CARBON MARKETS

Market, Implementation & Human Perspectives

2024-25

Amaly

With valuable contributions and strategic insights of thought leaders from

European Bank for Reconstruction and Development · IRENA International Renewable Energy Agency · REPP Renewable Energy Performance Platform · BOEING · ZURICH · WFP United Nations World Food Programme · WWF · Jane Goodall Institute · IUCN International Union for Conservation of Nature · fsdafrica · African Natural Capital Alliance · Pearl Initiative

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MESSAGE FROM MANAGING PARTNER

We are committed to delivering multi-stakeholder solutions that aid funders meet their financial, social and environmental goals through asset management with strong project development and execution capabilities to unlock deep value.

Our mission is to unlock funding for NGOs and rural communities to ultimately impact ONE BILLION lives. We work with organisations that are fiscally responsible, have robust governance structures and are mission-aligned.

We are a nonpartisan organisation creating a better world by providing diverse, equitable and inclusive solutions designed with and for rural communities.

FOREWORD

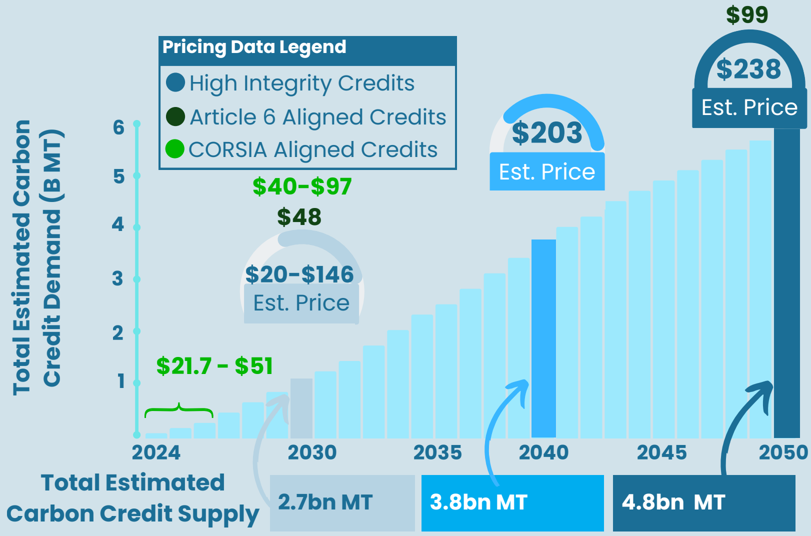
This report serves as a guide to NGOs, institutional funders and other stakeholders committed to combatting climate change and contributing sustainably to climate action. It not only underscores the urgency and importance of decarbonisation but also presents a roadmap to harnessing hidden value of carbon credits to unlock both environmental and social impact in developing countries. We hope the findings presented in this report will contribute to the development of environmentally conscious and economically fruitful decarbonisation and environmental projects.

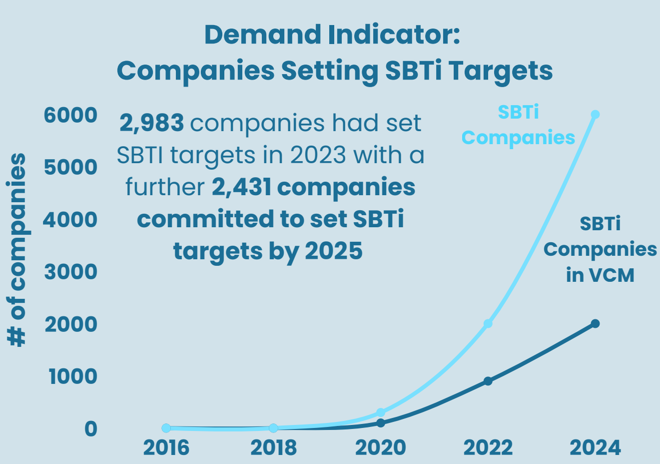
WAHID A KAMALIAN
Managing Partner
Amaly Asset Management

EXECUTIVE SUMMARY

This report demonstrates how well-designed carbon markets can unlock transformational, long-term funding for frontline communities while accelerating solutions to the planet's most pressing environmental, social, and development challenges. By tracing the full value chain—from credit origination to capital allocation—it offers investors, policymakers, NGOs, and corporates a holistic overview and practical roadmap for mobilising high-integrity carbon finance at scale.

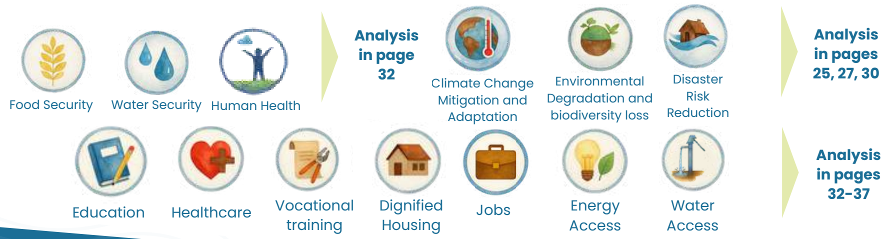
Chapter 1 grounds readers in the fundamentals: the evolution of carbon credits, the spectrum of project types, and the standards, governance frameworks, and quality protocols that underpin market integrity. This primer equips readers with a common vocabulary and due-diligence checklist. **Additionally, we analysed price formation across compliance and voluntary segments**, revealing how credit attributes, buyer preferences, and macro factors shape the revenue lifeline of projects with a focus on forestry and land use project types. Understanding these dynamics is pivotal to structuring bankable projects, forecasting returns, and achieving portfolio resilience. **Key takeaways:** accelerating convergence of voluntary and compliance systems (e.g., CORSIA, Article 6) is reshaping demand and supply; corporate demand is deepening, with 2,431 companies committed to set SBTi targets by 2025 (a clear leading indicator of resilient demand); high-integrity credits command durable price premiums and are structurally scarce—2024 CORSIA-eligible units averaged \$21.7/t with analysts flagging an up-cycle toward ~\$51/t, while high-integrity prices are modeled at ~\$203/t by 2040 and ~\$238/t by 2050 as demand outstrips quality supply.

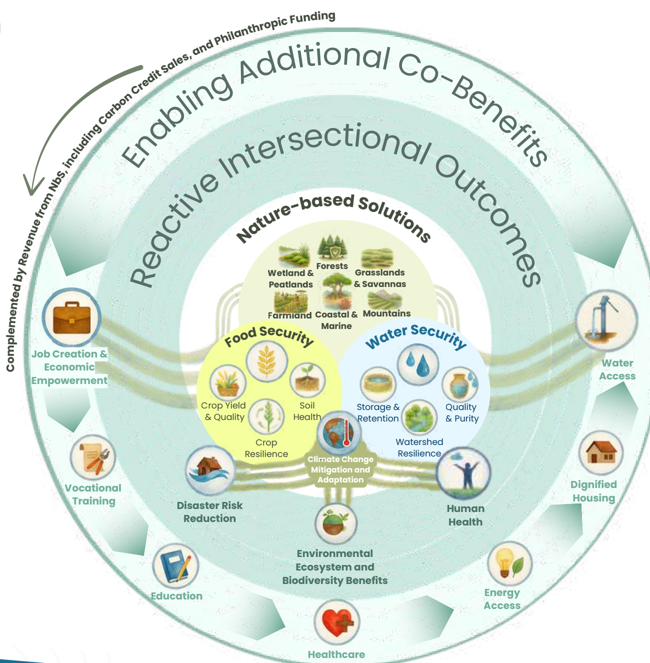




Chapter 2 provides a deep dive into Nature-based Solutions (NbS), beginning with our framework and examining direct impacts such as climate change mitigation and adaptation, and food and water security. It then explores reactive intersectional outcomes like disaster risk reduction, biodiversity and environmental benefits, and human health, followed by proactive co-benefits generated from NbS income streams complemented by philanthropic funding.

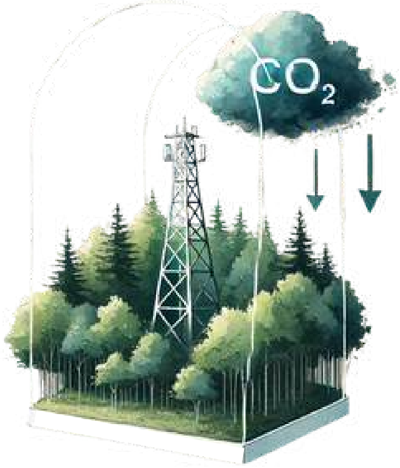
Key takeaway: each tonne of CO_2 offset can yield up to \$664 in additional economic, social, and environmental value beyond emission reductions. This multifaceted proposition reshapes NbS design and implementation, moving from carbon-centric approaches to holistic development strategies that tackle complex community challenges. Having strong community facilitators such as local NGOs and municipalities enabled by tailored digital-extensiion services, donor fundraising and traceability tech is critical to ensure optimal results





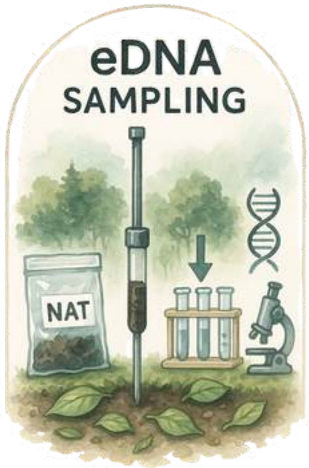
EXECUTIVE SUMMARY (continued)

Chapter 3 tackles scientific rigour: permanence, additionality, leakage, and the emerging stack of IoT-enabled GHG flux monitoring and blockchain-based traceability featuring insights from dMRV and data analytics innovators <Hyphen.earth> and <biometrio.earth>. The chapter shows how transparent data flows and verifiable benefit-sharing strengthen community trust and investor confidence. **Key takeaways:** integrity hinges on defensible baselines and proven additionality; permanence must be explicitly managed (industry benchmark ~100 years; ICVCM ≥40-year monitoring; typical 20% risk buffer contributions under some standards); and tech-enabled MRV plus third-party ratings materially improve bankability and pricing. It's critical to consider various technologies such as eddy-covariance towers, drones, eDNA and acoustic monitors with added blockchain layer for optimal results.



Eddy Covariance Towers

Drones (UAV)



Environmental DNA (eDNA) Sampling Kits

Smart Camera Traps and Acoustic Monitors

Cloud-based dMRV systems powered by Artificial Intelligence and Machine Learning algorithms ingest multiple high-quality datasets from spaceborne, airborne, and ground-based sensors and automate their processing into real-time information, providing insights into greenhouse gas emissions and removals. This provides a standardised, scalable, cost-effective, and secure avenue for project developers to identify areas of improvement, optimise project operations, and overall ensure the integrity of carbon accounting and trading

Chapter 4 maps the financing landscape—private equity, sustainable debt, philanthropy, blended structures—and explains how sovereign wealth funds are 'investing from soil to screen.' It also reviews national carbon registries, policy shifts, and the sovereign-linked funders' influence on global capital flows. **Key takeaways:** results-based grants de-risk early execution and align to national MRV; private equity typically targets 15–20% gross IRR, and 10–15% net IRR, with 7–9% hurdles; and robust governance and security (board/consent rights, carbon credit sale proceeds assignment, insurance) are now standard to protect integrity and returns.

Chapter 5 broadens the lens to corporate decarbonisation pathways covering (1) internal optimisation and circular byproducts, (2) energy transition, and (3) sustainable supply chains. Case studies in shipping, aviation, oil and gas, and construction and real estate development illustrate how high-quality credits complement on-site abatement with actionable frameworks and methodologies to aid the design of optimal decarbonisation raodmaps. **Key takeaways:** Leverage our proposed portfolio score and total incremental benefit approach to design optimal decarbonisation raodmap that shifts decarbonisation divisions from being a cost centre to a revenue generating business.

Finally Chapter 6 presents key obstacles—quality bottlenecks, policy uncertainty, liquidity gaps—and the sizeable opportunities emerging as data, technology, and finance converge. We **conclude with actionable recommendations**: regulators should establish operational carbon registries; investors must price risk-adjusted returns realistically clearly factoring premiums and discounts; corporations need robust due diligence and procurement Policies, Procedures and Processes (PPP); and project developers should embed community benefit-sharing, tech-enabled monitoring, and adaptive governance at an early stage.

Collectively, these chapters provide a strategic blueprint for harnessing carbon markets to deliver measurable climate impact and inclusive economic growth.

CHAPTER 1: INTRODUCTION

Climate change represents one of the most pressing challenges of our time, demanding urgent and coordinated global action to reduce Greenhouse Gas (GHG) emissions and limit global temperature rise. This requires both near-term cuts to GHG emissions and a credible path to net-zero*. As governments, corporations, and investors worldwide grapple with the transition to a low-carbon economy, carbon markets have emerged as a critical mechanism for pricing carbon emissions, incentivising emission reductions, and mobilising capital toward climate solutions (including scientific research and the application of technologies) and projects that deliver measurable environmental impact.

Carbon markets address the climate challenge by creating economic value for carbon reduction and removal activities, transforming what was once an environmental externality into a tradable commodity with real market value. This market-based approach harnesses the power of economic incentives to drive innovation and scale climate solutions across sectors, from renewable energy and energy efficiency to nature-based solutions and direct air capture technologies. By putting a price on carbon, these markets enable organisations to make informed decisions about their climate investments while providing a pathway for achieving net-zero commitments in a cost-effective manner.

Carbon markets can also serve as a transformative force that accelerates the deployment of climate finance to developing countries and underserved communities, where some of the most impactful and cost-effective emission reduction opportunities exist. In this context, buyers of carbon credits who participate in voluntary carbon markets can help establish robust monitoring, reporting, and verification systems while encouraging project developers to implement high-integrity standards that deliver genuine, additional, and permanent climate benefits. This emphasis on quality and transparency, increasingly demanded by market participants, reduces investment risk and empowers communities to participate meaningfully in the global climate response.

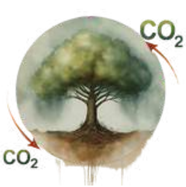
By integrating carbon markets with supportive regulatory frameworks and international cooperation mechanisms, stakeholders can help create a dynamic and effective system that accelerates decarbonisation (converting industries to carbon-neutral or carbon-negative) while delivering co-benefits for biodiversity, sustainable development, and social equity across the globe.

