanation
Fire Risk	Drained or dry peat can ignite easily, causing deep, hard-to-extinguish fires that rapidly release large amounts of carbon and generate harmful haze.
Land-Use Pressure	New roads, pipelines, and small farms open peatlands to encroachment and logging, damaging habitats and reducing carbon stocks.
Leakage	Protecting one area may shift deforestation to surrounding regions, offsetting climate benefits and requiring broader monitoring.
Hydrological and Subsidence Risk	Drained peat subsides and oxidises, releasing CO_2. Restoration requires ongoing interventions, which may restart carbon loss if not managed.
Baseline and Methodology Risk	Low prior deforestation limits creditable emission reductions. Inaccurate baselines or models risk invalidating credits.
Community and Social Risk	Unclear benefits or weak engagement can lead to conflict, sabotage, or loss of trust, making community involvement essential.
Institutional and Governance Risk	Overlapping government roles or unclear land boundaries can delay permits and stall projects; clear roles and agreements are necessary.
Market and Price Risk	Fluctuating carbon credit prices can threaten funding for maintenance and community programmes if market conditions worsen.
Permanence Risk	Fires, policy changes, or management lapses can eliminate stored carbon; strong safeguards and risk buffers are required.
Reputational Risk	Lack of transparency or past controversies can deter buyers; open reporting and verified results are critical to maintaining trust.
Land Tenure and Legal Risk	Unresolved land rights can cause disputes and legal delays; clear, documented ownership is essential for credit issuance.
Technical Failure	Equipment breakdowns or skill gaps can disrupt monitoring and restoration; regular maintenance and training mitigate this risk.
Extreme Weather / Geological Risk	Floods, droughts, or local subsidence can undermine peat restoration, so plans must adapt to changing weather and site conditions.

Source: ERIA study team compiled from Lestari et al. (2023); Kettridge et al. (2015); Setiadi, Sutopo, and Prasetyo (2025); CIFOR-ICRAF (2025); WRI Indonesia (2022).

4.4.8. Peatland Carbon Project: Risk Assessment Matrix with Mitigation Strategies

Table 4.10. Risk Assessment Matrix

Risk Category	Environmental Impact	Operational Impact	Likelihood	Severity	Mitigation Measures
Fire Risk	Massive CO_2 release (200–400 tCO_2/ha) Deep peat layer combustion Loss of critical habitat	Field team evacuation Damage to monitoring equipment Work stoppages	High	Very High	1. Maintain water tables via canal blocking 2. Establish community fire brigades 3. Deploy real-time satellite hotspot alerts 4. Pre-position firefighting equipment
Land-Use Pressure	New clearings create forest edges, accelerating drying and carbon loss	Increased boundary patrol costs Legal disputes Enforcement delays	Moderate	High	1. Secure formal land-use agreements 2. Create multiple buffer zones 3. Enforce legal zoning 4. Support alternative livelihoods (e.g. agroforestry)
Leakage	Emissions shift to adjacent peatlands or across borders, negating net climate benefit	Expanded MRV scope Reputational harm Cross-jurisdictional friction	Moderate	High	1. Establish a 50 km landscape buffer 2. Coordinate regionally with Malaysia and Brunei authorities 3. Fund alternative income programmes beyond project zone

Risk Category	Environmental Impact	Operational Impact	Likelihood	Severity	Mitigation Measures
Hydrological and Subsidence	Continued peat oxidation (20–40 tCO_2/ha/yr) Peat collapse undermines ecosystem function	Rising restoration and monitoring costs Complex data calibration	High	High	1. Install phased canal-blocking dams 2. Deploy hydrological sensor networks 3. Schedule annual subsidence surveys 4. Adaptive water-level management
Baseline and Methodology	Over-crediting reduces environmental integrity Under-crediting limits conservation funding	PDD validation setbacks Increased audit fees Buyer scepticism	Moderate	Moderate	1. Apply IPCC Tier 3 carbon accounting 2. Adopt conservative baseline assumptions 3. Engage independent third-party DOE early 4. Use multiple data sources
Community and Social	Illegal harvesting or intentional fires if benefits unclear Local resource shortages	Project interruptions Mediation expenses Trust erosion	Moderate	Moderate	1. Conduct genuine FPIC workshops 2. Codify transparent revenue-sharing (30–40% to communities) 3. Institute community grievance mechanisms 4. Regular reporting

Risk Category	Environmental Impact	Operational Impact	Likelihood	Severity	Mitigation Measures
Institutional and Governance	Policy shifts could open peat to development Gaps in enforcement allow degradation	Permit processing delays Inter-agency coordination burdens	Low–Moderate	High	1. Establish multi-ministerial REDD+ steering committee 2. Formalise tenure via legal audits 3. Draft clear MoUs amongst ministries
Market and Price	Lower credit prices hamper funding for ecological safeguards and community programmes	Budget shortfalls Scaling and staffing constraints	Moderate	Moderate	1. Pursue premium certifications (Gold Standard, CCB) 2. Diversify income (ecosystem service payments) 3. Secure long-term purchase agreements
Permanence	Catastrophic fire or policy reversal could reverse decades of stored carbon	Buffer pool depletion Insurance claims Emergency response overload	Moderate	Very High	1. Allocate 20% of credits to a non-permanence buffer 2. Maintain rapid-response fire and hydrology teams 3. Purchase parametric risk insurance
Reputational	Perceived opacity or data gaps undermine credibility	Increased scrutiny from certifiers Loss of project partnerships	Low–Moderate	High	1. Implement proactive transparency 2. Publish MRV datasets, audit reports, and community

Risk Category	Environmental Impact	Operational Impact	Likelihood	Severity	Mitigation Measures
	Risk of buyer and partner loss				minutes 3. Host annual stakeholder open houses
Land Tenure and Legal	Overlapping land claims may lead to unauthorised forest use or forced evictions	Stalled credit issuance Costly legal proceedings	Low–Moderate	High	1. Map and register all land-use rights 2. Secure conservation leases 3. Publicise permit documentation 4. Engage customary leaders in legal processes
Technical Failure	Sensor outages lead to blind spots in peat moisture and flux monitoring	Data gaps Field team downtime Increased maintenance overhead	Moderate	Moderate	1. Implement redundant sensor arrays 2. Schedule quarterly equipment checks 3. Train local technicians 4. Maintain spare parts inventory
Extreme Weather / Geological	Floods overtopping canals cause uncontrolled water release Drought intensifies peat vulnerability	Emergency field interventions Canal repair costs Schedule disruptions	Low–Moderate	Moderate	1. Integrate forecast data into hydrological models; design adjustable spillways 2. Develop standard operating procedures for extreme events

Source: ERIA study team, 2025..

4.4.9. Specific Fire Risk Mitigation Strategies for Belait Swamp Forest

Table 4.11. Fire Risk Mitigatoin for Belait Swamp Forest

Strategy	Description
Fire Risk Mapping and Early Warning	Use GIS, remote sensing, and regular satellite monitoring to map high-risk areas and detect fire hotspots early.
Peatland Water Management and Restoration	Rewet peatlands by blocking drainage canals and restoring water balance to reduce flammability.
Legal Frameworks and Enforcement	Strengthen and enforce bans on illegal burning and risky land use; implement zoning to prevent fire-prone development.
Community Engagement and Education	Train and involve local communities in fire prevention, awareness campaigns, monitoring, and response efforts.
Upgrading Firefighting Capacity	Invest in equipment, training, and buffer zones to enhance firefighting effectiveness.
Continuous Research and Monitoring	Track rainfall, humidity, and climate trends; study fire behavior to support long-term planning and adaptive management.
Inter-agency and Stakeholder Collaboration	Coordinate with government agencies, NGOs, and communities to unify fire management and optimise resource sharing.

Source: ERIA study team, 2025.

4.5. An Outlook on Project Eligibility Criteria

4.5.1. Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM) rules make the Belait Peat Swamp Forest ineligible for carbon project certification because the entire area is situated on peat soils. CDM-approved methodologies for afforestation and reforestation projects specifically exclude wetlands and areas with peat soils regardless of any other project merits or safeguards. Even before a project can demonstrate its environmental merits, additionality, or monitoring plan, this fundamental eligibility criterion prevents Belait from advancing in the CDM process. Standard steps such as preparing a Project Design Document, project validation, stakeholder consultations, and environmental impact assessments become moot if the core eligibility requirement is not met.

Table 4.12. CDM Project Eligibility Checklist Matrix

Criteria	Key Requirements	Evidence / Documentation Needed
Eligibility	Land must have been non-forested as of Dec 31, 1989 Peat soils and wetlands are not allowed Soil disturbance <10% of project area	Historical land use maps Soil classification surveys Satellite imagery pre-1989
Additionality	Project must exceed business-as-usual scenario Demonstrate financial barriers Show regulatory gaps	Financial analysis Documentation of investment barriers Legal review (mandatory conservation not required)
Baseline	Establish credible without-project scenario Use approved afforestation/reforestation (AR) methodologies Apply conservative assumptions	Baseline methodology (e.g. AR-ACM0003) Historical deforestation data Carbon stock measurements
Permanence	Commitment for 20–60 years Forest management plan required Include risk mitigation measures	Project duration commitment Forest management plan Risk assessment and mitigation documentation
Monitoring	Strict adherence to approved methodology Periodic verification required Data quality protocols enforced	MRV protocol Monitoring equipment records Third-party verification contracts
Safeguards	Conduct environmental and social impact assessments Stakeholder consultations Protect water regimes	ESIA report Stakeholder consultation records Water management plan

Source: ERIA study team, 2025.

4.5.2. Reducing Emissions from Deforestation and Forest Degradation Plus+

REDD+ is a practical approach for Brunei's peat swamp forests such as Belait, as it supports the protection of both forests and peatlands. The programme emphasises quantifying and rewarding verified emission reductions. In Brunei, strong government capacity, extensive forest coverage, and technical expertise position the country well to meet REDD+ expectations. The main challenge is that Brunei's already low deforestation rates may limit potential carbon finance, as the scope for additional emission reductions is naturally modest. Nevertheless, adopting REDD+ will help Brunei attract global climate funding, strengthen research and monitoring infrastructure, and reinforce its leadership in in peatland conservation. Establishing the necessary legal, technical, and monitoring frameworks will require time and commitment, but these investments are essential for full programme participation and long-term success.

Table 4.13. Key Criteria for Forest Carbon Standards Readiness

Criteria	Key Requirements	Evidence / Documentation Needed
National Strategy	• Comprehensive REDD+ strategy • Addresses drivers of deforestation • Ensures cross-sectoral coordination	• National REDD+ strategy document • Driver analysis report • Inter-ministerial agreements
Reference Level	• Forest Reference Emission Level (FREL) • Historical baseline (10+ years) • Statistical credibility	• FREL submission to UNFCCC • Satellite time-series data • Ground-based forest measurements
Monitoring System	• National Forest Monitoring System in place • Compliance with IPCC guidelines • Real-time tracking capability	• Remote sensing infrastructure reports • Field sampling protocols • Quality assurance and control documentation
Safeguards	• Implementation of Cancun safeguards • Safeguards Information System (SIS) • Protection of indigenous and local rights	• SIS documentation • FPIC procedures • Grievance mechanisms and records
Results-Based Payments	• Verified emission reductions • Independent third-party verification • Reporting to UNFCCC	• Verification reports • UNFCCC technical annexes • Payment agreements/contracts

Source: ERIA study team, 2025.

4.5.3. Verified Carbon Standard (VCS)

The Verified Carbon Standard (VCS) is internationally recognised for its scientific credibility and flexibility, particularly through its modular, customisable approach for different land uses. The recent update to its REDD+ Methodology (VM0007) positions VCS as one of the most robust pathways for certifying carbon projects in tropical peat swamp forests, such as Brunei's Belait. VM0007 features separate modules that enable project developers to accurately measure avoided deforestation, forest degradation, and peatland conservation, adapting scientific tracking to local conditions. For a project in Belait, this entails using modules that account for both soil carbon and hydrological conditions, with robust monitoring systems specifically tailored to peatland ecosystems.

The process begins with a detailed Project Description that outlines project boundaries, baseline conditions, proof of additionality, and a comprehensive monitoring plan for both carbon and environmental safeguards. VCS then requires third-party validation, a period for public comment and stakeholder response, and registration on the Verra Registry. Ongoing monitoring follows the established plan and must be independently verified at least every 5 years, with each successful cycle generating tradable carbon credits known as Verified Carbon Units. Safeguards are central, addressing land tenure, community involvement, and biodiversity, with attention to hydrology to protect stored peat carbon.

Brunei's Belait Peat Swamp Forest is well suited for VCS certification under this framework, as VM0007 explicitly accommodates tropical peatland projects. The technical requirements are moderate, mainly involving investment in LiDAR sensors for biomass, remote sensing tools, and proper field equipment, with expected setup costs around $200,000. VCS provides a strong, reliable, and relevant system for channeling international carbon finance into Belait's peat swamp conservation effort.

Table 4.14. VCS Project Checklist

Criteria	Key Requirements	Evidence/Documentation Needed
Project Description	Clear geographic boundaries; Credible baseline scenario; Justification of additionality	Project Description document; Boundary maps- Additionality analysis
Methodology	Verra-approved methodology; VM0007 for peatland projects; Modular approach	Methodology selection (VM0007); Module configuration; Technical justification
Validation	Third-party validation; 30-day public comment period; Risk assessment	Validation report; Public comment responses; Risk mitigation plan
Monitoring	5-year verification cycles; Continuous monitoring- VCU issuance	Monitoring reports; Verification statements; Registry documentation

Criteria	Key Requirements	Evidence/Documentation Needed
Safeguards	Environmental and social assessment; FPIC implementation; Biodiversity protection	Environmental and social impact assessment (ESIA) documentation; FPIC records; Biodiversity surveys

Source: ERIA study team compiled from DNV GL (2014); ESI (2017); Forest Trends (2012); Pontius (2018); Verra (2023); Verra (2024); Verra (2025); Verra CCB (2026).

4.5.4. Gold Standard

The Gold Standard for the Global Goals emphasises sustainable development, aligning with Brunei's priorities in climate action and community benefits. However, this framework is generally unsuitable for large-scale peat swamp forests like Belait, as it excludes wetlands and areas that have been forested in recent decades – unless a project qualifies under new blue carbon or restoration methodologies. For most of Belait's peat area, eligibility remains unlikely unless projects focus on specific degraded zones or adopt innovative approaches.

Even eligible projects must undergo a thorough process, including third-party validation, multi-level internal review, detailed annual reporting, and transparent evidence of climate and social co-benefits. Safeguards are rigorous, requiring inclusive stakeholder engagement, public disclosure of results, and special attention to biodiversity and vulnerable groups. While these standards align well with Brunei's technical capacity and policy goals, the framework's limits on wetlands and historic land cover pose a practical barrier for most peatland projects in their current form. Where eligibility is possible, the Gold Standard can still provide a reputable platform for projects centered on restoration or mixed-use landscapes that deliver measurable climate outcomes alongside local development outcomes.

Table 4.15. Gold Standard Project Eligibility Checklist Matrix

Criteria	Key Requirements	Evidence/Documentation Needed
Eligibility	- Non-forested for 10+ years - No wetlands or peatlands - SDG alignment required	- Land use history - Eligibility screening - SDG impact assessment
Sustainable Development	- Contribution to ≥ three SDGs - Community benefits (33% revenue) - Gender considerations	- SDG quantification - Benefit-sharing agreements - Gender action plan
Stakeholder Engagement	- Inclusive consultations - Grievance mechanisms - Cultural appropriateness	- Consultation records - Grievance procedures - Cultural assessment

Criteria	Key Requirements	Evidence/Documentation Needed
Monitoring	- Annual carbon and non-carbon monitoring - Public reporting - Development indicators	- Annual monitoring reports - Public disclosure - Impact measurement
Validation	- Independent validation - 5-level internal review - Compliance assessment	- Validation report - Internal review documentation - Compliance matrix

Source: ERIA study team compiled from Verra (2025); CCBA (2016); Sustainable Solutions (2023); Roe et al. (2013); SustainableCarbon (2024); SustainCERT (2024).

4.5.5. Climate, Community, and Biodiversity

The CCB Standards require land-use projects to deliver real, measurable benefits for climate, communities, and biodiversity, all supported by strong evidence and third-party validation. The process begins with a detailed Project Design Document, includes a public comment period, and undergoes independent audits to verify compliance with all criteria. Projects must also maintain ongoing monitoring and submit reports on climate, community, and ecosystem health, with reviews every 5 years to ensure standards are upheld. Safeguards are central to the CCB approach, covering land tenure, community participation, grievance mechanisms, and regular assessments of social and environmental risks. For Brunei, particularly the Belait Peat Swamp Forest, the CCB Standards align closely with national conservation goals and support high integrity in the international carbon market. Although certification can take around twenty-two months and may involve higher costs, it provides greater market value and stakeholder trust, making CCB Standards an ideal fit for Brunei's conservation and climate finance objectives.

Table 4.16. CCB Eligibility Checklist Matrix

Criteria	Key Requirements	Evidence/Documentation Needed
Triple Benefit	- Net positive climate impact - Community well-being improvement - Biodiversity conservation	- Impact assessments (all three pillars) - Baseline studies - Monitoring protocols
Project Design	- Compliance with 17 core criteria - Optional Gold Level criteria - Integrated approach	- Project Design Document - Criteria compliance matrix - Gold Level justification
Public Consultation	- 30-day public comment period - Stakeholder feedback	- Public comment documentation - Response records - Feedback integration plan

Criteria	Key Requirements	Evidence/Documentation Needed
	integration - Transparency requirements	
Validation	- Independent third-party audit - On-site inspections - Stakeholder interviews	- Validation report - Site visit records - Interview documentation
Monitoring	- 5-year verification cycles - Performance indicators - Adaptive management	- Monitoring reports - Performance data - Management adjustments

Source: ERIA study team, 2025.

4.5.6. ART TREES

ART TREES is a robust carbon certification framework designed for national or regional forest programmes, making it a strong fit for Brunei's centrally coordinated forest conservation goals. It requires governments or subnational authorities to lead, with clear baselines based on IPCC guidelines and transparent annual monitoring that combines satellite imagery with ground data. Projects must prepare a comprehensive concept and registration document, accompanied by annual reports detailing forest cover and carbon stock changes.

Independent third-party auditors validate both climate outcomes and safeguard measures, including Indigenous rights and benefit sharing, before credits are issued and registered. Implementation requires substantial investment in high-quality monitoring and institutional capacity and takes approximately forty-eight months. However, the result is credible, large-scale carbon certification that positions Brunei to access high-value carbon markets while reinforcing its leadership in peatland conservation.

Table 4.17. ART TREES Eligibility Checklist Matrix

Criteria	Key Requirements	Evidence/Documentation Needed
Jurisdictional Participation	- National or subnational government - Legal authority over forests - Minimum 2.5 million hectares	- Government authorisation - Legal framework documentation - Area calculations
TREES Documentation	- TREES Concept approval - Registration Document - Monitoring reports	- TREES Concept - Registration Document - Annual monitoring reports
Baseline	- Historical activity data - Compliance with IPCC	- Historical deforestation data - Emission factors - Baseline methodology

Criteria	Key Requirements	Evidence/Documentation Needed
	guidelines - Conservative approach	
Monitoring	- Annual spatially explicit monitoring - Remote sensing combined with ground data - Replicable methodologies	- Satellite monitoring system - Ground-based measurements - Data documentation
Safeguards	- 16 Key Cancun-aligned indicators - FPIC implementation - Grievance systems	- Safeguards framework - FPIC documentation - Grievance mechanisms

Source: ERIA study team compiled from TREES Standard, Version 2.0 (2021); TREES Standard, Draft Version 3.0 (2025);TREES Validation and Verification Standard (VVS), Version 2.0 (2021); TREES ESG Safeguards Guidance Document (2021); ART Safeguards Primer (2021) .

4.5.7. Jurisdictional and Nested REDD+ (JNR)

The Jurisdictional and Nested REDD+ (JNR) framework by Verra enables countries like Brunei to align national forest policy with local conservation projects under a single system. JNR requires countries to establish a unified baseline, develop integrated monitoring, and ensure coordination between government programmes and site-level efforts, such as the Belait Peat Swamp Forest. The framework emphasises stakeholder participation, legal clarity, and benefit sharing. Both projects and national programmes undergo independent validation and verification. With a typical setup time of around thirty months, JNR provides Brunei with a practical and scalable approach to carbon finance, balancing national coordination with local conservation action.

Table 4.18. JNR Eligibility Checklist Matrix

Criteria	Key Requirements	Evidence/Documentation Needed
Operational Scenario	- Select from three scenarios - Define credit allocation - Risk management approach	- Scenario selection rationale - Credit allocation mechanism - Risk management plan
Jurisdictional Baseline	- Development of jurisdictional FREL - Integration of historical data - Carbon stock assessment	- Jurisdictional FREL - Historical datasets - Carbon stock measurements

Criteria	Key Requirements	Evidence/Documentation Needed
Nested Integration	- Project coordination - Management of overlaps - Buffer reserves	- Integration protocols - Overlap resolution procedures - Buffer pool documentation
Stakeholder Engagement	- Inclusive consultations - Demonstration of legal authority - Benefit-sharing mechanisms	- Consultation records - Legal authority evidence - Benefit-sharing agreements
Validation	- Third-party audit - Compliance with technical protocols - Verra registration	- Validation report - Technical compliance documentation - Registration approval

Source: ERIA study team, 2025.

4.5.8. Eligibility Result Summary

Table 4.19. Eligibility Result Summary

Framework	Eligibility Status	Key Advantages	Major Challenges	Peat Soil Compatibility
CDM	Not Suitable	Established mechanism	Peat soil exclusion	No – explicit exclusion
REDD	Highly Suitable	Government alignment, peatland inclusion	National framework development	Yes – explicitly included
VCS	Moderately Suitable	Established peatland methodologies	Recent methodology changes	Yes – with updated VM0007
Gold Standard	Limited Suitability	Sustainable development focus	Wetland exclusions	Potentially – requires adaptation
CCB Standards	Highly Suitable	Comprehensive triple benefits	Complex assessment requirements	Yes – complements other standards
ART TREES	Highly Suitable	Jurisdictional approach, HFLD pathway	Long implementation timeline	Yes – includes peatland conservation
JNR	Moderately Suitable	Flexible nesting options	Complex institutional requirements	Yes – through nested approaches

Source: ERIA study team, 2025.

Project Duration Estimation based on Historical Projects

Historical analysis indicates that carbon project timelines – from concept to first credit issuance – depend on the project type and standard. CDM and Gold Standard projects typically reach credit issuance within 18 to 24 months, reflecting more streamlined or established processes. Large-scale REDD+ and VCS projects generally require 30 to 36 months due to the greater focus on stakeholder engagement, baseline establishment, and third-party verification. Projects involving additional certifications, such as CCB, usually follow a similar 30 to 36 months timeline, as validation is often conducted in parallel. Projects under national or jurisdictional frameworks, like ART TREES or JNR, take the longest – often up to forty-eight months – reflecting the complexity of regional coordination and baseline setting.

In summary, standard CDM and Gold Standard projects are often ready in under 2 years, while REDD+, VCS, and CCB projects typically require about 3 years. The largest and most complex jurisdictional approaches generally take up to 4 years from start to first credits issuance. This suggests that, for most new forest carbon projects, a realistic expectation is 30 to 36 months to reach credit issuance.

4.6. Project Eligibility

4.6.1. Case Studies from Malaysia

Key CDM Projects in Malaysia

<u>Introduction</u>

Malaysia joined the CDM voluntarily as one of the non-Annex I countries. After becoming a member of the UNFCCC on 9 June 1993 and following by the ratification on 13 July 1994, Malaysia officially became a Party to the Protocol officially on 4 September 2002. Malaysia has experience in projects with CDM projects in renewable energy supply, demand-side management, fuel switching, and forestry. These projects use equity and debt to raise capital and generate financial returns. The Danish International Development Assistance (Danida) funded the renewable energy (RE) and energy efficiency (EE) programme in 2004-2005. The contribution of CDM arises from replacing fossil fuels or avoiding methane emissions.

For off-grid electricity projects, diesel used in engines is often the replaced fuel. For grid-connected projects, the avoided emissions come from the power stations supplying the grid, calculated according to internationally approved methods using the PDD (Project Design Development) document (UNFCCC, n.d.-b).

<u>Discussions</u>

Calculations for Peninsular Malaysia, Sarawak and Sabah grids in 2007 indicate that 0.648, 0.873, and 0.807 kg CO_2 can be displaced per kWh of renewable electricity generated, respectively. For combined heat and power projects, GHG emissions may be reduced from the production of heat. Currently, no additional GHG savings are credited for heat produced from biomass combustion, which is assumed to be a zero-emission fuel source because the CO_2 is released during biomass burning is considered equal to the CO_2 uptake by the plants.

For displaced grids, CDM revenues can typically contribute between 1 and 1.5 sen/kWh generated, depending on the locality, as estimated by Danida (2005). In summary, the study estimated that the potential CERs obtainable were 26 million CERs in 2010 (NRES, 2025), amounting to a total of 125 million CERs generated before 2012. The Malaysian Energy Centre (PTM) predicts that the annual potential in Malaysia reached 18 million CERs in 2010, which is equivalent to approximately 100 million tonnes of CO_2 equivalent from 2006 to 2012 (Lim and Lam, 2014).

Based on previous assumptions, with an exchange rate of RM 4.7 per Euro and a current CERS price of RM 47 per tonne CO_2 equivalent, the annual income in 2010 was estimated at RM 1.2 billion/year from the sale of of CERs. Examples of CDM projects are provided in Table 4-19 Some common projects in Malaysia included the Seelong landfill gasfill utilisation in Johor Bahru, the Biomass energy plant in Perak, the Esajadi small hydropower project in Sabah, and the Jana Manjung biomass and coal power plant in Perak (UNFCCC, n.d.-a).

Table 4.20. An Overview of Types of CDM Projects which are Eligible

Type	CDM							
	Number		CERs/year (000)		2012 CERs (000)		CERs issued (000)	
Wind	2,523	28%	232,036	19%	312,679	12%	71,729	7%
Hydro	2,280	26%	316,853	26%	416,765	16%	94,482	10%
Biomass energy	906	10%	61,000	5%	157,093	6%	24,717	3%
Methane avoidance	776	9%	34,270	3%	96,666	4%	11,298	1%
EE own generation	481	5%	63,560	5%	183,561	7%	44,105	5%
Landfill gas	434	5%	65,831	5%	190,088	7%	24,688	3%
Solar	333	3.8%	11,464	0.9%	6,366	0.2%	145	0.01%
EE industry	163	1.8%	7,568	1%	17,165	1%	2,052	0.2%
Fossil fuel switch	150	1.7%	69,509	6%	167,428	6%	33,614	3%
Coal bed/mine methane	112	1.3%	72,128	6%	103,791	4%	15,387	1.6%
EE supply side (power plants)	110	1.2%	59,168	5%	51,187	2%	1,656	0.2%
EE households	108	1.2%	4,107	0.3%	5,282	0.2%	135	0%
N_2O	107	1.2%	57,793	5%	251,769	10%	212,767	22%
Afforestation and reforestation	69	0.8%	3,285	0.3%	20,956	0.8%	4,072	0%
Fugitive	66	0.7%	49,353	4%	84,158	3%	9,834	1%
Cement	50	0.6%	7,578	1%	26,568	1%	2,154	0.2%
Transport	48	0.5%	5,823	0.5%	7,030	0.3%	439	0%
EE service	37	0.4%	1,720	0.14%	1,022	0.04%	6	0%
Geothermal	35	0.4%	12,210	1%	13,242	1%	4,206	0.4%
Energy distribution	29	0.3%	10,422	1%	9,910	0%	316	0%
HFCs	23	0.3%	81,727	7%	476,504	18%	414,363	43%
PFCs and SF6	18	0.2%	5,540	0%	11,785	0.5%	1,758	0.2%
Mixed renewable	6	0.07%	412	0%	140	0.01%		
CO_2 usage	4	0.0%	116	0%	287	0.01%	10	0.001%
Agriculture	2	0.02%	59	0%	41	0%		
Tidal	1	0.01%	315	0%	1,104	0.04%		
Total	**8,871**	**100%**	**1,233,845**	**100%**	**2,612,586**	**100%**	**973,934**	**100%**
HFCs, PFCs, SF and N_2O reduction	148	1.7%	145,060	12%	740,058	28%	628,889	65%
Renewables	6,084	69%	634,290	51%	907,389	35%	195,279	20%
CH_4 reduction and Cement and Coal mine/bed	1,444	16%	229,336	19%	501,598	19%	63,371	6.5%
Supply-side EE	620	7%	133,149	11%	244,658	9%	46,078	4.7%
Fuel switch	150	1.7%	69,509	5.6%	167,428	6.4%	33,614	3.5%
Deman-side EE	308	3.5%	13,394	1.1%	23,469	0.9%	2,193	0.2%
Afforestation and Reforestation	69	0.8%	3,285	0.3%	20,956	0.8%	4,072	0%
Transport	48	0.5%	5,823	0.5%	7,030	0.3%	439	0.05%

Source: Lim and Lam (2014).

By December 2007, Malaysia had 20 registered CDM projects, with two undergoing corrections and one under review. As of August 2012, Malaysia had 108 CDM projects in the pipeline, representing 2.42% of the global total CDM projects.

Challenges

Small-scale renewable energy projects have claimed that the CDM does not fully achieve the objective of technology transfer, as these projects are less exposed to new technologies. It has also been argued that CDM has not been very successful in reducing carbon emissions. To address this, both nation-wide indirect and direct effects should be considered in CDM projects. Multiple approvals required from host and buying countries, as well as the UN, lead to processing delays and loss of interest. Frequent regulatory changes, including updates to rules, create uncertainties and slow progress. Additionally, the utilisation of renewable energy faces several barriers for new projects, such as high costs, lack of project funding and low demand for energy from renewable resources.

Conclusion

Malaysia's engagement in CDM projects has contributed to its renewable energy goals and emission reduction targets. To maximise CDM benefits, Malaysia should diversify related products, raising awareness amongst key stakeholders, and provide capacity building for potential projects. While challenges such as regulatory delays remain, international partnerships and a growing project portfolio underscore the nation's commitment to sustainable development.

Projects Involved Under CDM

Table 4.21. Projects under CDM

Project Name	Project Type	Notes
Seelong Gasfill Utilisation (Johor Bahru)	Waste-to-energy (Landfill Gas)	Focuses on methane avoidance through gas capture and energy production.
Biomass Energy Plant (Perak)	Renewable Energy (Biomass)	Uses agricultural or plantation waste for energy generation.
Esajadi Small Hydropower Project (Sabah)	Renewable Energy (Hydropower)	Generates hydroelectricity; not related to forestry.
Jana Manjung Biomass & Coal Power Plant (Perak)	Renewable Energy + Fuel Switch	Mixed biomass and coal combustion, energy-focused.

Source: Panapanaan et al. (2009).

CDM Project Eligibility Criteria and Compliance Demonstration

Table 4.22. CDM Project Eligibility Criteria and Compliance Demonstration

Project Name	Additionality	Permanence	Leakage	Baseline Integrity
Seelong Gasfill Utilisation (Johor Bahru)	Only viable with CDM; used the additionality tool	Maintained capture; logged operations	Gas not vented elsewhere (verified)	Pre-CDM: landfill venting methane
Biomass Energy Plant (Perak)	Needed CDM for fuel switch; scenario analysis	Sustainable feedstock; long-term audits	Feedstock origin documented	Fossil fuel use; historic buyer data
Esajadi Small Hydropower (Sabah)	Less attractive vs. diesel without CDM; local proof	Low impact; hydrology and maintenance logs	Proved no fuel displacement	Diesel power; off-grid needs documented
Jana Manjung Biomass & Coal (Perak)	Co-firing only feasible with CDM; barrier analysis	Secured supply; technical operations documented	No upstream land change	100% coal; proof from five-year records

Source: Panapanaan et al. (2009).

Risk Identified, Volatility, and Strategy Learned from Malaysian CDM Experience

Table 4.23. Risk Identified and Challenges from Malaysia

Risk Identified	Volatility/Challenge	Strategy Learned from Malaysian CDM Experience
Technology Failure / Operational Issues	Gas capture breakdown, plant reliability	Regular maintenance, performance logs, and investment in proven technology
Feedstock or Resource Supply Risk	Biomass feedstock shortage, river flow	Secure long-term supply contracts, scenario planning, and local buy-in
Revenue & Market Volatility	Low CER prices, unstable income	Conservative financial projections and diversification of CER revenue streams
Regulatory and Approval Delays	Multi-level approvals, policy shifts	Early engagement with stakeholders and monitoring of the policy environment
Limited Technology Transfer	Small renewable energy projects, slow tech adoption	Seek international partnerships and implement capacity-building programmes
Community / Local Stakeholder Concerns	Local opposition to hydro projects	Community engagement, transparent benefit-sharing, and clear information

Risk Identified	Volatility/Challenge	Strategy Learned from Malaysian CDM Experience
Leakage / Indirect Impacts	Fuel/resource replacement elsewhere	Project boundary analysis and chain-of-custody verification

Source: Panapanaan et al. (2009).

Learnings from Malaysian CDM Projects:

- Always map risks early and tie each to a clear action plan (e.g. contracts, audits, stakeholder engagement).
- Conservative financial and technical assumptions protect project bankability.
- Proactive engagement with both regulators and local communities keeps projects on track.
- Track supply chains and project boundaries to prevent unintended emissions or leakage

North Selangor Peat Swamp Forest, Malaysia (NSPSF)

The North Selangor Peat Swamp Forest is a major peatland complex in Selangor, Malaysia. It is managed to prevent peat drainage and recurrent fires while restoring natural water tables through canal blocking and rewetting. By avoiding peat oxidation and deforestation, the landscape reduces greenhouse gas emissions, protects one of Peninsular Malaysia's largest below-ground carbon stores, and conserves habitat for specialised peat swamp biodiversity.