***Note:** net-zero refers to greenhouse gas emissions reduced, avoided, or removed to balance those produced.

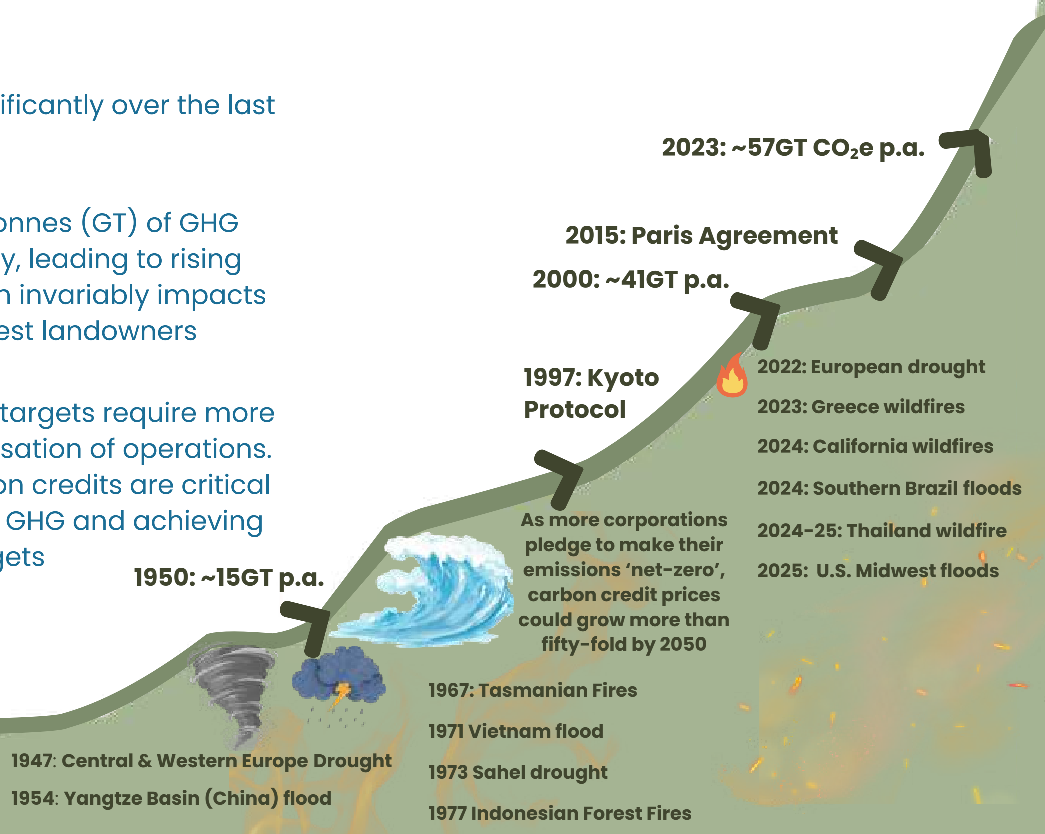
Current Situation — Companies are under immense pressure to meet net-zero targets

GHG increased significantly over the last 70+ years

More than 50 gigatonnes (GT) of GHG are emitted annually, leading to rising temperatures, which invariably impacts agricultural and forest landowners

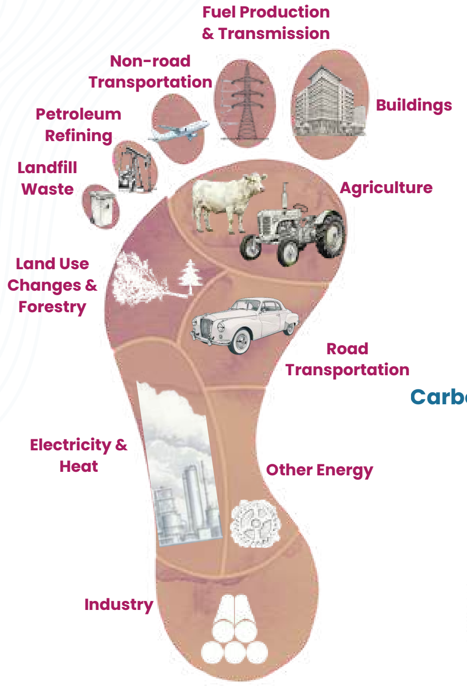


Ambitious net-zero targets require more than internal optimisation of operations. High-integrity carbon credits are critical to combating rising GHG and achieving global net-zero targets



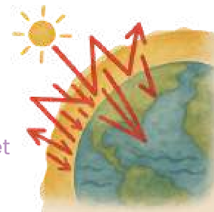
Sources: Our World in Data; UNEP Emissions Gap Report; Amaly Legacy Analysis

Climate Change Drivers *(Select examples)*



Carbon dioxide equivalent (**CO_2e**) represents **heat-trapping (greenhouse) gases** released through human activities such as deforestation and burning fossil fuels, as well as natural processes such as volcanic eruptions. They directly and indirectly affect Earth's systems by influencing climate, ecosystems and the atmospheric balance.

Gases that trap heat in the atmosphere and warm the planet



Carbon footprint = GHG emissions created by an individual, event, organisation, service, or product

Average 120.4 grams of CO_2e emitted per km driven by new passenger cars in EU in 2018

Mt St Helens (1980) volcano eruption **emitted ~1.1 trillion grams** of CO_2e **per hour** of venting

Average **102 grams** of CO_2 emitted **per km** flown by a plane

Average of **281 grams** of CO_2e emitted **per kWh** in Europe in 2018

Sources: EEA; BBC; EurekAlert; WMO; Amaly Legacy Analysis
Note: Full CO_2e values are often higher than CO_2, since CO_2e includes CO_2 plus other greenhouse gases expressed in CO_2-equivalent terms.

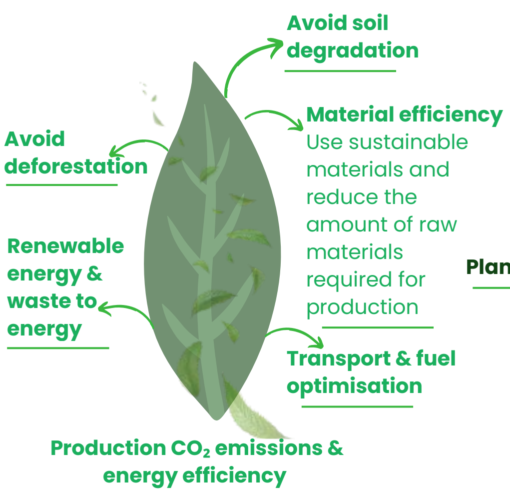
Mitigating Climate Change *(Select examples)*

1 REDUCING & AVOIDING CO_2e

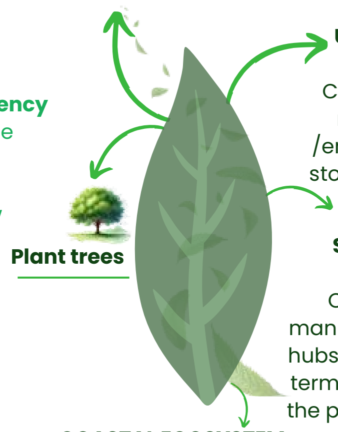
2 REMOVING & CAPTURING CO_2e

Minor Actions
mostly individuals

Major Actions
mostly communities & organisations



HEALTHIER SOILS
Better land management and agricultural practices to enhance the ability of soils to store carbon



UNDERGROUND STORAGE
Capture CO_2 from manufacturing /emission hubs and storing permanently underground

Storage hubs for utilisation
Capture CO_2 from manufacturing /emission hubs and store in storage terminals for utilisation in the production of building materials such as concrete.

COASTAL ECOSYSTEM (BLUE CARBON)
Managing, restoring and protecting mangroves, tidal marshes and seagrass meadows to store carbon

Source: CSERC; American University; Visual Capitalist; Desmog; Global Carbon Budget; WMO
Note: Over the past decade, ~48% of human-caused CO_2 emissions stayed in the atmosphere, while ~29% were taken up by land ecosystems and ~26% by the ocean. Conserving mature forests and planting new trees, along with maintaining other natural carbon sinks, is critical for net removal of CO_2e from the atmosphere.

Why Definitions Matter?

> "Defining carbon credit standards, methodologies and verification protocols at the project level not only impacts the environmental integrity and measurability of emission reductions and removals, but also unlocks access to premium pricing and market liquidity that is critical for scaling climate finance and ensuring the long-term viability of carbon reduction initiatives."

DR. DAVID GWENZI
VCS Advisory Group (Verra)

Defining Carbon Credits:

Carbon credits are transferable and tradeable instruments certified and issued by independent carbon registries to represent an emission reduction or removal of one metric tonne of CO_2e

1 carbon credit = Certified removal or reduction of **1 tonne of CO_2e issued by a registry**

Who is shaping the definition of carbon credits?

1 Carbon registries — VERRA, Gold Standard certified SDG impacts

2 Ratings and data providers — Calyx Global, Sylvera, BeZero, MSCI

3 High-integrity standards — iC, VCMI, SCIENCE BASED TARGETS

Verified Carbon Standard

Certificate of Verified Carbon Unit (VCU) Retirement

, in its capacity as administrator of the Registry, does hereby certify that on Verified Carbon units (VCUs) were retired on behalf of:

Project name:

VCU serial number:

Note: Sample illustration of a VCU retirement certificate (for design only; not a real certificate).

Carbon Footprint Offset Chronology

1970s — The term offset for emission compensation started with the **U.S. Clean Air Act**

1989 — **Early Carbon Project:** US company, Applied Energy Services, funded an agroforestry project in Guatemala to offset emissions from its Connecticut power plant.

1989 – 1992 — **IPCC** established in **1988** to assess climate science; **UNFCCC** adopted in **1992** as a **global framework for climate action**

1997-2005 — **Kyoto Protocol** agreed in **1997,** introducing binding emission reduction targets for developed countries and entered into force **in 2005**, the year **the EU Emission Trading System based on cap-end-trade system** became active

2005 — **EU Emissions Trading System:** EU's 2005 cap-and-trade system to fight climate change. It's the world's first and among largest carbon markets

2009 — **Copenhagen Climate Change Conference:** Sets a goal to limit global temperature rise to 2°C above pre-industrial levels.

2012 — **SDG 13**: Call to take urgent action to combat climate change (2012). Officially SDG13 was adopted in 2015

2015 — **The Paris Agreement:** Legally binding climate deal signed by 195 countries to **keep global warming below 2°C, aiming for 1.5°C.**

2020 — **UN Carbon Offset Platform**: 2 million Certified Emission Reductions (CERs) had been canceled by 2020.

2021 — **COP26:** Finalises **Article 6 rules for global carbon markets**, enabling cross-border credit trading and preventing double counting.

2022 — **UNFCCC's Supervisory Body for Article 6.4** (the successor to the CDM under the Paris Agreement) released its initial work plan crucial for compliance carbon markets

2024 — Switzerland and Thailand **complete the first transfer of Article 6.2 carbon credits (ITMO)** under the Paris Agreement.

Source: Amaly Legacy analysis
Note: UN Carbon Offset Platform was launched in September, 2015 and enables the voluntary cancellation of Certified Emission Reductions (CERs) from UN-certified CDM projects.

Carbon Dioxide Removal (CDR) & Carbon Capture, Utilisation and Storage (CCUS)

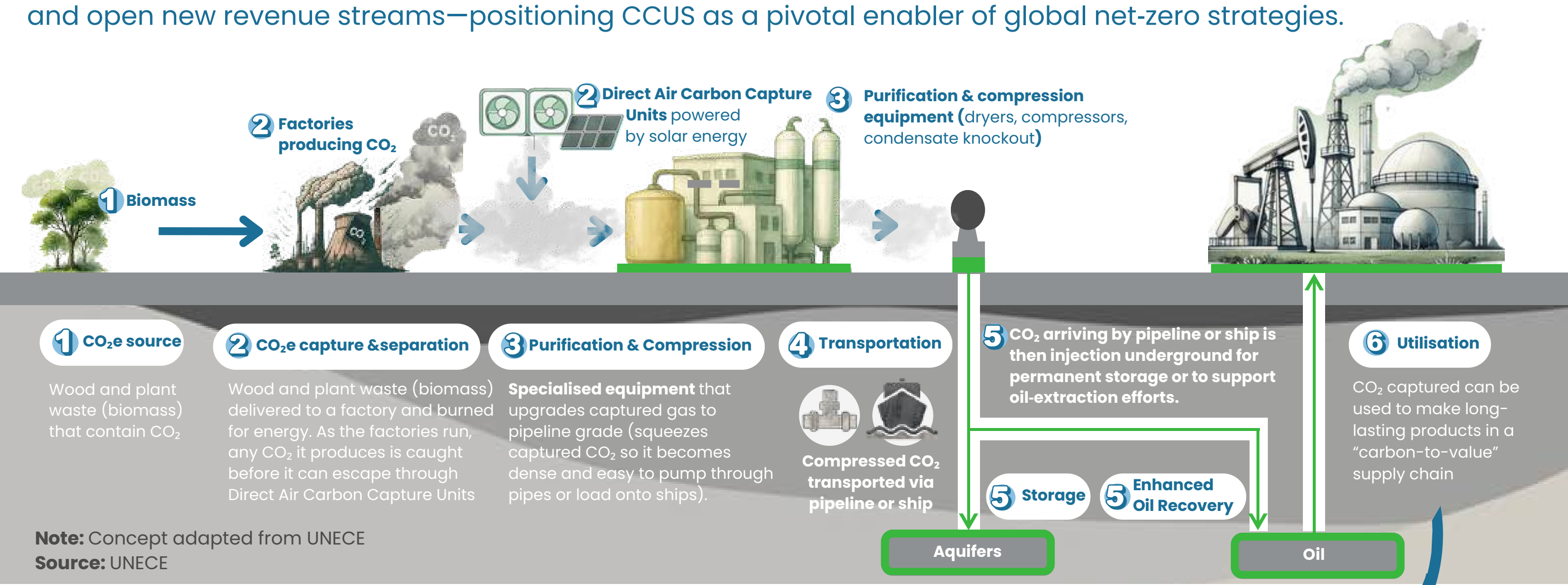
> **Term used to encompass a wide array of approaches that remove carbon dioxide directly from the atmosphere and store it to create negative emissions. Storage can occur in geological, bio-based or ocean reservoirs or in value-added products, like low-carbon concrete**

Contribution to UN SDGs

Directly furthers **SDG 13 'Climate Action'**. It also aligns with **SDG 8 'Decent Work and Economic Growth'** and **SDG 9 'Industry, Innovation and Infrastructure'** by enabling new supply chains to support this industry.

Visualising CDR and CCUS:

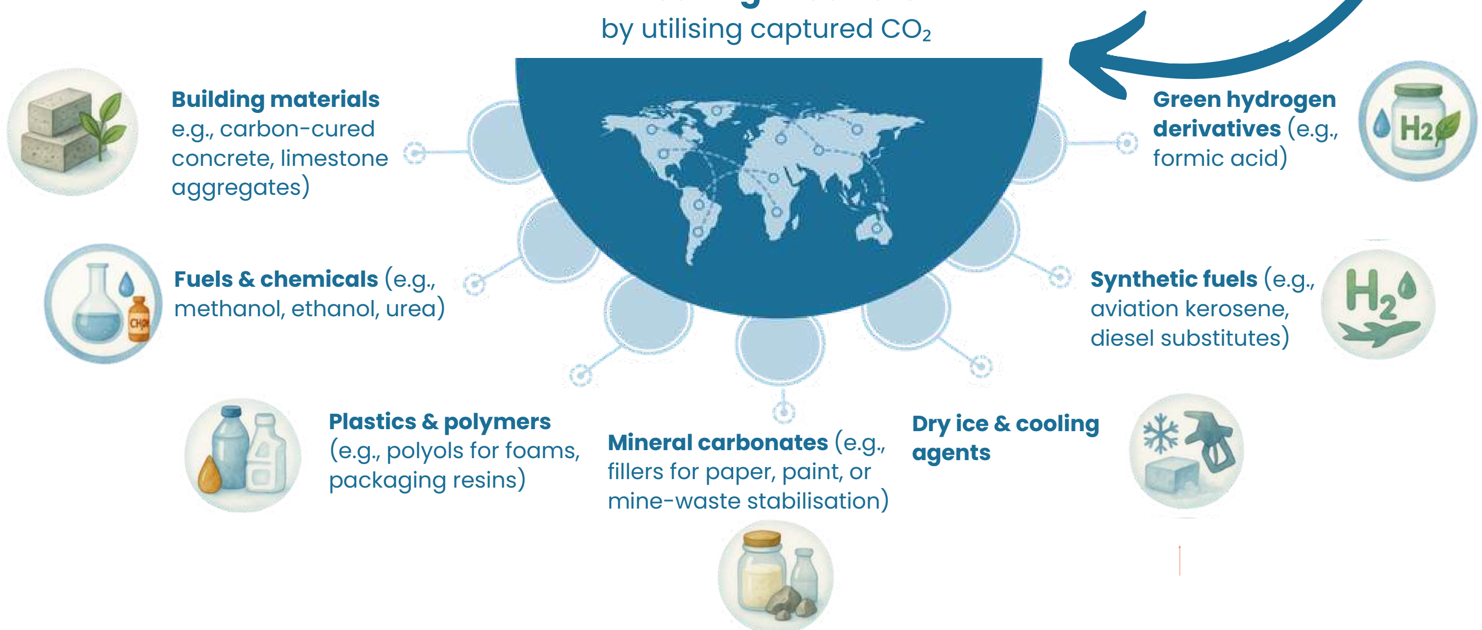
End-to-end schematic of CCUS by United Nations Economic Commission for Europe (UNECE) tracks a molecule of CO_2 from the point it is generated to its final fate—either locked away underground or converted into new products. It traces CO_2 from industrial, bioenergy and direct-air sources through capture, purification, and pipeline or ship transport, ending either in permanent geological storage or in utilisation routes that turn the gas into building materials, chemicals, plastics and carbonates. Scaled deployment of this integrated system can cut hard-to-abate industrial emissions and, when coupled with CO_2-removal pathways, deliver net-negative removals and open new revenue streams—positioning CCUS as a pivotal enabler of global net-zero strategies.



Note: Concept adapted from UNECE
Source: UNECE

Creating Products

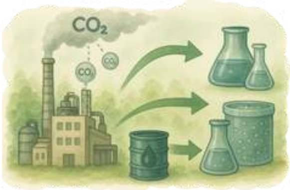
by utilising captured CO_2



Source: UNECE; and Amaly Legacy analysis
Notes: 1. Saline aquifers are underground layers of salty water within porous rock formations, often more than 1 km deep. CO_2 can be injected into these formations, where it can remain trapped long-term. **2.** CO_2-Enhanced Oil Recovery (CO_2-EOR) uses injected CO_2 to mobilise additional oil and gas. Depending on project design and life-cycle accounting, some CO_2-EOR projects can result in net CO_2 storage.

Industrial Carbon Removal: Readiness, Cost, and Systemic Considerations

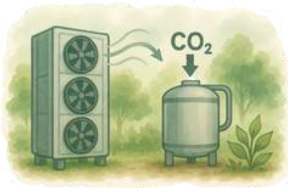
Here we offer a structured overview of leading industrial CDR technologies, highlighting their role in complementing CCUS strategies. It examines the current status, readiness levels, and cost efficiency of key solutions, most of which remain in exploratory phases due to challenges in achieving full efficiency and affordability. Alongside technological progress, the development of effective CDR frameworks increasingly depends on robust scientific modelling, societal considerations, and multi-stakeholder collaboration. The scientific community is still exploring frameworks for CDR and the modelling activities that underpin them; societal considerations and multi-stakeholder management are influential factors for effective CDR programmes.



Industrial CO_2 Utilisation

Industrial reuse of captured CO_2 to create value-added products, including fuels, chemicals, and plastics.

- **TRL:** 6
- **Cost:** ~$110/t$CO_2$
- **Strengths:** Value-added products; supportive policies.
- **Challenges:** High dependency on green hydrogen costs.



Direct Air Capture (DAC)

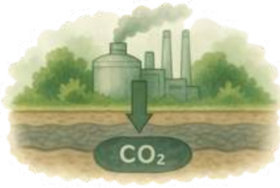
Tech that directly permanently removes CO_2 from ambient air through chemical or physical sorbents.

- **TRL:** 7-8
- **Cost:** ~$800/t$CO_2$
- **Strengths:** Highly scalable; applicable globally.
- **Challenges:** High energy intensity and cost barriers.

Carbon Mineralisation

Permanent storage of CO_2 through chemical reactions with minerals, forming stable carbonates.

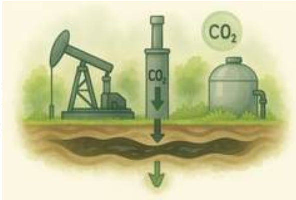
- **TRL:** 8-9
- **Cost:** ~$150/t$CO_2$
- **Strengths:** stable products, permanent sequestration
- **Challenge:** High energy demand for feedstock processing



Industrial Carbon Storage

Geological storage of captured CO_2 in underground reservoirs such as depleted oil/gas reservoirs.

- **TRL:** 9
- **Cost:** ~$70/t$CO_2$
- **Strengths:** reliable, well-understood storage.
- **Challenges:** High initial infrastructure investment.



Enhanced Oil Recovery (EOR)

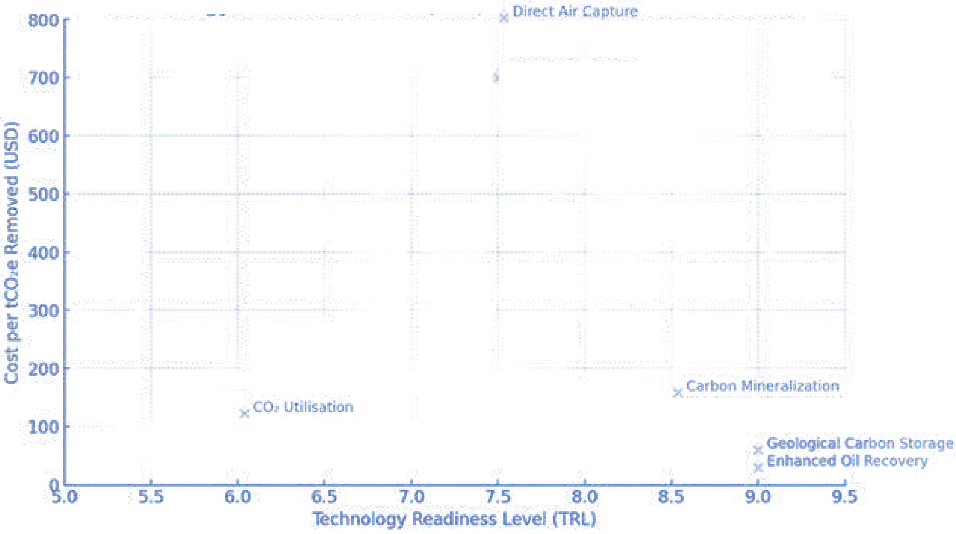
Injecting CO_2 into declining oil reservoirs to boost oil extraction and sequester CO_2 underground.

- **TRL:** 9
- **Cost:** ~$20/t$CO_2$
- **Strengths:** Cost-effective, mature tech.
- **Challenges:** Linked to fossil fuel use.

Sources: IEA, Brian D. Colwell, Carbon Brief, Amaly Legacy Analysis

Notes: 1. TRL refers to technology readiness level which is a scale from 1 to 9 used to assess the maturity of a particular technology. **2.** TRL6 means Technology demonstrated in relevant environment. **3.** TRL 7 means System prototype demonstration in operational environment. **4.** TRL 8 means system complete and qualified. **5.** TRL 9 means actual system proven in operational environment. **5. EOR:** Geophysical limitations stress that oil well operators must guarantee that those sites are safe and suitable for storage. Permitting and approvals can lead to long lead times for storage projects. **6. DAC:** Though mobility plays a part in this concept, costs are so high that even with governmental subsidies they are hard to be profitable. **7.** Cost are indicative based on secondary research and interviews, they are also pathway-specific and vary by technology configuration, energy prices, and site specifics, among other factors.

Technology Readiness Level vs Cost per tCO_2 Removed



Note: While the most promising technologies are at TRL 7, progress to TRL 9 will open space for disruption. A number of solutions emerged in the last decade (e.g., Skytree, Verdox, Global Thermostat), but none has yet achieved validation at large scale.

Balancing Immediate Impact and Future Potential in Industrial CDR

Mature solutions like Geological Carbon Storage and EOR provide immediate, cost-effective pathways for carbon removal. In contrast, emerging technologies such as DAC and CO_2 utilisation hold significant long-term promise for global scalability, despite current economic and technical hurdles. Unlocking their full potential will require coordinated strategic investment that aligns near-term emissions reductions with the advancement of future-ready technologies. Each industrial CDR pathway delivers unique strategic value, and targeted adoption is key to advancing industrial decarbonisation and achieving global net-zero goals.

Clean Energy Projects

Clean energy projects are **project activities that use, partly or in entirety, sources of energy that do not use up the Earth's finite mineral resources and that are replaced rapidly by natural processes**

Contribution to UN SDGs

Directly furthers **SDG 13 'Climate Action'** to facilitate the emergence of new supply chains to support this industry, aligns with **SDG 8 'Decent Work and Economic Growth'** and **SDG 9 'Industry, Innovation and Infrastructure'**

	Solar PV	Wind	Hydro	Geothermal	Biogas	Residue-based biomass power	Green hydrogen (electrolytic)
Emission Reduction	★½	★★½	★★½	★★★	★★	★★	★★
Cost - LCOE ($/MWh)	★★½	★★	★★	★★	★	★	
	$24 – $52	$25 – $150	$57	$60	$95-$380	$70-$274	-
MRV Simplicity	★★★	★★★	★★★	★★★	★★	★	★
SDG Co-Benefits	7, 8, 13	8, 9, 7, 13, 14	8, 9, 7, 13, 14, 6	7, 9, 13	8, 3, 7, 13, 12, 6	8, 7, 13, 12	8, 9, 7, 13, 12, 6
Overall ranking	★★	★★½	★★½	★★½	★½	★	★½

★ Rating

Sources: Amaly Legacy analysis, IRENA, Lazard; PV Magazine; IEA; GEP;

Note: 1. Wind: Onshore : $25-$73 USD/MWh; Off-shore: $72-$140 USD/MWh; Pitfalls: CAPEX plays pivotal role in cost structure. **2. Residue-based biomass power** depends on residue used for example Agricultural Residues (e.g., straw, bagasse): $80–$150 USD/MWh; Forest Residues (e.g., sawdust, bark): $90–$160 USD/MWh; Industrial Waste (e.g., rice husk, nut shells): $70–$130 USD/MWh. **3. Biogas: Biogas (power):** typical range $95–$160/MWh; feedstock can shift costs (e.g., agricultural waste $80–$150/MWh; energy crops $120–$250/MWh; wastewater/sludge $100–$180/MWh). **4. Nuclear:** We have excluded nuclear energy from our analysis, which is a critical energy project type to consider. **5. Green hydrogen (electrolytic):** not an electricity-generation technology; 2023–2024 production cost typically ~$3–$6/kg H_2 (region-dependent).

Powering Climate and Development Goals

Clean energy technologies not only deliver robust emissions reductions, but also vary widely in terms of affordability, monitoring simplicity, and co-benefits aligned with the SDGs. This comparative snapshot highlights the importance of balancing climate impact with practical deployment factors such as cost per MWh and ease of measurement, reporting, and verification (MRV). While solar, wind, and hydro remain front-runners in cost-effectiveness and scalability, solutions like biogas and green hydrogen offer compelling SDG co-benefits, particularly in energy access, waste valorisation, and industrial decarbonisation. As net-zero targets intensify, a diversified energy portfolio considering environmental integrity and development impact will be essential.

AHMED ALSHAMSI
Engineer, UAE Ministry of Energy and Infrastructure

وزارة الطاقـــة والبنيـــة التحتيـــة
MINISTRY OF ENERGY & INFRASTRUCTURE

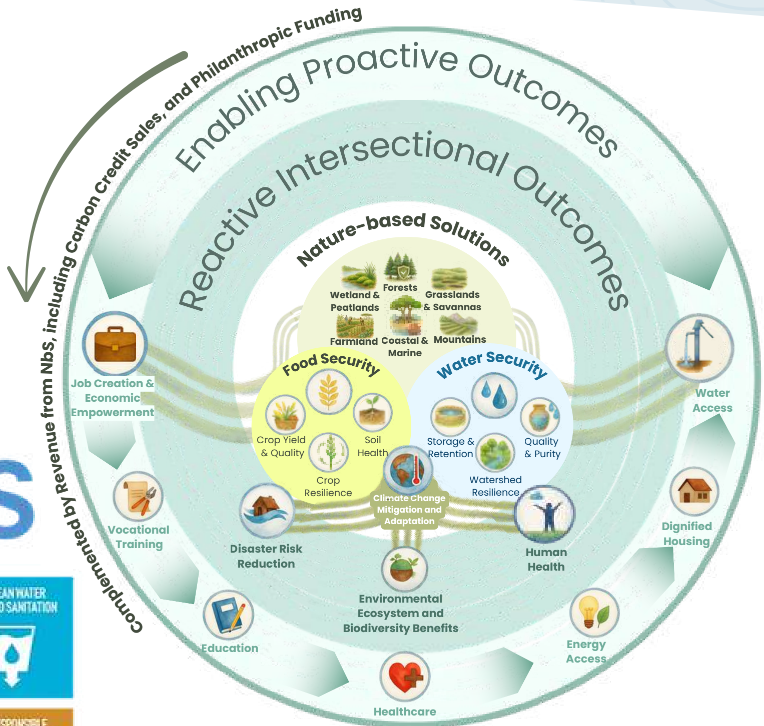
Carbon markets represent one of the most effective enablers of the global energy transition. They provide strong economic incentives that encourage industries to adopt cleaner technologies and expand the use of renewable energy sources. For the United Arab Emirates, where innovation and sustainability are established national priorities, carbon markets present a strategic pathway to mobilize climate finance, accelerate decarbonization, and enhance regional cooperation.

In alignment with these efforts, the UAE's Water Security Strategy 2036 underscores the necessity of ensuring sustainable and resilient water resources. A central component of this strategy is the transition from traditional multi-stage flash (MSF) desalination to energy-efficient reverse osmosis (RO) technologies. This shift not only reduces the carbon footprint of water production but also strengthens the overall sustainability of the water–energy nexus.

As the UAE builds on the momentum of COP28 and advances towards the Net Zero by 2050 strategic initiative, the integration of carbon market mechanisms with efficiency improvements in water and energy systems will serve as a critical pillar of national and organizational climate strategies.

Nature-based Solutions (NbS)

> **Nature-based Solutions are actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges such as climate change, human health, food and water security, and disaster risk reduction effectively and adaptively, simultaneously providing biodiversity benefits**



As per WWF, NbS can contribute to **achieving all the** SDGs

Sources: Amaly Legacy analysis, World Bank, WWF, IUCN.