The programme adopts high-integrity MRV, combining hydrological monitoring, hotspot detection, and satellite-based forest cover tracking with community engagement in fire prevention patrols and restoration activities. It aligns with IPCC-consistent peat methodologies and has been developed to meet voluntary standard expectations for climate community and biodiversity co-benefits.

Eligibility Criteria and Compliance – North Selangor Peat Swamp Forest (NSPSF)

Table 4.24 Eligibility Criteria and Compliance of North Selangor Peat Swamp Forest (NSPSF)

Subject	What NSPSF Did	How It Proved Compliance	Key Evidence	Why It Matters
Methodology Compliance	Used IPCC-style peat MRV with water-table targets and remote sensing	Documented methods and QA/QC in plans	IMP, hydrology and monitoring notes	Supports audit-ready carbon accounting

Environmental Impact Assessment	Assessed hydrology, fire, and biodiversity; planned restoration	Published plans with mitigation measures and indicators	EIA sections and restoration plans	Ensures no-harm and delivers co-benefits
Social Impact and Stakeholders	Engaged communities in fire patrols and rehabilitation	Maintained meeting, patrol, and grievance records	Minutes, patrol logs, programme reports	Builds trust and enhances project durability
Monitoring Systems	Tracked water levels, fires, canals, and vegetation via field and satellite	Maintained routine logs and annual updates	Logger data, canal registers, hotspot maps	Verifies results and guides management actions
Legal and Risk Management	Managed as state reserve with fire SOPs and buffer control	Demonstrated legal status and coordinated enforcement	SOPs, incident records	Reduces risk of reversal, leakage, and disputes

Source: Selangor State Forestry Department, 2014.

Requirements and Compliance – North Selangor Peat Swamp Forest (NSPSF)

Table 4.25. Requirement and Compliance of NSPSF

Criteria	What NSPSF Did	How It Proved Compliance
Additionality	Identified ongoing peat damage and fire risk; proposed canal blocking, rewetting, and community fire work beyond routine budgets	IMP 2014–2023 shows risks and funding gaps; activities exceed business-as-usual; state documents note that risks persist without new finance
Permanence	Raised water tables via canal blocks; implemented fire prevention and response; managed buffers and replanting	Water-level logs and maintenance records; fire reports and patrol logs; periodic reviews confirm reduced risk and sustained rewetting
Leakage	Used buffer zones and joint enforcement; involved communities and alternative livelihoods to reduce off-site pressure	Buffer plans and operations records; community programme evidence; satellite checks show no increase in nearby drainage or loss
Baseline Integrity	Built a conservative baseline using historic drainage, fires, and peat condition data	Historic maps, satellite series, and hydrology data support the ‘without-project’ scenario; clear strata and methods reviewed by state partners

Source: Selangor State Forestry Department, 2014.

4.6.2. Case Studies from India

CDM Bio Carbon Sub-Project

Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds

Forest & Afforestation activities are important carbon sinks, influencing climate by absorbing CO_2 from the atmosphere – the most prevalent and significant greenhouse gas (GHG) – and storing carbon in wood, litter, leaves, roots and soil. According to the Forest Survey of India (2013), the area under forest is estimated at 14,683 km^2. Open forest accounts for 13.71% of the total forest area, indicating significant scope for afforestation activities.

The HP Mid-Himalayan Watershed Development Project (HP-MHWDP) was implemented in the mid and high hills range of 600-1800 meters by the Government of Himachal Pradesh with the assistance of the World Bank. It covers 11 watershed divisions across 10 districts. The Bio Carbon Reforestation Project under CDM is an additional component of the HP MHWDP. The project was registered with UNFCCC on March 4, 2011. Its objectives are to protect watersheds, enhance tree cover, conserve biodiversity, improve livelihoods and generate carbon revenue. The project is being implemented in 139 Gram Panchayats (GPs), covering 3,216 hectares of degraded land. The focus is on reforestation, with farmers receiving cash incentives as potential sellers of carbon credits.

Clean Development Mechanism

The Clean Development Mechanism (CDM) is a mechanism under the Kyoto Protocol of the United Nations Framework Convention on Climate Change that allows developed countries to take action in developing countries to meet their greenhouse gas (GHG) emission reduction commitments. Article 12 of the Kyoto Protocol defines the dual purpose of the CDM as follows:

- To assist developing countries in achieving sustainable development and in contributing to the ultimate objective of the Convention (to address climate change)
- To assist industrialised countries in achieving compliance with their Quantified Emissions Limitations and Reductions requirements under Article 3 of the Kyoto Protocol

Under the Clean Development Mechanism (CDM) of the Kyoto Protocol greenhouse-gas emission offsets are measured in tons of CO_2 equivalents and are called 'Certified Emission Reductions' (CERs).

The Government of India (2008) defines 'forest' for consideration under CDM as land having growing trees with:

- A minimum area of 0.05 ha
- A minimum tree crown cover of 15% and
- A minimum height of 2 meters

The CDM project along with the potential carbon revenue will enable reclamation of highly vulnerable (sloping) lands subjected to soil erosion and land degradation. The project activities will promote biodiversity due to protection and planting of native tree species, reduce soil erosion and limit siltation of water bodies. All the three plantation models will also provide multiple products to the local communities, generating employment and livelihood activities. In the absence of the proposed CDM project activities, land degradation would continue and the communities will continue to face shortages of biomass products.

Objectives

The broad objectives of the Project:

- To sequester Green House Gases (GHG) through reforestation on degraded forest, community, and private lands.
- To fulfill global and national environmental objectives by developing innovative cost effective ways to minimise climate change risks.
- To provide multiple benefits to the poor farmers through meeting their needs of fodder, firewood, timber, and minor forest produce.
- Carbon credits (as cash incentives) and employment opportunities.

Project Area, Carbon Stock and Carbon Revenue

The A/R project area covers 3,216 hectares, distributed across different land categories: Forest Land (2943 ha), Community Land (227 ha), and Private land (46 ha). The project spans 139 Gram Panchayats (GPs) and involves 231 Village Development Societies comprising 4,374 members including 1,424 women members.

The implementation of A/R CDM project and associated carbon sequestration will generate from carbon credits, termed CERs. Carbon credit revenue is calculated based on growth and accumulation of carbon in tree biomass, including both aboveground and below ground biomass. Biomass stocks will be periodically measured from permanent plots to estimate the carbon revenue.

The total projected net greenhouse gas (carbon dioxide) removal by trees for the total project areas over the first 20-year crediting period, resulting from the implementation of afforestation under CDM is 828,016 t CO_2^{-e} of t CERs. This corresponds to CERs at a rate of 10.34 t CO_2^{-e}/ha/year. Carbon stocks will be verified at five-year intervals, and the CERs generated will be sold accordingly. Revenue from CERs derived from degraded forest land and community lands will be shared with the Gram Panchayats (GPs), and, in turn, distributed to individual families.

The CER revenue from the degraded private lands will be fully transferred to the respective farmers. The flow of CER revenue depends on the growth rate of trees and the carbon price. CERs (65,582) generated during the first five-year period (2006-2012) was sold at a rate of \$4.75/t$CO_{2,}$ yielding a total of \$3,11,514.50 (₹193 lakhs). After deducting

Project preparation costs, Kyoto Protocol fees, and other charges amounting to US$55,000, the net Carbon revenue amounting to $2,56,514.50 (₹163 Lakh) was retained by the project as overhead charges, while remaining 90% (₹146.56 Lakh) was shared amongst the beneficiaries (user groups and GPs) in a ratio of 80:20. Detail are provided in Table 4-261 Carbon Revenue First Cycle.

Details of the second cycle, which are to be distributed, are provided in section 'Carbon Revenue: Second Cycle for Distribution'.

Table 4.26. Carbon Revenue

Description	CERs (tCO_2-e)	CERs/year (tCO_2-e)	CER Revenue (₹) @ $5/$tCO_2$
Total for the whole project area	828,016	41,979	198,723,840
Average per hectare	207	10.34	2,481.6

Note: $1 = ₹48.–
Source: ERIA study team, 2025.

Table 4.27. Actual Revenue Generated: 2006-2017

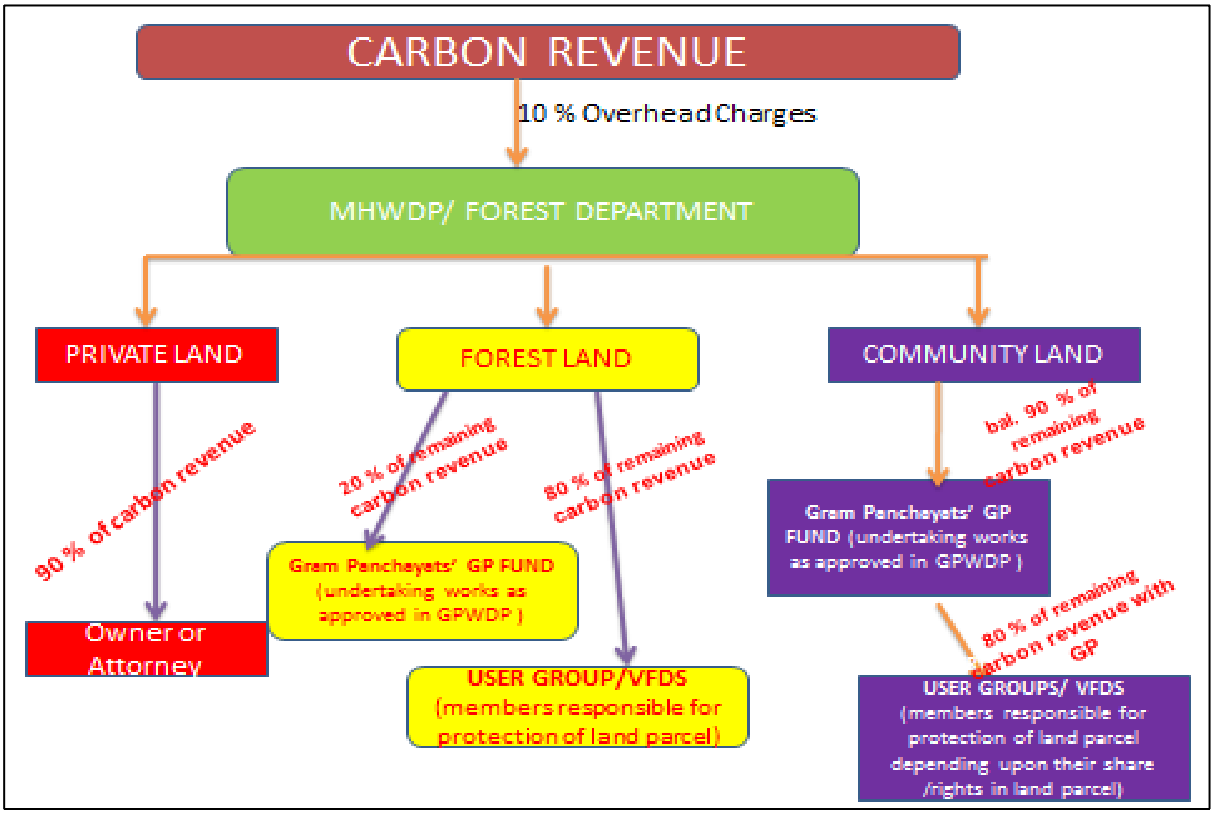
Area Planted (ha)	CERs verified	Revenue generated
3216	65,582	₹163 Lakh (1st Cycle)
3216	1,62,752	₹258 Lakh (2nd Cycle)

Note: $1 = ₹48
Source: ERIA study team, 2025.

Scheme of Distribution of Carbon Revenue

- Out of the total carbon revenue, 10% will be retained by MHWDP as overhead charges. The remaining 90% will be transferred to the GPs/User Groups.
- For forest land, 80% of the carbon revenue received (out of the 90%) will be distributed amongst the User Groups/VFDS, while the remaining 20% will go to the GP for activities aligned with the approved GPDP (Gram Panchayat Development Plan).
- For community land, 90% of the carbon revenue received after deduction goes to the GP, which will further distribute 80% of this amount amongst the User Groups. The remaining 20% will be used for activities in line with the approved GPDP.

Figure 4.25. Scheme of Distribution of Carbon Revenue



Source: ERIA study team, 2025.

The bio-carbon project has generated multiple socio-economic and environmental benefits. It has built valuable knowledge in project preparation, planning, management, and watershed protection, while contributing to the sequestration of CO_2 and the generation of carbon revenue. Communities have received cash incentives, and local institutions have benefited from payments that support infrastructure improvements. The project has also enhanced milk and NTFP production, created employment opportunities, and provided essential resources such as firewood, fodder, and timber, strengthening both livelihoods and sustainability.

Monitoring System:

An effective monitoring system has been established, covering a range of parameters such as area planted, condition of the land parcels, seedling survival, tree biomass growth, and other events occurring within the project area. Plantation journals are being maintained and regularly updated to record relevant information for each parcel.

The survival rate of the bio-carbon plantations was assessed in December 2016 across 3,216 hectares. About 558 hectares (17%) achieved a high survival rate of more than 75%, while 1,359 hectares (42%) recorded a medium survival rate between 50–75%. The remaining 1,299 hectares (41%) had a survival rate of up to 50%.

Details Of The Bio Carbon Project

Table 4.28. Details of the Bio Carbon Project

Inception Year	2006
Plantation area	3,216 ha
Parcels	292
Size of Parcels	1 – 150 ha.
GPs	139
Total Users	4,374
Women	1,424
Total Earning (after 1st verification)	₹163 lakh
Project overhead charges	10%
Balance (to be distributed)	₹146.56 lakh
Total Earning (after 2nd verification)	₹258 lakh
Project overhead charges	10%
Balance	₹232 lakh
Distributed with interest	₹242 lakh

Source: ERIA study team, 2025.

Table 4.29. Carbon Revenue First Cycle

Name of Division	Area with 75-100% survival	Revenue @ Rate Rs.6490 / hac	Area with 50-74% survival	Revenue @ Rate Rs.4865 / hac	Area with<50% survival	Revenue @ Rate Rs.3245/ hac	Total revenue
Mandi	171.16	11,10,828.4	164.11	7,98,395.15	8.84	28,683.85	**19,37,907**
Nurpur	52.60	3,41,391.52	9.74	47,385.10	6.69	21,719.76	**4,10,496**
Chowari	0.00	0.00	59.66	2,90,247.85	344.90	11,19,211.86	**14,09,460**
Namhol	2.44	15,845.34	35.31	1,71,783.15	44.09	1,43,061.67	**3,30,690**
Kullu	242.68	15,74,993.2	243.96	11,86,865.40	68.12	2,21,055.89	**29,82,914**
D.shala	12.74	82,697.53	48.86	2,37,715.09	0.00	0.00	**3,20,413**
Nahan	2.97	19,301.26	56.77	2,76,161.73	15.41	49,995.72	**3,45,459**
Rampur	20.61	1,33,757.60	0.00	0.00	687.32	22,30,346.59	**2,364,104**
Solan	5.43	35,247.19	39.44	1,91,875.60	0.00	0.00	**2,27,123**
Sujanpur	80.16	5,20,222.18	25.57	1,24,383.46	10.41	33,777.21	**6,78,383**
Swarghat	0.00	0.00	750.16	36,49,539.10	0.00	0.00	**36,49,539**
TOTAL	**590.80**	**38,34,284.21**	**1,433.58**	**69,74,351.62**	**1,185.78**	**38,47,852.53**	**1,46,56,488**

Source: ERIA study team, 2025.

Carbon Revenue: Second Cycle for Distribution

The second cycle of carbon revenue has been generated and is scheduled for distribution amongst the concerned beneficiaries. The allocation will follow the established scheme of revenue sharing, ensuring that communities, user groups, and local institutions receive their due share in line with project guidelines. Detailed figures and distribution patterns are provided as follow

Table 4.30. Second Cycle fo Carbon Revenue

Sr No	District	Division	Area Planted	Area with 75-100 % Survival	Revenue @ Rate ₹11490/hac	Area with 50-74 % Survival	Revenue @ Rate ₹8615/hac	Area less than 50 % Survival	Revenue @ Rate ₹5745/hac	Total Revenue
1	Shimla	Rampur	707.93	0.00	0	65.18	5,61,547	642.75	36,92,571	42,54,118
2	Solan	Solan	44.87	0.00	0	24.16	2,08,146	20.71	1,18,989	3,27,135
3	Kangra	Nurpur	69.04	48.44	5,56,535	11.91	1,02,582	8.69	49,943	7,09,061
4	Kangra	Dharamshala	61.60	12.74	1,46,409	0.00	0	48.86	2,80,714	4,27,123
5	Mandi	Mandi	344.11	34.90	4,00,995	174.27	15,01,337	134.94	7,75,253	26,77,585
6	Sirmaur	Nahan	75.16	0.00	0	33.69	2,90,234	41.47	2,38,227	5,28,462
7	Chamba	Chowari	404.56	1.00	11,546	57.18	4,92,585	346.38	19,89,962	24,94,093
8	Bilaspur	Swarghat	750.17	125.99	14,47,645	559.22	48,17,695	64.95	3,73,160	66,38,499
9	Bilaspur	Namhol	81.84	5.50	63,223	23.83	2,05,314	52.50	3,01,633	5,70,170
10	Kullu	Kullu	554.77	44.84	5,15,201	298.27	25,69,571	211.66	12,15,989	43,00,761
11	Hamirpur	Sujanpur	121.64	81.99	9,42,087	33.14	2,85,543	6.50	37,343	12,64,973
12	G. Total		3,215.68	355.41	40,83,641	1,280.85	1,10,34,555	1,579.42	90,73,782	2,41,91,979

Source: ERIA study team, 2025.

Kullu Division

A. Parcel details

Table 4.31. Parcel Details

Total Parcels	32
Total GPs	15
Total Area Planted	554.77 Ha
Total Revenue distributed	₹72,83,675
Biggest Parcel (GP:Burua)	149.27 Ha ID: KL009F1

Source: ERIA study team, 2025.

B. Parcel: KL009F1 (GP Burua)

Table 4.32. Parcel: KL009F1 (GP Burua)

Area	149.27 Hectares
Location	Burua Ghat
Year of Planting	2010-11 & 2011-12
Species	Deodar, kail, Ban, HC Nut, W/nut & Ailanthus
User Group	Jamdagni Rishi Van Vikas Society Upbhokta Samuh Village Burua
Beneficiary Details	Males: 43; Females: 102 = Total : 145
Head of the Group	Sh. Pem Chand, 98166-22904

Source: ERIA study team, 2025.

Table 4.33. summarises the eligibility criteria and compliance requirements of the Himachal Pradesh BioCarbon Forest project. It outlines each criterion, the actions undertaken by the project to meet these requirements, and the corresponding evidence demonstrating compliance.

Table 4.33. Himachal Pradesh Carbon Forest Eligibility Criteria and Compliance

Additionality	- Identified lack of prior reforestation and ongoing land degradation. - Project feasible only with CER revenue. - Engaged local communities as carbon credit beneficiaries. - Applied UNFCCC registration and government definitions for eligible activities.	- Registered as a CDM Project with UNFCCC, confirming eligibility. - Documented pre-project land use and absence of similar initiatives. - Submitted financial and cost-benefit reports to auditors. - Provided evidence of carbon cash incentives to local farmers and groups.
Permanence	- Planted native, resilient species on degraded lands. - Ensured survival through monitoring and plantation journals. - Implemented revenue-sharing to incentivise long-term care. - Allocated overhead for project maintenance and monitoring.	- Survival rate assessments conducted by parcel and GP. - Plantation journals and periodic verification reports maintained. - Maintenance plans audited by the World Bank and local institutions. - Overhead funding reserved for re-planting or reversion risks.
Leakage	- Worked across forest, community, and private lands to minimise resource-shifting risks. - Linked economic incentives (jobs, income, NTFPs) to project participation. - Engaged 231 local groups in monitoring and implementation.	- Monitoring reports included checks on resource use beyond the project area. - Regular village and stakeholder updates confirmed no increased harvesting elsewhere. - Land-use reports and field visits incorporated into project audits.
Baseline Integrity	- Used Forest Survey of India maps to define original land conditions. - Measured and reported historical carbon stocks. - Established permanent sample plots and tracked biomass/carbon trends using scientific protocols over 20+ years.	- Published baseline and subsequent stock reports (Tables 8.1 and 8.2 of project documents). - Third-party validation by the World Bank and UNFCCC. - Revenue distribution based solely on verified CER volumes.

Source: ERIA study team, 2025.

Technical and Safeguards Requirements

Table 4.34. Technical and Safeguards Requirements

Topic	What They Did	How It Proved Compliance
Methodology Compliance	- Followed A/R CDM methodology set by the UNFCCC. - Used permanent plot sampling for biomass growth and carbon stock assessment. - Applied IPCC default factors for tree and soil carbon estimates. - Registered the project and submitted annual audits.	- CDM registration documents and methodology references. - Data from permanent plot measurements and periodic verifications. - Annual audit and carbon stock reports validated by World Bank/UNFCCC.
Environmental Impact Assessment	- Assessed land-use changes, targeting only degraded land. - Promoted biodiversity through native species planting and watershed improvements. - Conducted soil erosion and habitat surveys.	- Published environmental monitoring data. - Biodiversity recovery and ecosystem restoration confirmed through surveys and reforestation records. - Reports shared with stakeholders and reviewed by the World Bank.
Social Impact & Stakeholder Consultation	- Engaged 139 Gram Panchayats, 231 user groups, and 4,374 villagers (including 1,424 women). - Provided local employment and ensured fair benefit-sharing. - Held group meetings and distributed revenue transparently.	- Attendance sheets, stakeholder communication logs, and revenue-sharing records. - Records of project awareness, training, and grievance mechanisms. - Reports validated by government and the World Bank.
Monitoring Systems	- Maintained regularly updated plantation journals. - Verified survival rates by site/area. - Conducted periodic third-party assessments and field audits (every 5 years).	- Parcel-level survival and growth data. - Published audit findings and annual monitoring reports. - GPS-based recordkeeping verified by World Bank and local forestry officials.
Carbon Accounting	- Estimated and reported carbon stock changes per hectare and project-wide.	- Verified CER claims filed with the UNFCCC.

Topic	What They Did	How It Proved Compliance
	- Calculated CERs based on measured biomass increments and periodic verification. - Adjusted revenue according to survival and growth rates.	- Maintained carbon stock and cash flow tables (see Tables 8.1 and 8.2). - Carbon revenue distributed proportionally to verified sequestration.
Legal & Risk Management	- Registered the project as a CDM initiative with the UNFCCC. - Established clear ownership and revenue-sharing structures (state, user groups, private farmers). - Retained 10% of revenue for overhead and risk management. - Prepared replanting plans for low-survival areas.	- UNFCCC/CDM registration certificate. - Government and contract documents detailing benefit distribution. - Overhead accounts and transparent audit trails. - Survival monitoring data guiding replanting.
Community Co-Benefits	- Provided direct cash benefits to local families. - Improved infrastructure, employment opportunities, and forest product availability. - Enhanced NTFP collection and livestock productivity.	- Revenue disbursement records and infrastructure upgrade logs. - Socio-economic surveys and before/after assessments. - Official recognition of improved village well-being and gender equity.
Biodiversity Conservation	- - Prioritised planting of native tree species. - Restored degraded land, ecosystems, and hydrological functions. - Reduced soil erosion and supported livestock fodder needs.	- Biodiversity and land-use monitoring statistics. - Independent (World Bank/UNFCCC) reports confirming ecosystem improvements. - Ongoing tracking of tree and species diversity in reforested areas.

Source: ERIA study team, 2025.

4.6.3. Case Studies from Indonesia

4.6.3.1. Rimba Raya REDD+, Central Kalimantan

Rimba Raya is a major REDD+ peat swamp conservation project in Central Kalimantan, Indonesia, established to prevent the conversion of tropical peat forests into plantations. Covering about 64,000 hectares as a buffer for Tanjung Puting National Park, the project reduces greenhouse gas emissions by avoiding deforestation and peat drainage while safeguarding one of the world's richest peat carbon reserves. It also conserves critical habitat for endangered species such as orangutans and invests in community development, including clean water access, health services, education, and diversified livelihoods.

The project was amongst the pioneers of early REDD+ initiatives, achieving validation under the Verified Carbon Standard and gaining high co-benefit recognition for its contributions to climate, community, and biodiversity. Its model links carbon revenue directly to on-the-ground actions, including forest patrols, fire prevention, hydrological management, and community programmes that reduce pressure on the forest while improving local well-being.

Rimba Raya REDD+ Eligibility Criteria and Compliance

Table 4.35. Rimba Raya REDD+ Eligibility Criteria and Compliance

Criterion	What Rimba Raya Did	How It Proved Compliance
Additionality	- Conducted a barrier analysis (e.g. land-tenure conflicts, lack of finance). - Developed a financial model showing plantation conversion was profitable only with carbon revenue. - Surveyed local practices, confirming no prior conservation projects.	- Submitted the VCS AFOLU Additionality Tool (VM0004) application, including concession maps overlaid with project boundaries (Figures 3 & 4, Audit Report May 2011). - Field verifiers confirmed pre-project patrols were underfunded and ineffective without CDM funding.
Permanence	- Performed a fire-risk assessment using 10 years of MODIS satellite burn-area data. - Applied the VCS Non-Permanence Risk Tool v3.3, setting aside 10% of credits in a buffer pool. - Trained and employed local fire brigades; built guard posts and fire towers.	- Produced field survey reports measuring burn depth and area, showing less than 5% carbon stock loss over monitoring periods. - Published buffer-pool ledger and third-party audit statements verifying correct buffer allocation and use. - Verified patrol logs, guard duty rosters, and fire-tower maintenance records signed off by Environmental Services Inc. and AENOR.

Criterion	What Rimba Raya Did	How It Proved Compliance
Leakage	- Defined a 100 km leakage monitoring zone around the reserve. - Applied VM0004 methodology with satellite imagery overlays to track new clearings. - Conducted an econometric market-leakage analysis to test whether deforestation shifted elsewhere.	- Presented Landsat change-detection maps showing no significant new clearings in the buffer zone. - Submitted econometric reports (with regression outputs) showing no statistical increase in nearby concessions. - Independent verifiers confirmed that minor incursions were offset by deductions in CER issuance.
Baseline Integrity	- Analysed multiple land-use scenarios, selecting the most conservative: palm-oil conversion. - Compiled historical deforestation rates from 17 neighboring estates. - Stratified the landscape into 24 sampling strata for robust accuracy.	- Filed the Combined Tool report documenting scenarios, with Table 8 showing past conversion rates and justifying the chosen baseline. - Submitted GPS-tagged field photos taken along concession roads, confirming active plantation development. - Received SCS Global Services audit endorsement attesting to conservative and credible baseline calculations.

Source: ERIA study team, 2025 compiled from Environmental Services (2019).

Topic	What Rimba Raya Did	How It Proved Compliance
Methodology Compliance	- Followed VM0004 v1.0 with documented minor deviations. - Used the Aerial Image Method to count tree crowns in virtual 1-ha plots. - Applied IPCC peat-carbon equations for soil carbon stocks.	- Supplied the methodology log (Figure 4-29) with explanations for each deviation. - Provided aerial-photo analysis outputs (3,382 images) cross-checked against field plot counts. - Included auditor reports confirming correct use of IPCC default factors for peat depth and bulk density.
Environmental Impact Assessment	- Commissioned independent EIA studies, including biodiversity surveys of flora and fauna. - Assessed ecosystem-service benefits such as water regulation and habitat connectivity.	- Published EIA report appendices listing survey transects, species inventories, and ecosystem-service valuation tables. - Achieved CCB Gold Level on environmental safeguards, documented in the verifier's summary report.
Social Impact and	- Conducted Free, Prior and Informed Consent (FPIC) workshops with 14	- Filed FPIC consent forms signed by each community leader. - Presented aggregated survey data

Topic	What Rimba Raya Did	How It Proved Compliance
Stakeholder Consultation	forest-edge communities. - Carried out household surveys and livelihood assessments. - Established a grievance mechanism and held public comment periods.	showing improved household incomes. - Included minutes from public hearings and records of grievance resolutions, verified by CCB auditors.
Monitoring Systems	- Monitored forest cover annually using Landsat/SPOT imagery. - Set up 28 field biomass plots and 131 peat-depth sampling points. - Instituted annual third-party verification cycles (2009–2019).	- Released QA/QC protocol documents detailing sampling methods and error margins. - Published field-survey logs and plot-location GPS files. - Verified by SCS Global Services, Environmental Services Inc., and AENOR over five monitoring periods, with all non-conformances addressed.
Carbon Accounting	- Processed 3,382 aerial photographs to map tree density. - Measured peat depth and bulk density at 131 points. - Applied IPCC emission factors conservatively.	- Submitted detailed carbon-stock tables, aerial-photo processing scripts, and peat-sampling data sheets. - Received auditor-signed carbon issuance statements confirming correct application of factors and conservative assumptions.
Legal and Risk Management	- Secured Ecosystem Restoration License (IUPHHK-RE) and all required permits. - Documented forest-use rights and land-tenure agreements. - Deployed VCS Risk Tools, fire-prevention, and emergency response plans.	- Provided copies of government-issued licenses and tenure documents. - Included risk-tool worksheets showing buffer calculations. - Presented emergency drill reports and fire-prevention training certificates endorsed by verifiers.
Community Co-Benefits	- Created local employment programmes, fire-brigade roles, and livelihood training. - Established health clinics, schools, and microfinance initiatives.	- Supplied payroll records, training attendance sheets, and before/after socioeconomic surveys. - Achieved CCB Gold Level for social co-benefits, as noted in the verification summary.
Biodiversity Conservation	- Managed habitat for 300+ bird species and 122 mammal species.	- Presented biodiversity-survey databases, camera-trap image logs, and restoration planting records.

Topic	What Rimba Raya Did	How It Proved Compliance
	- Implemented ecological restoration (replanting native species) and species-monitoring programmes. - Established a buffer zone adjoining Tanjung Puting National Park for orangutan conservation.	- Verified by CCB Gold auditors, citing species-population monitoring results and evidence of stable or increasing populations.

Source: ERIA study team, 2025.

4.6.3.2. Sebangau Peat Rewetting REDD+, Central Kalimantan

The Sebangau Peat Rewetting Project in Central Kalimantan aims to restore degraded tropical peat swamp forests by blocking drainage canals, raising water tables, and reducing peat oxidation and fire risk. Operating across key peat hydrological units, the project constructs simple and semi-permanent dams, rehabilitates burned areas with native peatland species, and strengthens community-based fire prevention and rapid response systems.

By rewetting drained peat, the Sebangau seeks to curb major CO_2 emissions from peat decomposition, reduce catastrophic haze-producing fires, and enable long-term ecological recovery. The programme combines hydrological restoration with monitoring of water levels, fire hotspots, and vegetation regrowth, while supporting local livelihoods through training and active involvement in restoration and patrols - linking climate mitigation to ecosystem resilience and community benefits.

Sebangau REDD+ Requirements and Compliance

Table 4.36. Sebangau REDD+ Requirements and Compliance

Criteria	What Sebangau Did	How It Proved Compliance
Additionality	- Demonstrated that peatland degradation and drainage would continue without intervention. - Showed that rewetting activities are not business-as-usual and depend on carbon finance. - Used historical land-use data and government plans to highlight ongoing peat-conversion threats.	- Applied VCS-approved peat rewetting methodologies to demonstrate additionality. - Submitted baseline scenario reports showing continued drainage and degradation in the absence of the project. - Independent third-party validation confirmed that activities go beyond regulatory requirements and are financially unviable without carbon credits.
Permanence	- Implemented hydrological restoration by blocking	- Used the VCS Non-Permanence Risk Tool to allocate a buffer pool (typically

Criteria	What Sebangau Did	How It Proved Compliance
	drainage canals to rewet peat. - Developed fire-prevention and rapid-response systems. - Established buffer pools to address non-permanence risk. - Carried out continuous monitoring of peat water tables and fire occurrences.	10–20%) of credits. - Verified water-table monitoring data demonstrated sustained rewetting. - Fire-incidence reports and patrol logs were independently audited. - Annual monitoring reports confirmed low risk of carbon reversal.
Leakage	- Monitored potential displacement of peatland degradation to adjacent areas. - Defined leakage zones surrounding the project boundary. - Engaged local communities to reduce shifting cultivation and drainage outside the project area.	- Satellite imagery and remote sensing data showed no significant increase in peat drainage or deforestation within leakage zones. - Leakage assessments were conducted and verified under approved REDD+ methodologies. - Community engagement records confirmed reduced pressure on surrounding peatlands.
Baseline Integrity	- Developed a credible baseline scenario based on historical peat drainage and land-use change. - Applied hydrological and ecological data to model expected carbon emissions without intervention. - Stratified peatland areas to improve accuracy of carbon stock estimation.	- Baseline scenario validated by independent auditors using government land-use plans and historical satellite data. - Hydrological models and field measurements supported baseline emission estimates. - Sampling and stratification methods were audited to ensure accuracy and conservative assumptions.

Source: ERIA study team, 2025.

Sebangau REDD+ Technical Requirement and Safeguards

Table 4.37. Sebangau REDD+ Technical Requirement and Safeguards

Topic	What Sebangau Did	How It Proved Compliance
Methodology Compliance	- Applied VCS-approved peat rewetting methodologies (e.g. VM0035 or updated versions). - Used IPCC guidelines for peat carbon stock and emission calculations. - Employed hydrological monitoring and remote sensing for data collection.	- Submitted detailed methodology application documents. - Hydrological and carbon accounting data independently verified. - Auditor reports confirmed adherence to VCS and IPCC standards.
Environmental Impact Assessment	- Conducted biodiversity surveys of peat swamp flora and fauna. - Evaluated ecosystem service improvements such as water regulation and habitat restoration.	- Published EIA reports including species inventories and ecosystem service valuations. - Achieved validation/verification under CCB or equivalent standards for environmental safeguards.
Social Impact and Stakeholder Consultation	- Implemented Free, Prior and Informed Consent (FPIC) with local indigenous and forest-dependent communities. - Conducted socioeconomic surveys and livelihood assessments. - Established grievance mechanisms and ongoing stakeholder engagement.	- Filed FPIC documentation and consultation records. - Socioeconomic impact reports verified by third-party auditors. - Grievance logs and public meeting minutes included in verification packages.
Monitoring and Verification	- Used remote sensing (Landsat, Sentinel) to monitor peatland and vegetation. - Conducted field measurements of water-table depth and peat condition. - Maintained annual third-party verification cycles.	- Documented and implemented QA/QC protocols. - Auditor verification reports confirmed data accuracy and compliance. - Multi-year monitoring datasets submitted for verification.

Topic	What Sebangau Did	How It Proved Compliance
Carbon Accounting	- Quantified carbon stocks and emission reductions using aerial imagery, peat depth sampling, and hydrological data. - Applied conservative emission factors and accounted for non-permanence risks.	- Submitted detailed carbon accounting spreadsheets and field data. - Independent audits confirmed conservative assumptions and accurate emission reduction calculations. - Buffer pools established and audited for risk mitigation.
Legal & Risk Management	- Secured necessary permits and land-use rights for peatland restoration. - Developed risk management plans addressing fire, drought, and illegal activity. - Implemented community-based fire management programmes.	- Provided copies of permits and land tenure documentation. - Risk assessment reports and emergency response plans verified. - Fire management training and patrol records audited by verifiers.
Community Co-Benefits	- Created local employment opportunities in restoration and monitoring. - Supported healthcare, education, and sustainable livelihood initiatives. - Integrated traditional knowledge into peatland management practices.	- Employment records and community programme reports documented. - Verified social impact assessments showed improved well-being. - Achieved recognition or certification for social co-benefits (e.g. CCB Gold Level).
Biodiversity Conservation	- Protected habitats for peat swamp species, including endangered flora and fauna. - Conducted species monitoring and ecological restoration. - Established buffer zones adjacent to protected areas.	- Submitted biodiversity survey reports and monitoring datasets. - Independent audits verified compliance with environmental standards. - Documented positive trends in species populations and habitat quality.

Source: ERIA study team, 2025.

4.7. Carbon Market Trends and Price Dynamics in 2024 and 2025

Voluntary Carbon Market Overview

The voluntary carbon market entered 2024 under heightened scrutiny, shifting its focus from low-cost volume to a high-integrity credits. Transaction volumes fell by 25%, reducing total market value down to US$535 million, a 29% year-on-year decline. By contrast, credit retirements remained stable at 182 million tonnes of CO_2 equivalent. This divergence suggests that while corporate buyers are maintaining their offsetting commitments, they are becoming more selective, moving away from inexpensive avoidance credits toward projects aligned with the Integrity Council's Core Carbon Principles (CCPs).

Transactional Demand

The voluntary carbon market is shifting toward high-integrity credits, with only 8% of current supply meeting CCP benchmarks. While demand remains steady – 182 $MtCO_2e$ retired in 2024 – buyers increasingly require robust validation, monitoring, and third-party verification. This creates scarcity-driven price premiums for compliant projects. For Belait's peat swamp forest project, rigorous biomass assessments, community engagement, and continuous remote sensing will be critical to secure buyer trust and capture premium market value.

Price Trends

Forest-based credits, particularly those linked to avoided deforestation, continue to command significant premiums. Older vintages of REDD+ credits traded at US$2 to US$6 per tonne, whereas new high-integrity REDD+ credits range from US$10 to US$16 per tonne. The Verified Carbon Standard (VCS) remains the dominant certification, with average prices of US$6.34 per tonne in 2024. Specialist projects with strong permanence assurances and rigorous monitoring prices of up to US$15 per tonne, reflecting growing demand for high-integrity supply. Gold Standard credits command the highest premiums, typically ranging from US$10 to over US$40 per tonne, as they require projects to demonstrate contributions to at least three SDGs and to undergo comprehensive stakeholder consultations. With its deep peat layers that store exceptionally high carbon stocks, along with co-benefits in flood regulation and local livelihoods, Belait's PSF project is well positioned to compete in the upper tier of this price range.

EU Emissions Trading System and North American Compliance Markets

The European Union Emissions Trading System (EU-ETS) remains the world's largest carbon market. After peaking at over €85 per tonne in 2023, allowance prices eased to around €71 per tonne in early 2024 (about US$76), reflecting intervention measures and market-stability provisions. Compared with the voluntary market – where most credits trade between US$6 and 16, with Gold Standard projects reaching US$40 or more – the

EU ETS benchmark underscores both the value gap and the potential upside for high-integrity peatland credits like Belait's PSF project.

CORSIA and Aviation Sector Demand

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) requires participating airlines to offset any emissions above 2020 levels, with the first phase running from 2024 to 2026 and mandatory participation beginning in 2027. Forecasts estimate that first-phase demand at 50-100 million eligible emissions units, equivalent to about 40 million credits after eligibility adjustments. CORSIA-eligible credits already carry a premium of roughly US$20 per tonne over benchmark offsets, and future shortage scenarios could push prices as high as US$50 per tonne in later phases. By adopting CCP-approved methodologies and securing Letters of Authorisation, the Belait PSF project can access this burgeoning demand, offering airlines high-integrity credits enriched by rigorous monitoring, strong social safeguards, and measurable carbon permanence within one of Southeast Asia's most intact peat ecosystems.

CORSIA Market Opportunity (2024–2035)

Scheme Overview: Airlines must offset emissions above 2020 levels. Voluntary from 2024–2026, mandatory from 2027 onwards.

Demand Forecast: 50–100 million eligible emission units in the first phase, ≈40 million credits after eligibility filters.

Price Premium: CORSIA-eligible credits trade at ~US$20/ton above benchmarks; shortage scenarios could lift prices to US$50/tonne.

Implication for Belait PSF: By adopting CCP-approved methodologies and securing Letters of Authorisation, the project can access this high-value market, offering airlines rigorously monitored, socially safeguarded, and permanence-assured peatland credits.

4.8. Lesson Learned from Adopting New Methodologies for Belait Peat Swamp Forest Carbon Project

Belait's Strategic Advantages

Regulatory and Governance Superiority

1. Streamlined Legal Framework

   Belait operates within Brunei's highly stable governance system, supported directly by the government through the National Forest Resources Inventory 2023-25, managed by Lunima Sdn Bhd in partnership with the Forestry Department. In contrast to Indonesia's complex multi-agency regulatory environment, which led to the revocation of Rimba Raya's license, Brunei provides clear forest ownership structures spanning 488,000 hectares (84% of land area). This consistency in policy direction greatly reduces regulatory risks.

2. Proactive Government Investment The government's substantial investment in advanced monitoring infrastructure – such as LiDAR technology introduced in 2009 and comprehensive 3D Digital Terrain Models - demonstrates an exceptional commitment to forest carbon projects. These efforts provide Belait with robust baseline data, a critical advantage that most competing projects lack.

3. Exceptional Ecological and Carbon Advantages

   High Carbon Density

   Recent NFRI findings show that Belait holds exceptionally high ecosystem carbon stocks, averaging 2,665.83 tonnes CO_2 equivalent per hectare. This includes 455 tonnes C/ha aboveground and 1,545.50 tonnes C/ha belowground. These values far exceed regional benchmarks and represent some of the world's deepest and most carbon-rich deposits.

4. Superior Aboveground Biomass

   Belait's aboveground biomass ranges from 470-560 tonnes per hectare, well above the regional average of 350 t/ha for tropical rainforests in Asia. This reflects old-growth forest conditions, which command premium pricing in carbon credit markets.

5. Pristine Peat Dome Structure

   The Badas Peat Dome contains between 21,425-35,308 cubic meters of peat per hectare. Its intact structure eliminates costly restoration needs while ensuring maximum carbon storage potential. Compared with similar projects, it holds 57% more total carbon stock and significantly deeper peat deposits.

6. Advanced Technological Infrastructure

   Brunei has become one of the world's best-mapped countries through comprehensive LiDAR coverage, achieving 15-centimeter accuracy in both horizontal and vertical dimensions. The integration of airborne LiDAR, NASA's GEDI satellite data, and machine learning algorithms (SVM achieving R^2 = 0.70 with 6% error margin) sets a new benchmark for the region.

7. Hybrid Monitoring Excellence

   The pioneering hybrid approach - combining satellite data, airborne LiDAR, and ground-truth measurements with machine learning corrections - has improved biomass estimates by 75.9%, far surpassing the accuracy of earlier projects such as Rimba Raya.

8. Market Positioning and Certification Advantages

   Multiple Revenue Stream Potential

   Beyond carbon credits, Belait provides exceptional biodiversity value (Shannon Index 1.70-2.99) and has been designated an Important Bird Area, supporting rare species such as Storm's stork and Bornean bristlehead. This ecological richness enables certification under multiple premium standards and enhances overall project value (Pg Nor Zamzam Pg Hassan, 2016).

9. Timing and Market Maturity

   Belait's timing advantage enables it to capitalise on favourable market conditions and the quality premiums commanded by pristine forests. The project also offers strong diversification across multiple revenue streams beyond carbon credits, reducing the risks associated with the reliance on a single income source.

10. Risk Management Superiority

    Comparatively Lower Fire Risk Profile

    Unlike degraded Indonesian peatlands, Belait's intact waterlogged conditions greatly reduce fire susceptibility and reversal risks. The forest's natural water regulation capacity provides inherent fire protection.

    <u>Hydrological Stability</u>

    The intact peat dome structure sustains natural water tables, eliminating the need for complex rewetting interventions that challenge projects such as Sebangau. This lowers both technical complexity and long-term maintenance costs.

Lessons Learned from Case Studies

1. Regulatory and Legal Framework Failures

   <u>License Revocation Consequences</u>

   Rimba Raya's license revocation in 2024 offers important lessons for Belait project development. The Indonesian Ministry of Environment and Forestry cancelled the permits due to boundary disputes, unpaid government fees, and unauthorised permit transfer of rights to third parties. These issues underscore the importance of clear legal frameworks and strict regulatory compliance throughout project lifecycles.

   <u>Single-Point-of-Failure Dependencies</u>

   Verra's suspension of Infinite EARTHs registry account in May 2024 effectively halted all Rimba Raya carbon credit activities. This illustrates the importance of securing multiple certification pathways and avoiding single points of failure that could erase years of investment overnight.

2. Impact of Alleged Price Inflation

   Baseline Inflation Damage

   Accusations of baseline inflation and over-issuance of credits severely undermined Rimba Raya's reputation and market credibility. Academic studies suggested that more than 90% of its issued credits may not reflect real emission reductions, largely due to inflated baseline deforestation assumptions.

3. Revenue Vulnerability

   Over-reliance on carbon credit revenues without diversification created significant vulnerability to market volatility and regulatory changes. Projects were hit hard during price declines, falling from $9.10 (2015) to $3.80 (2023), highlighting the risks of depending on a single-revenue-stream.

4. Community Engagement Challenges - Financial Transparency Gaps

   Both Rimba Raya and Sebangau projects faced limited financial transparency at the community level, leading to trust deficits and resistance that ultimately undermined long-term sustainability.

5. Infrastructure Maintenance Issues

   Sebangau's experience with deteriorating canal-blocking structures underscores the importance of community-integrated monitoring. Many of the structures were dismantled by villagers who depended on the canals for traditional activities, demonstrating the need to align project interventions with local livelihoods.

Recommendations for Belait Peat Swamp Forest Development

1. Technical Excellence and Accuracy

   Site-Specific Allometric Equations

   Drawing on lessons from successful projects in Riau, Indonesia, Brunei should develop site-specific allometric equations rather than relying on pan-tropical models. This approach can reduce carbon estimation errors by 20-50%, ensuring Belait's carbon stocks are accurately measured while leveraging the National Forest Resources Inventory 2023-25 data.

2. Hybrid Monitoring Systems

   Belait can combine satellite LiDAR data (available since 2009) with a detailed monitoring network – integrating eddy covariance towers, automated soil sensors, and satellite-based systems – will further strengthen reliability. By applying machine learning approaches that have achieved error margins as low as 6% in biomass estimation. Belait can significantly surpass the accuracy of earlier projects such as Rimba Raya.

3. Legal and Governance Framework

Compliance Excellence

Rimba Raya's setback demonstrates that technical excellence alone cannot substitute for robust legal compliance. Belait must establish comprehensive legal documentation from project inception, including clear boundary demarcation, scheduled government fee payments, and strict controls on permit transfers. Regular legal audits and proactive government engagement will help prevent the regulatory oversights that undermined Rimba Raya's decade-long investment.

4. Government Relations Management

Proactive engagement with authorities and transparent communication are critical. Unlike Rimba Raya, which struggled with stakeholder management, Belait should maintain regular dialogue with government agencies and align with national climate goals to minimise legal risks and double counting issues. By leveraging Brunei's streamlined governance structure, the project can benefit from consistent policy support.

5. Community Engagement and Revenue Sharing

Local Community Integration

Building on the successful Sebangau project model in Indonesia, Belait should actively involve local communities in monitoring and project activities. Local residents can be trained as forest guardians, receiving financial incentives for maintaining monitoring infrastructure, similar to Sebangau's canal guardianship programme. Additionally, village-level financial reporting systems should be established, with annual public meetings conducted in local languages to explain budget allocations.

6. Revenue Diversification Strategy

Over-dependence on carbon sales makes projects vulnerable to market fluctuations, as demonstrated by Rimba Raya. To ensure financial stability and safeguard community benefits, revenue streams should be diversified; carbon credit sales can account for 60% of income, sustainable aquaculture and non-timber forest products for 15%, community-managed ecotourism for 15%, and biodiversity payments or conservation partnerships for the remaining 10%. This balanced mix not only stabilises finances but also reinforces conservation incentives.

7. Market Positioning and Certification

<u>Premium Certification Strategy</u>

Belait should pursue highest-tier certifications – such as CCB Gold, SD VISta covering all 17 UN SDGs – to recognise its exceptional co-benefits. The project can be positioned as a premium carbon product, appealing to buyers willing to pay premiums for verified high-integrity credits. Simultaneously, pursuing multiple certifications (VCS, Gold Standard, ART-TREES) will mitigate risks associated with single-point-of-failure.

8. Baseline Integrity

   Belait should employ conservative, scientifically robust baseline scenarios to ensure long-term credibility. Adopting ultra-conservative baseline methodologies that underestimate rather than overestimate potential deforestation may reduce short-term credit generation but strengthens market trust. This approach positions the project for sustained acceptance and helps avoid the pitfalls experienced by Rimba Raya.

9. Risk Management and Infrastructure

   Adaptive Infrastructure Design

   Infrastructure should be designed to support both conservation objectives and community needs. Modifications can accommodate limited navigation or traditional uses where appropriate, minimising community resistance while maintaining ecological integrity. Maintenance programmes should provide local employment opportunities, creating economic incentives for long-term infrastructure preservation.

10. Fire Prevention and Management

    Implement a comprehensive fire prevention strategy that includes community fire brigades, early warning systems using GIS and remote sensing, and water management infrastructure. Maintaining higher water tables in peat areas will reduce fire risk, building on lessons from Sebangau's rewetting efforts while leveraging Belait's naturally lower susceptibility to fire.

11. Regional Collaboration and Integration

    ASEAN Partnership Integration

    Join the ASEAN Peatland Management Strategy to align Belait with regional conservation goals. Draw on successful cross-border models, such as the Kalimantan-Sarawak fire management partnerships, to enhance both project credibility and operational effectiveness.

12. Strategic Implementation Framework

    Phased Development Approach

    Learn from Rimba Raya's rapid scaling challenges by adopting a phased development that enables adaptive management and continuous improvement. Begin with pilot areas of 5,000-7,500 hectares to test methodologies before implementing them across the full 25,000-hectare area.

13. Long-term Governance Structure

    Establish governance structures that endure beyond individual project phases and political shifts. Develop endowment funds and institutional frameworks to ensure project continuity beyond initial carbon credit periods, leveraging Brunei's stable political environment as a competitive advantage for long-term permanence.

14. Financial and Economic Implementation

    Conservative Financial Projections

    Based on current market conditions and Belait's premium positioning, project conservative carbon credit prices of $15-25 per tonne, with potential for premiums up to $50 per tonne for the highest-quality credits. Plan for 30-year revenue streams with built-in price escalation mechanisms.

    Diversified Revenue Model

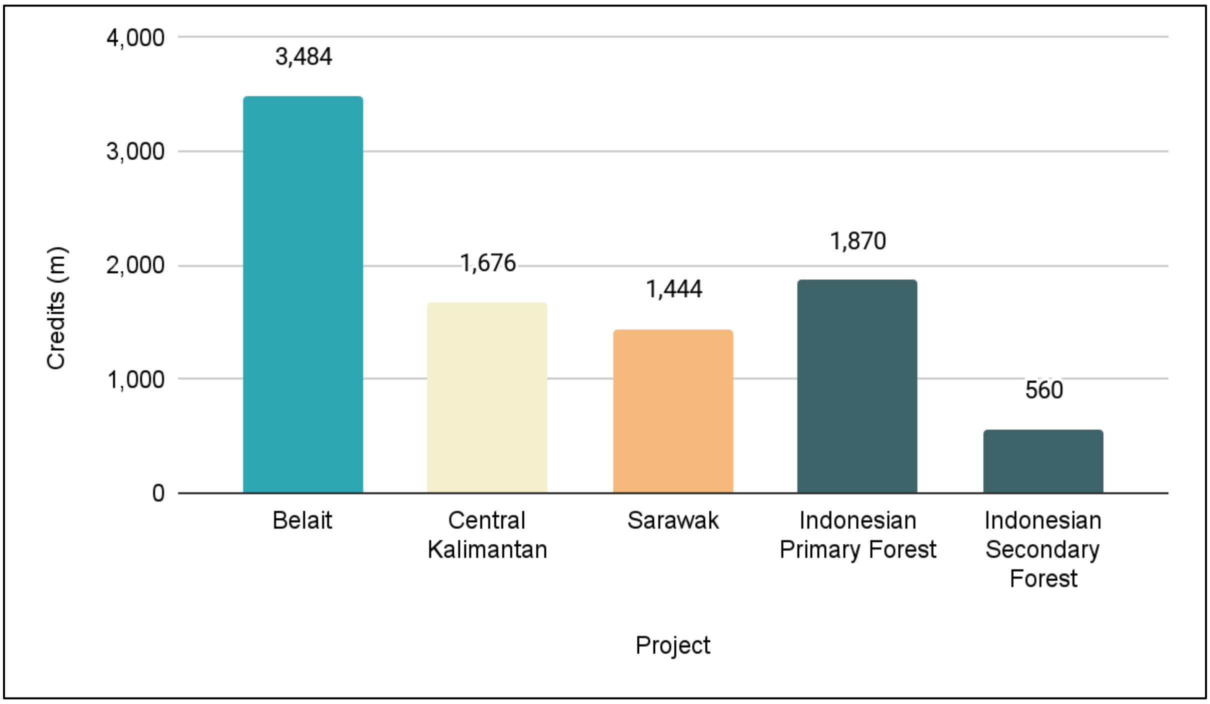
    Structure the project to generate revenue from multiple sources beyond carbon credits, reducing reliance on volatile markets while maintaining conservation incentives and safeguarding communities from market fluctuations.

By learning from Rimba Raya's successes in community engagement and monitoring while avoiding its regulatory pitfalls, Belait is positioned to become Southeast Asia's premier forest carbon initiative, setting new standards for peat swamp forest conservation and carbon market integrity. Implementing these lessons and strategic recommendations will allow the Belait Peat Swamp Forest carbon project to avoid the failures that undermined projects like Rimba Raya, while leveraging Brunei's unique advantages to establish a world-class model for tropical peatland conservation and carbon finance.

4.9. Carbon Project Pricing Estimation

Brunei's Belait Peat Swamp Forest offers exceptional potential for carbon credit generation, benefiting from its high carbon density and pristine condition. Based on comprehensive analysis from the National Forest Resources Inventory (NFRI) 2023-25 and comparative regional data, Belait demonstrates remarkable carbon storage capacity of 3,264 tonnes per hectare belowground and 220 tonnes per hectare aboveground, positioning it for premium carbon credit pricing in international markets.

Figure 4.26. Carbon Density Comparison



Source: ERIA study team, 2025.

Belait Peat Swamp Forest: Carbon Storage and Market Potential

The Belait Peat Swamp Forest exhibits exceptional carbon storage capacity, with total ecosystem carbon stocks of 2,665.83 tonnes of CO_2 equivalent per hectare, far exceeding regional averages. Its belowground peat soil stores 1,545.50 tonnes per hectare, ranking amongst the deepest and most carbon-rich peat deposits globally, while aboveground biomass ranges from 470 to 560 tonnes per hectare – well above the regional average of 350 tonnes per hectare for tropical rainforests in insular Asia. Comparative analysis with other Southeast Asian peat swamp forests highlights Belait's superior performance. Total carbon stocks in Central Kalimantan peat swamp forests are 1,676 tonnes per hectare, while Sarawak forests contain 1,444 tonnes per hectare. Indonesian primary peat swamp forests average 1,870 tonnes per hectare, whereas secondary forests hold only 560 tonnes per hectare. This positions Belait with a carbon density 1.86 times higher than Central Kalimantan and 2.41 times higher than Sarawak forests.

The Belait peat soil contains average carbon stocks ranging from 21,425 to 35,308 cubic metres per hectare, with peat depths reaching up to 20 metres. Such exceptional depth reflects stable, long-term carbon accumulation over millennia, offering superior permanence and lower reversal risks compared to shallower peat deposits in degraded forests. The waterlogged conditions slow decomposition, ensuring long-term carbon storage and making Belait highly suitable for avoided deforestation carbon credits.

Market Positioning and Pricing Projections

Belait's carbon pricing potential is strongly supported by its exceptional carbon density relative to established regional projects. The Rimba Raya REDD+ project provides a direct pricing benchmark, having generated $248.5 million in total revenue from 33.6 million VCUs, with an average price of $7.39 per tonne of CO_2 and peak prices reaching $12 per tonne under optimal market conditions.The voluntary carbon market has experienced significant price volatility, declining from approximately $9.10 per tonne in 2015 to $3.80 per tonne in 2023, before stabilising around $6–$8 per tonne. Belait's pristine condition and regulatory stability position it to capture premium pricing above these market averages, with conservative projections starting at $8 per tonne – an 8% premium over Rimba Raya's average.

The revenue projections for Belait Peat Swamp Forest, a which is a virgin forest, may surpass those of restoration-based projects, As a rough estimation with assumptions under three scenarios, a revenue stream ranging from $2,376 to $ 6,930 could be estimated under conservative, moderate, and premium carbon pricing scenarios.

Superior Performance Compared to Regional Projects

Belait's annual CO_2 impact potential far surpasses that of restoration-based approaches, highlighting the advantages of conserving pristine forest over restoring degraded ecosystems. Its projected annual emission reduction of 10-15 tonnes CO_2 per hectare through avoided deforestation is 6-9 times higher than Sebangau's achieved 1.61 tonnes per hectare through restoration activities. This performance differential translates directly into superior revenue potential and stronger project economics.

Revenue Allocation and Community Benefits

- Revenue Distribution

The projected revenue allocation underscores Belait's commitment to sustainable development and community engagement, surpassing industry standards for community benefit sharing.

Close to 35% of revenue is dedicated to community development programmes, well above the typical industry range of 25-30%. Conservation management receives 25% to ensure long-term protection, while monitoring and verification systems receive 20% to maintain scientific credibility. Government administration accounts for 15%, with 5% reserved for contingency planning.

Conservation management receives 25% to ensure long-term forest protection, while monitoring and verification systems are allocated 20% to maintain scientific credibility. Government administration accounts for 15%, with the remaining 5% reserved for contingency planning. This allocation structure strengthens transparency and long-term project durability.

- Community Impact Projection

With projected revenues of $216-630 million over 30 years, community benefits could total $76-221 million, supporting sustainable livelihoods, education, healthcare, and infrastructure development across affected communities. This translates to approximately $836-2,431 per hectare in direct community benefits, significantly exceeding comparable regional projects including Rimba Raya's $5,261 per hectare total revenue.

- Competitive Advantages Supporting Premium Pricing
  a.) Regulatory Stability and Risk Mitigation

  Belait's pristine condition eliminates the restoration costs and regulatory risks that undermined Rimba Raya's operations. While Rimba Raya faced license revocation in 2024 due to regulatory violations and land tenure disputes, Belait benefits from Brunei's stable governance framework and clear government support under the National Climate Change Policy. The forest's exceptional biodiversity, with Shannon-Wiener diversity indices ranging from 1.70 to 2.99 – the highest recorded in Borneo – surpasses Rimba Raya's biodiversity metrics and positions Belait for triple certification under VCS, CCBA Gold Standard, and UN SDG frameworks. This comprehensive certification approach typically commands 20–30% price premiums over single-standard projects.

  b.) Technology and Monitoring Advantages

  Belait's advanced monitoring capabilities – combining hybrid GEDI satellite data, airborne LiDAR at 20-meter resolution, and machine learning corrections – deliver a 75.9% improvement in biomass estimates compared to satellite-only approaches. This technological sophistication surpasses both Rimba Raya's monitoring systems and Sebangau's community-based methods, ensuring highly accurate carbon accounting that supports premium pricing credibility.

  Additionally, site-specific allometric equations reduce estimation errors by 20-50% compared to the pan-tropical models used by other projects, providing measured rather than estimated carbon density values and eliminating the baseline inflation issues that contributed to Rimba Raya's operational challenges.

- Economic Impact and National Benefits
  a.) GDP Contribution and Economic Multipliers

  Carbon credit revenues of $216-630 million represent a significant economic impact for Brunei, generating multiplier effects through community spending, employment creation, and infrastructure development. The project supports Brunei's economic diversification goals while reinforcing its leadership in climate action within the ASEAN region.

b.) Technology Transfer and Capacity Building

Belait's development as a world-class carbon project positions Brunei as a regional leader in peatland conservation technology and methodology. Its advanced monitoring systems and community engagement models provide replicable templates for Southeast Asia, creating additional revenue opportunities through technical consulting and capacity building services.

Belait Peat Swamp Forest demonstrates exceptional potential for premium carbon credit generation. Its superior carbon density, pristine condition, and strong government support position it for market leadership above proven benchmarks such as Rimba Raya. Evidence-based pricing projections of $8-15 per tonne CO_2, supported by Belait's measured carbon density of 3,264 tonnes per hectare and regulatory advantages, indicate a conservative revenue potential of $216-630 million over 30 years.

The comprehensive analysis confirms that Belait can achieve premium pricing 8-103% above Rimba Raya's average while delivering exceptional community benefits of $76-221 million over the project lifetime. This positions Brunei as a regional leader in forest carbon markets while contributing significantly to global climate mitigation efforts through scientifically robust, government-backed forest conservation.

Strategic implementation should prioritise triple certification, advanced monitoring systems, and enhanced community engagement to maximise both environmental impact and financial returns. The project's success will demonstrate that conserving pristine forests delivers superior outcomes compared to restoration approaches, setting new standards for tropical peat conservation while generating substantial revenue for sustainable development.

Conclusions

This chapter evaluated whether Brunei's Belait Peat Swamp Forest qualifies for top forest carbon standards and compared it to successful regional projects. Belait stands out for its intact peat, high carbon storage, and rich biodiversity, all supported by strong governance and robust monitoring systems.

Certain certifications may not apply. REDD+, VCS with updated methods, and ART TREES align well with Belait's peatlands and Brunei's regulatory framework, whereas older standards like CDM and Gold Standard pose barriers because peatlands are excluded. Strategic selection of certification is therefore essential.

Regional best practices indicate that legal clarity, reliable monitoring, transparency, and community engagement are critical for success. Belait demonstrates the value of integrating conservation with economic planning. By maintaining high standards, fostering trust with communities, and diversifying revenue streams, Brunei can position itself as a leader in the carbon market while advancing its climate objectives.

Challenges remain, including accurate carbon measurement, consistent long-term monitoring, and fair revenue sharing with local communities. These challenges reflect evolving rules and the time required to build strong local capacity.

Future research should address these gaps by improving measurement tools, expanding both local and remote monitoring, clarifying financial flows, and strengthening legal frameworks. With sustained commitment and adaptive strategies, Brunei can demonstrate that robust conservation delivers both economic and social benefits.

Chapter 5

Ensuring Environmental Integrity of Forest Carbon Markets in Brunei – Principles of Additionality, Permanence, Leakage, and Baselines

The environmental credibility of forest carbon markets depends on strict adherence to principles that ensure real, measurable, and durable climate benefits. Without robust risk-management frameworks and safeguards, carbon credits risk undermining climate objectives, eroding market confidence, and weakening public trust. This chapter examines the core integrity principles that must underpin forest carbon market development in Brunei Darussalam.

Focusing on additionality, permanence, leakage prevention, and credible baselines, the chapter explains how these principles are defined under international standards and why they are particularly critical in peatland-based carbon projects. Peat swamp forests present unique integrity risks due to their sensitivity to disturbance, complex long-term carbon storage dynamics, and vulnerability to fire, drainage, and land-use change.

The chapter assesses how Brunei's policy environment, forest governance framework, and data systems interact with these integrity requirements. It highlights institutional and regulatory gaps that could affect credit quality, including land tenure clarity, long-term protection mechanisms, and enforcement capacity. At the same time, it identifies opportunities to strengthen integrity through conservative baselines, buffer mechanisms, and alignment with national climate commitments. By situating environmental and social integrity principles within Brunei's national context, this chapter provides policy-relevant guidance on how to design forest carbon projects that meet international expectations while safeguarding ecological outcomes and public credibility.

For policymakers in Brunei, this means ensuring each carbon credit truly represents a real, additional, and lasting reduction in greenhouse gas emissions. This chapter examines four core integrity principles – Additionality, Permanence, Leakage, and Baselines – through an analytical, policy-oriented lens. Rather than providing mere descriptions, we evaluate how Brunei can operationalise each principle in policy design and project implementation.

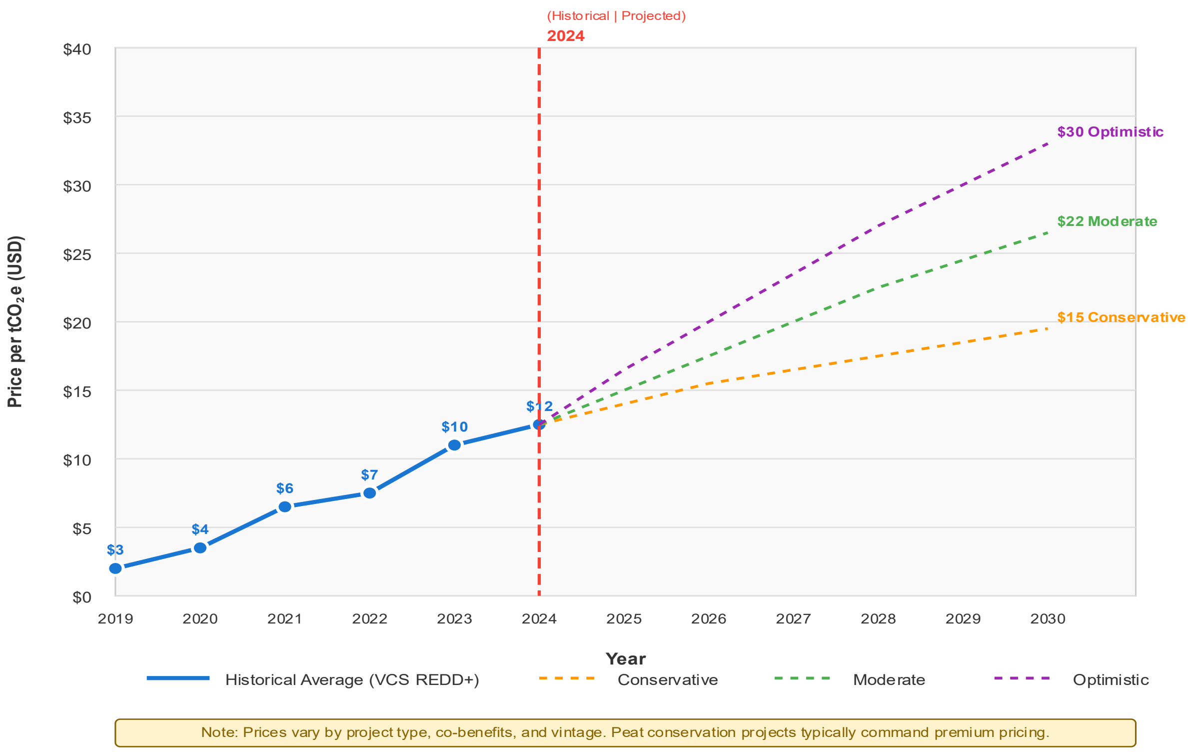
This chapter examines four critical methodological challenges confronting Brunei's carbon offset programme development. The chapter focuses on the fundamental issue of additionality verification within the context of Brunei's historically minimal deforestation rates, necessitating the establishment of credible counterfactual scenarios. It evaluates mechanisms for converting Brunei's robust forest protection frameworks into verifiable permanence assurances for carbon sequestration. Additionally, the chapter addresses leakage mitigation strategies and monitoring protocols to prevent emission displacement beyond designated project boundaries. Finally, the chapter considers baseline establishment methodologies for quantifying emission reduction achievements. These findings will inform the Brunei Forestry Department's regulatory framework development and project assessment criteria to ensure adherence to stringent integrity benchmarks in carbon offset certification.

Each section below defines one principle and analyses Brunei's context, using examples and metrics to highlight challenges and solutions. Policy recommendations are provided for each principle, supported by comparative insights from regional projects in Indonesia and Malaysia. Analytical tables and figures substantiate key points, giving policymakers evidence-based options. By the end of this chapter, government stakeholders should grasp concrete steps to integrate these integrity principles into Brunei's forest carbon policy and project development process.