Co-benefits

NbS offer various co-benefits, which are **additional positive outcomes of a project beyond its main goal** of GHG emissions reduction or carbon sequestration — including improved land tenure, improved crop yields, job creation, enhanced **biodiversity**, **human well-being**, **disaster risk resilience**, and preservation of cultural heritage.

NbS Unlock Strategic Multiple Pathways for Climate Action and Community Impact

NbS represent a strategic convergence of two powerful climate action pathways: mitigation and adaptation. While **mitigation targets the root causes of climate change by reducing emissions and capturing carbon, adaptation focuses on defensive, tailored interventions that uniquely safeguard local communities against climate extremes, such as flooding and storms, by strengthening local resilience.** Understanding this dual nature positions decision-makers to harness the full spectrum of NbS advantages, unlocking superior value beyond traditional, single-purpose approaches.

At the core, **NbS addresses address climate mitigation and adaptation**, **food security**, and **water security**. These **drive reactive outcomes** like disaster risk reduction, reduced environmental degradation and biodiversity loss, and better human health, while **enabling proactive outcomes** such as job creation, vocational training, education, healthcare, dignified housing, and equitable energy and water access. Carbon credit sales partly fund these activities, enhancing economic empowerment, community sustainability, and project co-benefits to drive higher credit prices and create a virtuous cycle of impact.

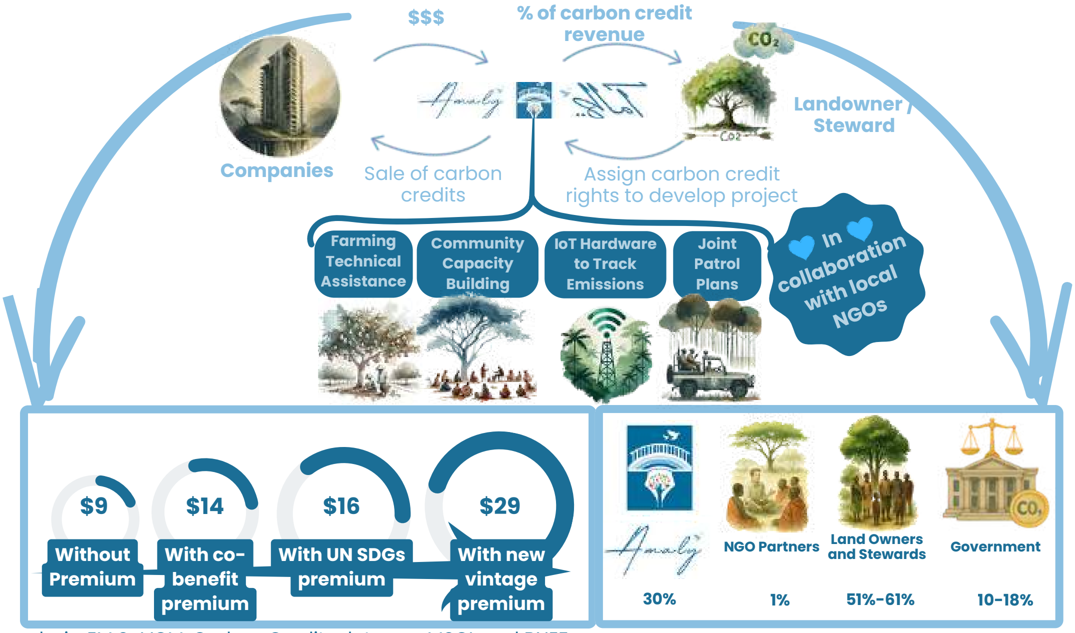
> Most Nature-based Solutions deliver both mitigation and adaptation benefits while simultaneously addressing pressing societal challenges such as food security, water availability, and disaster risk reduction. Compared to single-purpose technological interventions like direct air capture or industrial carbon capture, NbS offer cost-effective, durable, and multi-dimensional value propositions—restoring ecosystems while enhancing resilience, livelihoods, and biodiversity.

CHARLES KARANGWA
Head of Nature-based Solutions, IUCN

IUCN International Union for Conservation of Nature

Carbon Credits Ecosystem

We aim to explain the different stakeholders involved in a carbon credit project and the commercial premise through the lens of a forest conservation (NbS) project structured by Amaly Asset Management in East Africa.



Sources: Amaly Legacy analysis, EM SoVCM, Carbon Credits dot com, MSCI, and BNEF
Note: New methodologies are emerging that generate removal credits for avoided deforestation project. Removal credits pricing from Afforestation, Reforestation, and Regeneration projects (ARR) projects in 2024 was around $20 (base price). **2.** Distribution % are based on revenue, net income distributions allocate nearly 80% to local stakeholders. **3.** Distributions are in line with an East African country's local laws and regulations where the project is based and varies slightly based on the type of managing authority/land stewards.

1 Land Stewards & Regulators Offer land and/or regulatory support to develop projects	**Land owners & stewards**	Indigenous peoples, local villages, private landholders or public agencies that hold legal or customary tenure and give FPIC before any activity begins.
	Municipal & regional authorities	Represent collective interests of land stewards, monitor social safeguards, mediate grievances.
	National regulators & ministries	Set carbon-market rules, approve methodologies, and may run domestic registries or taxation schemes. Their oversight anchors legal certainty for credit issuance and trade.
2 Project Development Stakeholders Develop or aid development of carbon credits	**Project developers**	Design and implement emission-reduction or removal activities and interventions.
	Standard-setting bodies	Publish methodologies, register projects, maintain carbon registry, including issuance and retirement of credits.
	Digital MRV (dMRV) providers	Automate data collection, generate continuous, tamper-resistant data on carbon stocks and co-benefits, and provide analytics using remote sensing, IoT and blockchain.
	Accredited auditors / VVBs	Accredited third-party auditors - validation and verification bodies - independently confirm and validate baseline, methodology, additionality, and achieved reductions/removals.
	Rating Agencies	Independent rating agencies that assess integrity, permanence, and co-benefits of issued credits that aid investor and buyer decisions.
3 Funders Fund project development	**Investors, financiers & philanthropists**	These actors inject upfront cash so developers can design the project, install monitoring systems, and pay for validation, with repayment ultimately linked to carbon-credit revenue.
4 Buyers, Brokers & Exchanges Facilitate or directly purchasing carbon credits	**Buyers**	Buy and retire credits against their own emissions and/or achieve regulatory, CSR or net-zero goals.
	Brokers & Intermediaries	Match supply with demand, bundle credits, manage documentation, and handle retirement on behalf of clients, earning a spread or service fee.
	Exchanges	Provide transparent price discovery, standardised contracts, and secure settlement for spot or forward trades.

"Carbon solutions have demonstrated that climate and nature can be valued together, creating the capacity not only to repair the damage humanity has caused, but also to safeguard biodiversity, restore degraded ecosystems, and deliver real benefits for local communities. Each tonne of carbon locked away becomes more than a climate outcome: it is an investment in healthy soils, thriving forests, resilient coastlines, and the living systems that underpin our economies and societies"

DOROTHY MASEKE
Lead of Nature Finance & TNFD and Head of Secretariat at the African Natural Capital Alliance

AFRICAN NATURAL CAPITAL ALLIANCE

Carbon Credit Markets: Compliance vs. Voluntary (Roles, Drivers and Examples)

Carbon credits are classified into two key markets—compliance and voluntary markets—each serving distinct roles in global decarbonisation. The compliance market, valued at $800+bn in 2021, is driven by regulation and legal obligations, while the $535mn (2024) voluntary market ($2bn peak in 2021) is fueled by corporate net-zero commitments and stakeholder pressure rapidly gaining traction as companies respond to investor, consumer, and regulatory pressure to demonstrate positive environmental footprint. Here we outline the structure, drivers, and major transactions shaping both markets, as companies—from airlines to tech leaders—accelerate climate action through carbon credit strategies.

Compliance Carbon Market

- Regulated by Governments, intergovernmental organisations and industry standard-setting bodies where participation is **mandatory** to meet legally binding national or international emissions reduction targets
- Carbon prices are **stable** for each compliance segment and are influenced by policies
- Value of market is ~$800bn

VS

Value of carbon markets

$800+ BN

$2 BN

Voluntary Carbon Market

- **Not** mandated by law, accreditation via independent registries to meet non-regulatory voluntary environmental goals
- **Variable** price and influenced by the specifics of each project, such as location, type, and perceived impact
- Value of market is $2bn

Compliance Carbon Credits' Demand Drivers

1. Emissions trading schemes and carbon taxes
2. Achieving national climate targets (NDCs)
3. Offsetting aviation emissions under CORSIA

CORSIA
CARBON OFFSETTING AND REDUCTION SCHEME FOR INTERNATIONAL AVIATION

From 2027 (Second Phase), CORSIA offsetting is mandatory on routes between participating States, with exemptions for LDCs, SIDS and LLDCs (unless they opt in) and below-threshold operators. Airlines must cover emissions above the baseline using CORSIA-eligible fuels and/or CORSIA credits on those covered routes. Penalties aren't set by ICAO—they're set and enforced by each State's law, so consequences vary by jurisdiction (e.g., the UK has proposed per-tonne penalties for non-cancellation).

Voluntary Carbon Credits' Demand Drivers

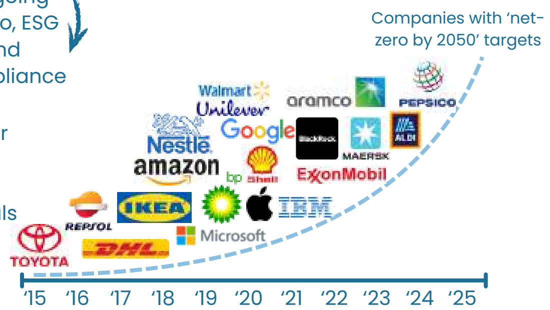
1. Government pressure with possible fines
2. Executive pay linked to net-zero pledges
3. Societal and customer pressure jeopardising sales

Net-Zero pledges, ESG reporting

Corporations going beyond net-zero, ESG reporting and regulatory compliance

Building a stronger case for their commitment to environmental goals

Voluntary carbon credit market is estimated at **$2bn in 2022,** and could be worth upto **$50bn by 2050** according to McKinsey



Sources: Reuters, McKinsey, Carbon Credits Dot Com, Amaly Legacy analysis

Notable Transactions

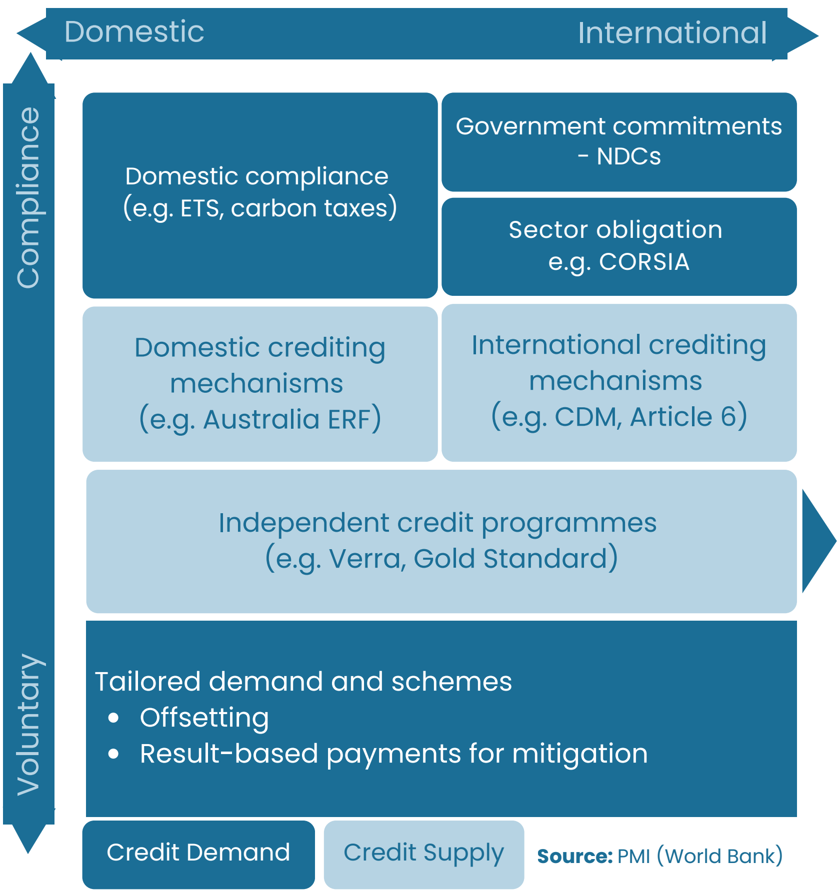
Qatar Airways	Qatar Airways became the first carrier to purchase carbon credits on the IATA Aviation Carbon Exchange using IATA Clearing House	**British Airways** **Purchased 33,000 carbon-removal credits in 2024**	British Airways's aims to cut gross emissions by 15% by 2030 versus 2019. Its carbon footprint stood at 11.9 MT of CO_2e in 2022, compared to 19.0 MT of CO_2e in 2019
JetBlue Airways	JetBlue purchased carbon credits from the Larimar project aligned with CORSIA. This project is expected to reduce emissions by over 200,000 MT of CO_2e annually	**Etihad Airways** **Purchased 80,000 carbon credits in 2021**	Etihad has a **2050 net-zero target** and aims to reduce CO_2e emissions to **50% by 2035**. Its carbon footprint stood at **5.3 MT in 2022**, compared to **9.1 M tonnes** in 2019

Sources: British Airways, Qatar Airways, Etihad Global, GreenAir News, Xpansiv

Carbon Credit Registries

As carbon markets evolve, registries have become the linchpin ensuring environmental integrity, transparency, and interoperability across both compliance and voluntary ecosystems. Leading registries such as Verra and Gold Standard not only issue and track credits, they also offer labels that help align credits with emerging uses under CORSIA and Article 6 (e.g., CORSIA-eligible and Article 6-authorised labels).

Carbon Credit Market



Source: PMI (World Bank)

Examples of Carbon Registries

VERRA, Gold Standard, PLAN VIVO (For nature, climate and communities), SOCIALCARBON®, American Carbon Registry, CLIMATE ACTION RESERVE

Verra has the largest volume of issued/retired credits globally … in addition, Verra offers labels and mechanisms to align credits with CORSIA and Article 6 enabling issuance of credits for compliance purposes

	VERRA	Gold Standard	CLIMATE ACTION RESERVE	PLAN VIVO
VCU issued	**1.3+bn** Carbon Tonnes	**388mn** Carbon Tonnes	**222.3mn** Carbon Tonnes	**10.8mn** Carbon Tonnes
VCU Retired	**816.6mn** Carbon Tonnes	**192mn** Carbon Tonnes	**71.1mn** Carbon Tonnes	**Data N/A**
Geographies	**Global**	**Global**	**Americas, Africa***	**Africa, Asia, Latin America & Pacific**

Largest volume of issued and retired credits

Source: Amaly Legacy analysis
Notes: **1.** Cumulative figures until 2024; **2.** Climate Action Reserve is expanding to Asia and Latin America

Convergence of Compliance and Voluntary Regimes

Traditional compliance markets—such as the EU ETS, New Zealand ETS, and California's Cap-and-Trade—are built on government-mandated emissions caps and trading schemes. Alongside these, a growing number of governments are recognising the integrity and rigour of voluntary carbon credits—particularly those issued by leading registries like Verra—and are integrating them into compliance regimes. From national schemes in Colombia and South Africa—and, most recently, in the United Arab Emirates through its 2024 National Register for Carbon Credits (Cabinet Resolution No. 67 of 2024)—governments now allow the use of high-integrity credits to meet announced commitments and regulatory obligations. In addition, under global mechanisms like CORSIA and the Paris Agreement's Article 6, high-quality credits are increasingly accepted for compliance uses. This convergence is blurring the lines between voluntary and compliance markets, offering new pathways for credit developers to access regulated demand.