5.1. Additionality: Ensuring Real Emission Reductions

Figure 5.1 Voluntary Carbon Market Price Trends, 2019–2030 shows global voluntary carbon market price trends, both historical values and projections from 2019 to 2030. Traded carbon prices vary based on the volume of credits that could be generated by a forest project as well as the number of buyers.

Figure 5.1. Voluntary Carbon Market Price Trends, 2019–2030



Source: ERIA study team, 2025.

Additionality simply means that a project should make a real, extra impact on climate mitigation--- not just claim credit for something that would have happened anyway. For example, if a forest was never under threat, then setting up a carbon project to protect it doesn't really add anything new. For Brunei, the challenge is to show that its forest carbon project truly brings extra benefits – cutting or removing emissions that wouldn't have been reduced otherwise. This is a tough task for countries like Brunei, where forests are already well protected – forest reserves cover about 235,519 ha (≈41% of total land area), with a further 86,675 ha proposed for gazettement (bringing forest reserves to ≈55.9%) – and where recent satellite-based monitoring indicates very low annual natural forest loss (e.g. 646 ha in 2024).

The Convention on Biological Diversity (CBD), Fourth National Report: Brunei Darussalam – reports that forest reserves cover 235,519 ha (41% of total land area) and that an additional 86,675 ha (15%) was proposed for further gazettement, bringing forest reserves to 322,195 ha (55.884% of total land area). Global Forest Watch (GFW), Brunei Deforestation Rates & Statistics dashboard – reports that in 2024 Brunei lost 646 ha of natural forest, based on satellite monitoring.

Brunei's HFLD paradox. Brunei Darussalam is a classic High Forest Cover, Low Deforestation (HFLD) context. The country has maintained near-zero deforestation for decades, with ~488,000 ha of natural forest remaining in 2020 (≈84% of land area) and very low annual natural forest loss (e.g. 646 ha in 2024). It also maintains a strong domestic conservation framework – forest reserves cover 235,519 ha (≈41% of total land area), with proposals for additional gazettement bringing protected forests to ≈55.9% of national territory.

This exemplary record poses a credibility challenge for forest carbon crediting: additionality can be questioned if the counterfactual is assumed to be 'continued near-zero loss anyway.' Critics may argue that Brunei's forests would remain intact with or without carbon finance. Policymakers must therefore be both conservative and creative in justifying additionality, by identifying credible future threats and avoidable emissions sources that project interventions can measurably address. To safeguard environmental integrity, Brunei should adopt conservative, transparent baselines and justify crediting through clearly evidenced risks – such as peat fire during extreme droughts, peat degradation under drainage pressures, localised encroachment, infrastructure-driven fragmentation – as well as measurable removals from restoration where appropriate (ART, 2024).

Case study box 1 – Belait peat swamp forest: 'Avoided degradation / avoided fire' as additionality

Brunei's Belait peat swamp forests are exceptionally carbon-dense and can become a major emissions source if drainage, fragmentation, or drought-driven peat fires occur. The draft already notes Belait-specific risks and the rationale for rewetting, firebreaks, and community patrols as targeted interventions. In an HFLD context, this is one of the most defensible additionality pathways because it focuses on non-zero, plausible emissions that a project can measurably reduce, even if national deforestation is low. What to measure/credit (conservatively): (i) avoided peat fire emissions (ex-ante risk modelling + monitored fire occurrence), (ii) avoided peat oxidation from drainage (water-table monitoring), (iii) avoided degradation/edge effects (remote sensing + field plots), plus a conservative buffer for uncertainty.

Case study box 2 – Ulu Temburong National Park: financing 'durability' and avoided degradation

Ulu Temburong National Park (managed by Brunei's Forestry Department) is a flagship protected area and an example where classic 'avoided deforestation' crediting may be weak, but avoided degradation and permanence/durability measures can be more credible (e.g. strengthened patrol capacity, biodiversity/carbon monitoring, visitor management, fire preparedness, and buffer-zone management) (Forestry Department, Ministry of Primary Resources and Tourism, Brunei Darussalam, n.d.). Additionality angle: carbon finance is used to fund incremental protection and monitoring activities beyond baseline budgets – reducing the probability and impact of future degradation/reversals and improving measurable ecosystem outcomes.

Case study box 3 – Forest reserve gazettement & Heart of Borneo: preventing 'tomorrow's emissions'

Brunei's legally protected forest reserve system (~41% of national land area) and proposed further gazettement can be framed as an additionality pathway when carbon finance is linked to costed legal/administrative completion, boundary demarcation, enforcement capacity, and long-term management – i.e. preventing future pressures from translating into emissions (Forestry Department, Government of Brunei Darussalam, n.d.). This also aligns with regional conservation cooperation under the Heart of Borneo Declaration (2007), which provides a credible policy narrative for maintaining intact forests while managing cross-border pressures and ecological connectivity (World Wildlife Fund, n.d.)

Proving real impact. Building on the HFLD additionality challenge outlined above, the following policy approaches are recommended to demonstrate additionality in Brunei's forest carbon projects:

Target specific threats. Even if national deforestation is near zero, #current localised risks# exist. Brunei's peat swamp forests (such as the 25,000 ha Belait peat forest) could emit significant CO_2 if they catch fire during extreme dry spells. Under current conditions, resources to address peat fire risk are limited, making these emissions a plausible 'would-happen' scenario.

A carbon project can introduce targeted interventions such as peatland rewetting (e.g. blocking canals/ditches or constructing small dams to raise the water table), fire-prevention and rapid-response measures (e.g. firebreak/control lines where appropriate, hotspot monitoring, and trained community patrols), and community-based fire management to reduce ignitions and enable early suppression. Rewetting is particularly relevant because drainage dries peat, increasing fire risk, and peat fires can generate large, episodic ('intermittent') greenhouse-gas emissions, especially during drought/El Niño conditions. Global guidance highlights that drained/degraded peatlands create significant GHG emissions and that drier conditions after drainage increase fire risk, while also noting the major climate and health burden of peat fires. ramsar.org Rewetting is also recognised in IPCC guidance as generally reducing CO_2 emissions from organic soils compared to the drained condition, and it is operationalised in carbon-crediting practice through methodologies that quantify emission reductions from raising peat water tables (including a methodology explicitly applicable to Brunei). ipcc-nggip.iges.or.jp+1 Evidence from Southeast Asian peatland fire contexts further documents practical measures such as canal blocks (rewetting structures) and fire patrols as part of prevention/preparedness packages that reduce fire occurrence risk.

Policymakers should require project developers to document site-specific threats and drivers (e.g. drainage networks, ignition sources, drought sensitivity, accessibility/encroachment pressure, and any observed illegal clearing risks) and to specify the concrete measures used to counter them, including how these measures are monitored and enforced. This aligns with UNFCCC REDD+ guidance: during the development and implementation of national strategies/action plans, countries are expected to address drivers of deforestation and forest degradation (amongst other governance and safeguards issues), and COP decisions under the Warsaw Framework explicitly emphasise action on drivers. For HFLD settings, where additionality is often scrutinised, credible claims typically depend on demonstrating that the credited intervention changes outcomes relative to a plausible 'without-project' scenario (i.e. 'would the mitigation happen in the absence of the project activity?'). Standards and platforms addressing HFLD crediting similarly stress that HFLD jurisdictions must have an implementation strategy that sets out the actions they are taking to mitigate drivers of deforestation and degradation.

Include enhancement (carbon removals). If avoiding deforestation yields few credits (because baseline deforestation is minimal), Brunei can add reforestation or forest enrichment components to actively remove CO_2 from the atmosphere. Planting trees on degraded lands or enriching secondary forests creates carbon sinks that are clearly additional to business-as-usual, since such tree planting would not occur otherwise.

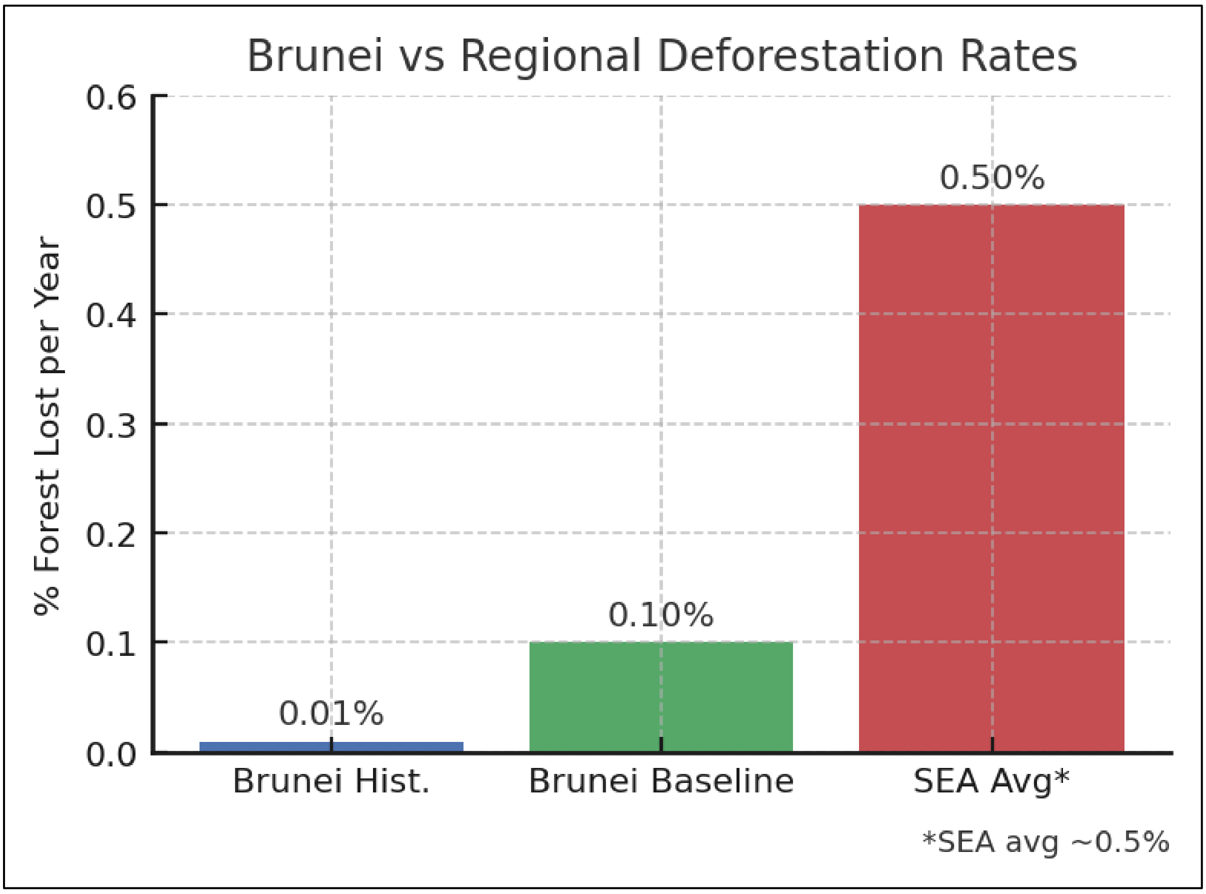
Brunei has some degraded patches – former logging sites, mining sites, Imperata grasslands – that are not fully stocked with forest. By incentivising tree planting in these areas (beyond existing government tree-planting programmes), policy can ensure extra carbon sequestration that counts as additional. These carbon removal credits would supplement modest avoided deforestation credits, strengthening the overall additionality claim.

Policy action: Establish guidelines for integrating restoration activities into carbon projects and ensure they are additional to any pre-existing reforestation commitments. For instance, if the national 500,000 Tree Planting initiative targets certain sites, carbon projects should target different sites or exceed those efforts.

Leverage HFLD methodologies. International carbon standards have begun to recognise the dilemma of HFLD countries like Brunei. Programmes such as the ART-TREES (Architecture for REDD+ Transactions) offer HFLD crediting methods that reward countries for maintaining low deforestation. These methods often use a blended reference level (combining the country's historical deforestation with a regional or global benchmark) to set a baseline above zero.

Figure 5.2 illustrates this concept: Brunei's historical deforestation rate (~0.01% of forest area per year) is orders of magnitude lower than regional averages, so a strictly historical baseline would yield practically zero credits. An HFLD-adjusted baseline might allow a small creditable deforestation rate (e.g. 0.1%), acknowledging the hypothetical risk that Brunei could have followed regional deforestation trends without active intervention. This gives Brunei 'headroom' to earn credits for avoided deforestation, rewarding its conservation performance.

Figure 5.2. Deforestation Rates in Brunei Darussalam Compared with ASEAN



Source: FAO, 2011.

Brunei's historical deforestation rate (~0.01% per year) is negligible compared to a regional average (~0.5% per year). An HFLD-adjusted baseline (e.g. 0.1%) would allow Brunei to claim credits for preventing a small amount of deforestation that might have occurred in a business-as-usual scenario. Keeping the baseline conservative (far below regional rates) helps ensure additionality while still generating creditable emissions reduction.

Policymakers should consider aligning Brunei's project with such recognised HFLD frameworks. By using an internationally approved baseline approach, Brunei gains credibility and avoids the perception of 'gaming' the baseline. Countries like Guyana and Gabon have successfully used HFLD adjustments: Guyana negotiated an HFLD baseline and sold 33.5 million credits in a landmark deal, while Gabon secured payments by adopting a modest deforestation reference level. These precedents show that HFLD countries can monetise conservation without sacrificing integrity.

Project future risks (Preventive additionality). Brunei can justify additionality by highlighting future pressures that a project will pre-empt. While deforestation is almost nil today, new threats could emerge such as proposed infrastructure (e.g. roads, townships), economic shifts increasing interest in agriculture or mining, or climate-driven increases in drought frequency and peat fire risk.

A forward-looking policy should encourage project developers to use scenario analysis and modelling to identify plausible future emissions. For instance, if urban expansion or a new plantation might clear forest in 5–10 years, the project could intervene now by working with the government to conserve those areas or redirect development. By acting proactively, Brunei can claim credit for ensuring those projected emissions never occur.

This approach, sometimes called predicted or ex-ante additionality, must be backed by solid evidence (citing regional trends or specific development plans). The policy implication is that Brunei's carbon project proposals should include a risk assessment of future deforestation drivers and document how project actions will mitigate those drivers. If done transparently and conservatively, the narrative 'we are avoiding tomorrow's emissions by acting today' can be convincing to auditors and buyers, especially when reinforced with data from similar contexts.

Learn from peer HFLD projects. The Ministry should compile lessons from other low-deforestation countries that overcame the additionality hurdle. Guyana and Suriname (both HFLD nations) have articulated their additionality case through initiatives like the 2019 Krutu Declaration and results-based agreements. Guyana provides a useful example. It initially secured an agreement with Norway and later sold credits through ART-TREES. By applying rigorous methodologies and presenting a compelling narrative, Guyana demonstrated that even in low-deforestation settings, buyers can be convinced to pay a premium – approximately US$15 per credit.

Such cases show the power of a clear, evidence-backed narrative: 'Our forests stand today because of past care, but without global support, rising pressures could drive future emissions. Your investment helps prevent that.' Brunei can apply the same approach – grounding its case in transparency and conservative estimates to make its additionality claim credible and widely accepted.

Policy makers should encourage pilot projects to undergo third-party review or preliminary validation by an accredited verifier to test the additionality argument before full implementation. Early feedback from experts can help refine the project justification, ensuring that by the time credits are issued, additionality is well-documented and defensible.

Blueprint for action: Additionality. Brunei can surmount the additionality challenge by tightening project criteria and national guidelines around this principle. The Forestry Department should require that any carbon project proposal:

a) Identifies specific 'would-be' emission sources (however small) that it will address
b) Incorporates enhancement components (tree planting/restoration) to generate new carbon sinks

c) Uses a conservative baseline or an HFLD-recognised methodology to quantify avoided emissions
d) Provides data-driven scenarios of future risks the project aims to avert
e) Benchmarks its approach against other HFLD projects' best practices

A checklist approach can be adopted to review and benchmark with questions such as: (i) is the project truly beyond business-as-usual? (ii) what evidence supports this? The policy should favour projects that take a multi-pronged approach to additionality and may include a default 'additionality buffer' – issuing only a fraction of calculated credits initially – to account for uncertainty in a low-deforestation context. By erring on the side of caution and requiring robust justification, Brunei's regulators will build trust that any credits issued reflect real, additional emission reductions.

5.2. Permanence: Guaranteeing Long-Term Carbon Storage

What is permanence? Permanence refers to the longevity of carbon storage achieved by the project – once emissions are avoided or sequestered, they should remain out of the atmosphere for the long term. In forest carbon, this means ensuring that protected forests are not later cut down and that sequestered carbon (in trees or soil) is not released in the future. Buyers of carbon credits want confidence that a ton of CO_2 'saved' today isn't simply emitted back a few years later due to fire, logging, or project collapse. Most standards require guarantees of 30, 50, or even 100 years of permanence, often backed by buffers or insurance mechanisms.

Brunei's natural advantages. Brunei's forest permanence is supported by a strong legal protection framework. Brunei reports that its gazetted national forest reserves cover about 41% of the country's total land area and are protected by law. The core legal instrument is the Forest Act (Chapter 46), which empowers the Government to constitute 'reserved forests' (forest reserves) and regulates activities within them. For example, the Act includes provisions that restrict land conversion and use in areas proposed/proclaimed as reserved forests and prohibits the taking of forest produce from a reserved forest unless licensed/authorised, backed by offences and penalties.

In addition, Brunei's national reporting notes that the Forest Act classifies forests into functional categories – including protection, conservation and national parks alongside production forests – supporting the point that commercial harvesting is not generally applicable across all forest categories. Brunei is exceptionally well-positioned on permanence with proper safeguards in place. Unlike countries where a conservation project is an 'island' in a sea of deforestation, Brunei's baseline condition is already one of preservation.

Once Brunei's carbon is stored in its forests, robust governance makes it unlikely to be deliberately lost. However, non-anthropogenic risks remain – notably, wildfire in peat swamp forests and potential climate-related impacts (drought, storms). Brunei's peat areas face periodic drought stress, and regional haze events have shown peat fires can happen in Borneo. Therefore, even if human-driven deforestation is negligible, projects must guard against natural disturbances and ensure carbon storage is resilient.

Locking in long-term protection. The following measures should be integrated into Brunei's forest carbon policy to maximise permanence:

Long-term commitments. Brunei's policy should extend the time horizon of carbon projects and institutional commitments. This might involve requiring project proponents to sign on to a 30+ year monitoring and protection plan. Given Brunei's stable governance, the government can bolster permanence by pledging that project areas will remain protected post-crediting period through legal designation or project extensions.

The Forestry Department could include in any project approval a clause that forest areas involved in carbon projects cannot be converted or downgraded in protection status for decades. This ensures that even after credits are generated and sold, the carbon remains stored. Brunei can also harness its existing protected area network (like the Heart of Borneo reserves) to overlap with project sites, thereby 'locking in' legal protection that outlives the project duration.

A useful international precedent for long-term permanence commitments is California's compliance forest offset programme. There, the 'project life' extends to 100 years following any credit issuance, during which project operators must continue to monitor, verify and report carbon stocks. California also manages reversal risk through a forest buffer account funded by withholding a portion of issued credits, and it distinguishes between unintentional reversals (compensated via the buffer) and intentional reversals (requiring replacement of credits/compliance instruments). Importantly, obligations can continue through ownership changes, strengthening enforceability over decades. Brunei could adopt a scaled version of this approach – e.g. mandating 30+ years of monitoring and protection commitments, linking any downgrading or conversion of credited forest areas to cancellation/replacement obligations, and further 'locking in' permanence by aligning project areas with long-standing legal protection and the Heart of Borneo protected-area network.

Safety nets for carbon storage. In carbon market practice, it is standard to set aside a portion of credits into a buffer pool as insurance against future reversals. Brunei's low risk profile means buffer requirements can be relatively modest. Where a typical project in a higher-risk country might put 15--20% of credits into a non-tradable buffer, Brunei's project might negotiate a ~10% buffer.

These buffer credits (deposited in a national or standard-wide pool) would be available to offset any future carbon loss. For example, if a fire destroys part of the project forest in 2030, an equivalent amount of credits from the buffer would be invalidated, ensuring that buyers do not end up with a 'phantom' credit. The policy could also explore sovereign guarantees: Brunei's government might commit to compensating for any reversal not covered by the project by cancelling an equivalent number of credits from another national pool or from future issuances.

Risk mitigation on the ground. Prevention is key to permanence. Brunei's project design should include robust measures to prevent the main risks to carbon storage. For wildfires in peatlands, this means funding fire prevention and rapid response capacity – maintaining water tables (through rewetting peat), training fire brigades in local communities, and installing monitoring (watchtowers or satellite alerts).

Given that Brunei's forests are largely healthy, the emphasis is on maintaining vigilance: continual patrolling, community engagement (so locals report issues like illegal activities or fire promptly), and annual risk reviews to identify new threats (like invasive species or illegal incursions). Policymakers should require that project proponents submit a 'Permanence Plan' covering these aspects: identification of risks and the actions in place to mitigate them over time, including post-project arrangements.

Monitoring and adaptive management. Ensuring permanence requires continuous MRV (Measurement, Reporting, Verification) focused not just on carbon stocks but on risk indicators. Brunei's policy could institute an annual check-in or reporting obligation for carbon projects: even if credit issuance occurs only every 5 years, there could be yearly reporting on forest cover status, fire incidents, and implementation of risk mitigation measures.

The government can assist by integrating project areas into national forest monitoring systems (satellite-based alerts, etc.) so that any disturbance is caught quickly. Since Brunei's land area is small, nationwide forest monitoring is feasible and should be leveraged – the Forestry Department can virtually keep an eye on all project and non-project forests as an extra layer of assurance.

Exit strategy & legacy. What happens after the crediting period? Brunei should plan for an orderly 'phase-out' or transition for each project so that carbon storage is maintained indefinitely. For example, if a 10-year pilot protects a forest and issues credits, by year 8--9 the government should evaluate integrating that area into a long-term conservation programme or securing alternate funding to continue protection.

The policy framework could encourage or require a portion of project revenue to be set aside in a trust fund that supports post-project conservation of the area. Alternatively, Brunei may consider institutionalising successful pilot sites by incorporating them into the national protected area system or by aligning them within a jurisdictional REDD+ framework upon project completion.

Blueprint for action: Permanence. Brunei's carbon credit policy should embed permanence by design. Recommended provisions include:

a) Mandatory credit buffers (10--15% of credits withheld for 100-year permanence insurance)

b) Long-term legal protection requirements for project sites (no land use reclassification for 30+ years)
c) Comprehensive risk management plans from project developers, covering fire, natural disasters, and socio-economic risks
d) Government oversight and support in risk mitigation (integrating project areas into national fire monitoring systems, providing emergency response resources)
e) Post-project sustainability plans to ensure continuity

By making these expectations clear upfront, Brunei will signal to the market that its credits are backed by exceptional durability. This could justify a 'premium' tag for Brunei's credits, attracting buyers who value long-term certainty. As an HFLD country with highly stable forests, Brunei can market an advantage in permanence: a ton of CO_2 kept out of the air by Brunei is extraordinarily unlikely to find its way back – a claim few others can make so confidently.

5.3. Leakage Prevention: Avoiding Displaced Emissions

What is leakage? Leakage occurs when emissions are unintentionally shifted outside a project's boundaries. Protecting one forest area can be undermined if deforestation or carbon-emitting activities simply move elsewhere, reducing or nullifying the climate benefit. For example, loggers or farmers barred from a project site may relocate to a nearby area, offsetting the emissions saved within the project.

Leakage can be local (within-country) or international (if activity crosses borders), and can be market-driven (reducing timber supply in one place raises prices, inducing more logging elsewhere). High-integrity projects assess and mitigate leakage so that a credit truly represents a net global reduction in emissions, not just a local shift.

<u>Natural barriers to displacement.</u> Brunei's leakage risk is expected to be minimal due to unique geographic, economic, and governance factors. Brunei has a small land area (World Bank: ~5,270 km^2) and a very large share of land already reserved or protected as forest – meaning there is relatively little unreserved land where displaced activities could realistically relocate. Brunei's UNFCCC communications note that around 41% of land is gazetted as forest reserve and that national policy commits a much larger share as permanent forest reserves, complemented by extensive coverage under the Heart of Borneo (HoB) initiative.

Domestically, Brunei is small and well-regulated: there is no large population of landless farmers or itinerant loggers who, if blocked in one forest, would move to another. The nation's forests are mostly intact and there is limited pressure on them; thus, protecting one area is unlikely to cause deforestation to emerge elsewhere in Brunei. Unlike countries with extensive frontier lands, Brunei does not have a scenario where deforestation is displaced to a different province; effectively, no internal deforestation frontier remains.

Internationally, could leakage occur to Malaysia or Indonesia? In theory, if Brunei severely restricts any remaining timber or agricultural expansion, demand might shift across the border. Brunei's Forest Act (Cap. 46) prohibits felling or removal of timber and clearing for cultivation within reserved forests except where authorised, and related rules require licences for taking forest produce; unauthorised clearing, cultivation, or timber cutting on State land is also an offence under the Land Code (Cap. 40). In theory, if such restrictions further tighten supply, some demand could shift to neighbouring jurisdictions across Borneo. However, Brunei's contribution to regional timber or palm oil output is negligible, so cross-border market leakage is also negligible in practice.

These conditions mean Brunei's forest carbon projects can confidently claim low leakage. Nonetheless, explicit policy measures are still required to verify and maintain this low leakage profile.

Preventing emissions flight. Ideally, policy-makers should incorporate the following approaches:

Nationwide Monitoring: One of Brunei's advantages is its manageable size – the entire country's forest cover can be monitored with high-resolution satellites on a regular basis. The Forestry Department should commit to track deforestation at the national level throughout the project's duration. This way, if a project successfully halts deforestation in one district, officials can verify that deforestation did not increase in other districts simultaneously.

Annual national forest cover reports can be part of the MRV framework, serving as a leakage check. If these reports show stable or improving forest cover countrywide while the project operates, that provides strong evidence of no domestic leakage. By institutionalising nationwide monitoring, Brunei can empirically demonstrate that 'saving a hectare here didn't cost a hectare there.'

Strengthening integrity with conservative emission reductions. Even when leakage risk is low, good practice is to apply a conservative deduction in credit calculations. In Brunei, for example, a small precautionary discount – such as around 5% of verified emission reductions – could be applied as a safeguard. Many REDD+ standards recommend similar ranges when no significant leakage is detected. This withheld portion would not be issued as credits, ensuring that any unforeseen or undetected leakage does not lead to over-crediting..

In Brunei's context, this approach is largely precautionary, but it strengthens the credibility of the carbon credits. Evidence suggests that leakage would likely be near zero, so this small buffer serves primarily to enhance confidence. When combined with buffer pools for permanence, such conservative accounting ensures that Brunei's credits rest on a solid and trustworthy foundation.

Alternative livelihoods to prevent leakage. The most effective way to prevent leakage is to ensure that stakeholders who might have caused emissions no longer need to do so, even outside the project area. In Brunei, large-scale commercial leakage is unlikely, but isolated cases may still occur – such as a family planning a small forest clearing for agriculture or a timber license holder seeking another site if one is closed.

To address this, the project should implement or fund alternative livelihood programmes for affected communities and stakeholders. For example, where communities are asked to refrain from expanding agricultural activities into forest areas, the project could support them by promoting sustainable intensification of existing farmland or facilitating alternative income sources, such as eco-tourism or agroforestry initiatives. By providing these options, potential sources of emissions are transformed into contributors to the solution, ensuring that pressures are not simply displaced elsewhere.

<u>Importance of regional coordination</u>. On the international front, Brunei can coordinate with neighbouring Sarawak and Sabah (Malaysia), as well as Indonesian Kalimantan, to share information on forest protection efforts. Since these areas form part of Borneo's shared ecosystem, dialogue can help prevent transboundary leakage. For instance, if Brunei tightens forest controls, coordination under initiatives such as the Heart of Borneo, the ASEAN Peatland Management Strategy, and the ASEAN Agreement on Transboundary Haze Pollution can help ensure activities do not simply shift regionally.

For carbon market integrity, Brunei should also ensure that any credits sold internationally – particularly under mechanisms linked to the Paris Agreement's Article 6 – are transparently reported and reconciled with national accounting, to avoid double counting (a form of accounting leakage).

<u>Blueprint for action: Leakage</u>. Brunei's carbon policy should emphasise that leakage must be negligible and managed. Recommended actions:

a) Include a national leakage monitoring requirement, leveraging Brunei's small size to track forest cover nationwide
b) Apply a small leakage discount to credit issuance as a safety margin (5--10% reduction in credited volume)
c) Mandate stakeholder engagement and livelihood measures that address potential displacement of activities
d) Enforce transparent accounting to avoid double-counting (especially if credits might be sold to fulfil another country's NDC under Article 6)

By codifying these measures, Brunei can confidently demonstrate that its forest carbon credits cause no harm elsewhere. This is a significant selling point: while many offset projects globally face criticism over leakage risks, Brunei can present empirical evidence showing effectively zero leakage. A compelling message to buyers is that Brunei's projects protect forests without shifting deforestation pressures to another location.

5.4 Robust Baselines: Credible Reference Scenarios for Emissions

What is a baseline? The baseline (or reference level) represents the counterfactual emissions scenario that would occur without the project. It is the business-as-usual trajectory against which project impact is measured. If baseline emissions are set too high, projects risk over-crediting; if set too low, genuine mitigation may go unrewarded. A robust baseline is realistic, conservative, and transparently derived from data.

For forest projects, baselines typically include expected deforestation rates and associated CO_2 emissions in the absence of intervention. High-integrity projects adopt baselines that stakeholders can reasonably accept as fair representations of what would have happened otherwise.

Challenges in defining the reference point. Baseline setting is especially challenging for Brunei. Historically, deforestation has been near zero. A purely historical projection would therefore imply a baseline of essentially zero hectares deforested per year – yielding little or no crediting potential. This would be unfair to Brunei, as it would receive no recognition for continued stewardship or for addressing emerging risks.

Conversely, it would lack credibility for Brunei to claim a high baseline deforestation rate without strong evidence. The policy challenge is therefore to justify a conservative, non-zero 'middle-ground' baseline: higher than historical rates to reflect plausible future pressures, but well below regional averages to remain conservative (avoiding exaggeration). Such a baseline should also account for non-area-based emissions sources, particularly peat soil carbon losses.

Guyana (HFLD) – creating a conservative 'middle-ground' reference level

Guyana – like Brunei – has been treated as High Forest, Low Deforestation (HFLD) and faced the same baseline dilemma: a purely historical projection can yield very low crediting potential, even when future pressures are plausible. ART's TREES standard includes an HFLD crediting approach intended to allow limited, conservative crediting in such contexts. How the baseline / crediting level has been constructed:

Start from a historical emissions baseline (a defined historical period). Apply a capped HFLD 'adjustment' linked to (i) an HFLD score and (ii) forest carbon stocks – designed to be well below regional averages and therefore conservative. The approach is often described in public Guyana materials using an adjustment term related to 0.1% of forest carbon stock (in some contexts described as aligned with World Bank/FCPF approaches), and is included in Guyana's own REDD+/reference level documentation. The resulting crediting level was then subject to validation/verification under TREES. What this demonstrates (baseline integrity lesson)

Guyana's example shows a workable 'middle-ground baseline' logic for HFLD settings: not zero (acknowledging plausible future pressures) but strictly constrained/capped (to reduce over-crediting risk) and documented in a way stakeholders can scrutinise through public technical annexes and validation.

Crafting Credible Benchmarks

Blend historical data with future factors. Start with the data: Brunei should use a credible reference period (2000--2020) to calculate its historical deforestation rate. Suppose that comes out to ~0.01% of forest area per year (virtually zero). That's the anchor. Next, justify an upward adjustment by factoring in anticipated changes. A review of the regional trends – particularly in the neighbouring countries which have had deforestation rates between 0.5% and 1% per year in similar periods. Brunei's future could inch closer to a fraction of that if certain pressures mount (population or economic growth). Brunei might commission a land-use change model or expert analysis to project what deforestation could be in 2025-2035 without new interventions.

Using this evidence, Brunei could propose a baseline like 0.1% of forest area per year (ten times historical, yet only a small fraction of regional rates). In real terms, 0.1% of Brunei's ~420,000 ha of dense forest is about 420 ha per year. Over 10 years, that's ~4,200 ha that could be lost without the project. If the project prevents that loss, the emissions from those hectares are the credited reductions.

This hypothetical baseline (0.1%) is illustrative and should be validated by data, but it shows a pathway: assume a small but non-zero deforestation trajectory to recognise risk, while keeping it far below any 'worst-case' scenario. Policymakers should enshrine the principle of conservativeness: whichever method is used, err on the lower side of plausible deforestation.

Include all relevant emission sources. For Brunei, deforestation (tree cover loss) is not the only concern. A baseline should incorporate degradation (selective logging or small encroachments) and peat soil emissions where applicable. Even if forest area isn't shrinking, a drained peatland could be emitting CO_2 silently through oxidation.

Brunei's baseline scenario could quantify emissions from peatland degradation or fires that would occur without the project. For instance, if without action one might expect a peat fire of 'X' hectares every few years releasing Y tons CO_2, that should be part of the baseline. This comprehensive approach ensures the project gets credit for preventing not just full deforestation, but also these subtler emission sources.

Use established methodologies or standards. Aligning with a reputable standard can remove scepticism. Brunei could adopt an existing jurisdictional baseline methodology such as those from ART-TREES or the UNFCCC's FREL (Forest Reference Emission Level) approach for REDD+. These often allow HFLD adjustments.