Pure Compliance Markets

EU Emissions Trading System

EU ETS

World's first international emissions trading system and the EU's flagship policy to combat climate change

California Cap-and-Trade Program

California's strategy to reduce GHG emissions, covering approximately 80% of the state's GHG emissions

Voluntary Carbon Standard in Compliance Market

VCUs Used for Carbon Tax Obligations

Select governments have introduced carbon tax obligations and are permitting the use of high-integrity carbon credits from Verra's programme. Below are two case studies:

- **Case Study of Colombia Carbon Tax:** The Colombian government implemented a National Carbon Tax in 2017, mandating polluting industries to be taxed for GHGs they emit. Entities can offset a defined share of liability with **high-integrity credits.**
- **Case Study of South Africa Carbon Tax:** Projects certified by Verra that generate carbon credits (VCUs) are eligible for use by entities in South Africa to satisfy a portion of their tax liabilities, as set out in the country's Carbon Offset Regulations.

Article 6 Adjusted Credits

PARIS AGREEMENT

- **The Paris Agreement is a legally binding international treaty on climate change, adopted by 195 Parties at COP21 in Paris; Parties set nationally determined contributions (NDCs).**
- Article 6 of the Paris Agreement is the mechanism enabling countries and companies to trade carbon credits to meet their climate commitments and NDCs effectively.
- Countries buy these credits to comply with international emissions-reduction commitments and strengthen relationships with trading partners. Companies may pay a premium for Article 6-aligned credits to support contribution to a country's NDC, especially where they have commercial interests in that country.
- In addition to host-country letters of authorisation (**LoAs**) and corresponding adjustments, Verra provides Article 6 labels under its programme.

CORSIA

- The International Civil Aviation Organization (ICAO) implemented the CORSIA scheme with the objective of stabilising emissions, and it applies to international flight operators.
- Eligible carbon credits allow flight operators to comply with obligations under the CORSIA scheme.
- VCUs that meet ICAO's eligibility criteria under Verra's programme are eligible to receive a CORSIA-eligible label.

Source: UAElegislation.gov, GFIntegrity, Verra, Amaly Legacy analysis

Rationale for Aligning with Article 6 of the Paris Agreement

Premium:

- **Enhanced value of carbon credits** by ensuring that projects meet stringent environmental-integrity and transparency requirements set by the host country's carbon regulations to align with Article 6.

Broader Demand Pool:

- Aligning with Article 6 **unlocks a broader pool of buyers** to trade your carbon credits in both voluntary and compliance carbon markets.
  - Unlocks demand from more **corporations supporting governments** by contributing to NDC objectives.
  - Allows **governments** to buy these credits **for use toward their NDCs, with the host country applying a corresponding adjustment.**

Due-diligence Defence for Buyer Governments:

- The ICJ clarified states have binding duties to prevent climate harm and cooperate. Buying Article 6-authorised, correspondingly-adjusted credits evidences diligence and cooperation, reducing exposure to "greenwashing/double-counting" claims.

Verra Announces **First Application of Article 6 Authorised Labels to VCUs from a Cookstove Project in Rwanda** in 2023

In partnership with the government, the DelAgua Live Well Clean Cookstove Programme in Rwanda received the first Article 6 labels on its VCUs. This was achieved after obtaining Letters of Authorisation from the Rwanda Environment Management Authority, indicating a commitment to corresponding adjustments under the Paris Agreement

Source: ICJ, Verra

Rationale for aligning with CORSIA

Access to the International Aviation Market:

- Gives access to the international aviation market

Alignment with International Standards:

- CORSIA sets international standards for MRV. Therefore, by complying with CORSIA, projects align and adhere to these standards and global best practices.
- Attracts partnerships, investors, and stakeholders who are associated with the aviation sector

126	Volunteer States in Phase I (2024)	**Source:** ICAO
625	Flight operators under CORSIA (Dec 2023)	**Source:** ICAO
800 Mt CO_2	CO_2 emissions from aviation (2022)	**Sources:** IEA, European Commission
$1.45 Trillion	Est. capex on sustainable aviation fuel production facilities to 2050	**Source:** ICAO, ATAG

Implementation is Divided into Three Phases:

Pilot Phase (2021-23)	First Phase (2024-26)	Second Phase (2027-35)
Voluntary		Mandatory
Flights between states that have volunteered to participate. No offsetting requirements accrued for 2021–2023 under the pilot phase.		Mandatory except for flights to/from least developed countries, small island developing states, and landlocked developing countries

CORSIA will inject new demand for carbon credits of about **107–161 million units in the first phase (2024–26)** according to IATA (June 2025), which is likely to result in a significant price premium for eligible Verra-certified credits with a CORSIA label. With ICAO **approving eligible emissions-unit programmes** (e.g., Verra VCS) to supply CORSIA-eligible credits, this will boost demand for eligible Verra-certified credits as well.

> **"Only ~7.6 million credits currently meet CORSIA eligibility versus ~135–182 million units of airline demand in Phase I (2024–26), with Phase II demand ~0.825–1.6 billion units — 9–10× current supply"**
>
> ***Forecast demand estimate for carbon credits from CORSIA 2024 - 2035 by Carbon Market Analysts at Abatable***
>
> **Sources:** Abatable (Reuters), IATA, BeZero, and Amaly Legacy analysis

Understanding Third-Party Ratings

Carbon ratings assess the quality of carbon credits by interrogating risk factors and drivers, such as additionality, baselines, leakage, permanence, and data transparency. High carbon ratings can help to strengthen carbon credit claims via third-party validation.

Independent ratings agencies support decision making for project developers and buyers of carbon credits

BeZero: Rating agency for global carbon markets.

Robust methodology and analyst-led approach supported by geospatial analysis, curated datasets, proprietary models, and sector-specific frameworks.

In order to be eligible for a BeZero Carbon Rating, a project must meet the following criteria:

- The project must have applied an additionality test or provide sufficient information on how it is deemed additional
- The project must have sufficient publicly available information
- The project must be audited by a recognised third-party auditor in order to ensure the robustness of the data and information published

Carbon Credit Rating Agencies

BeZero

Sylvera

Renoster

BeZero assesses three key risk factors for each project rating

Additionality	The likelihood that a credit purchased and retired leads to a tonne of CO_2e being avoided or sequestered that would not have otherwise happened.
Carbon Accounting	The likelihood of having carbon accounting consistent with achieving a tonne of CO_2 avoided or removed.
Permanence	The likelihood that the carbon avoided or removed by the project will remain so for the time committed.

Source: BeZero
Note: For pre-issuance projects that have not yet issued credits, BeZero also assesses project execution risk.

The BeZero Carbon Rating scale

AAA	AA	A	BBB	BB	B	C	D
Highest	Very high	High	Moderate	Moderately low	Low	Very low	Lowest

> ***Harnessing the demand for high-quality carbon credits requires the right tools to build trust and transparency. Carbon ratings are essential to the functioning of carbon markets, and already some of the biggest businesses rely on BeZero's analysis for the clarity they need to make confident carbon decisions.***

BeZero

Strategic contribution to our report from BeZero

Source: Analysis by BeZero and Amaly Legacy

Frameworks and Initiatives Guiding High-Integrity Carbon Markets

Below are some standards that can be considered to enhance integrity and quality of carbon credits

Integrity Council for the Voluntary Carbon Market (ICVCM): An independent governance body that sets standards for high-quality carbon credits to establish trust in the voluntary carbon market.

Core Carbon Principles: Principles for informing and guiding the assessment of carbon-crediting programmes and carbon credits.

It covers **governance**, **emissions impact**, and **sustainable development**, ensuring that credits are transparently managed, resulting in real emission reductions, and contributing positively to sustainable development.

Voluntary Carbon Markets Integrity Initiative (VCMI): A multi-stakeholder initiative focused on ensuring the integrity of voluntary carbon markets.

Collaborates with various stakeholders including civil society, the private sector, indigenous peoples, local communities, and governments to enhance the quality of carbon credits and support net-zero transitions.

Main initiatives include:

- **VCMI Claims Code of Practice – Provides companies with a rulebook** for making credible claims when using carbon credits as part of climate commitments
- **VCM Access Strategy Toolkit by VCMI – Guidance for countries** to engage with high-integrity VCMs

Science Based Targets Initiative (SBTi): Develops guidance & tools for corporates to reduce their GHG emissions

SBTi provides **a framework for corporate net-zero target setting** in line with climate science. Has developed detailed criteria and standards for setting both **near-term and net-zero science-based targets**. Companies submit their targets to SBTi, which **assesses and validates** them, ensuring **transparency and accountability in the target-setting process**.

Criteria:

Scope 1 and Scope 2: The targets must cover company-wide scope 1 and scope 2 emissions, as defined by the GHG Protocol Corporate Standard.

Requirement to have a scope 3 target: If a company's relevant scope 3 emissions are 40% or more of total scope 1, 2, and 3 emissions, they shall be included in near-term science-based targets. All companies involved in the sale or distribution of natural gas and/or other fossil fuels shall set **separate scope 3 targets for the use of sold products**, irrespective of the share of these emissions compared to the company's total scope 1, 2, and 3 emissions.

Standards, Certifications and Principles That Support High-Integrity Claims

Climate, Community & Biodiversity Standards
A VERRA STANDARD

Sustainable Development Verified Impact Standard
A VERRA STANDARD

FPIC
Free, Prior & Informed Consent

FSC

Source: Amaly Legacy analysis

True Price Signals: Market Growth and Demand

As the carbon market rapidly evolves, accurate pricing analysis requires a sharp focus on quality. While market data can be overcrowded by low-integrity credits, real value lies in understanding how high-integrity carbon credits fare—those with verifiable impact, trusted methodologies, and strong demand from blue chip buyers. These credits are the true benchmark for pricing, given their resilience amid increasing overall supply and rising demand from companies committed to genuine climate action.

Market Dynamics

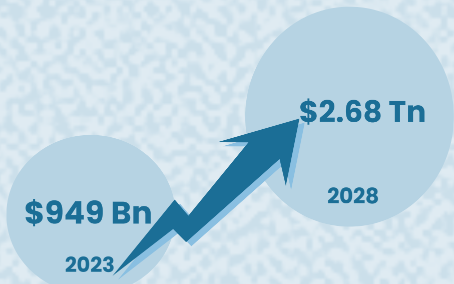
IS THE MARKET GROWING?

✅ **Outlook:** By 2050, global carbon market is estimated to reach **$22 trillion p.a.** while **voluntary carbon markets could reach $1.1 trillion p.a.** [1,7]

*Demand for carbon credits could rise upto **15x by 2030**, and up to **100x by 2050***

~ Taskforce on Scaling Voluntary Carbon Markets[2]

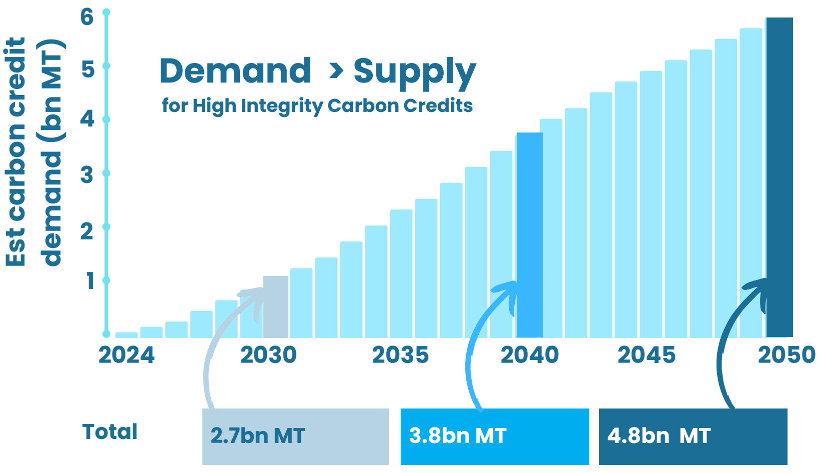
Carbon Market Growth



99% share of **Compliance Market** in 2024

Despite the growth of carbon markets, compliance markets still account for the vast majority of carbon-credit volume and value. As voluntary credits converge to meet compliance protocols such as CORSIA and Article 6, they both tap into—and help expand—the rapidly growing compliance market by adding eligible supply and stimulating new regulatory demand.

✅ **Supply vs Demand of High Integrity Carbon Credits**



Source: BNEF
Note: Analysis of pricing of high-integrity carbon credits, inelastic demand for these credits, and overall supply of these credits.

Demand Dynamics

IS DEMAND STRONG AND RESILIENT?

✅ **Metric 1: Volume of Retired Credits**: The ten largest standards collectively retired 182 mn MT of CO_2e each year **from 2021 to 2024, underscoring stable, resilient and consistent demand.**[4]

Who is Buying?

SHELL | DELTA AIRLINES | HP

MICROSOFT | NESTLE

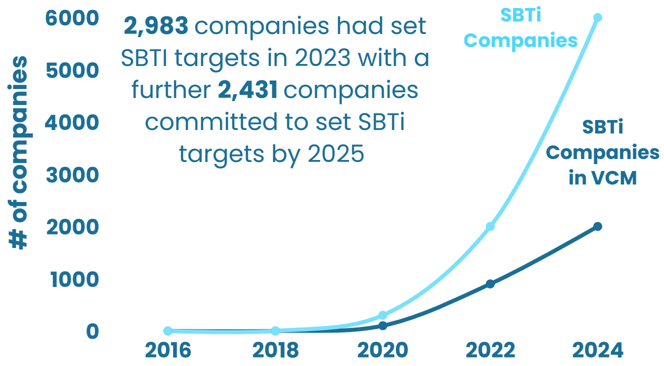
What Is Being Purchased? *(2024 Snapshot)*

91% Reduction Credits **Vs** **9%** Removal Credits

91% of retired credits originated from projects that reduce emissions, such as **renewable energy and forest conservation**, while **9%** came from removal projects, like **reforestation** or advanced REDD+ projects with an embedded removal component.[5]

Note: Contact Amaly Legacy team to explore strategies to embed removal credits within REDD+ pojects

✅ **Metric 2: Demand Indicator: Companies Setting SBTi Targets**



Source: Alliedoffsets and GenZero
Note: SBTi commitments have exponentially increased, signifying broader corporate transformation.