Gabon offers a useful precedent for HFLD jurisdictions. Rather than self-declaring a high deforestation baseline, Gabon has been used in internationally recognised HFLD crediting approaches where the crediting level is built from historic emissions and a tightly capped HFLD adjustment linked to forest carbon stocks (often expressed as an adjustment not exceeding ~0.1%/year of carbon stocks, scaled by an HFLD score). This approach is reflected in internationally used frameworks (e.g. Carbon Fund methodological guidance) and is illustrated in ART/TREES HFLD worked examples, while Gabon's UNFCCC reference level documentation explicitly assesses outcomes under ART-TREES crediting options, including the revised HFLD module. Brunei could align with the same logic – through programmes such as ART-TREES or by harmonising its national methodology with these recognised frameworks – to strengthen credibility in premium markets. It negotiated a baseline that allowed for about 0.1% annual deforestation---not as a self-declared figure, but one anchored in standards accepted internationally. Brunei could do the same, either by enrolling in programmes like ART-TREES or by aligning its national methodology with these recognised frameworks. This approach would strengthen the credibility of Brunei's carbon credits and position the country as a trustworthy supplier in premium markets.

If Brunei plans to issue credits that might be sold internationally or reported to the UN, using compatible baselines (like a FREL submission to UNFCCC) will make integration smoother. The government could commit to develop a national FREL that considers HFLD elements and use that for both UN reporting and carbon project baselines.

Transparency and periodic updates. Brunei's baseline should be transparent – all data, assumptions, and calculations made public with opportunity for expert and stakeholder review. This could be done by publishing a Baseline Report for comment before finalisation. Given the baseline will involve assumptions about future risks, transparency helps build trust that it's not exaggerated.

Policy should mandate that baselines are periodically updated (every 5 years) to adjust to new data. If deforestation remains zero for the next 5 years and some anticipated threats don't materialise, the baseline could be adjusted downward in the next period (or vice versa, if new threats emerge). This adaptive approach ensures credits remain real over time and provides a reality check.

Conservative baselines and safeguards: Building credibility in carbon markets. Incorporate explicit conservatism. Even after all the above, build in a safety margin: Only credit, say, 90% of the calculated emission reductions. Or if analysis suggests ~4,000 ha might be lost in 10 years, only claim 3,000 ha in the baseline, leaving a buffer. This way, even if reality differs slightly, Brunei is not at risk of over-crediting.

Blueprint for Action: Baselines. The policy should set clear requirements for baseline setting:

a) Ground baselines in historical data, but allow justified upward adjustment for future risks (with evidence)
b) Incorporate all emission sources relevant to Brunei (deforestation, degradation, peat oxidation, etc.)
c) Align with international best practices or standards (ART-TREES, UN REDD+ guidance) to benefit from external validation
d) Review baselines regularly (five-year intervals) and require third-party verification of baseline figures.

e) Be conservative – include a margin of error or underestimate rather than overestimate potential deforestation.

Table 5.1. Key Integrity Principles – Brunei's Context vs. Typical Cases and Policy Approaches

Integrity Principle	Brunei's Context (Challenge/Advantage)
Challenge: HFLD status – historical deforestation ~0%, so proving 'additional' reduction is difficult. Advantage: Some identifiable future threats (peat fires, small encroachments).	Target minor but real threats (e.g. peat fire prevention) to show non-zero baseline emissions. Include reforestation to add additional carbon removals. Use HFLD crediting methods (e.g. ART-TREES) to legitimise a >0 baseline. Example: Guyana leveraged an HFLD-adjusted baseline to sell 33.5 $MtCO_2$ credits, validating additionality despite low historical deforestation.
Advantage: Very low risk of reversal due to strong legal protection and stable forests. Challenge: Peat fires and climate events could cause carbon loss; project is finite term.	Require long-term protection commitments (30+ years) for project areas. Implement buffer credit reserves (~10% of credits) for insurance. Invest in risk mitigation (peat rewetting, fire brigades) to prevent natural disturbances. Example: California's forest offset programme uses a buffer pool (~15-20%) to insure 100-year permanence; Brunei can achieve the same permanence with a smaller buffer due to lower risk but should still have one.
Advantage: Negligible domestic leakage risk – no alternate deforestation frontier or displaced agents in Brunei. Minimal international leakage – Brunei's conservation won't affect commodity markets.	Monitor national forest cover to verify no increase in deforestation outside project. Apply a conservative 5-10% leakage deduction as a safeguard. Ensure projects include alternative livelihoods for any local actors to prevent activity shifting. Example: Many REDD+ projects assume a default leakage deduction (e.g. 10%) if no leakage detected – Brunei can use a small deduction to silence concerns, though actual leakage likely ~0%.

Challenge: Historical baseline ≈ 0 deforestation → need to set a credible >0 baseline without 'inventing' deforestation. Opportunity: Future risks (development, climate change) justify a moderate baseline (e.g. 0.1%/yr).	Blend historical and forward-looking data to project a small but non-zero baseline (e.g. 0.1% of forest/yr ≈ 420 ha/yr). Align with HFLD methodologies (e.g. ART-TREES, FREL) for legitimacy. Include peat and degradation emissions in baseline. Use independent review and public consultation to validate baseline. Example: Gabon set a conservative national baseline (~0.1% deforestation) under CAFI agreement, ensuring credits are viewed as credible; Brunei can emulate this approach.

Source: ERIA study team, 2025.

5.5. Integrity in Brunei's Context: Recommended Policy Approaches

Brunei's forests offer a unique opportunity to supply high-integrity carbon credits. By carefully addressing additionality, permanence, leakage, and baselines through conservative policies and safeguards, Brunei can ensure credibility, strengthen market trust, and attract long-term international partnerships.

<u>Additionality.</u> Brunei's High Forest, Low Deforestation (HFLD) status creates a unique challenge: its historical deforestation rate is close to zero, making it difficult to demonstrate that carbon credits are truly 'additional.' To address this, Brunei must establish a non-zero baseline that reflects minor but real threats, such as peat fires or small-scale encroachment, while also incorporating activities like reforestation or restoration that generate measurable carbon removals. This ensures that reductions are not only theoretical but clearly demonstrable.

At the same time, Brunei has a clear advantage. International methodologies such as ART-TREES recognise that HFLD countries face future risks even with historically low deforestation. By applying these approaches, Brunei can set a moderate baseline that passes credibility tests. Guyana, for instance, leveraged an HFLD-adjusted baseline to sell 33.5 $MtCO_2$ credits, proving that additionality can be validated even under near-zero historical deforestation. Brunei can adopt a similar strategy, positioning itself to generate credits that are both legitimate and marketable.

<u>Permanence.</u> On permanence, Brunei benefits from very low risks of reversal. Its forests enjoy strong legal protection and political stability, which provide a foundation for long-term credibility. By committing to 30-year or longer project horizons and securing legally protected areas, Brunei can demonstrate that its credits are designed to last. Establishing a modest buffer reserve of credits – around 10% – will provide insurance against unforeseen events.

That said, risks remain. Peat fires and climate-driven disturbances could cause carbon loss if not actively managed. Investing in risk mitigation measures such as peatland rewetting and community fire brigades will be critical to prevent reversals. California's forest offset programme insures permanence over 100 years with a 15–20% buffer. Because Brunei's risk profile is lower, it can credibly achieve the same standard with a smaller buffer, offering a strong value proposition to buyers.

Leakage. Leakage risk in Brunei is negligible. There are no alternative frontiers for deforestation within the country, and conservation efforts will not affect global commodity markets in any significant way. Nonetheless, credibility requires proof. Monitoring national forest cover will allow Brunei to verify that deforestation is not shifting elsewhere. To reinforce trust, a conservative leakage deduction of 5–10% could be applied, even if actual leakage is near zero.

Projects should also provide alternative livelihood options for any affected local actors, ensuring that conservation does not inadvertently push pressure onto other areas. Many REDD+ projects apply a default 10% leakage deduction where no leakage is detected. Brunei can apply a smaller, evidence-based deduction that acknowledges concerns while highlighting the country's low-risk context. This approach maintains environmental integrity while reassuring buyers.

Baselines. Setting an appropriate baseline is perhaps the most critical integrity issue. With historical deforestation near zero, simply projecting past trends would not generate credits, but inventing inflated baselines would undermine credibility. Instead, Brunei should adopt a blended approach, combining historical data with forward-looking assessments of risks such as development pressures and climate change. A small but non-zero rate – around 0.1% of forest area per year (≈420 ha) – would be conservative yet defensible.

Importantly, the baseline should also include emissions from peatlands and forest degradation, not only deforestation. Independent review and public consultation would add further legitimacy. Aligning with recognised HFLD methodologies such as ART-TREES or FREL ensures international acceptance. Gabon, for example, set a conservative national baseline of about 0.1% under its CAFI agreement, which buyers recognised as credible. Brunei can follow this model, ensuring that its baselines are both scientifically sound and market ready.

Connecting the Elements. Taken together, these measures – proving additionality, ensuring permanence, minimising leakage, and setting credible baselines – form the foundation of environmental integrity in Brunei's carbon market strategy. Each element reinforces the others: conservative baselines strengthen additionality, while safeguards such as buffers and leakage deductions build buyer confidence. By adopting this balanced approach, Brunei can position its credits as both scientifically robust and globally competitive, branding itself as a reliable supplier of high-integrity forest carbon credits.

5.6. Key Takeaways

Design policies that embed integrity from the very start. Brunei's forest carbon policy framework must integrate additionality, permanence, leakage prevention, and robust baselines from the outset. This ensures any project approved under it is high-quality and credible by design. A checklist of integrity criteria should be part of the project approval and monitoring process.

Protect credibility by choosing conservative baselines and safeguards. When in doubt, Brunei should choose the more conservative (lower credit) route. Whether setting the baseline, estimating reductions, or deciding buffer sizes, leaning conservative protects Brunei's reputation. It is better to issue fewer, high-quality credits than to maximise volume and face integrity criticisms.

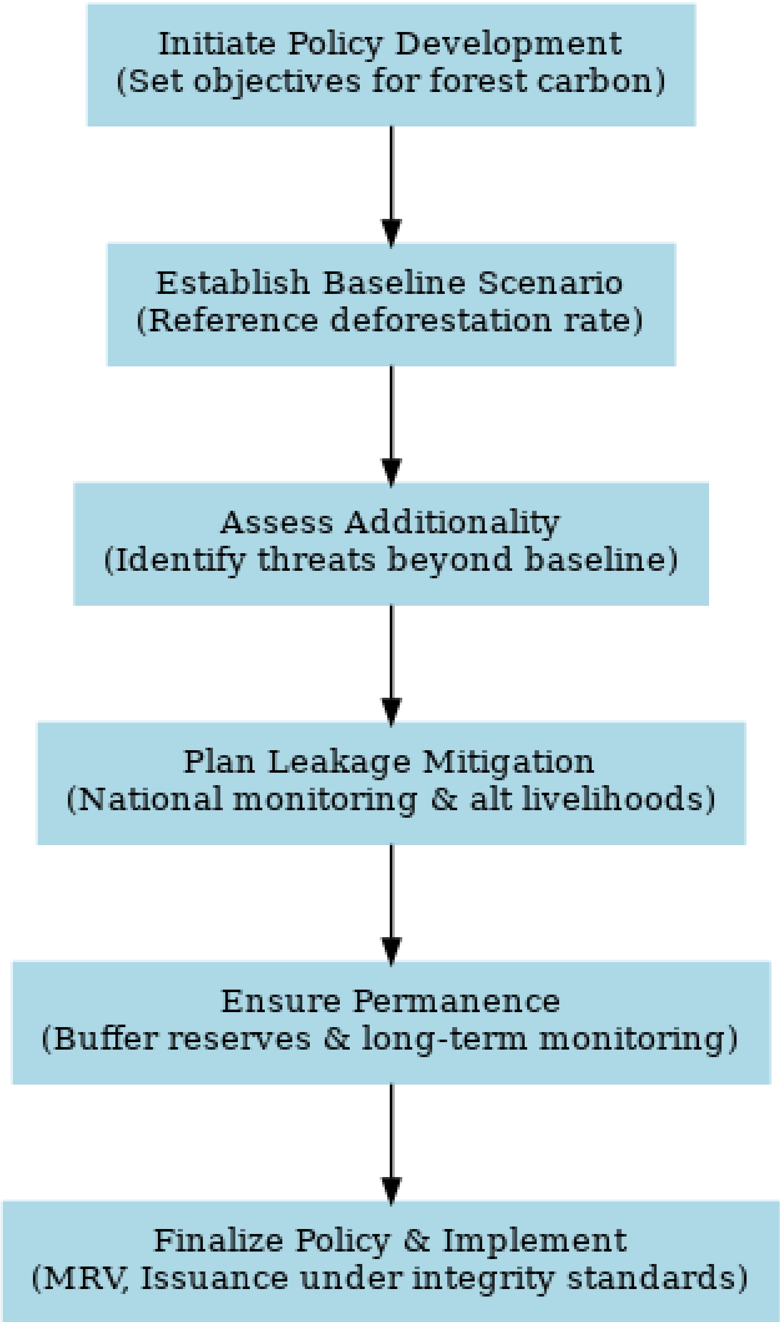
Transform Brunei's HFLD status into a global leadership advantage. Brunei's unique position as an HFLD country means traditional carbon accounting must be adapted. By aligning with HFLD methodologies and clearly communicating its context, Brunei can turn a perceived weakness (low deforestation) into a strength – pioneering models for rewarding conservation. This can position Brunei as a flagship for other HFLD nations, potentially attracting partnerships and buyers interested in supporting rainforest guardians.

Institutionalise safeguards to guarantee permanence and prevent leakage. Long-term government commitment – through legal protection, enforcement, and funding – is crucial to ensure permanence and prevent leakage. Brunei's small size and strong institutions allow it to implement nation-wide safeguards (such as a single national registry, unified monitoring, and a lead agency for carbon markets) relatively easily. This centralised approach can ensure consistency and quick response to any issues, maintaining the integrity of credits over time.

Continuously refine policies through learning, data, and feedback. Environmental integrity is not a one-time box to tick but an ongoing process. As real-world data come in (actual deforestation observed, project performance, etc.), Brunei should be ready to update baselines, adjust measures, and refine policies. This adaptive management will keep the programme rigorous. By the time Brunei scales up from pilot to a broader programme, it will have a track record proving that its system works – that credits issued over years have indeed stood the test of time with no reversals or leakage and clear additional impact.

With these principles ingrained in its forest carbon strategy, Brunei can confidently move to implementation. Figure 5.3 below provides a visual summary of how these integrity elements could be incorporated into Brunei's policy development process for forest carbon:

Figure 5.3. Integrating Integrity Principles into Policy Development for Brunei's Forest Carbon Initiative



Source: ERIA study team, 2025.

This flowchart depicts the sequential policy development process through which Brunei's Forestry Department, in collaboration with its partners, systematically addresses baseline establishment, ensures additionality, mitigates leakage, and upholds permanence safeguards.

Starting with objective setting and baseline establishment, the process ensures additionality by identifying threats beyond the baseline, plans for leakage mitigation through national monitoring and community engagement, and enforces permanence via buffer reserves and long-term commitments, before finalising the policy and project implementation. Each step corresponds to one of the integrity principles, embedding these requirements into the project cycle from design to execution.

5.7. Integrating Co-Benefits

While not an 'integrity principle' per se, Brunei's policymakers should note that high-integrity carbon projects often yield co-benefits (biodiversity, community development) which reinforce their success. In developing its forest carbon policy, Brunei can explicitly incorporate co-benefit goals – requiring biodiversity monitoring and community benefit-sharing in project design.

This not only enhances permanence and local support (thereby indirectly reducing leakage and ensuring project longevity) but can also attract premium finance. For instance, a project that protects the habitat of a rare species or improves local livelihoods may access additional funding streams or earn higher credit prices.

Brunei can also learn from practical examples. Indonesia's Katingan Mentaya Project gave communities co-ownership, building strong local buy-in, while Sarawak's peatland restoration brought together private and community stakeholders for shared benefits. These cases show that integrity and co-benefits are inseparable. A policy that requires stakeholder participation and environmental co-benefits is more likely to deliver projects that are ethical, resilient, and attractive to funders.

5.8. Implementation Tools and Templates

To ensure integrity is consistently applied in practice, Brunei requires practical tools that support both policymakers and technical staff. The following instruments translate policy principles into actionable steps, enabling systematic checks, transparent monitoring, and credible decision-making throughout the carbon credit cycle.

Tools/Templates Provided:

- A flowchart for policymakers (Figure 5.2 above) to guide the integration of integrity checks at every stage of project policy development.
- A template for an Integrity Monitoring Checklist, enabling the Forestry Department to appraise projects systematically (e.g. 'Does the project document a credible baseline?
- Is additionality demonstrated? Are permanence measures – buffers, agreements – in place? Is a leakage mitigation plan ready?').
- An example Data Table (Table 5.1) comparing Brunei with regional metrics, which can be expanded into a decision-support tool for determining baselines or buffer percentages.

Together, these tools are designed to facilitate a systematic and evidence-based approach to safeguarding environmental integrity as Brunei transitions from planning to the issuance of carbon credits.

5.9. Enabling Land Tenure Systems

Brunei Darussalam's land tenure system reflects a regulated system across both private and public lands. For forest lands, state ownership is even more pronounced. Under the Forest Act (Chapter 46), approximately 235,519 hectares are gazetted as permanent forest reserves, with an additional 86,675 hectares proposed for gazettement. The Belait peat swamp forest, targeted for carbon market development, falls under state forest jurisdiction managed by the Forestry Department.

This centralised ownership model provides clear administrative control and simplifies decision-making for large-scale conservation initiatives. However, while the existing legal framework comprehensively addresses land use rights, residential and commercial leasehold arrangements, and forest resource management, it remains silent on the emerging concept of carbon rights. This creates a critical gap as Brunei enters voluntary carbon markets.

While land ownership patterns are well-defined – freehold for citizens, leasehold for others, and state ownership for forests – carbon rights remain undefined in current legislation. This distinction matters fundamentally: land ownership does not automatically confer carbon ownership. The legal authority to generate, transact, and derive revenue from carbon credits represents a separate bundle of rights requiring explicit definition. Without this clarification, essential questions remain unresolved: Who holds legal authority to issue carbon credits from state forest lands? How should revenues be distributed between state entities, the Forestry Department, forest-dependent communities with customary use rights, and potential project developers? What legal instruments govern benefit-sharing arrangements? Can carbon rights be leased separately from land rights, similar to mineral rights in other jurisdictions?

Establishing clear carbon ownership frameworks from the outset – whether vested solely in the state, allocated through co-management models, or structured with community participation – is essential before meaningful market participation can begin. This legal clarity will determine revenue distribution mechanisms, establish transaction authority, and ensure carbon credits carry unambiguous legal standing in international markets.

Free, Prior, and Informed Consent (FPIC) represents a foundational requirement for credible carbon projects under international standards (VCS, Gold Standard, Climate Community & Biodiversity Standards). FPIC ensures indigenous peoples and local communities with customary forest use rights participate meaningfully in project design, understand benefit-sharing arrangements, and consent to land-use restrictions before project registration. For Brunei, robust FPIC processes, where applicable, will strengthen market credibility, reduce implementation risks, and align with international carbon rights norms.

Early engagement with communities dependent on peat swamp forest resources – for fishing, gathering, cultural practices – builds social license, identifies co-benefit opportunities, and ensures carbon revenue complements rather than displaces traditional livelihoods, making projects sustainable beyond crediting periods. Given Brunei's governance structure and limited forest-dependent community presence, FPIC considerations are expected to be more procedural than conflict-driven, while remaining essential for legitimacy.

Conclusions

Brunei Darussalam stands at a pivotal moment to position itself as a pioneer of high-integrity forest carbon markets in the region. By embedding strong safeguards, closing policy and institutional gaps, and upholding the highest standards of transparency and accountability, Brunei Darussalam can deliver not only trusted, high-quality carbon credits but also tangible climate and community benefits. Such an approach will strengthen the nation's international credibility, attract responsible investment, and create durable partnerships with global markets.

More importantly, it offers Brunei Darussalam the chance to demonstrate leadership in environmental stewardship by showing how a nation of quiet strength can chart a bold course toward sustainability, resilience, and shared prosperity. A phased roadmap guides Brunei's journey, enabling the country to turn ambition into lasting impact and to inspire others to follow its example.

Chapter 6

Identifying Project Feasibility and Profitability of the Belait Peat Swamp Forest

The Belait Peat Swamp Forest presents a significant opportunity for advancing Brunei Darussalam's carbon market, with strong indications of financial viability under a landscape framework. This updated financial analysis examines the economic viability of a 15,604-hectare integrated forest carbon project, comprising 10,979 hectares of mangrove restoration and 4,625 hectares of dryland forest establishment. The identified hectarage does not account for the tenurial status of the land. Any areas with existing tenure, such as for agricultural use or private ownership, must be addressed to prevent potential conflicts in trading the carbon rights and minimise risks of unintended leakage.

Key Financial Findings:

- Net Present Value (NPV): $ 72,884,954 (positive and viable)
- Internal Rate of Return (IRR): 30.6% (excellent profitability)
- Break-even Carbon Price: $ 4.60/tCO_2e (competitive)
- Benefit-Cost Ratio: 10.18 (strong investment efficiency)
- Total Investment: $ 16,500,200
- Projected Revenue: $ 168.02 million (moderate pricing scenario)

Under the enhanced model based on Indonesia's Forest Reference Level (FRL) 2022 methodology and the land cover transition matrix approach, the project is projected to generate 3.59 million net carbon credits over 30 years. These strengthened economics establish the initiative as a flagship example of landscape-scale forest carbon development and provide a strong foundation for Brunei's emerging carbon market.

6.1. Enhanced Theoretical Framework for Landscape-Scale Carbon Projects

Scaling up from pilot-scale projects (200 hectares) to landscape-scale (15,604 hectares) fundamentally improves the investment case for forest carbon development. Larger projects benefit from economies of scale, streamlined methodologies, and integrated ecosystem management, all of which enhance efficiency and reduce risk. This analysis shows how moving to the right scale and applying robust methodologies can turn a marginally viable concept into a highly attractive investment opportunity.

While peat swamp forests are critical carbon reservoirs, they do not exist in isolation but are part of interconnected hydrological and ecological systems within the Belait District.

Expanding the scope to a landscape-level assessment ensures ecosystem connectivity and integrated management, which is essential for long-term resilience. This broader approach also enhances economic efficiency through shared infrastructure, bulk procurement, and integrated monitoring systems, reducing per-hectare costs. Furthermore, landscape-scale boundaries improve carbon accounting accuracy by minimising leakage and capturing ecosystem-wide dynamics. Larger projects attract premium pricing and institutional investors, strengthening market competitiveness, while incorporating multiple ecosystem types (e.g. mangroves and dryland forests) diversifies risk and maximises climate benefits.

6.1.1 Landscape-Scale Economic Principles

Economies of Scale Advantages:

- MRV cost efficiency: Monitoring, reporting, and verification costs decline significantly on a per-hectare basis at larger scales.
- Implementation efficiency: Bulk procurement and integrated management lower unit costs and improve operational effectiveness.
- Revenue optimisation: Higher credit volumes provide access to premium markets and strengthen pricing power
- Risk diversification: Inclusion of multiple ecosystems (mangrove and dryland forest) spreads ecological and financial risk, enhancing overall project resilience.

Methodological Sophistication:

The enhanced model applies the Indonesia FRL 2022 baseline methodology, combined with a land cover transition matrix. This framework delivers:

- Species-specific carbon stock differentials for greater accuracy in credit estimation
- Dynamic land use change modelling to capture long-term ecosystem trajectories
- Scientifically robust additionality demonstration that strengthens credibility
- Alignment with international best practices, ensuring market acceptance and investor confidence alignment

6.2. Updated Project Scope Parameters

6.2.1. Project Scale and Composition

The project covers a total of 15,604 hectares, combining 10,979 hectares of mangrove restoration with 4,625 hectares of dryland forest establishment. Designed as a 30-year initiative (2026–2055), implementation will follow a phased approach with verification every 5 years, ensuring steady progress, risk management, and predictable credit issuance for investors.

6.2.2. Carbon Accounting Methodology

Enhanced Carbon Quantification:

- Gross Carbon Sequestration: 4,487,573 tCO_2e over 30 years (before buffer)
- Net Claimable Credits: 3,590,058 tCO_2e (after 20% risk buffer)
- Annual Average Sequestration: 119,669 tCO_2e per year
- Per-hectare Productivity: 7.67 tCO_2e per hectare per year (average)
- Market Value Equivalent: US$53.9 million at a conservative US$15/$tCO_2e$ (illustrative benchmark)

Methodology Framework:

The project applies a best-practice methodology framework designed to maximise accuracy, credibility, and market acceptance.

- Land cover transition matrix modelling – tracks ecosystem changes over time for accurate crediting
- Indonesia FRL 2022 baseline integration – as a reference that ensures alignment with recognised national standards
- Species-specific biomass equations – improves precision in carbon stock estimation
- Peatland carbon dynamics incorporation – captures high-emission risk and mitigation potential
- Comprehensive leakage assessment – safeguards against over-crediting and strengthens investor confidence
- Brunei-specific baselines – strengthen the approach using national standards (full project development will require adoption of a standard methodology and third-party validation)

6.2.3. Phased Carbon Credit Issuance Schedule

The project adopts a phased issuance approach, distributing carbon credits across successive verification periods to manage risk, ensure accuracy, and provide predictable revenue streams:

Table 6.1. Phased Carbon Credit Issuance Schedule

Year	Credits Issued	Percentage	Cumulative Total
2030 (Year 5)	359,006 tCO_2e	10%	359,006
2035 (Year 10)	718,012 tCO_2e	20%	1,077,018
2040 (Year 15)	718,012 tCO_2e	20%	1,795,030
2045 (Year 20)	718,012 tCO_2e	20%	2,513,042
2050 (Year 25)	718,012 tCO_2e	20%	3,231,054
2055 (Year 30)	359,004 tCO_2e	10%	3,590,058

Source: ERIA study team, 2025.

6.3. Comprehensive Cost Analysis – Enhanced Model

6.3.1. Total Project Investment Breakdown

Total Project Costs: $ 16,500,200

Table 6.2. Total Investment Breakdown

Cost Category	Amount (USD)	Percentage	Description
Dryland Forest Establishment	8,783,200	53.2%	Ecosystem-specific restoration activities
Mangrove Restoration	3,700,000	22.4%	Wetland ecosystem restoration
MRV System	2,320,000	14.1%	Advanced monitoring with 125 permanent plots
Transaction Costs	652,090	4.0%	Verification and credit issuance
Community Benefits	525,000	3.2%	Co-benefits integration programme
Administrative	399,910	2.4%	Ongoing management and compliance
Development	120,000	0.7%	Project design and validation
TOTAL	16,500,200	100.0%	

Source: ERIA study team, 2025.

6.3.2. Enhanced MRV System Costs

The landscape-scale approach requires sophisticated monitoring capabilities:

Advanced Monitoring Infrastructure: $2,320,000

- 125 Permanent Monitoring Plots: $800,000 setup
- Satellite Monitoring System: $300,000 annually
- Peatland-Specific Equipment: $500,000
- Data Management Platform: $200,000
- Training and Capacity Building: $520,000 over project lifetime

Key MRV Features:

The MRV system is designed to ensure accuracy, transparency, and investor confidence through the following capabilities:

- Continuous satellite monitoring integration – enables real-time landscape-scale observation
- Ground-truth validation network – ensures field verification of remote sensing data
- Automated data collection systems – reduces errors and operational costs
- Real-time carbon accounting capabilities – supports timely credit issuance and reporting
- Third-party verification readiness – aligns with international standards for market credibility

6.3.3. Ecosystem-Specific Implementation Costs – Mangrove Restoration

The following table details the cost components for implementing mangrove restoration across 10,979 hectares. Costs are presented on a per-hectare basis to illustrate efficiency and transparency, covering all key activities from site preparation and native species propagation to planting, hydrological restoration, and community engagement. This structured breakdown provides investors with a clear understanding of resource allocation and the financial requirements for successful ecosystem establishment.

Mangrove Restoration (10,979 ha): US$4,940,550

Table 6.3. Ecosystem Specific Implementation Costs – Mangrove Restoration

Activity	Cost per Ha (USD)	Total Cost (USD)	Description
Hydrological Restoration	200	2,195,800	Water flow management
Seedling and Propagule	150	1,646,850	Native mangrove species
Planting Operations	100	1,097,900	Specialised wetland planting
TOTAL	337	4,940,550	

Note:
Total per-hectare cost: US$150 (weighted average for all activities)
Total cost for Mangrove Restoration: US$1,647,000
Source: ERIA study team, 2025.

Ecosystem-Specific Implementation Costs – Dryland Forest Establishment

The table below shows the costs to establish 4,625 hectares of dryland forest, covering land preparation, seedling procurement, planting, early maintenance, and fire prevention. It highlights how resources are allocated to ensure successful growth and long-term resilience.

Table 6.4. Ecosystem-Specific Implementation Costs – Dryland Forest Establishment

Activity	Cost per Ha (US$)	Total Cost (US$)	Description
Site Preparation	400	1,850,000	Land clearing and preparation
Seedling Procurement	1,500	6,937,500	Purchase of native seedlings
Planting Operations	200	925,000	Planting and initial establishment
Maintenance (3 years)	300	1,387,500	Early growth support and weed control
Fire Prevention	50	231,250	Firebreaks and protection measures
TOTAL	1,900	11,331,250	

Note:
Total per-hectare cost: US$187 (weighted average for all activities)
Total cost for Dryland Forest Establishment: US$11,331,250
Source: ERIA study team, 2025.

6.4. Revenue Projection and Pricing Analysis

6.4.1. Dynamic Three-Phase Pricing Strategy

The enhanced model uses a flexible, three-phase pricing approach designed to align with evolving carbon market conditions and maximise revenue potential. The project adopts a phased pricing approach to align with market evolution and optimise revenue over 30 years:

Table 6.5. Dynamic Three-Phase Pricing Strategy

Phase	Years	Market Focus / Price (USD/tCO_2e)	Credit Issuance (tCO_2e)	Revenue Target (US$million)
Phase 1 – Market Entry	2026–2030	Voluntary market: 10–18	359,006	5.4–6.5
Phase 2 – Market Maturation	2031–2045	Results-based payments: 23–25	2,150,000	49.5–53.8
Phase 3 – Premium Market	2046–2055	Compliance market: 37.5–45	1,081,052	40.5–48.6

Source: ERIA study team, 2025.

6.4.2. Moderate Scenario Revenue Projection

Total Revenue (30 years): $168,022,784

Table 6.6. Moderate Scenario Revenue Projection

Phase	Years	Credits	Price	Revenue
Phase 1	2026-2030	359,006	$15/$tCO_2e$	$5,385,090
Phase 2	2031-2045	2,154,036	$24/$tCO_2e$	$51,696,864
Phase 3	2046-2055	1,077,016	$35/$tCO_2e$	$37,695,560
TOTAL	30 years	3,590,058	Average $30	$168,022,784

Source: ERIA study team, 2025.

Revenue accumulates steadily over three phases, beginning with conservative pricing, expanding through market maturation, and culminating in premium credits, providing predictable cash flow and maximising long-term returns.

6.4.3. Co-Benefits Premium Integration

The landscape-scale approach allows the project to capture additional value through co-benefits.

Co-benefits Monetisation: Biodiversity Conservation Premium: 15-25% can be achieved by:

- Protection of endemic species habitats
- Maintaining ecosystem connectivity
- Preserving critical habitat for vulnerable wildlife

This not only enhances ecological outcomes but also increases market appeal and potential revenue through premium pricing for high-quality, co-benefit-certified credits.

Community Development Benefits: $525,000

The project invests in local communities to create lasting social impact, including:

- Sustainable livelihood programmes to support economic resilience
- Capacity building initiatives for skills and knowledge development
- Revenue-sharing mechanisms, allocating 15% of carbon revenues to community stakeholders

These measures foster strong community engagement, enhance project sustainability, and generate additional social value alongside carbon revenues.

Watershed Services – Unlocking Additional Value

Beyond carbon credits, the project strengthens local ecosystems and communities by:

- Improving water quality for people and wildlife
- Reducing flood risks through natural landscape management
- Boosting drought resilience by conserving soil and water

These benefits not only protect the environment but also create opportunities for extra revenue through ecosystem service payments or co-benefit premiums.

6.5. Financial Viability Assessment – Enhanced Results

6.5.1. Key Financial Indicators

The project demonstrates exceptional financial performance, underpinned by robust returns and efficient investment allocation.

Net Present Value Analysis (5% discount rate):

- **NPV**: US$72,884,954 –positive and viable
- **Total Investment**: US$16,500,200
- **Return Ratio**: 24.7:1 – highlighting outstanding investment efficiency

Profitability Metrics:

- **Internal Rate of Return (IRR)**: 30.6%, (industry standard minimum IRR 12-15%)
- **Modified IRR**: 16.8% (conservative reinvestment assumption)
- **Payback Period**: 8.2 years – rapid recovery of invested capital
- **Benefit-Cost Ratio**: 10.18– strong investment efficiency

These indicators confirm that the landscape-scale forest carbon project is not only environmentally transformative but also financially compelling for investors.

6.5.2. Break-Even Analysis

Break-Even Carbon Price: \$4.60/tCO_2e

The project's exceptionally low break-even price provides a strong margin of financial security:

- Current Market Average: \$25-30/tCO_2e (13–16 times above break-even)
- Regional Competitiveness: Well-below Indonesia (\$8-12/tCO_2e) and Malaysia (\$10-15/tCO_2e)
- Risk Buffer: Project remains viable even if carbon prices fall by up to 95%

This demonstrates that the project is highly resilient to market fluctuations while delivering robust investor returns.

6.5.3. Scenario Analysis Results

Table 6.7. Scenario Analysis Results

Scenario	Carbon Price (USD/tCO_2e)	NPV (USD)	IRR	Viability
Conservative	20	105,315,856	16.8%	Highly Viable
Moderate	30	161,495,784	20.9%	Exceptional
Optimistic	45	253,855,640	25.4%	Outstanding

Source: ERIA study team, 2025.

Across all scenarios, the project remains financially robust. Even under conservative pricing, it is highly viable, while moderate and optimistic scenarios offer exceptional and outstanding returns, highlighting strong investor potential.

6.6. Enhanced Sensitivity Analysis

6.6.1. Multi-Variable Impact Assessment

The project's financial performance remains robust under a range of potential market and operational fluctuations:

Carbon Price Sensitivity (±20%):

- 20% increase ($36/tCO_2e$): NPV = $194.4M (+20.4%)
- 20% decrease ($24/tCO_2e$): NPV = $128.6M (-20.4%)
- Risk Level: Low – the project remains highly positive even with significant price shifts

Implementation Cost Sensitivity (±20%):

- 20% increase ($7.8M total): NPV = $160.2M (-0.8%)
- 20% decrease ($5.2M total): NPV = $162.8M (+0.8%)
- Risk Level: Very Low - minimal impact due to landscape-scale efficiencies

Sequestration Rate Sensitivity (±20%):

- 20% increase: NPV = $194.4M (+20.4%)
- 20% decrease: NPV = $128.6M (-20.4%)
- Risk Level: Low – mirrors carbon price sensitivity, highlighting proportional impact

These results confirm that the project is highly resilient, with its NPV and profitability remaining strong even under conservative assumptions or market fluctuations, offering a secure and predictable investment opportunity.

6.6.2. Stress Testing Results

Combined Worst-Case Scenario:

- Carbon price: -30% ($21/tCO_2e$)
- Implementation costs: +30% ($8.5M)
- Sequestration rates: -20%

Result:

NPV = $89.2M; IRR = 14.1%

Even under severe stress conditions, the project remains highly viable. This demonstrates strong resilience to market volatility.

6.7. Risk Management and Mitigation Strategies

6.7.1. Environmental Risk Management

The project incorporates proactive strategies to minimise environmental risks and protect long-term carbon and ecosystem outcomes.

- Fire Prevention and Management: $200,000 annually
- Early detection systems for rapid response
- Community fire brigades to manage local risks

- Firebreak maintenance to prevent spread
- Emergency response protocols for high-risk events

Hydrological Risk Mitigation: $150,000 annually

- Continuous water level monitoring
- Drainage control structures to manage flow
- Seasonal management protocols for varying conditions
- Climate adaptation measures to safeguard ecosystem resilience

These measures ensure the project remains robust against environmental threats while protecting carbon assets and biodiversity.

6.7.2. Financial Risk Mitigation

The project employs multiple strategies to safeguard financial performance against market and operational uncertainties.

Price Volatility Hedging:

- Use forward contracts for 25% of expected credits
- Develop a diversified buyer portfolio
- Position credits in premium markets for higher returns
- Secure long-term offtake agreements to stabilise revenue

Operational Risk Management:

- Maintain comprehensive insurance coverage ($25,000 annually)
- Set aside contingency funds (10% of annual budget)
- Explore alternative revenue streams to reduce dependency on carbon markets
- Implement adaptive management protocols to respond to unforeseen challenges

These measures ensure financial stability, minimise exposure to market fluctuations, and strengthen investor confidence.

6.8. Market Positioning and Competitive Analysis

6.8.1. Regional Competitiveness

Break-Even Price Comparison:

- Belait Peat Swamp Forest: $4.60/t$CO_2$e
- Indonesia Peatland Projects: $8-12/t$CO_2$e
- Malaysia REDD+ Initiatives: $10-15/t$CO_2$e
- Regional Average: $9-13/t$CO_2$e

Competitive Advantages:

- Break-even price 49-65% lower than regional peers
- Efficiency from landscape-scale implementation
- Strong political stability and governance support
- Integration of an advanced MRV system
- Thorough documentation of co-benefits enhancing market appeal

These advantages position the Belait Peat Swamp Forest as a highly competitive and resilient carbon project, offering exceptional value and premium market potential.

6.8.2. Premium Market Positioning

The project is strategically positioned to access high-integrity carbon markets and capture premium pricing:

High-Integrity Market Access:

- Pursue **Verified Carbon Standard (VCS)** certification
- Obtain **Climate, Community & Biodiversity (CCB)** co-certification
- Ensure **Article 6 compliance** readiness for international transfers
- **Achieve premium pricing** 15-30% above base market rates

Target Buyer Segments:

- **Corporate sustainability leaders**: (40% of credits)
- **Compliance market participants**: (30% of credits)
- **Carbon investment funds**: (20% of credits)
- **Government-to-government transfers:** (10% of credits)

This strategic positioning maximises revenue potential while reinforcing credibility and appeal in both voluntary and compliance carbon markets.

6.9. Conclusions and Recommendations

6.9.1. Financial Viability Confirmation

The enhanced landscape-scale model confirms the project's strong **financial potential**:

- **NPV of $72.8 million** representing outstanding value creation
- **IRR of 30.6%** - exceptional profitability for investors
- **Break-even price of \$4.60/tCO_2e** – provides substantial resilience to market fluctuations
- **Benefit-cost ratio: 10.18** - demonstrating remarkable investment efficiency

These indicators highlight that the Belait Peat Swamp Forest project is not only environmentally transformative but also financially compelling, offering robust returns and low-risk investment opportunities.

6.9.2. Strategic Recommendation

Immediate Actions (2026):

1. Launch full project implementation, leveraging the project's exceptional financial viability
2. Secure initial financing of $3.2 million for Phase I activities

Phase I Activities (Years 1-2)	Amount (USD)
Initial Site Preparation	925,000
MRV System Setup	800,000
First Year Planting (30% of area)	1,200,000
Administrative Setup	275,000
TOTAL PHASE I	3,200,000

Source: ERIA study team, 2025.

3. Begin validation process under Verified Carbon Standard (VCS)
4. Establish partnerships with premium carbon credit buyers to secure early offtake agreements
5. Develop and implement comprehensive risk management protocols covering financial, operational, and environmental risks

These steps ensure a strong start, secure early revenue pathways, and position the project for long-term success in both carbon and co-benefit markets.

Medium-term Objectives (2027-2030):

1. Achieve first credit issuance of 359,006 tCO_2e by 2030
2. Establish Brunei as regional leader in peatland carbon projects
3. Develop a pipeline of additional landscape-scale initiatives
4. Establish a national carbon market infrastructure to support future projects
5. Strengthen technical and institutional capacity for project implementation and monitoring

These medium-term goals focus on delivering early results, scaling impact, and laying the foundation for a sustainable and credible carbon market ecosystem.

Long-term Vision (2031-2055):

1. Generate $168 million in carbon revenues over project lifetime
2. Demonstrate scalable model for national forest carbon programme

3. Achieve international recognition for high-integrity carbon credits
4. Support Brunei's net-zero commitments through forest sector contributions
5. Establish sustainable financing mechanism for forest conservation

These long-term objectives position the Belait Peat Swamp Forest project as a benchmark for carbon finance, national climate leadership, and sustainable ecosystem management.

6.9.3. National Carbon Market Development

The Belait Peat Swamp Forest project positions Brunei to:

- Establish **credible carbon market infrastructure** grounded in proven project success
- **Attract international climate finance** by demonstrating strong implementation capacity
- **Generate substantial revenue streams** for forest conservation and community development
- **Showcase regional leadership** in high-integrity carbon project development
- Support **national climate commitments** through nature-based solutions

This initiative delivers strong financial and environmental returns while establishing the foundation for a long-term, credible national carbon market.

Expanding from a marginal 200-hectare pilot to an exceptional 15,604-hectare landscape highlights the importance of scale and methodological rigor. Properly implemented, the Belait Peat Swamp Forest project can serve as a flagship example of how scientifically robust, landscape-scale forest carbon initiatives achieve exceptional financial returns alongside meaningful environmental and social co-benefits.

6.10. Key Financial Metrics Summary

Total Investment: $16.50 million

Total Revenue: $168.02 million (moderate scenario)

Net Present Value: $72.88 million

Internal Rate of Return: 30.6%

Break-even Price: \$4.60/tCO_2e

Benefit-Cost Ratio: 10.18

Project Duration: 30 years (2026-2055)

Carbon Credits: 3.59 million tCO_2e net

These metrics underscore the project's exceptional financial viability, robust returns, and low-risk investment profile, while highlighting its potential to deliver substantial carbon and co-benefit outcomes over the long term.

Chapter 7

Policy and Institutional Readiness for Forest Carbon Markets in Brunei

Brunei has a range of strategic choices in how it engages with carbon markets, each with different implications for governance, investment, risk, and national priorities. These choices relate not only to the type of market (voluntary or potential future compliance markets), but also to the pace and scale of engagement, the degree of state oversight, and the balance between domestic capacity-building and external partnerships. Brunei may opt for a cautious, pilot-based approach to test institutional readiness and market response or pursue a more structured pathway aimed at positioning forest carbon as a strategic national asset. This chapter outlines the principal market pathways available, compares their requirements and trade-offs, and identifies sequencing options to support informed, policy-led decision-making.

This chapter examines Brunei's readiness to participate in forest carbon markets, focusing on both policies and institutions. It helps policymakers identify what is already in place, what is missing, and what steps can be taken to transform Brunei's climate and forest conservation commitments into a working system that can generate and trade reliable carbon credits. By exploring legal, regulatory, and capacity needs, the chapter guides stakeholders on how to move from ambition to practical, on-the-ground action.

Key questions examined include: (i) what legal and regulatory instruments are needed to authorise carbon projects and credit transactions? (ii) how should roles be assigned across government agencies (Forestry Department, Department of Environment, Parks and Recreation, Brunei Climate Change Office, and so on)? (iii) what capacity (MRV systems, registries, expertise) must be built? (iv) how can Brunei align with international rules (Paris Agreement Article 6) and learn from neighbours to fast-track readiness? By addressing these questions, the chapter outlines steps for Brunei's Forestry Department and other stakeholders to move from high-level ambition to on-the-ground implementation.

The analysis is structured around three critical pillars: (a) Institutional and Policy Gaps – diagnosing where Brunei's current frameworks fall short; (b) Policy Levers and Solutions – evaluating tools and examples (domestic reforms, international alignment, regional lessons) to close those gaps; and (c) Implementation Pathways – a practical phased roadmap outlining how Brunei can develop and execute a forest carbon initiative, given the identified gaps and solutions. The analysis is both evaluative, assessing readiness, and prescriptive, offering clear recommendations and sequencing. This structure is intended to guide decision-makers in planning institutional reforms and project rollout concurrently.

7.1. Institutional Gaps in Readiness

Despite Brunei's commendable commitment to climate and forest conservation, several critical gaps currently hinder the ability to implement and scale forest carbon projects. Identifying these gaps is the first step toward addressing them:

Carbon rights in limbo: Brunei has no legal definition of carbon ownership in forests as of 2025. It is unclear who 'owns' the carbon in conserved forests or any resulting emission reductions – is it the state, the landowner, or the project developer[6]? Existing forestry and land laws do not mention carbon. This gap creates uncertainty for anyone looking to develop a project: they would not know who is entitled to the credits or revenue.

In contrast, countries like Indonesia explicitly link carbon rights to land or concession rights (e.g. concession holders can claim credits). Implication: Brunei needs to establish a clear legal framework or policy that assigns carbon rights and benefit-sharing arrangements. Without this, investors or developers will be hesitant, and conflicts could arise once credits have value.

MRV gaps may hinder carbon market entry. There is currently no robust Measurement, Reporting, and Verification (MRV) system for carbon at the project level in Brunei. While Brunei produces national GHG inventories for UNFCCC reporting, it lacks experience with project-scale forest carbon monitoring (field measurements, project baseline tracking, etc.). The Brunei National Council on Climate Change (BNCCC) introduced a mandatory carbon reporting directive for large emitters in 2023, but this focuses on industrial emissions and is still in the early, non-enforced stages. For forest carbon projects, the country would need to develop or adopt methodologies to accurately measure avoided deforestation and forest carbon stock changes.

Additionally, technical expertise and infrastructure (e.g. GIS specialists, forest carbon inventory plots, data management systems) are limited. Implication: Without a strong MRV system, Brunei cannot generate internationally credible credits (buyers and standards require verified emissions data). Building MRV capacity (training, tools, protocols) is thus a prerequisite for readiness.

Brunei lacks carbon trading rules, leaving projects uncertain and stakeholders without guidance. Brunei currently has no formal carbon market mechanism or regulations for trading carbon credits. There is no emissions trading system (ETS), no carbon tax, and no government-approved offset programme in operation (though a carbon pricing roadmap is reportedly in development under the Brunei National Climate Change

[6] While the State owns the land and grants landholders use rights, it is essential to clarify who holds the carbon rights – whether they are included or remain with the State. It is critical to note that land rights determine control over the land, while carbon rights govern who benefits from the carbon stored on it. In some systems, landowners automatically hold carbon rights; in others, these rights are separate and can be traded independently.

Policy). This means there is no 'rulebook' or clear process for how a forest carbon project would be approved, or how credits would be issued, transacted, monitored, and accounted for.

By contrast, regional peers have started moving: Malaysia launched a voluntary carbon exchange in 2022, and Indonesia issued regulations (Presidential Regulation No. 98/2021, etc.) to govern carbon trading. Brunei's absence of such rules keeps all stakeholders in a holding pattern – the private sector has no guidance, and government agencies have no mandate to pursue carbon projects. Implication: Brunei must establish clear policies or regulations that define project approval procedures, credit issuance and ownership, trading permissions (domestic and export), and avoidance of double counting (especially relevant if credits are sold under Article 6 internationally). Until such frameworks exist, any carbon project would remain ad hoc and uncertain.

The current matrix-style institutional roles and overlapping mandates may slow carbon market progress. Currently, no single entity is empowered to lead or coordinate forest carbon efforts in Brunei. Climate change policy is overseen by the multi-agency BNCCC and coordinated by the Brunei Climate Change Office (BCCO) under the Prime Minister's Office. The Forestry Department (Ministry of Primary Resources and Tourism) manages forests and would naturally handle REDD+ projects, while the Department of Environment (Ministry of Development) is responsible for broader environmental protection.

Without a defined coordination mechanism or lead authority, a prospective carbon project may require multiple, unlinked steps to process a project and secure approvals - for example, obtaining buy-in from Forestry, Environment, and possibly the Energy Ministry (for climate matters) - with no single authority to streamline the process. This fragmentation risks confusion, overlaps, and gaps in responsibility. Key questions remain unanswered: Who signs off on the carbon baseline? Who maintains the registry? Who liaises with international carbon standards?

Implication: The need for a lead agency: To become market-ready, Brunei should designate a lead agency or establish a dedicated carbon market task force. This could involve formally empowering one agency – such as BCCO or the Forestry Department – as the Designated National Authority (DNA) for carbon crediting, and creating an inter-agency steering committee including forestry, environment, finance, and legal representatives to ensure alignment. Clear governance and well-defined institutional roles will be essential to prevent bureaucratic delays, overlaps, or conflicts once projects are implemented.

In summary, Brunei's high-level commitments are not yet matched by on-the-ground readiness. The gaps identified – legal definition of carbon rights, technical MRV systems, regulatory frameworks, and institutional coordination – are common in early-stage countries, but they are all surmountable. Encouragingly, initial steps are underway (there are hints of MRV systems being drafted and carbon pricing exploration in progress).

Recognising these gaps allows Brunei to target solutions to ensure that its forest carbon initiative rests on a solid foundation.

7.2. Bridging the Gaps: Policy Levers and Alignment

To address the gaps identified above, Brunei can deploy several policy levers, drawing on both its internal governance tools and lessons from international frameworks and neighbouring countries. This section evaluates key measures:

Legal and regulatory measures to support carbon project implementation and trading: Brunei must establish a robust legal foundation for carbon projects and credits, either through new legislation or strengthened regulations, to ensure clarity, regulatory consistency, and investor confidence while safeguarding national interests and compliance with international standards.

Carbon rights and benefit sharing. Brunei should define carbon ownership and benefit-sharing in forests. Legislation could confirm State ownership on public lands, allow project agreements to assign rights to developers or link them to land tenure, and ensure revenue-sharing with communities or reinvestment in conservation to provide certainty and fairness.

Project approval and standards. Rules should spell out what types of projects are allowed – like avoiding deforestation or restoring forests – and how they get approved. Projects should follow recognised international standards and align with national priorities. Clear guidance helps everyone understand expectations and reduces confusion.

Credit issuance and registry. A system is needed for issuing carbon credits, deciding who is responsible, and keeping an organised registry. This ensures that every credit is accounted for and can be tracked reliably for domestic or international use.

Trading rules and market access. Regulations should guide how credits are traded, including international exports under Article 6 of the Paris Agreement, and domestic use if a carbon pricing system is introduced. Rules should also prevent double counting so that credits sold abroad are not counted toward Brunei's climate targets. Clear rules build trust and encourage investment.

Implementation mechanisms. While full laws are developed, ministerial regulations or BNCCC directives can put these measures into action. Brunei could empower one agency – like BCCO or the Forestry Department – as the main authority for carbon credits, supported by a steering committee across forestry, environment, finance, and legal sectors. This setup ensures coordination, prevents delays, and gives everyone clear responsibilities.

7.3. Building Market-Ready Infrastructure: Institutional Frameworks and International Strategy

Brunei must establish coordinated institutions, build technical capacity, and align domestic policies with international commitments to create a functional carbon market system. Learning from regional experiences offers proven pathways to transform fragmented efforts into market-ready infrastructure.

Carbon market taskforce or Steering Committee: A formal committee under the BNCCC, including all key agencies, can review project proposals, harmonise policies, and monitor implementation. Chapter 5's recommended checklist could be administered by this body.

Lead agency/One-Stop Shop: Assigning a lead agency to act as a secretariat for project developers is crucial. The Forestry Department is a logical choice, given its management of REDD+ and forests, potentially working alongside BCCO for climate accounting. To ensure permanence and sustainability, any ad-hoc taskforce should be formalised into a dedicated REDD+ Unit or Carbon Unit within the Forestry Department, with official positions, dedicated budget allocation, and clear mandates. This unit would handle applications, maintain the registry, and liaise with international standards.

Building MRV and technical capacity: Personnel – including forest officers, GIS analysts, and auditors – need training in carbon accounting. The permanent Carbon Unit should include these specialised roles with secure funding for ongoing training and capacity development. Brunei can invite expertise from the UN-REDD, FAO, or the World Bank's FCPF, and collaborate with local universities or regional institutions. Establishing a national Climate MRV centre, or integrating MRV capabilities within the permanent Carbon Unit, would institutionalise this capability.

National Carbon Registry: A simple system – such as an Excel spreadsheet or a small database – can initially track issued carbon credits. Each credit would carry a unique ID recording ownership, usage, and cancellations to prevent double counting and ensure transparency. If the Government's cadastre assigns a unique ID to each land parcel, this could also be incorporated into the database after verification. Over time, the registry could be upgraded or linked to regional trading platforms to enhance efficiency and market access.

Aligning with International Commitments

Brunei can leverage its international obligations to accelerate carbon market development:

Paris Agreement (NDC & Article 6): Brunei's NDC target of 20% emission reduction by 2030 and net-zero goal by 2050 provide strong motivation for domestic carbon projects. Forest carbon projects can help meet NDC goals or generate credits for international sale. Article 6 participation requires rigorous MRV and transparency – the 'stick' that justifies investing in systems now – while the potential to sell credits abroad serves as a 'carrot,' opening access to climate finance. Aligning domestic rules with Article 6 ensures market readiness and credibility.

Convention on Biological Diversity (CBD): Brunei's CBD commitments, including the Post-2020 Global Biodiversity Framework, emphasise conservation. Carbon projects that also meet biodiversity targets can attract international support or premium buyers. Policies should mandate co-benefit reporting and consider biodiversity-related funding as part of project financing.

ASEAN and Regional Pacts: Brunei's engagement in the ASEAN Agreement on Transboundary Haze and Peatland Management Strategy is directly relevant. Peat protection through carbon projects supports these obligations and enables Brunei to seek technical assistance or co-funding from ASEAN programmes. Participation in BIMP-EAGA offers a platform for regional collaboration, knowledge sharing, and joint initiatives, such as learning from Indonesia's peat restoration or Malaysia's state-level projects. Aligning domestic policies with regional frameworks ensures coherence and maximises technical and financial support.

Learning from Indonesia and Malaysia

Brunei can gain valuable insights from neighbouring countries that are already more advanced in carbon market development.

Indonesia: Indonesia has built a comprehensive system, including carbon pricing rules, forestry regulations, carbon rights linked to land tenure, a national REDD+ registry, and a dedicated climate change agency. It has successfully sold millions of credits and implemented large-scale projects like Katingan. For Brunei, the key takeaways are to clarify ownership early, establish MRV and registry systems before scaling up, and centralise oversight. Adapting parts of Indonesia's regulations can save time and provide tested technical standards.

Malaysia: Malaysia has taken a pragmatic approach, starting with voluntary markets and state-level initiatives. The Bursa Carbon Exchange and pilot auctions show the benefits of testing the market even as policies evolve. By clarifying carbon ownership at the state level and building capacity in parallel, Malaysia has been able to launch projects effectively. Brunei can adopt a similar strategy: begin pilot projects under interim guidelines, coordinate between national and local levels, and continue building technical and institutional capacity alongside policy development.

Summary of Potential Adaptation Measures: Table 7.1 outlines Brunei's primary gaps in forest carbon readiness and identifies corresponding policy solutions. It also highlights lessons from Indonesia and Malaysia, offering practical examples that Brunei can adapt. The table provides a clear, actionable snapshot for policymakers to guide legal, institutional, and technical steps.

Table 7.1. Readiness Gaps vs. Policy Responses (with Regional Examples)

Identified Gap in Brunei	Policy Lever to Address	Relevant Example (Indonesia/Malaysia)
Undefined Carbon Rights – No legal clarity on who owns credits and benefits.	Issue a regulation or law defining carbon rights. Declare State ownership of environmental services with licensed use for projects; set benefit-sharing percentages for locals/developers.	Indonesia: Tied carbon credits to land concession rights explicitly. Malaysia: Sarawak amended forest law to recognise carbon projects and asserted state ownership, with revenue sharing to communities.
Lack of Carbon Trading Rules – No project approval or credit issuance framework.	Develop Carbon Market Regulations under BNCCP Strategy 6. Define project eligibility, approval process (via committee), MRV requirements, registry, trading rules (including Article 6 compliance). Start with voluntary market guidelines if needed.	Indonesia: Presidential Regulation 98/2021 established carbon trading framework, followed by detailed MoEF Regulation 7/2023 for forestry projects. Malaysia: Launched Bursa Carbon Exchange (BCX) for voluntary trading in 2022 while working on a Climate Change Act. Shows value of interim voluntary platform.
Nascent MRV and Registry Capacity – Technical systems not yet in place.	Create a dedicated MRV unit (or empower BCCS/Forestry) to develop project-level MRV protocols (forest carbon inventory, satellite monitoring, verification procedures). Establish a National Carbon Registry (even a simple one) under government custody for transparency. Seek international training and partnerships for MRV development.	Indonesia: Built a national REDD+ registry preventing double counting; developed a Forest Reference Emission Level (baseline) for the country. Malaysia: Set up a Climate Change MRV Centre; participating in World Bank FCPF to build readiness including MRV and reference levels. Both: Used UN and World Bank programmes to get technical support (Brunei can do the same).
Fragmented Roles / No Lead Agency – Unclear governance structure.	Form an official Carbon Steering Committee (multi-agency) under BNCCC for policy coordination. Appoint a Designated National Authority (DNA) for carbon market (e.g. BCCS or Forestry Dept) to serve as one-stop shop for project proponents and international liaison. Clearly delineate roles via a memorandum or policy directive (who approves	Indonesia: Created a Climate Change Directorate in Environment Ministry to centralise REDD+ oversight, simplifying coordination. Malaysia: Uses a top-level Climate Action Council to align federal and state actions. Brunei's smaller government can be even more streamlined – e.g. a single taskforce can report directly to BNCCC (like a mini Climate Council).

Identified Gap in Brunei	Policy Lever to Address	Relevant Example (Indonesia/Malaysia)
	projects, who manages registry, who represents Brunei in int'l transactions).	

Source: ERIA study team, 2025.

Regional Collaboration and Market Linkages

Brunei can also leverage partnerships:

- It could partner with Singapore's Climate Impact X or Malaysia's BCX to list its credits, rather than building its own exchange. This is a quick way to tap into existing trading infrastructure. Singapore, for example, is positioning itself as a carbon trading hub; with proper agreements, Brunei might not need its own exchange.
- Join multilateral programmes: Brunei could participate in the LEAF Coalition, a public-private initiative purchasing REDD+ credits, or the World Bank's upcoming scaling carbon credit fund. These programmes often provide support to help countries prepare for carbon trading.
- Peer learning: Establish a regular exchange – perhaps under BIMP-EAGA or ASEAN – with technical teams from Indonesia, Malaysia, and other countries to share knowledge on forest carbon implementation. This costs little but can greatly accelerate learning and help avoid pitfalls.

In deploying these levers, the strategy is clear: move from intent to implementation by addressing regulatory and capacity gaps, using proven models as a guide. Brunei stands to benefit from being a 'fast follower' – many countries have navigated this path in the last decade, allowing Brunei to cherry-pick best practices and adapt them to its context. The next section lays out a phased Implementation Roadmap, tying these solutions into a time-bound sequence of actions.

7.4. Implementation Pathways: A Phased Roadmap

To operationalise the above strategies, we propose a phased roadmap for Brunei to achieve full readiness and initiate a forest carbon pilot project. This is structured in four phases, reflecting a logical progression from preparation to scaling. The roadmap serves as an actionable pathway for policymakers, breaking the complex process into manageable steps:

Phase 1: Preparation and Design (Year 1: ~2025–2026) – Laying the Groundwork. In this initial phase, Brunei focuses on policy setup and project design:

Secure high-level endorsement: Obtain formal government approval for the forest carbon initiative, such as a BNCCC resolution or Ministerial decree in 2025, to provide political legitimacy and urgency. Simultaneously, establish the Carbon Market Steering Committee (or Taskforce) with representatives from all relevant agencies. This committee will oversee planning, coordinate actions, and ensure alignment across forestry, environment, finance, and legal sectors.

Draft interim guidelines: Develop a draft Carbon Project Regulation or Guideline by late 2025 covering essential rules, including project eligibility, carbon rights (with temporary provisions if legislation is pending), MRV requirements, registry setup, and the approval process. Circulate the draft amongst relevant ministries for review and input, refine it, and ensure it is clear, practical, and implementable.

Stakeholder consultations: Engage early with local stakeholders, particularly in targeted project sites such as Temburong or Belait. Conduct Free, Prior, and Informed Consent (FPIC) consultations to explain the project objectives, address concerns, and collect local knowledge on forest use and management. Early engagement will build support, identify potential conflicts, and help design mitigation measures before project implementation.

Technical project design: Initiate the design of a pilot carbon project by selecting an appropriate carbon standard, such as ART-TREES for a national-scale approach or Verra VCS for a project-level approach. Begin drafting the Project Design Document (PDD), clearly defining project boundaries, baseline scenarios, and additionality justification (using methods from Chapter 5). Outline monitoring plans and safeguards. Engage experts – such as experienced project developers or third-party auditors – to ensure compliance with international standards. Begin setting up the MRV system by gathering historical deforestation data, establishing forest inventory plots, and integrating with Brunei's national GHG inventory.

Policy finalisation: By early 2026, aim to finalise key policy instruments. Adopt a stand-alone Carbon Regulation or guideline – even as an interim measure until formal legislation is passed. Finalise MOUs between the Forestry Department, external partners (universities, NGOs, consultants), and local communities, documenting consent and benefit-sharing arrangements. Establish a basic carbon registry under BCCO or Forestry by mid-2026; even an Excel-based system can track credits initially.

Capacity building and outreach: Launch training programmes for teams implementing and monitoring the project – including rangers, forestry staff, and community members – covering skills such as forest monitoring, fire management, and carbon data collection. Conduct a public awareness campaign to communicate the forest carbon initiative, emphasising that it attracts international investment while Brunei maintains control. Early public buy-in will facilitate smooth implementation.

Validation milestone: By late 2026, the pilot project design should be validated by an independent auditor under the chosen carbon standard, confirming the credibility of the baseline, additionality, and monitoring plans. Domestically, ensure institutional arrangements are operational: the steering committee is active, guidelines issued, registry functioning, and communities informed. By the end of Phase 1, Brunei should be ready to launch field activities.

Phase 2: Pilot Implementation and Initial Credit Issuance (Year 2: ~2027). From Plan to Action, and First Results. With design and frameworks in place, 2027 is about implementing the pilot and issuing the first credits:

Scale-up planning: Using lessons from the 2027 review, finalise strategies for expanding the carbon programme to additional forest areas. Identify priority sites based on carbon potential, community readiness, and ecological value. Update project design documents and MRV systems to accommodate larger areas and multiple project types, ensuring consistency with international standards.

Policy and regulatory strengthening: Amend or finalise legislation and regulations as needed, incorporating insights from Phase 1 implementation. Clarify carbon ownership for long-term leased or privately held plots, refine benefit-sharing frameworks with communities, and strengthen enforcement mechanisms. Ensure that the carbon registry is fully operational and linked to national and regional reporting systems.

Capacity building and institutional support: Expand training programmes for forestry staff, community participants, and technical teams to cover large-scale monitoring, advanced MRV techniques, and safeguards implementation. Strengthen institutional coordination by reinforcing the roles of the steering committee or taskforce and clarifying responsibilities across ministries, local authorities, and community bodies.

Community engagement and livelihoods: Scale up community livelihood initiatives linked to the carbon projects. Introduce new programmes such as value-added forest products, sustainable agriculture, and eco-tourism enterprises. Ensure ongoing FPIC consultations, transparent benefit-sharing, and grievance mechanisms to maintain strong local support and minimise potential conflicts.

Monitoring, verification, and reporting: Expand MRV systems to cover additional sites and activities. Conduct periodic internal and third-party verifications, and integrate data with Brunei's national GHG inventory. Use monitoring reports to track performance, inform policy adjustments, and maintain credibility with international and domestic buyers.

Credit issuance and market development: Issue verified carbon credits for scaled-up projects, maintaining transparent registry records. Explore diverse market opportunities, including international buyers, domestic companies, and voluntary corporate commitments. Use early sales data to refine pricing, promote high-integrity credits, and strengthen Brunei's position as a credible carbon market participant.

Ongoing review and adaptive management: Establish a routine cycle of annual or biannual review sessions with stakeholders. Evaluate successes, challenges, and lessons learned, and update guidelines, training, and operational procedures accordingly. Continuous learning and adaptive management will ensure sustainable growth of the carbon programme and readiness for future phases.

Phase 3: Scale-Up and Integration (Years 3–5: ~2028–2029) – Expanding Impact and Embedding into Policy. In this phase, Brunei moves from a single pilot toward a larger programme and integrates forest carbon into its broader climate strategy:

Expand the project or initiate new ones: If the pilot was successful in year 2, consider expanding its area or replicating additional pilot sites. By 2028, Brunei could explore covering more forest areas under carbon management. This might involve additional community engagements in new districts and possibly partnering with private landowners or companies interested in conservation. Since Brunei's total forest area is not huge (~70% of 5,765 km^2), scaling could mean moving from, say, a 50,000 ha pilot to covering most high-value forests under one programme by 2029. This aligns with maximising both climate and financial benefits.

Strengthen policy into law: Use years 3–5 to draft and enact more permanent legislation if needed. For example, pass the Climate Change Act or amendments that solidify carbon rights and market provisions. The pilot's lessons will inform this – policymakers can now answer: how should we legally define ownership, what institutional structure worked, etc., based on real experience. By 2029, Brunei should have a robust legal framework, not just interim guidelines.

Institutionalise mechanisms: Make permanent the institutional arrangements. If an ad-hoc task force was used, formalise it into a REDD+ Unit or Carbon Unit within the Forestry Department by creating official positions and a dedicated budget for it. Ensure the registry system is upgraded (perhaps move to a secure online platform or adopt a blockchain-based system for transparency). Continue building MRV sophistication – e.g. deploy higher-resolution monitoring or participate in global satellite initiatives. Also, continue staff development – by now Brunei could have certified experts or even its own pool of verifiers.

International positioning: With a track record, Brunei can engage internationally by Year 4–5. For instance, present its results at UNFCCC meetings as an HFLD success case. It could seek a deal under Article 6 with a partner country (similar to how Bhutan or Papua New Guinea have sought). Or join the LEAF Coalition to sell credits to governments/companies that committed to buying from high integrity jurisdictional programmes. Brunei could also explore issuing a small portion of credits into CORSIA (the aviation offset market) if prices are favourable. Essentially, integrate with the global carbon market on Brunei's own terms now that it has something concrete to offer.

Domestic carbon pricing integration: If Brunei implements the planned carbon tax or cap-and-trade for its industries (as hinted in BNCCP Strategy 6), ensure the forest credits can interface with it. For example, allow domestic emitters to use a limited number of Brunei forest credits for compliance. This provides a local demand and keeps revenue internal, while also driving up the value of the credits (compliance markets often pay more than voluntary).

Monitoring and adaptive management: Over years 3–5, continue regular monitoring and verifications (likely generating credits annually or biennially). Check for any leakage or issues and adapt accordingly. By seeing performance over multiple years, Brunei can adjust the baseline if needed for the next period (perhaps making it more conservative if little deforestation occurs, or vice versa if a new threat emerges).

Mid-Point evaluation: Around 2029, conduct a comprehensive evaluation of the programme. Have deforestation rates remained near zero? Are communities satisfied with benefits? What is the financial outcome (credits sold vs. costs)? Bring in an external evaluator if possible to audit the programme's impacts (carbon and co-benefits). This will be valuable for transparency and learning.

Phase 4: Long-Term Consolidation (Post-2030) – Sustaining and Mainstreaming. By 2030 and beyond, the aim is to transition from a 'project' mindset to a permanent, integrated component of Brunei's climate and development strategy:

Institutional mainstreaming: Incorporate the forest carbon programme into national development plans and budgets. It should become a regular programme of the Forestry Department with steady funding (augmented by a share of carbon revenue). Also mainstream into climate reporting – e.g. include the emission reductions in Brunei's NDC achievements (with corresponding adjustments if sold internationally).