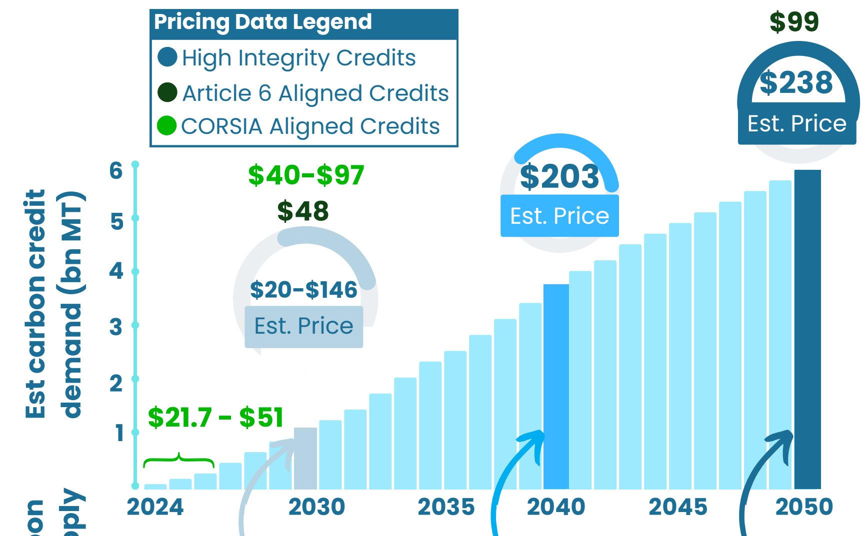
Sources: 1. BloombergNEF; 2. Taskforce on Scaling Voluntary Carbon Markets; 3. Grandview Research; 4. Forest Trends' Ecosystem Marketplace. 2025. State of the Voluntary Carbon Market 2025. Washington DC: Forest Trends Association. 5. CarbonCredits.com; 6. CarbonBrief; 7. Investcorp.

Carbon Credit Price Outlook

Despite volatility in carbon pricing, the high-integrity segment of voluntary carbon markets is undergoing a transformative shift as demand dynamics are shifting with compliance schemes converging with voluntary carbon credits. As more companies commit to SBTI and net-zero pathways, the value of high-quality carbon credits—those with measurable co-benefits and verifiable climate impact—is increasing. In the long run demand will outstrip supply of high-integrity carbon credits with prices estimated to reach $238 per credit. Forestry and land use projects, especially those aligned with the UN SDGs, can command price premiums, reflecting their broader environmental and social value. As the global carbon market matures, it is clear that diversified, high-integrity credits will play a critical role in helping corporates meet their climate goals while unlocking new financing pathways for sustainable development.

Estimates of High Integrity Carbon Credit Price vs Supply

(Compliance Labels e.g. Article 6 & CORSIA reference pricing markers included)



Total	2.7 bn MT	3.8bn MT	4.8bn MT
REDD+	1.5bn MT	1.7bn MT	2bn MT

Source: BloombergNEF, Carbon Pulse

Notes: 1. Analysis of pricing of high-integrity carbon credits, inelastic demand for these credits, and overall supply of these credits. **2. CORSIA:** Analysts tracking Phase 1 (2024-26) say CORSIA-eligible prices could reach ~$51/t as the scheme tightens. CORSIA-eligible credits traded/assessed in the ~$18–$22/t band (MSCI) and averaged $21.70/t in 2024 auctions (IATA and Xpansiv) and forecasted at $27-91 (MSCI) and $40-$97 (BloombergNEF) during the latter stages of Phase II (2033 to 2035). **3. Article 6:** ICJ's July 2025 opinion clarifying states' legal duties on climate action is likely to strengthen Article 6 demand.

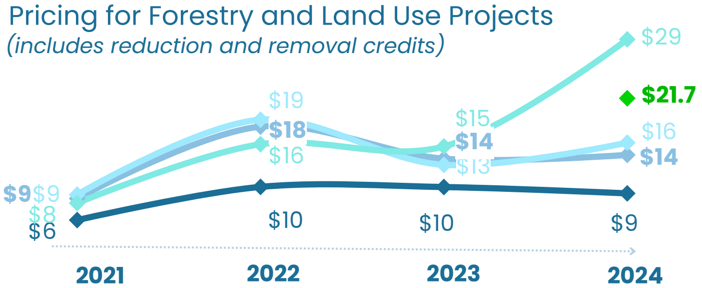
BloombergNEF's analysis shows that in a high-quality offset market with inelastic demand, corporates buy credits as a backstop for residual emissions, pushing demand to **~5.9 bn MT in 2050**, while high-quality supply rises from **to ~4.8 bn MT**—leaving the market undersupplied from ~2045 onward; However, we believe that as compliance labels are integrated into high-integrity supply (e.g., Article 6 authorizations / corresponding adjustments and CORSIA-eligible units), **demand will outstrip supply earlier and more persistently:** BNEF's CORSIA outlook flags prices on track to ~$97 by 2027 and notes that eligible-credit availability depends on approvals—signs of near-term tightness in compliance-grade supply. Independent assessments further quantify the constraint: only ~7.6 mn credits currently meet CORSIA eligibility versus ~135–182 mn units of airline demand in Phase I (2024–26), with Phase II demand ~825 mn–1.6 mn units—9–10× current supply—highlighting a structural compliance-label supply gap. Industry coverage points to a timing mismatch between when eligible units are available and when airlines must comply, reinforcing risk of shortfalls and price spikes.

On pricing of high-integrity credits BNEF's analysis indicates moving to ~$203 in 2040 and ~$238 in 2050. These volumes and price paths explicitly refer to high-integrity credits; any Article 6 or CORSIA figures shown in our visuals are reference price markers only, not separate volume curves. The implication is clear: as integrity standards harden and net-zero deadlines near, pricing should rise and high-quality demand will outstrip supply, supporting a durable premium for verified, high-integrity credits.

Voluntary Carbon Credit Pricing (With Compliance Labels)

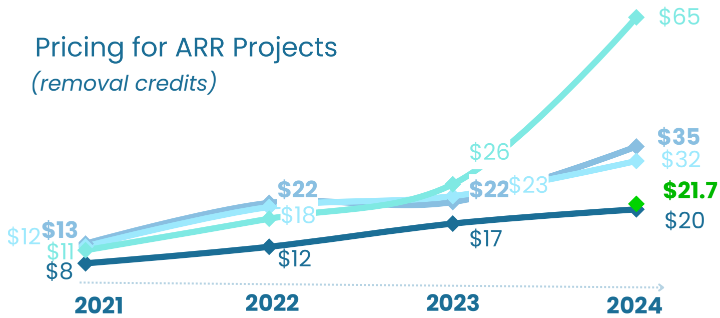
Pricing for Forestry and Land Use Projects

(includes reduction and removal credits)



Pricing for ARR Projects

(removal credits)



Pricing Data Legend
- **Without premium**
- **With co-benefit premium**
- **Illustrative Cumulitive Case**
- **With new vintage premium**
- **With UN SDGs premium**
- **CORSIA Compliance Credits**

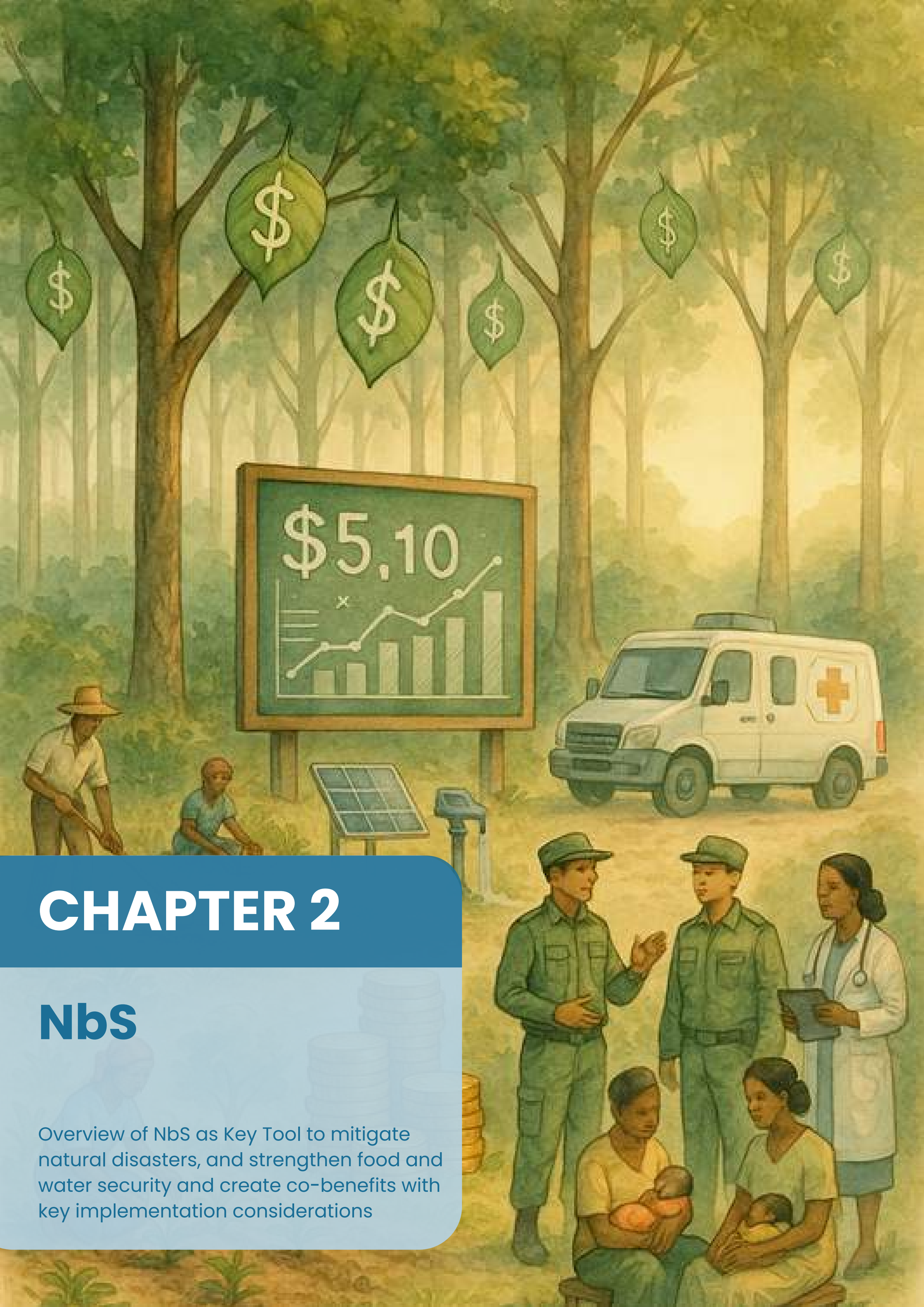
Illustrative application of price premiums to forestry and land-use credits (including ARR removal credits) shows significant potential **of high-integrity carbon credits.** We focused on forestry and land-use projects as they have lower implementation cost and very high potential to contribute towards development goals. If the project is:

- demonstrating clear co-benefits it attracts an average price premium of ~78%,
- clearly contributing to the UN SDGs it attracts an average price premium of ~86%, and
- from a new vintage it attracts an average price premium of 91% (impacted by 2024's 217% outlier premium).

Credits with higher ratings, especially those using hardware tech for more accurate measurement, can command a **price premium of 200%+ compared to lower-rated credits**; highlighting nuances in price premiums

Sources: EM SoVCM, Carbon Credits dot com, MSCI, BNEF, Amaly Legacy commentary

Notes: Premiums are EM's volume-weighted market averages; attributes are correlated, so premia are not additive. The chained lines are illustrative cases only. "Recency" uses a rolling ≤5-year cutoff that shifts each year. SDG/co-benefit coverage varies by registry and year; EM periodically updates historical averages as more trades are reported (hence small differences between EM 2023/2024/2025 editions)



CHAPTER 2

NbS

Overview of NbS as Key Tool to mitigate natural disasters, and strengthen food and water security and create co-benefits with key implementation considerations

OVERVIEW OF NBS LANDSCAPE

NbS can transform the way we address some of the world's toughest challenges, making it a critical carbon credit pathways. In this section of the report we examine how NbS restores ecosystems, delivers co-benefit returns, shields communities from climate shocks, and secures the future of our food, water, and health.

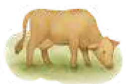
Natural Ecosystems	NbS	Definition	Select Applicable Carbon Methodology
Forests	Forest Conservation	Prevention of forest loss on land that would otherwise have been deforested through policy changes, funding mechanisms, or conservation actions such as establishing protected areas, and promoting economic development compatible with mitigation.	VM0048 (Verra)
	Reforestation and Afforestation	Afforestation is establishing new forests on historically non-forested land, while reforestation is restoring forests on recently deforested areas; both practices involve planting trees or allowing natural regeneration to increase carbon sequestration.	VM0047 (Verra)
	Sustainable Forest Management	Stewardship of forests to maintain their biodiversity, productivity, and regeneration capacity while providing continuous economic, social, and environmental benefits through selective harvesting, reforestation, ecosystem conservation, and community engagement.	VM0045 (Verra)
Coastal and Marine	Mangrove Restoration	Process of re-establishing mangrove forests in areas where they have been lost or degraded, using methods such as replanting native species with the goal of sequestering carbon, protecting coasts, supporting biodiversity, and improving local livelihoods.	VM0033 (Verra)
	Coral Reef Protection	Conservation and restoration of reef ecosystems to support biodiversity, coastal resilience, and carbon sequestration, contributing to reduced pollution and overfishing.	No approved methodology by any of the major registries we consider
	Seagrass Conservation	Protection and restoration of underwater seagrass meadows to maintain their role as carbon sinks, support marine biodiversity, improve water quality, and protect coastlines.	VM0033 (Verra)
	Living Shorelines	Coastal stabilisation projects that protect and stabilise coastal edges made of natural materials such as plants, sand, or rock, designed to reduce erosion, provide habitat, and enhance coastal resilience by maintaining the natural connection between land and water.	VM0033 (Verra)
Farmland	Regenerative Agriculture	Holistic and sustainable approach to farming and land management that aims to restore and enhance health of ecosystems, improve soil quality and promote biodiversity using reduced tillage and synthetic fertilisers, integrated pest management, crop diversity, cover cropping, and composting, among others.	VM0042 (Verra)
Grasslands	Grassland Conservation	Protection and management of grasslands through preventing ploughing or development, restoring degraded areas, controlling invasive species, adjusting grazing intensity, and replanting native grasses to maintain biodiversity and improve soil carbon.	VM0032 (Verra)
	Rotational Grazing	Rotational grazing is a livestock management practice where animals are moved between paddocks on a planned schedule to allow pastures to recover, which improves soil health, increases carbon sequestration, and supports sustainable grassland ecosystems.	VM0032 (Verra)
	Savanna Fire Management	Strategic use of controlled, early season burning—often based on Indigenous knowledge—to reduce the frequency and intensity of late dry season wildfires, thereby lowering greenhouse gas emissions and increasing carbon storage.	No approved methodology by any of the major registries we consider
Mountains	Watershed Management	Land management strategies that improve a watershed's ability to retain and deliver water to rivers, lakes, and ponds, thereby enhancing water quality and quantity, supporting agriculture, biodiversity, and long-term water security.	No approved methodology by any of the major registries we consider
	Terracing and Contour Farming	Terracing creates flat steps on slopes to slow water, prevent soil erosion, and make steep land farmable. Contour farming follows land elevation lines to form barriers that reduce runoff and erosion; both directly protect soil, improve water retention and enhance crop yields on sloped fields.	See regenerative agriculture
	Alpine Meadow Conservation	Protection, management, and restoration of high-altitude grassland ecosystems to maintain native plant and animal diversity, prevent land degradation, and support water regulation, using practical measures such as controlled grazing, invasive species removal, and habitat monitoring.	Depends on land-use
Wetland	Wetland Restoration	Rehabilitation of degraded wetland sites by restoring natural hydrology, replanting native vegetation, managing invasive species, and reestablishing habitat conditions to enhance carbon sequestration, water filtration, flood control, and biodiversity support.	VM0033 (Verra)
	Constructed Wetlands	Engineered creation of artificial wetland systems on non-wetland sites using water control structures, substrate materials, and native vegetation to provide water treatment, habitat, flood control, and carbon sequestration benefits.	VM0024 (Verra)
	Peatland Management	Conservation, restoration, and sustainable use of peat-forming wetlands through rewetting drained areas, preventing conversion, controlling water levels, and maintaining natural hydrology to support biodiversity and preserve carbon storage, (preventing degradation that releases stored carbon).	VM0036 (Verra)

Sources: Verra, Amaly Legacy analysis

Notes: 1. For the purpose of this analysis, we excluded urban ecosystems. **2.** Only select notable methodologies were included in our analysis, unless segment has many notable methodologies, in which case we only mentioned the category broadly. **3.** Maintaining natural hydrology means preserving or restoring the natural patterns of water flow, distribution, and levels within an ecosystem. **4.** The regenerative practices that Amaly considers have been presented on page 30. **5.** Somme NbS project types do not yet have approved methodologies under the major registries considered, though niche methodologies exist for certain NbS, and several registries are developing new methodologies.