Scale nationally or jurisdictionally: Brunei could decide to go full national scale with its forest carbon initiative. This means instead of a project-by-project approach, treat the entire country's forest estate as one programme (often termed a jurisdictional REDD+ programme). By 2030, Brunei can submit a national Forest Reference Emission Level (baseline) to the UNFCCC, covering all its forests. This would enable accessing results-based payments (e.g. the UN's REDD+ finance or Green Climate Fund) directly at national level. Alternatively, Brunei might integrate with ART-TREES as a national participant, producing credits on a national scale. The groundwork laid by the pilot can feed into this – essentially using pilot data to upscale to a national REDD+ strategy.

Policy evolution: By this stage, global contexts might shift (e.g. new rules for carbon markets, higher price on carbon, etc.). Brunei should remain adaptive – update its laws/policies to match best practices. Possibly move from voluntary market orientation to compliance market if a global carbon market under Paris solidifies.

Regional leadership: Brunei can take on a role championing HFLD countries' cause, sharing its success story. It could host regional workshops or lead an ASEAN programme on carbon sequestration given its experience.

Sustainable finance for conservation: Ideally, the carbon initiative yields a steady revenue stream that can fund Brunei's broader conservation and community development efforts. By 2030+, the programme could be generating significant finance (especially if carbon prices rise). Brunei should manage this via a transparent mechanism – e.g. a Conservation Fund where carbon revenues are deposited and allocated to forest management, local communities, and further climate initiatives. This will ensure the longevity and local support for keeping forests standing even beyond the project crediting periods.

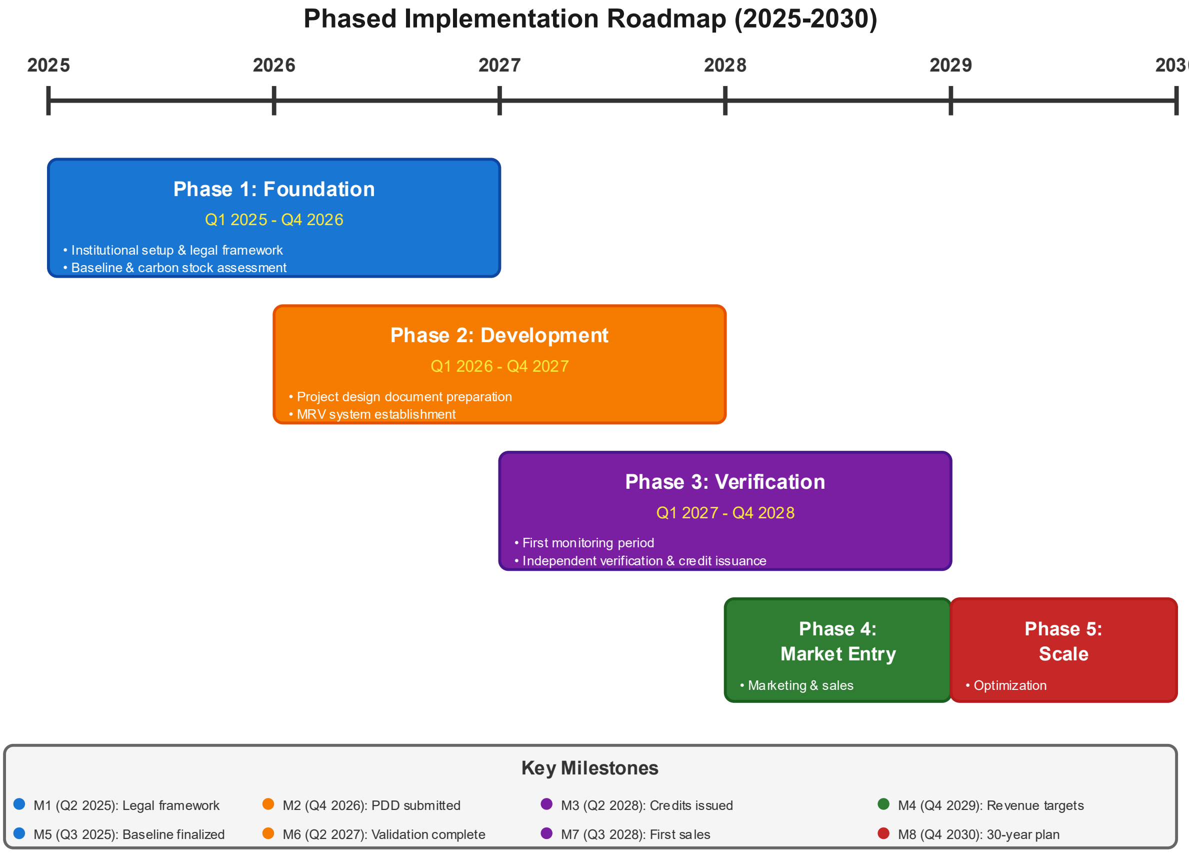
By following this phased approach, Brunei can transition from having virtually no carbon market infrastructure in 2024, to a position by 2030 where it has a fully operational forest carbon programme that contributes to its economy and international climate goals. The roadmap also ensures that integrity and credibility (the focus of Chapter 5) are maintained at each step. Starting small and building up allows for learning and adjustment, reducing risks.

Key Milestones & Pathway Summary:

- 2025: Carbon taskforce formed; pilot project design started; draft regulations issued.
- 2026: Pilot project validated; interim registry and MRV in place; community buy-in secured.
- 2027: First credits issued and sold; proof of concept achieved.
- 2028–29: Policy framework strengthened (possibly via law); project expanded; integration with national systems; multiple verifications completed successfully.
- 2030: Brunei delivering a national-scale programme or ready for one, with long-term mechanisms set; forest carbon is now a mainstream part of Brunei's climate action toolkit.

Throughout these phases, regular monitoring, reporting, and stakeholder engagement are essential to maintain momentum and trust. Figure 7.1 could illustrate this timeline of actions and milestones, helping communicate the plan to high-level decision-makers:

Figure 7.1. Phased Implementation Timeline – Notional figure



Source: ERIA study team, 2025.

A timeline graphic would show Year 1: Setup tasks; Year 2: Pilot operations and credits; Years 3–5: scaling activities; Year 5+: consolidation. This helps ensure everyone has a common understanding of the path forward.

Conclusion

By addressing institutional gaps with targeted policy levers and following a clear implementation roadmap, Brunei can rapidly enhance its readiness for forest carbon markets. The diagnostic in this chapter makes it evident that while Brunei starts from a strong foundation of political will and forest protection, the machinery to mobilise carbon finance needs to be built. The experiences of Indonesia and Malaysia reassure us that this is feasible within a few years, especially given Brunei's smaller scale and capacity to act decisively.

For the Brunei Forestry Department and its partners, the immediate next steps are finalising the necessary regulations and institutional arrangements, securing leadership buy-in, and launching the pilot project development.

7.5. Implementation Roadmap and Timeline

7.5.1. Phase 1: Foundation (2026–2027)

Year 1 Activities:

- Finalise Project Design Document
- Complete validation and registration processes
- Conduct initial site preparation (2,000 ha)
- Deploy MRV system (Phase 1)
- Intensify community engagement initiatives

Investment Required: $3.2 million (49% of total project costs).

This foundational phase establishes the technical, regulatory, and community framework, ensuring the project is ready for full-scale implementation while building early stakeholder confidence.

7.5.2. Phase 2: Implementation (2028–2030)

Scaling Activities:

- Execute full-scale restoration across project sites
- Complete MRV system activation for comprehensive monitoring
- Conduct stakeholder capacity building to strengthen local engagement
- Achieve first verification and credit issuance (2030)
- Advance market positioning and buyer development

Investment Required: $2.1 million (32% of total project costs)

This implementation phase transitions the project from foundational setup to full operational scale, delivering tangible carbon outputs and establishing market credibility.

7.5.3. Phase 3: Operations (2031–2055)

Maintenance and Optimisation:

- Conduct ongoing monitoring and verification to ensure carbon integrity
- Implement adaptive management to respond to environmental and operational changes
- Oversee credit issuance and sales to maintain revenue streams
- Expand co-benefits programme for communities and ecosystems
- Facilitate knowledge transfer and replication for future landscape-scale projects

Investment Required: US $1.2 million (19% of total project costs)

This operational phase ensures long-term sustainability, optimises carbon and co-benefit outcomes, and secures consistent financial returns over the project's lifetime.

7.6 . Policy and Institutional Framework Requirements

7.6.1. Regulatory Infrastructure Development

Essential Policy Components:

- Establish a national carbon credit ownership framework
- Define clear MRV standards and protocols
- Implement benefit-sharing regulations
- Set up mechanisms for international carbon transfer
- Develop robust registry and tracking systems

Implementation Support Requirements:

- Deliver technical capacity building programmes for stakeholders
- Strengthen institutional coordination mechanisms
- Establish stakeholder engagement protocols for transparency
- Apply quality assurance frameworks for credible outcomes
- Drive market development initiatives to support demand and uptake

These frameworks are critical to ensure the project operates within a secure legal and institutional environment, enhancing credibility, market access, and long-term sustainability.

7.6.2. International Alignment

Paris Agreement Compliance:

- Prepare for participation in Article 6 mechanism
- Establish corresponding adjustments procedures for cross-border credit integrity
- Integrate project outcomes with NDCs
- Strengthen international cooperation frameworks for climate action
- Ensure robust transparency and reporting systems

Aligning with international standards enhances the project's credibility, enables participation in global carbon markets, and ensures compliance with evolving climate policies.

7.6.2.1 COP 30 - Forward-Looking Policy Recommendations for Brunei's Peatland Carbon Strategy

Article 6 Cooperation and HFLD Baselines

COP30 further clarified many Article 6 rules but left key questions for HFLD countries. The meeting adopted further guidance on Article 6.2 'initial reports' and review processes and foundational standards for Article 6.4 (the Paris carbon crediting mechanism) on baselines, additionality, leakage, and non-permanence. In practice, this means any Brunei carbon project must rigorously follow the new article 6.4/PACM methodology rules.

Crucially for Brunei's High Forest, Low Deforestation (HFLD) context, technical experts at COP30 noted it remains 'contentious' whether HFLD baselines can meet the requirement of a below-business-as-usual scenario. In other words, Brunei must use conservative, science-based baselines (e.g. modeling hypothetical deforestation) when claiming avoided emissions.

Engaging buyers in Article 6.2 deals will require transparent corresponding adjustments to prevent double-counting of credits. For Article 6.4, COP30 decisions encouraged planning nature-based removals (including peat restoration), since removals were confirmed eligible under the new mechanism – but with strict rules. Brunei should prepare to meet the new permanence standards (buffers, long-term monitoring) as outlined by COP30, ensuring that any peatland credit issued is truly additional and durable.

Global Stocktake and Nature-Based Solutions

COP30's outcomes built on the first Global Stocktake (completed at COP28), which heavily emphasised forests and ecosystems. The stocktake 'emphasizes the importance of conserving, protecting and restoring nature and ecosystems [...] including halting and reversing deforestation and forest degradation by 2030'. By UNFCCC rule, Parties' NDCs must be informed by these stocktake findings.

For Brunei, this means explicitly integrating peatlands – a major tropical forest type in the country – into its climate commitments. Peat swamp forests are amongst Brunei's largest carbon reservoirs and biodiversity hotspots; intact peat forests 'sequester carbon more efficiently than secondary forests'. Therefore, Brunei should revise its NDC and associated policies to include quantitative targets or strategies for peatland conservation and restoration, aligning with the stocktake's call for full land-sector mitigation. Incorporating peatland measures (e.g. wetland protection, reforestation of drained peat areas) directly responds to the Global Stocktake's nature-focus and positions Brunei to claim climate co-benefits from its conservation of these ecosystems.

Strengthening Peatland MRV and Transparency

COP30 underscored that 'we cannot manage what we don't measure.' In fact, the multilateral development banks at COP30 launched new guidance urging projects to 'strengthen monitoring and verification systems with traceability and community participation'.

Brunei must heed this by investing in robust MRV infrastructure for peatland carbon. This includes building on IPCC wetlands guidelines and UNFCCC reporting frameworks to accurately inventory peat GHG fluxes (CO_2 and methane), tracking land-use change, and detecting peat fires. Practical steps include installing water-table sensors, enhancing fire-alert systems, and using high-resolution satellite mapping of peatland hydrology. Data from these systems should feed into Brunei's national GHG inventory under the Transparency Framework (Article 13) to ensure clarity and credibility.

In short, COP30's emphasis on MRV/Transparency means Brunei should develop a peatland MRV system that meets international standards, enabling confident reporting of any carbon credits generated from peat projects.

Accessing High-Integrity Carbon Markets

The COP30 'Belem Package' gave a clearer framework for carbon markets, which Brunei can use to access finance. For example, COP30 decisions give increased 'certainty for planning Article 6.2 deals and PACM-eligible activities, with clearer requirements for reporting, methodologies, and treatment of long-lived storage'. Brunei should position itself to issue high-quality A6.4 emission reductions (A6.4ERs) for approved peatland projects under the new Paris carbon market once methodologies (e.g. peatland restoration) are finalised.

On the Article 6.2 side, Brunei can explore bilateral credit agreements (e.g. with countries seeking offsets) but must ensure corresponding adjustments. Importantly, high-integrity markets demand strict safeguards. COP30 reinforced that credits must meet robust additionality and permanence criteria. Brunei should adopt institutional safeguards (such as clear land tenure for peat and legally binding community agreements) so that projects qualify under Article 6 rules and voluntary standards. For example, the Article 6.4 decision 'requests the Supervisory Body to facilitate the engagement of Indigenous Peoples and local communities' in carbon projects. Brunei's peat carbon strategy should therefore include genuine benefit-sharing and consultation with local and indigenous communities, aligning with both UNFCCC guidance and voluntary market expectations. By doing so, Brunei can access premium markets for 'high-integrity' carbon credits while maintaining social and environmental safeguards.

Aligning with REDD+ and Jurisdictional Standards

COP30 spotlighted new approaches to REDD+. In Belém, countries launched the Scaling J-REDD+ Coalition to build a global market for jurisdictional forest credits. This international alliance 'aims to create a stable market for high-integrity jurisdictional forest carbon credits' and to mobilise roughly \$3–6 billion per year by 2030. It brings together tropical forest governments (Guyana, Ghana, Ethiopia, etc.), donors (Singapore, Norway, UK), Indigenous groups and credit platforms (ART, Verra, Emergent, etc.). Brunei should explore joining or aligning with these emerging frameworks. For instance, adopting jurisdiction-wide REDD+ programmes (rather than small isolated projects) can meet the Coalition's quality benchmarks and attract scale finance. Brunei can also keep pace with new jurisdictional credit standards (like ART/LEAF guidance) and voluntary integrity initiatives (e.g. ICVCM Core Carbon Principles). Early alignment will ensure that any future Brunei REDD+ or peat-based credits qualify as 'high-integrity' under the evolving market standards championed at COP30.

Ensuring Permanence and Reversal Management

COP30 formalised the treatment of permanence (reversal risk) in carbon projects. Specifically, negotiators endorsed a new non-permanence standard under the Article 6.4 mechanism (agreed in October 2025) and signalled that detailed rules on buffers and long-term monitoring will be further refined.

This means any Brunei project must plan for very long time horizons. In practical terms, peatland projects should include permanence strategies such as legal protections on hydrology (e.g. maintaining high water tables), fire prevention programmes, and community-based stewardship agreements. A fraction of credits should be set aside in buffer pools to guard against any unexpected carbon loss. Brunei may also consider long-term financing mechanisms (such as trust funds or insurance) to back up project longevity. By internalising these COP30-guided practices on reversals, Brunei will meet UNFCCC requirements and reassure buyers of the credits' durability.

Integrating Peatlands into NDCs and Long-Term Plans

Finally, in line with the Global Stocktake, Brunei's next NDC should explicitly integrate peatland actions. The stocktake's emphases on forests and ecosystems imply that countries need more comprehensive land-use targets.

Brunei can reflect this by adding peat-specific commitments (for example, quantitative targets to avoid X ha of peatland conversion, or reduce peat CO_2 emissions by Y $MtCO_2$) and by linking adaptation actions (like peat fire management) with mitigation. Doing so aligns with the Paris Agreement's Article 5 on conservation and also opens doors to results-based finance (for example, payments under REDD+ or bilateral aid for forest protection). Embedding peatland conservation in the NDC – supported by the MRV and institutional measures above – will signal Brunei's commitment to nature-based solutions and help achieve both climate and biodiversity goals, as COP30's discussions have underscored.

In summary, Brunei's peatland carbon strategy should actively incorporate COP30 outcomes: it must adapt to the evolving Article 6 frameworks (with clear baselines and permanence buffers), build transparent MRV systems, and position projects to meet high-integrity market criteria. Emphasising peatland protection in NDCs and joining emerging REDD+ alliances will align Brunei with the global push for nature-based mitigation. These steps – informed by the latest UNFCCC guidance – will maximise Brunei's readiness to attract international carbon finance while safeguarding the long-term integrity of its peat ecosystems.

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Appendix A1 – Peat Swamp Forest Estimation Methodology

Forest Diversities

Diversity Index refers to the variety and variability of plant life within forest ecosystems. It's a key component of biodiversity and plays a vital role in ecosystem health, resilience, and function. Here are six indices commonly used to assess vegetation diversity in forests.

1) Species Richness (N) is one of the simplest yet most powerful measures of biodiversity. It refers to the number of different species present in each area, ecosystem, or community – regardless of the number of individuals of each species.
2) Shannon Diversity Index (H') – also known as the Shannon-Wiener or Shannon-Weaver Index – is a widely used metric in ecology to quantify biodiversity by considering both species richness and species evenness.

   $H' = -\sum_i^S pi\ \ln(pi)$ .... (0-1)

3) Effective species (S) is a concept used in biodiversity studies to translate diversity indices – like the Shannon or Simpson index – into a more intuitive number: the 'effective number of species.'

   $Es = \exp(H')$ .... (0-2)

4) Simpson Diversity Index (D) is a powerful ecological metric that captures both species richness and dominance in a community. Unlike Shannon's index, Simpson's gives more weight to common or dominant species, making it especially useful for understanding how balanced – or skewed – a forest ecosystem is.

   $D = \sum_i^S pi^2$ .... (0-3)

5) Pielou's Evenness Index (denoted as J') is a measure of how evenly individuals are distributed across the species in a community. It complements species richness by showing whether species are equally abundant or if a few dominate.

   $J' = \frac{H'}{\ln(S)}$ .... (0-4)

6) Margalef's Richness Index is a biodiversity metric that adjusts species richness based on sample size, making it especially useful when comparing ecosystems with different numbers of individuals surveyed.

$$e = \frac{S-1}{\ln(N)} \quad \text{(0-5)}$$

Source: ERIA study team, 2025.

Figure A1 present the results of diversity index calculations in the CFI Plot. In general, this plot contains a variety of tree species, with no single species dominating over the others. The indicators are as follows:

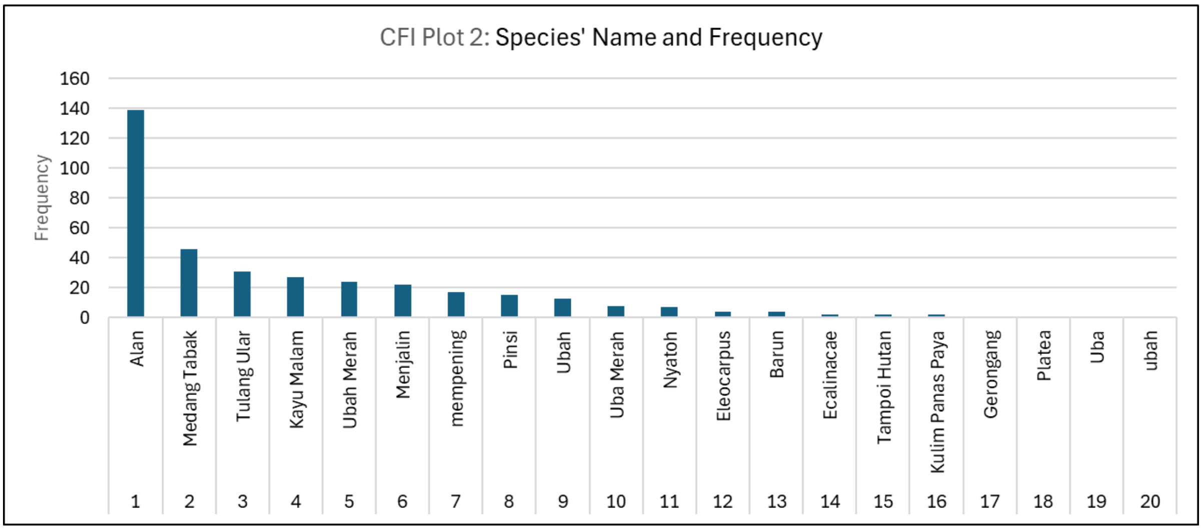
1) **Species Richness of 27**, there are distinct species identified within the surveyed plot or area, which reflects the variety of plant life and contributes to the overall ecological health and resilience of the forest ecosystem.
2) **Shannon Diversity Index of 2.263** indicates a **moderate to high level of diversity**: it means that the forest community contains a variety of species, and their populations are relatively well-balanced rather than dominated by just a few species.
3) **Effective species of 9.611** means that the diversity and evenness of the forest community are equivalent to having about **9.6 equally common species**, even if the actual number of species (species richness) is higher or lower.
4) **Simpson's Diversity Index of 0.823** suggests that the forest community is **quite diverse**, with no single species dominating the ecosystem. This means that most individuals are spread relatively evenly across many species, which is a sign of a healthy and resilient ecosystem.
5) **Pielou's Evenness Index of 0.687** suggests a **moderately even distribution**: most species in the forest plot have relatively similar numbers of individuals, but there is still some dominance by certain species. This level of evenness supports ecosystem stability and resilience, as it indicates that no single species overwhelmingly dominates the community.
6) **Margalef's Richness Index of 4.389** indicates a relatively **high level of species richness** in the surveyed area, accounting for the total number of species and the number of individuals sampled. Higher values reflect greater biodiversity, while lower values suggest fewer species relative to the sample size.

Table A1. Number of Trees and Diversity Indices in the CFI Plot 2

No	Diversity Indices	Value	Note	Percent	Top 20th	Shannon DI		Simpson DI		Pielou DI
						pi	ln (pi)	ni-1	ni(ni-1)	N(N-1)
0	Number of Plants (N)	374			361					
1	Species Richness (S)	27			15					
2	Shannon Diversity (H')	2.263	High							
3	Effective Species (Es)	9.611	High							
4	Simpson Diversity (D)	0.823	High							139,502
5	Pielou's Evenness (J')	0.687	Mod							
6	Margalef Richness €	4.389	High		98.1%					
No	Plant Names	SUM								
1	Alan	139		37.2%	37.2%	0.372	-0.990	138	19182	0.138
2	Medang Tabak	46		12.3%	12.3%	0.123	-2.096	45	2070	0.015
3	Tulang Ular	31		8.3%	8.3%	0.083	-2.490	30	930	0.007
4	Kayu Malam	27		7.2%	7.2%	0.072	-2.628	26	702	0.005
5	Ubah Merah	24		6.4%	6.4%	0.064	-2.746	23	552	0.004
6	Menjalin	22		5.9%	5.9%	0.059	-2.833	21	462	0.003
7	mempening	17		4.5%	4.5%	0.045	-3.091	16	272	0.002
8	Pinsi	15		4.0%	4.0%	0.040	-3.216	14	210	0.002
9	Ubah	13		3.5%	3.5%	0.035	-3.359	12	156	0.001
10	Uba Merah	8		2.1%	2.1%	0.021	-3.845	7	56	0.000
11	Nyatoh	7		1.9%	1.9%	0.019	-3.978	6	42	0.000
12	Eleocarpus	4		1.1%	1.1%	0.011	-4.538	3	12	0.000
13	Barun	4		1.1%	1.1%	0.011	-4.538	3	12	0.000
14	Ecalinacae	2		0.5%	0.5%	0.005	-5.231	1	2	0.000
15	Tampoi Hutan	2		0.5%	0.5%	0.005	-5.231	1	2	0.000
16	Kulim Panas Paya	2		0.5%	0.5%	0.005	-5.231	1	2	0.000
17	Gerongang	1		0.3%	0.3%	0.003	-5.924	0	0	0.000
18	Platea	1		0.3%	0.3%	0.003	-5.924	0	0	0.000
19	Uba	1		0.3%	0.3%	0.003	-5.924	0	0	0.000
20	ubah	1		0.3%	0.3%	0.003	-5.924	0	0	0.000
21	Nyatoh Ketiau	1		0.3%		0.003	-5.924	0	0	0.000
22	Perious	1		0.3%		0.003	-5.924	0	0	0.000
23	Semundu	1		0.3%		0.003	-5.924	0	0	0.000
24	Medang Ketup	1		0.3%		0.003	-5.924	0	0	0.000
25	Mempening	1		0.3%		0.003	-5.924	0	0	0.000
26	Rambutan	1		0.3%		0.003	-5.924	0	0	0.000
27	Sterculia	1		0.3%		0.003	-5.924	0	0	0.000

Source: ERIA study team, 2025.

Figure A1. Top 20th of the Species and their Frequency



Source: ERIA study team, 2025.

Important Values

The Important Value (IV) consists of:

1) Relative Density (KR) – Proportion of individuals of a species compared to the total number of individuals of all species.
2) Relative Frequency (FR) – How often a species occurs across sample plots relative to all species.
3) Relative Dominance (DR) – Usually based on basal area (for trees) or canopy cover, indicating how much space a species occupies.

Table A2 and Figure A2 present the results of the Importance Values calculations in the CFI Plot 2. The Alan tree, with 139 individuals out of a total of 374 trees, has the highest Importance Value (125.0%), followed by the Medang Tabak tree (18.6%). Overall, this plot has:

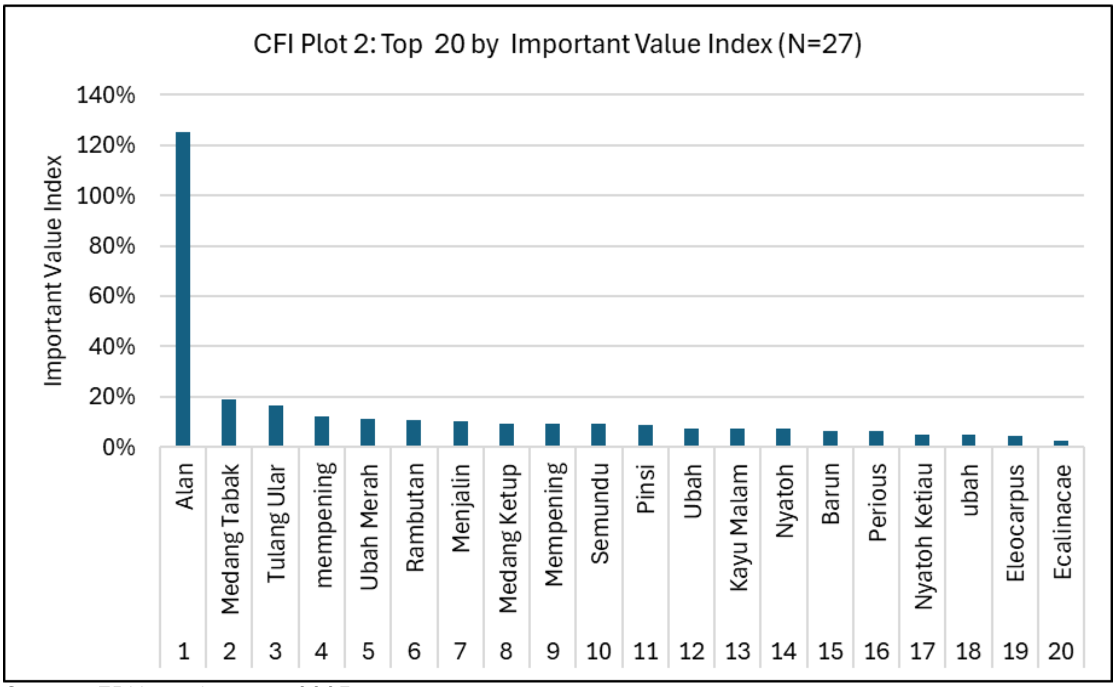
1) Basal area 38.901 means that the sum of the cross-sectional areas of all trees in one hectare of forest, the total is 38.901 square meters.
2) Individual Density 1,202.6 means that, on average, there are approximately 1,203 individual trees in each hectare of the surveyed forest plot.

Table A2. Importance Value Index in the CFI Plot 2.

No	Species	Tree	Mean	BA	Individual	Relative	Frequency	Relative	Dominant	Relative	Important
			DBH (cm)	m2/ha	Density	Density		Frequency		Dominance	Value
		F			K=F/BA	KR=Ki/∑Ki	F	FR=Fi/∑Fi	D=BA	DR=Di/∑Di	IV=KR+FR+DR
		374		38.901	1202.6	100%	374	100%	38.901	100%	300%
1	Alan	139	54.60	34.04	4.1	0.34%	139	37.2%	34.039	87.5%	125.0%
2	Medang Tabak	46	18.70	1.42	32.4	2.70%	46	12.3%	1.418	3.6%	18.6%
3	Tulang Ular	31	12.00	0.36	86.1	7.16%	31	8.3%	0.360	0.9%	16.4%
4	Kayu Malam	27				0.00%	27	7.2%	0.000	0.0%	7.2%
5	Ubah Merah	24	17.30	0.63	37.9	3.15%	24	6.4%	0.634	1.6%	11.2%
6	Menjalin	22	18.90	0.65	33.6	2.80%	22	5.9%	0.654	1.7%	10.4%
7	mempening	17	11.90	0.19	87.6	7.29%	17	4.5%	0.194	0.5%	12.3%
8	Pinsi	15	15.50	0.32	47.4	3.94%	15	4.0%	0.316	0.8%	8.8%
9	Ubah	13	22.70	0.39	33.6	2.79%	13	3.5%	0.387	1.0%	7.3%
10	Uba Merah	8				0.00%	8	2.1%	0.000	0.0%	2.1%
11	Nyatoh	7	14.20	0.12	58.6	4.87%	7	1.9%	0.120	0.3%	7.0%
12	Eleocarpus	4	17.20	0.10	39.1	3.25%	4	1.1%	0.102	0.3%	4.6%
13	Barun	4	14.10	0.06	62.0	5.16%	4	1.1%	0.065	0.2%	6.4%
14	Ecalinacae	2	25.80	0.10	19.1	1.59%	2	0.5%	0.105	0.3%	2.4%
15	Tampoi Hutan	2				0.00%	2	0.5%	0.000	0.0%	0.5%
16	Kulim Panas Paya	2				0.00%	2	0.5%	0.000	0.0%	0.5%
17	Gerongang	1	55.50	0.24	4.1	0.34%	1	0.3%	0.242	0.6%	1.2%
18	Platea	1	39.30	0.12	8.2	0.69%	1	0.3%	0.121	0.3%	1.3%
19	Uba	1	27.00	0.06	17.5	1.45%	1	0.3%	0.057	0.1%	1.9%
20	ubah	1	15.60	0.02	52.4	4.35%	1	0.3%	0.019	0.0%	4.7%
21	Nyatoh Ketiau	1	15.30	0.02	54.3	4.52%	1	0.3%	0.018	0.0%	4.8%
22	Perious	1	13.20	0.01	73.0	6.07%	1	0.3%	0.014	0.0%	6.4%
23	Semundu	1	10.90	0.01	107.5	8.94%	1	0.3%	0.009	0.0%	9.2%
24	Medang Ketup	1	10.80	0.01	108.7	9.04%	1	0.3%	0.009	0.0%	9.3%
25	Mempening	1	10.80	0.01	108.7	9.04%	1	0.3%	0.009	0.0%	9.3%
26	Rambutan	1	10.00	0.01	126.6	10.53%	1	0.3%	0.008	0.0%	10.8%
27	Sterculia	1				0.00%	1	0.3%	0.000	0.0%	0.3%

Source: ERIA study team, 2025.

Figure A2. Top 20th of the Importance Value Index in the CFI Plot 2



Source: ERIA study team, 2025.

Tree Biomass and Carbon

Tree Height and Diameter

Figure A3 to Figure A8 present the relationship between DBH and total plant height (H1) and plant height to the first branch (H2), as well as the relationship between H1 and H2 at three PSF locations, namely Badas (Figure A3 and Figure A4), SgMau (Figure A5 and Figure A6), and TgMaya (Figure A7 and Figure A8). The allometric model used to estimate H from DBH is as follows:

$$\mathrm{H} = \mathrm{a}\ln(\mathrm{DBH}) - \mathrm{b} \quad \text{.......} \quad (0\text{-}6)$$

In which the values of a and b, as well as R^2, are shown in the figures. The allometric model produces an R^2 value that is not very large but is representative enough to show the closeness of the relationship between H and DBH. Furthermore, the relationship between H1 and H2 is a linear equation as follows:

$$\mathrm{H2} = \mathrm{aH1} \quad \text{.......} \quad (0\text{-}7)$$

As a general overview, there are significant differences in tree size and height amongst the three locations. Trees in Badas are larger (DBH) and taller (H) than those in the other two locations. The diameter and height of trees in Badas reach 80 cm and exceed 80 m, respectively. Meanwhile, the diameter and height of trees in SgMau are around 80 cm and 60 m, while in TgMaya, only around 60 cm and 40 m. This shows that the thickness of land cover in this PSF is spatially heterogeneous.

Figure A3. Height versus DBH in Badas.

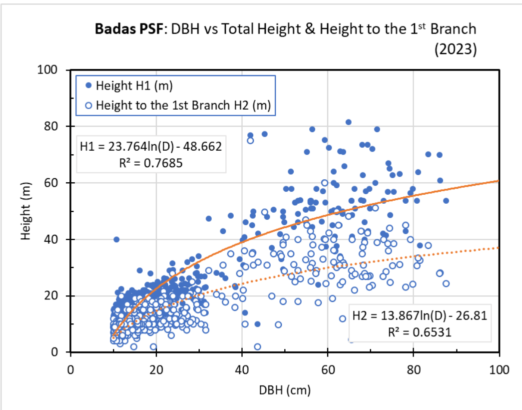


Figure A4. Height Relation in Badas.