OVERVIEW OF NBS LANDSCAPE *(Continued)*

High-performing NbS go beyond carbon—unlocking resilient returns through biodiversity gains, bio-ingredient value chains, and diversified revenue streams that outperform traditional land uses. A robust assessment must account for each NbS type's impact on biodiversity, integration within high-value bio-ingredient value chains (edible crops, bio-actives, nutraceuticals), commercial maturity, scalability potential, and breadth of co-benefits. Well-structured NbS projects deliver resilient, risk-adjusted returns by combining carbon sequestration with diversified revenue streams—from scalable products such as nuts, resins, and seaweeds—often outperforming conventional land uses in both value and stability.

	Biodiversity	Biological Assets and Byproducts	Commercial Maturity (CM) and Scale	Co-Benefits
Forests  ★★★	Very high – hosts ~80% of terrestrial species	**Extensive and mature:** resins/gums, essential oils, latex/rubber, medicinal plants and botanicals, edible nuts / fruits (cacao, nuts), natural dyes / pigments, biopharma compounds, timber byproducts (cellulose), honey from forest bees, biofuels from residues	• **CM:** High – long-established global supply chain • **Scale:** Forest conservation is most scalable NbS; ARR is least scalable in the forestry category	★★★ 3/3 – jobs, eco-tourism, farming Technical Assistance (TA) to reduce conversion, sustained thinning /timber, wildlife protection
Coastal and Marine  ★★★	Very high – coral reefs host ~25% of marine species despite <1% ocean floor coverage	**Growing:** algae/seaweed biopolymers and extracts, marine cosmeceuticals and nutraceuticals, pharmaceuticals, bio-actives from mangroves/seagrass (tannins, fibers), marine collagen/peptides, edible seaweeds (nori, kelp), biofuels from algae, aquaculture feed additives	• **CM:** Medium – large seaweed market; other bio-ingredients remain niche • **Scale:** Medium-High – blue carbon offers scale; coral/seagrass restoration constrained by technical complexity	★★★ 3/3 – blue-carbon + coastal-protection (flood-losses avoided); fisheries jobs, disaster risk reduction, water quality
Farmland  ★★½	High – enhances pollinators and soil microbes relative to conventional agriculture	**Extensive and growing:** core **edible crops**; botanical extracts **(herbs/spices)**, compost teas / vermicompost, bio-stimulants (plant-based), aromatic herbs/oils, bio-pesticides, bio-fertilisers, nutraceuticals from cover crops	• **CM:** Mature edible crop supply chains with fast-growing alternative segments • **Scale:** Medium – farmer adoption and systemic barriers slow execution	★★½ 2.5/3 – farmer income, food security, soil-water benefits
Grasslands  ★★	Medium – high plant diversity, supports herbivores	**Limited:** medicinal/culinary herbs (echinacea, rooibos), honey from wildflowers, grasses for bio-fuels/ethanol, livestock feed supplements, niche botanicals (aloe, hoodia)	• **CM:** Low – limited extractives, fragmented grazing markets • **Scale:** Low–Medium – **large land potential**, but mixed evidence /high dependency on local herder engagement	★★ 2/3 – grazing jobs and watershed benefits, fewer exportable ingredients
Mountains  ★★	High – high endemism due to elevation / isolation	**Niche:** alpine botanicals and herbs (gentian, rhodiola), medicinal honey (high-altitude varietals), edible berries/mushrooms, bio-actives for pharma/cosmetics, watershed plants for teas/extracts	• **CM:** Low–Medium; niche high-value botanicals (small-scale) • **Scale:** Medium-High – watershed protection growing, but topography and remoteness limit speed	★★ 2/3 – critical water-security and disaster risk reduction; modest ingredient potential
Wetland  ★	Medium – important for birds /amphibians, variable richness	**Minimal:** niche wetland herbs (cranberry, sundew), peat alternatives (sphagnum moss for packaging/horticulture), medicinal plants (willow bark), bio-fibers from reeds/cattails	• **CM:** Low – niche ingredients; peat unsustainable • **Scale:** Medium – strong carbon/water mitigation but constrained by hydrology and event unpredictability	★ 1/3 – huge carbon and water filtration value; limited livelihood/housing impacts; store soil carbon

Forests lead as richest terrestrial source of high-margin ingredients (e.g., edible fruits/nuts, bio-actives like essential oils/medicinals), with broadest co-benefits and commercial maturity that is highly scalable — outperforming other NbS in delivering diversified returns at scale. Coastal and marine NbS rival forests in co-benefits via blue carbon, storm defense, fisheries, and growing seaweed/edible bio-ingredients, but lag in maturity— a high-potential frontier exceeding land-based alternatives. Regenerative agriculture excels in livelihoods and soil health, with scaling edible crops (e.g., herbs/proteins) and bio-ingredients, though less diversified than forests/coastal systems. While other NbS shine in niche services, they lack commercially mature ingredient chains, and difficult to scale, limiting high-return potential. Overall, forests provide the most mature, diversified NbS profile, with coastal and marine considered next frontiers; together all three offer rich edible crops/bio-ingredients than other ecosystems.

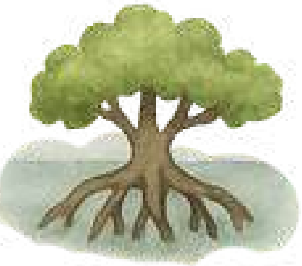
Sources: NOAA Fisheries, FAO & UNEP, Amaly Legacy analysis and primary interviews

High Impact NbS Analysed Further in Our Report

Coastal and Marine NbS

Climate Change Challenges and Impacts

Disaster Risk Reduction From Implementing NbS



Mangrove Restoration

Biodiversity Benefit e.g.

Mangrove roots act as nursery habitats for shrimp and prawns, providing shelter and food that help sustain commercial shrimp stocks

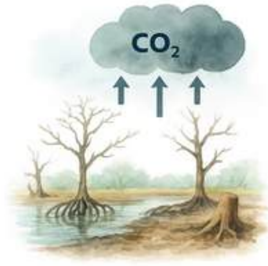
Coastal Development → Mangrove loss → Increased storm surge vulnerability[1]

Intensified storms → Catastrophic coastal flooding → Infrastructure damage

Community displacement → Economic stress → PRESSURE for more coastal development

Further mangrove destruction → Lost carbon storage → MORE climate warming

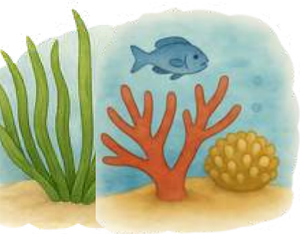
Coastal vulnerability, extreme flooding, ecosystem destruction



✅ **Restored mangroves** sequester carbon in roots, soil and biomass

❌ **Degraded mangroves** release carbon from roots, soil and biomass

NbS Cascade Intervention Impact: Breaks this coastal vulnerability spiral by reducing storm surge water levels via wave attenuation, sequestering more carbon per hectare than other coastal wetlands, and providing natural coastal defense that performs better than hard infrastructure during major storms.



Coral Reef and Seagrass Conservation

Biodiversity Benefit e.g.

Key nursery and feeding grounds for commercially important species, including spiny lobster and other crustaceans

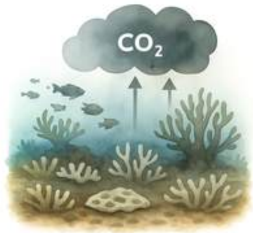
Rising CO_2 → Ocean acidification

Coral reef degradation → Marine biodiversity collapse → Lost carbon sequestration

Fisheries collapse → Food security crisis → Increased pressure on remaining ecosystems

Habitat destruction → Reduced ocean carbon sink → ACCELERATED climate change

Ocean chemistry disruption, ecosystem collapse, food system failure



✅ **Restored coral reef & seagrass** enhance biodiversity and support carbon sequestration

❌ **Degraded coral reefs & seagrass** release stored carbon + reduce ocean health

NbS Cascade Intervention Impact: Breaks this marine collapse spiral by maintaining critical blue carbon systems that capture CO_2, supporting marine protected areas that sequester carbon, and preserving marine biodiversity.

Living Shorelines

Biodiversity Benefit e.g.

Oyster reef habitat—foundation species boosts nekton and benthic fish diversity and supports established commercial aquaculture oyster supply chain

Sea level rise → Coastal erosion → Installation of hard infrastructure (seawalls/bulkheads)

Hard Infrastructure failure → Enhanced scour/erosion → MORE infrastructure needed

Habitat loss → Reduced natural protection → Increased storm damage costs

Economic stress → Demand for cheaper hard solutions → PERPETUAL infrastructure cycle

Degraded coasts, failing infrastructure, escalating costs

✅ **Protected shoreline** stabilises coast and sequesters carbon

❌ **Degraded shoreline** leads to erosion and carbon release

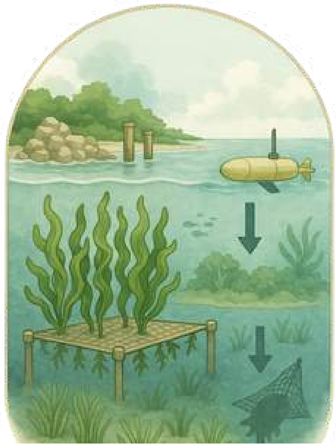
NbS Cascade Intervention Impact: Breaks this maladaptive infrastructure cycle by performing better than hardened shorelines during major storms, providing natural storm defenses that dissipate wave energy, and aiding carbon sequestration, habitat enhancement, and water quality improvement.

TOM QUIGLEY
Co-founder & Managing Director, Superorganism (Early-Stage Venture Fund)
Superorganism

> *Nature provides myriad benefits to humans and the global economy, and as we erode the fabric of biodiversity around us, we increase risks to business and to our own lives. 55% of the global economy is moderately reliant on nature. Nature-based solutions allow us to thrive alongside nature, and reap the many benefits of ecosystem services*

Integrated Approaches to Boost Impact of Coastal and Marine NbS

Alongside mangrove restoration, coral reef and seagrass conservation, and living shorelines, we layer three complementary tools that make Blue NbS more resilient and investable. First, we introduce **Coastal Ocean Alkalinity Enhancement (OAE)**, which raises local alkalinity (the capacity of a water-based solution to neutralize acids) to buffer acidification (adding naturally alkaline (non-acidic) minerals into seawater so it resists becoming more acidic while increasing ocean CO_2 uptake); Second, **targeted, permitted Ocean Fertilisation (OF)** in offshore nutrient-rich but iron-poor waters (plenty of major nutrients, but lacking sufficient iron for microscopic ocean plants to grow and pull in CO_2) stimulating brief bursts of microscopic ocean plant growth with carbon retained deep underwater; and Third, **marine permaculture - large-scale seaweed cultivation -** allocating a verified share of harvested seaweed biomass — and the carbon it holds — to deep-ocean storage or long-lived products.



	Coastal OAE	Targeted OF	Marine Permaculture
USE	• Blend finely milled alkaline minerals into living shoreline berms, mangrove sediment lifts, reef-rehab substrates, and beach nourishment. • Deploy small electrochemical OAE units at ports/outfalls to add alkalinity locally.	• Research-grade, permitted micronutrient additions (e.g., iron) in naturally iron-limited offshore waters—never in sensitive nearshore zones. • Use biodegradable carriers and autonomous floats/gliders for tracking.	• Cultivate macroalgae on offshore arrays or within sheltered bays; co-locate with living shoreline structures and seagrass. • Route biomass to (i) permitted deep-ocean storage, (ii) durable products, or (iii) substitution markets.
BENEFITS	• Buffers coastal acidification, improves coral calcification and seagrass productivity, stabilises shorelines, and increases ocean CO_2 uptake.	• Stimulates short-lived phytoplankton blooms that export particulate carbon below the mixed layer; and potential fisheries co-benefits.	• Photosynthetic CO_2 uptake, wave attenuation, habitat creation, water-quality improvements, and thermal stress buffering for nearby reefs.
Integrity Claim	• Site-specific monitoring with carbon mass balance; MRV tied to dosing records and hydrodynamic modelling. • Life-cycle assessment of mineral sourcing/transport; and clear project boundaries.	• Conservative accounting of measured carbon export and residence time only; continuous oxygen, N_2O and ecosystem monitoring; and compliance with international rules.	• Credit only durable storage fractions (deep-sea deposition or long-lived products); MRV on biomass, depth-time, and fate; and safeguards against deoxygenation, nutrient leakage, or invasive species.

These interventions layer seamlessly onto core Blue NbS actions, strengthening climate, biodiversity, and coastal resilience outcomes. For Mangrove Restoration, OAE in sediment lifts raises pH and cuts sulfide toxicity, while seaweed arrays dampen waves and trap sediments; any ocean fertilisation is kept strictly offshore with modelled flow paths. In Coral and Seagrass Conservation, local OAE buffers lagoon pH and supports calcification, marine permaculture adds shading and improves water clarity, and OF remains outside coral influence zones. For Living Shorelines, alkalinity-enriched fills and shell hash in sills and breakwaters boost protection, while kelp/oyster co-structures provide hybrid defence; OF is excluded from nearshore entirely. Together, these complementary measures enhance durability, expand co-benefits, and uphold the integrity of carbon claims.