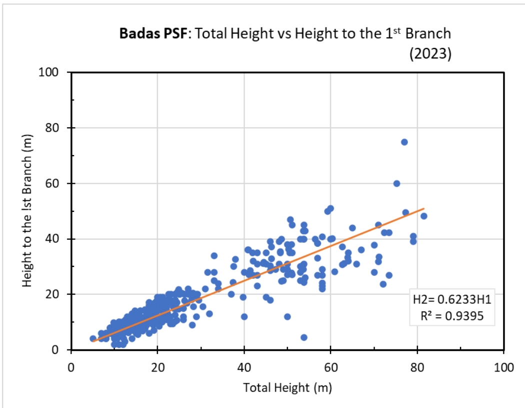


Figure A5. Height versus DBH in SgMau

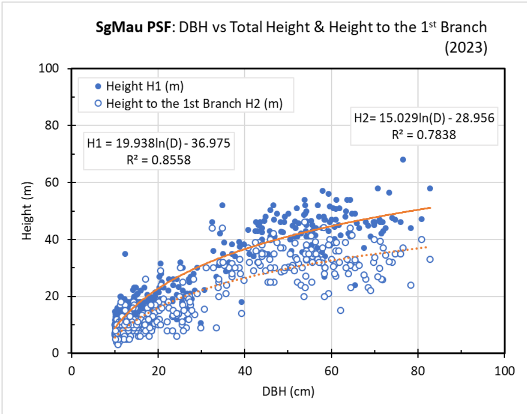


Figure A6. Height Relation in SgMau

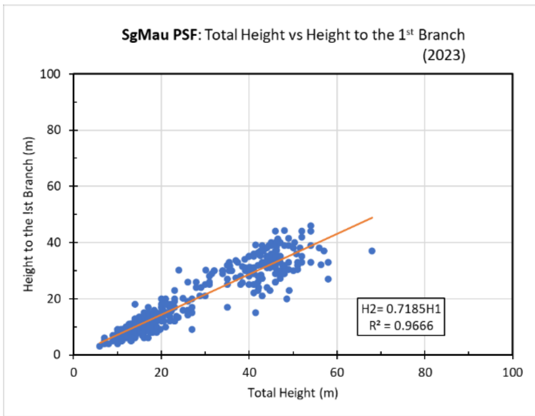


Figure A7. Height versus DBH in TgMaya

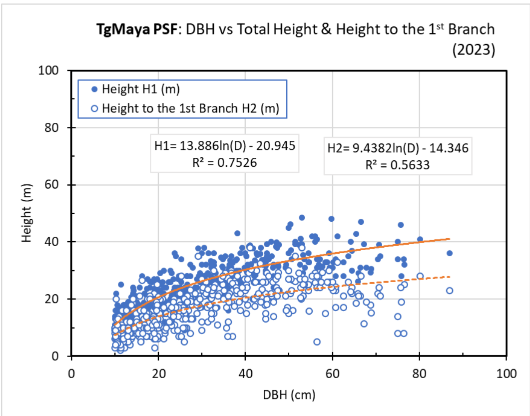
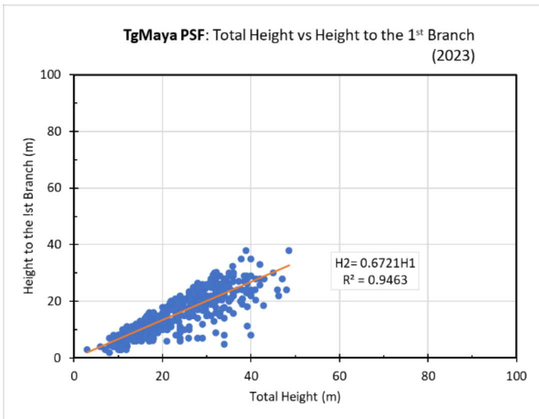


Figure A8. Height Relation in TgMaya



Source: ERIA study team, 2025.

Estimation of the Biomass and Carbon Density

Table A3 presents the ABG biomass and carbon density at Badas, Sg. Mau and Maya are based on the calculation results and estimates by the Istomo model and the Ujang model as shown below. Badas has the highest biomass and carbon content compared to the other two locations. Overall, in Beliat PSF, the carbon content is 222.35 tC/ha based on sample data, while the Istomo model estimates 242.46 tC/ha, and the Ujang model estimates 356.72 tC/ha.

Istomo model:

$AGB=0.0145\ D^3-0.4659\ D^2+30.64\ D-263.32$; $BGB=0.201\ AGB$; D=DBH (cm) ....(0-8)

Ujang model):

$AGC=0.087\ D^{2.47}$ (kg); D=DBH (cm) ....(0-9)

Table A3. ABG Biomass and Carbon, and Compared with Two Other Methods.

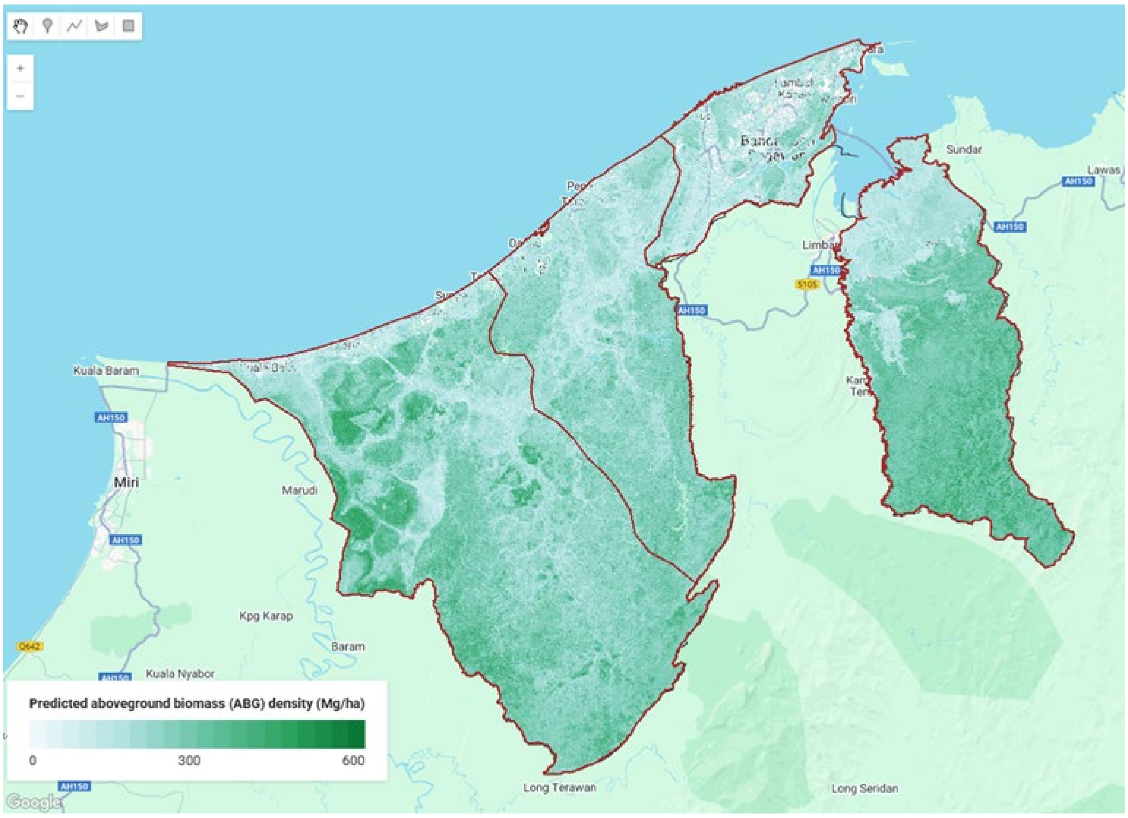
Plots	Data (2024)				Istomo (2006)				Ujang et al (2012)			
	Biomass (t/ha)			Carbon (tC/ha)	Biomass (t/ha)			Carbon (tC/ha)	Biomass (t/ha)			Carbon (tC/ha)
	AG	BG	Total	Total	AG	BG	Total	Total	AG	BG	Total	Total
1. Badas	502.6	101.0	603.6	283.70	488.7	98.2	586.9	275.85	690.1	138.7	828.8	389.53
2. Sg. Mau	385.6	77.5	463.1	217.65	376.8	75.7	452.5	212.69	601.4	120.9	722.2	339.46
3. Sg. Maya	293.5	59.0	352.5	165.70	423.1	85.1	508.2	238.85	604.4	121.5	725.9	341.18
Average				222.35				242.46				356.72

Note:
AGB=0.0145 D^3-0.4659 D^2+30.64 D-263.32; BGB=0.201 AGB; D=DBH (cm) (Istomo, 2006)
AGC=0.087 $D^{2.47}$ (kg); D=DBH (cm) (Ujang et al, 2012)
Source: ERIA study team, 2025.

Spatial Distribution of the Biomass and Carbon Density

Previous estimates of ABG biomass were based only on limited data or the area of sampling. Tree types and sizes naturally vary and are spatially distributed. Based on Remote Sensing data in 2024 with a resolution of 100 m, the distribution of carbon content was obtained as presented in Figure A9and Table A4. The total carbon content was only 58,580 MtC with a density value of 92.06 tC/ha, which was much lower than the previous calculation. The peatland itself contained 11,605 MtC (19.8%) with a density value of 104.5 tC/ha.

Figure A9. **Estimated** AG Biomass Density based on RS data of 100 m in 2024



Source: ERIA study team, 2025.

Table A4. Estimated AG Carbon in Different Land Types (2024)

No	Land Types	Total (MtC)	Percent (%)	Area (ha)	Density (tC/ha)
1	Mixed Dipterocarps	32.373	55.3	270,957	119.5
2	Peat Swamp Forest	11.605	19.8	111,087	104.5
3	Non-Forest	11.225	19.2	157,192	71.4
4	Montane Forest	1.016	1.7	7,373	137.9
5	Heath forest (Kerangas)	0.859	1.5	8,684	98.9
6	Freshwater Swamp Forest	0.808	1.4	9,944	81.3
7	Mangrove Forest	0.694	1.2	12,383	56.1
Total/Average		58.580	100.0	577,620	92.06

Note:
AG: Above Ground.
Carbon Fraction 0.47, the IPCC Default Value.
Source: ERIA study team, 2025.

Changes of Biomass and Carbon

Naturally, ABG biomass is highly dependent on land cover conditions. Land cover changes from year to year tend to vary due to many factors, such as the collapse of old trees, changes in land use, forest fires, and so on. Based on RS data for the 2019-2024 period, Table A5 presents an estimate of AG and BG biomass and carbon, and their changes.

Table A5. Changes of ABG Biomass and Carbon

Year	Above Ground			Below Ground		
	Biomass (Mt)	Carbon (MtC)	Changes (MtC/y)	Biomass (Mt)	Carbon (MtC)	Changes (MtC/y)
2019	112.162	52.716		26.918	12.651	
2020	116.505	54.757	2.041	27.961	13.141	0.489
2021	117.460	55.206	0.448	28.190	13.249	0.107
2022	116.831	54.910	-0.295	28.039	13.178	-0.070
2023	124.966	58.734	3.823	29.992	14.096	0.917
2024	125.024	58.761	0.027	30.005	14.102	0.006

Note:
ABG: Above and Below Ground
Root-to-Shoot ratio 0.24 for tropical forests.
Carbon Fraction 0.47, the IPCC Default Value.
Source of figure: ERIA study team, 2025.

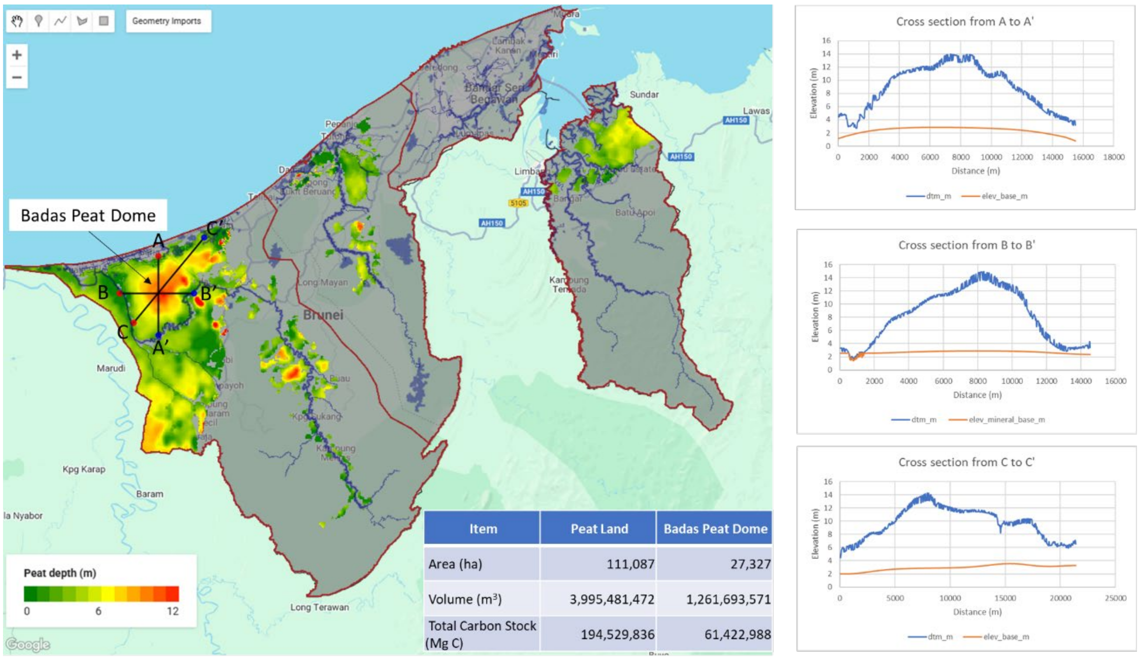
In general, changes in land cover result in positive changes in biomass and carbon change, except for the 2021-2022 period, which has a negative value, indicating that forest fires have occurred. After that, the changes in biomass and carbon change rose again and then tended to stabilize at around 0.027 MtC/y for AGB and 0.006 MtC/y for BGB. Here, the BGB/AGB ratio uses a constant of 0.24 and Carbon/Biomass of 0.47.

Peat Carbon Stock

Spatial Peat Depth and Carbon Stock

Naturally, the depth or thickness of peat in peatlands varies spatially and has a highest point called a peat dome. Based on RS data from some sources, peat domes have been identified in Belait, as shown in Figure 0-10 below. The largest peat dome is in the west, covering an area of approximately 27,327 ha with a volume of 1.261 million ha and a carbon content of around 61 MtC. Its height varies spatially, with the highest peak reaching 14 m above sea level. Using this map, the Beliat PSF covers 111,087 ha with a total peat volume of 3.995 billion m^3 containing carbon about 194.5 MtC.

Figure A10. Spatial Distribution of the Peat Depth



Item	Peat Land	Badas Peat Dome
Area (ha)	111,087	27,327
Volume (m^3)	3,995,481,472	1,261,693,571
Total Carbon Stock (Mg C)	194,529,836	61,422,988

Source of figure: ERIA study team, 2025.

The 2024 report, based on measurements taken from 30 plots comprising 270 and 120 data points, showed that the peat depth was 437 ± 183 cm (Figure A11) and the peat volume per area was 4.127 ± 1.482 m^3/m^2 or 41,266 ± 14,824 m^3/ha (Figure A12).

Figure A11. Peat Depth Distribution

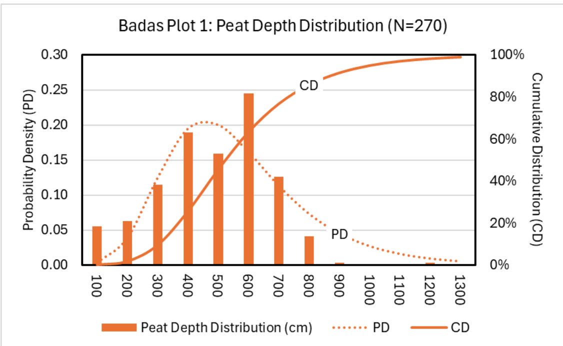
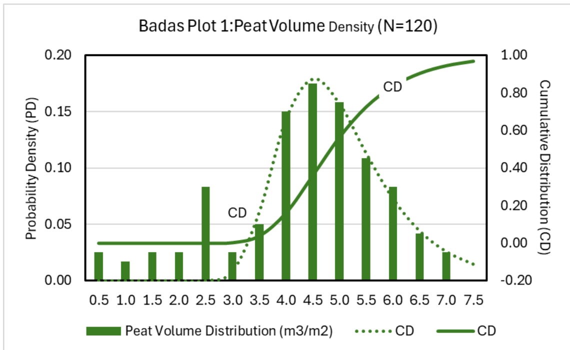


Figure A12. Peat Volume Distribution



Source: ERIA study team, 2025.

Peat Bulk Density

The peat bulk density (BD) commonly depends on the maturity of the peat, classified as Sapric, Hemic, or Fibric. Sapric, which is the most mature and compacted, has the highest bulk density, followed by hemic and fibric. Here in the Beliat, the peat BD sampled from

31 points at three sites was 0.027 ± 0.013 g/cm^3. Based on this range, it can be confirmed that the peat falls within the range of values for Fibric: 0.10 ± 0.06 g/cm^3 [7]. The DB decreases with depth as shown by Figure 0-13 and its distribution appears in Figure A14.

Figure A13. Bulk Density with Depth

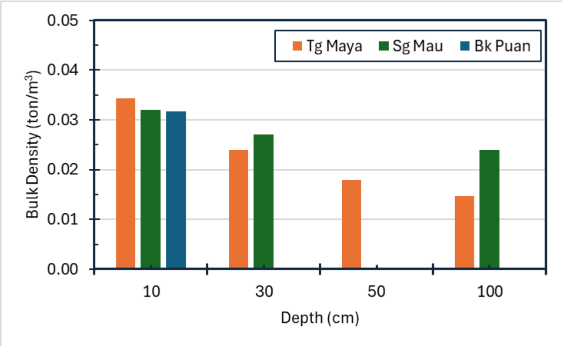
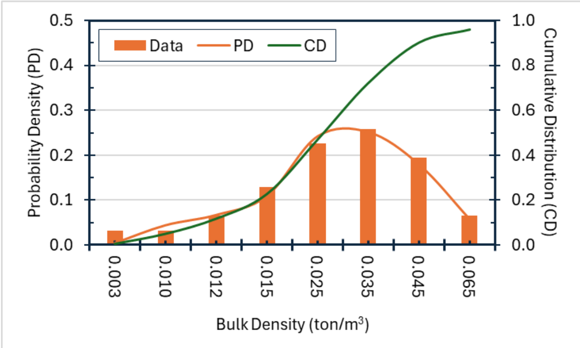


Figure A14. Bulk Density Distribution



Source: ERIA study team, 2025.

While other sources reported the bulk density in the Belait and Ulu Mendaram up to 140 cm-depth was 0.089 ± 0.032 g/cm^3, and along the Seria By-Pass Road in the Badas peatland was 0.069 ± 0.016 g/cm^3. These relatively low bulk densities confirm that the peat is classified as Fibric type.

Peat Carbon Stock

The peat carbon content (CC) depends on its maturity. The 2024 report used a single value of 0.6 tC/t. This value falls within the range of values for Fibric: 0.52 ± 0.07 tC/t according to 789 samples in Sumatra and Kalimantan [8]. Other sources reported that the carbon content in Belait up to 140 cm-depth was 0.60 ± 0.08 tC/t, and based on 33 samples collected in theBelait Mendaram, was 0.547 ± 0.147 tC/t.

The carbon stock in the whole area is calculated as follows:

$$\text{CS} = \text{CD} \times \text{A} \quad \text{(0-10)}$$

Table A6. Peat Carbon Stock in the Beliat PSF

Variables	NFI (1996)	Report (2024)	ERIA (2025)*
Peat land Area (ha)	103,705	61,659	111,087
Bulk Density (t/m3)			
Mean	0.10	0.10	0.089
StDev	0.06	0.06	0.032
Carbon Content (%)			
Mean	60.3%	60.3%	54.6%
StDev	8.0%	8.0%	14.7%
Peat Depth (m)			
Mean	4.366	4.366	
StDev	1.834	1.834	
Volume per Area (m3/ha)	41,266	41,266	35,967
Carbon Stock			
Density (tC/ha)	2,487	2,487	1,748
Total (MtC)	258	153	194
Uncertainty (MtC)	158	94	87
*Based on spatial analysis			

Source: ERIA study team, 2025.

[7] Verified by the authors in the field in September 2025.
[8] Peat Maturity and Thickness for Carbon Stock Estimation - International Peatland Society.

$$CD = CV \times BD \times CC \quad (0\text{-}11)$$

The uncertainty is calculated as follows[9]:

$$\Delta CD = CD\sqrt{\left(\frac{\Delta CV}{CV}\right)^2 \times \left(\frac{\Delta BD}{BD}\right)^2 \times \left(\frac{\Delta CC}{CC}\right)^2} \quad (0\text{-}12)$$

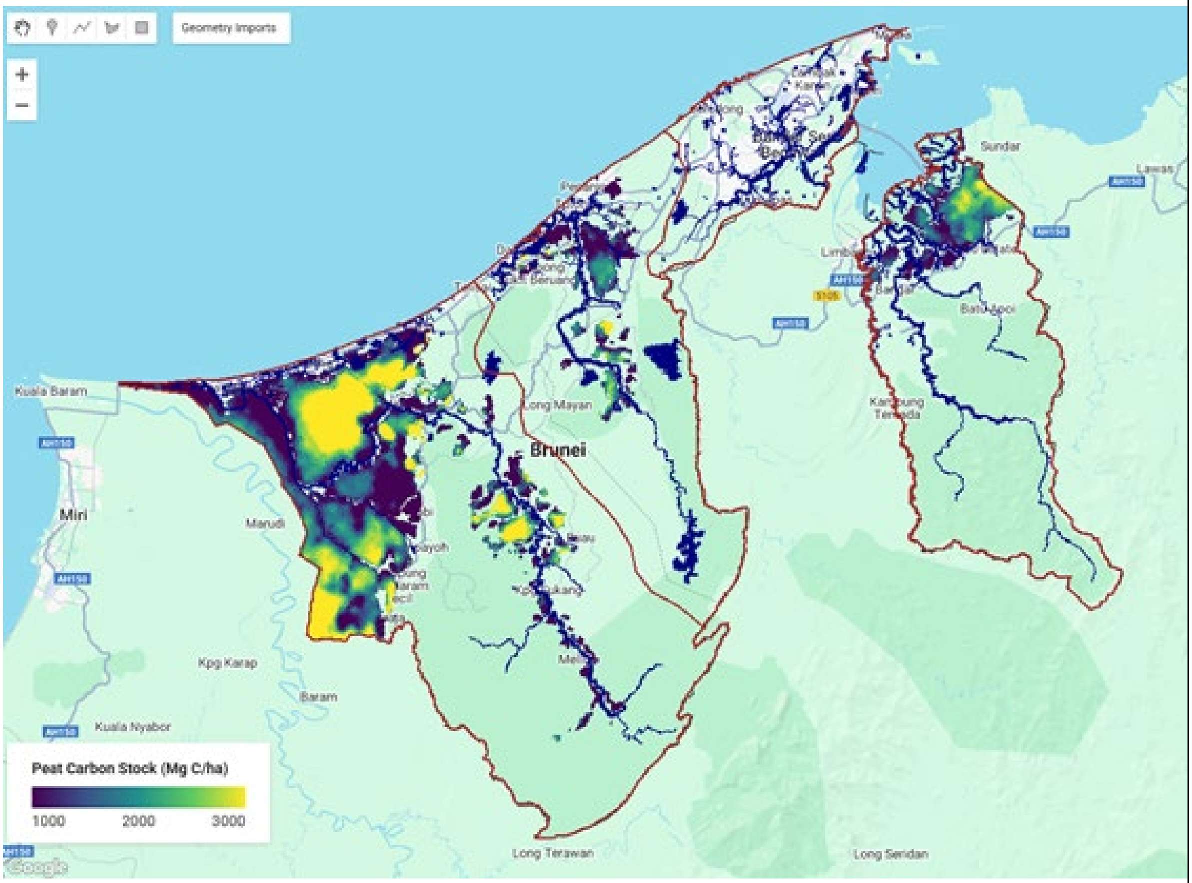
In which, CS is carbon stock (t), $\mathbf{CD}$ is carbon density (tC/ha), $\mathbf{A}$ area (ha), $\mathbf{CV}$ is carbon volume per area (m3/ha), $\mathbf{BD}$ is bulk density (t/m3) and $\mathbf{CC}$ is carbon content (tC/t). As shown in Table 0-6 the report (2024)[10] estimated the total carbon deposit of 153 ± 94 MtC.

While based on the spatial distribution of carbon density (Figure 0-15), total carbon deposit is 194.5 ± 87.2 MtC. The highest carbon density values are distributed in the peat dome and surrounding areas. The highest carbon densities are found in peat domes and their surrounding regions. Therefore, it is essential to preserve these areas as the richest in carbon deposits.

[9] 7 Steps to Calculate Measurement Uncertainty - ISOBudgets

[10] Borhan. Report on Carbon Stock in the Peat Swamp Forest of Brunei Darussalam. Dated 29 June 2024.

Figure A15. Carbon Density Distribution



Source : ERIA study team, 2025.

Land Used Carbon Emission

Table A7 below presents land use/activities for the period 2019-2024 and the resulting carbon emission. In 2019-2020, there were forest fires covering an area of 229 ha and 248 ha, which produced emissions of 106,256 tC/y and 115,072 tC/y, contributing significantly to total emissions of 174,644 tC/y. After that, emissions decreased to 61,258 tC/y in 2024. There was also a decrease in emissions due to the expansion of forest growth from 2,694 ha in 2019 to 3,871 ha in 2024.

Table A7. Land Use/Activity and Carbon Emission

Land Use/Activities	2019	2020	2021	2022	2023	2024
	Area (ha)					
1. New Deforested Land		0.00	0.00	0.00	33	62
2. Degraded tropical moist forests (TMF)	9,938	9,964	9,986	10,031	10,043	10,050
3. Forest Regrowth	2,694	3,048	3,683	3,871	3,868	3,871
4. Conversion to a water body	673	675	678	678	679	680
5. Other land cover	2,366	2,309	2,163	2,112	2,111	2,108
6. Forest fires	229	248	0	0	0	0
Land Use/Activities	Annual Emission (tC/y)					
1. New Deforested Land		0	0	0	6,003	11,278
2. Degraded TMF	60,869	61,029	61,163	61,439	61,512	61,555
3. Forest Regrowth	-29,524	-33,403	-40,362	-42,422	-42,389	-42,422
4. Conversion to a water body	17,752	17,804	17,884	17,884	17,910	17,936
5. Other land cover	14,492	14,142	13,248	12,936	12,930	12,911
6. Forest fires	106,256	115,072	0	0	0	0
Total		174,644	51,933	49,836	55,965	61,258

Note:
Carbon Emission=Activity (ha) x Emission Factor (ton/ha/y).
Source: ERIA study team, 2025.

Appendix A2 — Glossary

Activity data	Measured or observed data on land-use changes or interventions used in carbon accounting
Adaptive management	Iteratively adjusting actions based on monitoring results and changing conditions
Additionality	Proof that emissions cuts would not happen without the project
Afforestation and Reforestation	Planting trees on non-forest land and restoring forests on previously forested land
Allometric equation	A formula that estimates tree biomass from measurements like diameter and height
Allometric model calibration	Local field work to tune biomass equations for species and site conditions
Alluvial deposit	Sediment laid by rivers that can influence peat formation and hydrology at edges of peatlands
Article 6	Rules for international carbon markets and credit trading under the Paris Agreement
ART TREES	A jurisdictional REDD crediting framework emphasizing large-scale, high-integrity results
The Baseline	The without-project scenario used to calculate emission reductions
Benefit sharing	Agreed distribution of project revenues to communities and stakeholders
Biodiversity	The variety of species and ecosystems in an area
Biomass	The mass of living plant material, often used to estimate stored carbon
Buffer pool	A reserve of credits set aside to insure against non-permanence risks such as fires
Bul density	The mass of dry soil per unit volume used to calculate peat carbon stocks
Canal blocking	The installation of dams or plugs to raise peatland water tables and reduce emissions and fire risk

Canopy height	The height of the forest's upper layer, used to infer biomass
Canopy height model	A LiDAR-derived surface showing vegetation height used to estimate biomass
Carbon credit	A tradable unit equal to one metric tonne of CO_2 equivalent reduced or removed
Carbon stock	The amount of carbon stored in biomass and soils
CH_4 flux	Methane exchange between land and atmosphere measured as part of greenhouse gas accounting
Conservative assumption	A cautious choice that avoids overestimating emission reductions
Conservation lease	A legally binding agreement that grants rights to manage land for conservation and climate outcomes
Core Carbon Principles	Integrity criteria defined for high-quality carbon credits
CO_2e	Carbon dioxide equivalent, a way to sum different greenhouse gases into one unit
Data QAQC plan	A documented process for quality assurance and quality control of measurements and analyses
Demarcation	The act of mapping and marking clear boundaries of a project or protected area for legal and management purposes
Dissolved organic carbon	Carbon compounds carried by water out of ecosystems
DOC export	Loss of dissolved organic carbon through drainage waters from peatlands
Double counting	Claiming the same emission reduction by more than one party or programme
Double counting safeguard	Rules and tracking that prevent the same reduction from being claimed by more than one entity
Eddy covariance tower	Instrument that directly measures exchanges of CO2 and methane between land and the atmosphere
Eddy flux footprint	The upwind area contributing to gas measurements captured by an eddy covariance tower
Emission factor	A coefficient that converts activity data into emissions estimates

Encroachment	Unauthorized entry, settlement, or resource extraction within a protected or project area
FPIC	Free, Prior and Informed Consent, the right of communities to approve or reject activities affecting them
Gazettement	The formal legal process by which a government officially declares and records an area in the government gazette as protected or reserved, giving it enforceable status and management rules
GEDI	NASA LiDAR instrument that measures forest canopy height and structure from space
Gold Standard	A high-integrity certification that requires measurable sustainable development benefits
Grievance mechanism	A formal process for stakeholders to raise and resolve complaints
Grievance redress	A formal channel to receive, assess, and resolve complaints from stakeholders
HFLD status	Classification for areas with high forest cover and historically low deforestation rates
Hotspot detection	Satellite-based identification of active fires
Hotspot monitoring	Continuous satellite-based detection of active fires for rapid response
Hydrology	The study and management of water levels, flows, and balance in ecosystems
Hydrological unit	A contiguous peat or watershed area that functions as one water system for management and modelling
Important bird area	A site identified as globally important for bird conservation
JNR	Jurisdictional and Nested REDD+, an approach to align project-level and government-level accounting
Jurisdictional	Covering an entire government area such as a nation or province rather than a single project site
Jurisdictional programme	Government-led accounting and crediting that covers a province or nation

Leakage	When protecting one area shifts deforestation or emissions to another area
Leakage belt	A monitored zone outside the project boundary used to detect displaced deforestation or degradation
Market premium	Additional price achieved by credits with superior integrity, co-benefits, or eligibility for schemes such as CORSIA
Market volatility	Large and rapid price changes in carbon credit markets
Nested	Integrating a local project within a larger jurisdictional accounting system
Nested accounting	Aligning project-level measurements with jurisdictional totals to prevent double counting
Net ecosystem exchange	The net balance of carbon taken up by plants minus carbon released from respiration and decomposition
Non-permanence buffer	A pooled reserve of credits set aside to insure against reversal risks such as fire or drought
Non-permanence risk	The chance that stored carbon is later released by events like fire
Oxidation	Chemical reaction where exposed peat releases CO_2 when it dries and decomposes
Peatland	Waterlogged organic soils formed from partially decomposed plants that store large carbon stocks
Paris Agreement	Global pact to limit warming and cut greenhouse gas emissions
Peat Dome	Raised peatland with the thickest peat at the center that depends on high water tables
Peat oxidation	The aerobic decomposition of peat when exposed to air, releasing CO_2
Permanence	The durability of carbon benefits over time and protection against reversal
Price premium	Higher price earned by credits with superior integrity or co-benefits
QC and QA	Quality control and quality assurance processes to ensure data accuracy

Reference period	The historical time window used to establish deforestation or degradation trends for baselines
Registry	The database that issues, tracks, and retires carbon credits to prevent double counting
Registry retirement	The act of permanently removing credits from circulation to claim climate benefit
Remote sensing	Collecting data about the Earth from satellites or aircraft
Remote sensing fusion	Combining multiple satellite and airborne datasets to improve detection and accuracy
Reversal	A loss of previously credited carbon due to events like fire, drainage, or illegal logging
Rewetting	Restoring water levels in drained peatlands to cut emissions and fire risk
Safeguards	Rules to protect people, rights, and ecosystems in carbon projects
Safeguards Information System	A national framework that documents how social and environmental safeguards are met
Soil chamber	Device that measures greenhouse gases released from soil
Stratification	Dividing the project area into classes or strata for more accurate sampling and modelling
Stratified sampling	Dividing an area into homogeneous classes to improve measurement precision and reduce bias
Subsidence	Land surface sinking when peat dries and compacts or decomposes
Subsidence rod	A fixed marker used to measure vertical sinking of peat surfaces over time
Tenure security	The clarity and legal protection of land and resource rights for governments, communities, or private holders
Theory of change	A structured explanation of how activities produce outputs, outcomes, and impacts

Uncertainty analysis	Quantifying the range of possible error in measurements and models to ensure conservative results
Verification statement	An independent auditor’s report confirming monitored results and credit issuance eligibility
VM0007	A VCS REDD methodology with modules for avoided deforestation and peatland accounting
Water table	The level below the ground surface where soil is saturated with water, critical for peat stability