Sources: Amaly Legacy analysis

Forest NbS

Climate Change Challenges and Impact

Disaster Risk Reduction From Implementing NbS

Forest Conservation

Biodiversity Benefit e.g.

Native forests support wild honeybee populations, which underpin large-scale wild honey production and pollination services for regional agriculture

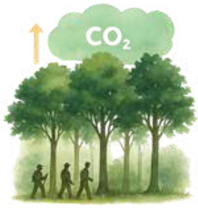
Deforestation → Massive carbon release (from forest disturbances)

Escalating warming → Fire/drought → Forest loss

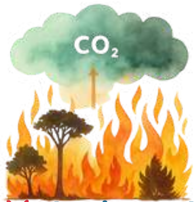
Biodiversity loss → Reduced climate regulation

Worsened climate impacts on crops → Pressure to expand farmland conversion → Deforestation

CO_2e release, ecosystem collapse, reduced climate resilience



✅ **Protected forests** naturally store carbon within their vegetation, biomass and soils.



❌ **Clearing and burning forests** release stored carbon into the atmosphere.

NbS Cascade Intervention Impact: Maintains existing carbon stores (protected areas contain significant terrestrial woody carbon), preserves biodiversity hotspots housing mammal and bird species, and protects climate regulation.

Reforestation & Afforestation

Biodiversity Benefit e.g.

New or restored forests can sustain high-value edible mushrooms—e.g., truffles—harvested commercially in established supply chains

Land degradation → Reduced carbon storage + Increased surface heat

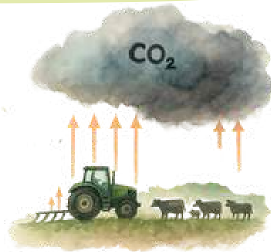
Higher local temperatures → Increased evaporation → Regional drought stress

Soil degradation → Poor water retention → Enhanced flood/drought extremes

Agricultural stress → Food insecurity → PRESSURE for more land conversion

Degraded landscapes, climate extremes, vulnerable communities

✅ **Regrowing forests** capture carbon slowly over decades



❌ **Farmland conversion** esp. conventional farming increase carbon emissions

NbS Cascade Intervention Impact: Breaks this degradation cycle by sequestering carbon in newly planted forests, restoring local climate regulation that can reduce temperatures, and rebuilding water cycle functions that enhance drought resilience and flood control.

Sustainable Forest Management

Biodiversity Benefit e.g.

Managed forests with FSC or PEFC certification maintain biodiversity while supporting long-term, legal timber harvests for global wood product markets

Unsustainable logging → Forest fragmentation → Reduced climate resilience

Weakened forests → Increased vulnerability to fire/pests/disease → Mass die-offs

Ecosystem simplification → Lost biodiversity → Breakdown of natural defenses

Economic pressure → Intensified exploitation → Further degradation

Vulnerable forests, climate instability, ecosystem collapse

✅ **Sustainably managed forests** capture carbon in vegetation and soil

❌ **Clearing & burning forests** releases carbon stored in vegetation and soil

NbS Cascade Intervention Impact: Breaks exploitation cycle by maintaining forest resilience through biodiversity protection, implementing adaptive strategies like controlled burns and selective harvesting that reduce fire risk, and ensuring long-term carbon storage while providing economic benefits that reduce pressure for destructive practices.

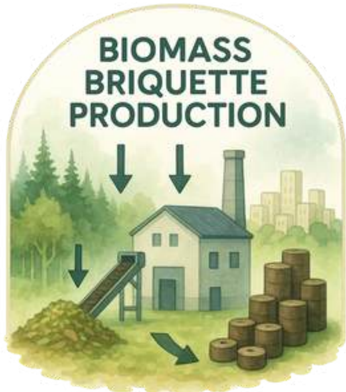
STANLEY ANYETEI

Advisor, Green Finance Initiative, WWF-NL

> *"As the world races for scalable climate and bio-ingredient solutions, forests uniquely merge natural capital resilience with high-margin product chains—proving that conservation can outperform conventional assets in risk-adjusted returns. Restoration projects deliver up to 600% ROI (i.e. a $1 investment returning $7) in ecosystem and social benefits, while timber and forest products add persistent cash flows and capital growth."*

Complementary Strategies to Increase Forestry NbS Project Resilience

Fuelwood collection is a major driver of deforestation in rural areas. Achieving measurable deforestation reductions now requires comprehensive fuel transition strategies that address the root causes of wood harvesting while maintaining rigorous carbon accounting standards. From community-level cookstove adoption to local biofuel production systems, these integrated approaches transform rural energy consumption patterns. Together, they create sustainable feedback loops between reduced forest pressure, improved public health outcomes, and verified emissions reductions that meet forestry carbon methodologies' requirements for high-integrity carbon credits, reduce pressure on wood demand, and improve public health by lowering indoor air pollution.



	Strategy 1: Clean Cookstove Distribution & Training Programmes	**Strategy 2: Community-Based Briquette Production Systems**	**Strategy 3: Waste Biomass Sourcing Supply Chain & Market**
USE	• Deploy subsidised improved cookstoves with comprehensive community training on proper use, maintenance, and repair techniques	• Install small-scale hydraulic or screw-press machines locally to convert agroforestry waste and farm residues into marketable fuel briquettes	• Implement strict sourcing protocols ensuring briquette production uses only agri residues, crop waste, and non-forest biomass materials
BENEFITS	• Dramatically reduces fuelwood consumption, cuts indoor air pollution, and improves respiratory health outcomes	• Utilises waste biomass streams and produces clean-burning fuel alternatives that reduce demand for forest wood	• Generates additional income streams for rural communities independent of forest resources
Integrity Claim	• Quantifies biomass-use reductions against baseline and verifies adoption/usage (e.g., sensor-enabled or survey-verified), enabling defensible crediting	• Generates biogenic carbon emissions that cycle naturally without net atmospheric CO_2e additions, unlike forest-derived charcoal that releases carbon	• Maintains traceable chain of custody proving waste-to-energy conversion (no forest wood inputs) to support baseline integrity (VM0048)*

Consideration: Wouldn't Biomass Briquettes Produce CO_2e and Impact Carbon Credit Generation?

While it's true that compressing biomass into briquettes consumes energy and produces some CO_2e emissions—dependent on the energy source—this is a small trade-off. Unlike charcoal, which is made from forest wood in inefficient kilns and generates high CO_2e and black carbon emissions, briquette production has a dramatically lower carbon footprint. When briquettes are burned, the CO_2 released is biogenic—originating from recently grown biomass—and is considered part of the natural carbon cycle. As a result, the CO_2 component is generally not counted as a net addition in carbon accounting systems (non-CO_2 gases such as CH_4 and N_2O are still counted). To ensure introducing briquette production doesn't negatively impact your baseline calculations under carbon credit standards such as Verra VM0048 methodology, it's vital to confirm that the briquettes use only waste biomass—not forest-derived wood. Methodologies such as VM0048 are sensitive to baseline integrity and do not penalise projects for switching to clean, non-forest biofuels as long as they adhere to the methodology's prescribed activity data, risk maps, and carbon stock assumptions.

Summary:

Overall, the three interventions form an integrated package to reduce pressure on wood resources while protecting VM0048 baselines.

Sources: *Amaly Legacy analysis*

* **Note:** Traceable biomass with documented proof of waste-to-energy conversion rather than forest-derived fuel production supports baseline integrity.

Beyond Carbon: Monetising Forest Natural Ingredients' Value Chains

NbS can unlock powerful revenue streams that go far beyond carbon credits. By sustainably harvesting forest-sourced ingredients—such as resins, gums, essential oils, and natural rubber—NbS projects can tap into global supply chains traditionally dominated by petrochemicals. These bio-inputs offer brands not only measurable emissions reductions but also access to premium "clean label," or "natural origin" claims that justify higher price points. The result: **a dual-income pathway with carbon credits and natural ingredient exports delivering recurring commercial returns**.

Resins from trees replacing petroleum-based resins

- **Adhesives**
  - *hot-melt glues for packaging*
- **Coatings and varnishes**
  - Wood finishes
- **Inks**
  - Printing inks
- **Rubber additives**
  - Tyre tackifiers

Advantage of Natural Ingredient: Renewable and biodegradable, reducing toxicity and waste; supporting forest economies and biodiversity; lowering long-term environmental footprints through carbon sequestration in sourcing.

65-75% Emissions | (20)-50% Δ Price

Gums from trees replacing synthetic gums

- **Food stabilisers**
  - Soft drinks
- **Emulsifiers in cosmetics**
  - Lotions
- **Pharmaceuticals**
  - Pill coatings
- **Printing inks**
  - Lithography

Advantage of Natural Ingredient: Biocompatible and non-allergenic, enhancing product shelf-life naturally; biodegradable, minimising microplastic pollution; ethically sourced, supporting arid-region livelihoods.

80-90% Emissions | (65)-100% Δ Price

Essential Oils from trees replacing synthetic fragrances

- **Fragrances**
  - Perfumes and candles
- **Pharmaceuticals**
  - Cough syrups
- **Pesticides**
  - Natural insecticides
- **Cleaning products**
  - Disinfectants

Advantage of Natural Ingredient: Antimicrobial and therapeutic properties without residues; biodegradable and less flammable; promoting sustainable forestry, reducing overexploitation risks.

50-70% Emissions | 200-400% Δ Price

Forest-derived materials can **reduce emissions by 50–90% compared with petroleum-based inputs**, offering a clear carbon advantage. Prices vary by quality and sourcing territory, with **a mixture of cost savings and premiums that requires granular pricing assessments of raw ingredients by subtype, quality, and territory**. Overall, the market demonstrates a willingness to pay—especially for products marketed as "natural," "biodegradable," or "origin-certified." These attributes justify higher price points and help secure long-term demand and revenue resilience in sectors ranging from food and pharma to beauty and packaging.

Sources: Amaly Legacy analysis

Agriculture & Farmland

Regenerative Agriculture

Biodiversity Benefit e.g.

Flower-rich cover crops and hedgerows support wild and managed bees, boosting commercial honey yields and crop pollination services

Climate Change Challenges/Impact

Industrial Monoculture + Synthetic Inputs → Soil Biology Destruction + Carbon Loss

50-70% Historic SOC Loss + Chemical Dependency → Water Pollution + N_2O Emissions

Tillage + Bare Soils → Erosion (10-100x Natural Rate) + Microbial Collapse

Nutrient Depletion → MORE Synthetic fertilisers → Accelerated Emissions

System Failure & carbon emissions → Agricultural Abandonment → Food Insecurity

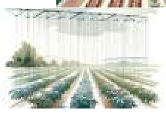
Disaster Risk Reduction From Implementing NbS

✅ Regen Ag promotes soil health and carbon sequestration

❌ Traditional Ag degrades soil and releases carbon emissions

NbS Cascade Intervention Impact: breaks this spiral through an integrated approach: diverse crops (cover crops, intercropping, rotation) sequester carbon, no-till practices reduce emissions, organic inputs and composting increase soil organic carbon, and water conservation with residue management reduces nitrogen leaching, transforming degraded lands into thriving carbon-sequestering agroecosystems.

Agroforestry
Integrating trees with crops to enhance biodiversity and ecosystem services

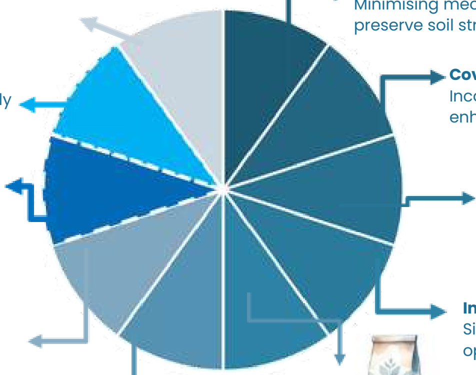


Sustainable Water Management
Implementing strategies to preserve and efficiently use water resources

Composting and Residue Management
Utilising composting and residue management practices to enhance soil fertility and health

Integrated Pest Management (IPM)
Employing comprehensive strategies to manage pests sustainably and effectively

Managed or Rotational Grazing
Mimicking natural grazing patterns by strategically moving livestock through different pastures



Reduced Tillage
Minimising mechanical soil disturbance to preserve soil structure and health

Cover Crop Utilisation
Incorporating cover crops to enhance soil health and biodiversity

Crop Rotation
Alternating different crops to improve soil fertility and reduce pests

Intercropping
Simultaneously cultivating multiple crops to optimise land use and biodiversity

Reduced Synthetic Fertiliser Use
Decreasing reliance on synthetic fertilisers for sustainable agriculture

Regenerative Agriculture

- **Diverse Crops:** Emphasises diverse crop cultivation for enhanced biodiversity
- **Organic Inputs:** Favours organic inputs/reduce reliance on synthetic fertilisers and pesticides
- **Water and Nutrient Conservation:** Focuses on sustainable water management to optimise water use and reduce nutrient runoff
- **Minimal Soil Disturbance:** Preserves soil structure, enhancing soil health and promoting carbon capture

Traditional Agriculture

- **Monocropping:** Single-crop cultivation limiting biodiversity and ecosystem resilience
- **Chemical Inputs:** Relies heavily on synthetic inputs for crop production
- **Inefficient Water Use:** Leads to environmental stress, reduced ecosystem resilience and nutrient runoff
- **Tillage (Soil Disturbance):** Contributes to soil erosion and degradation

Source: Amaly Legacy analysis

Execution Risk Mitigation

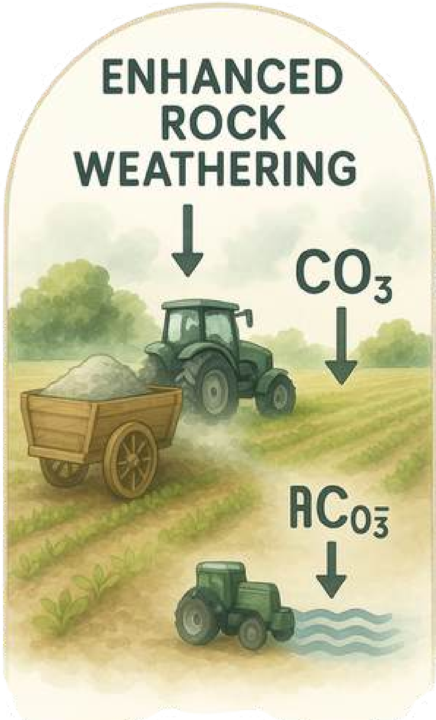
> “ Parametric insurance is emerging as a transformative tool for regenerative agriculture and sustainable procurement. It offers rapid financial recovery from climate and supply-related risks by triggering payouts based on objective data such as rainfall, soil moisture, or crop indices without the need for lengthy claims processes. Technologies like Earth observation, AI, and IoT sensors enhance accuracy and accessibility for both smallholders and large farms. For farmers transitioning to regenerative practices, this insurance reduces risk and enables faster recovery, often before major losses occur. To further incentivize adoption, corporations aiming to source sustainably and lower their Scope 3 emissions can subsidize insurance premiums, directly connecting their sustainability goals to farmer resilience. This collaborative model supports livelihoods, promotes biodiversity, and improves soil carbon sequestration while securing access to sustainably-produced commodities.

NADIA BOUMEZIOUT
Head of Sustainability & Information Governance
Zurich Middle East

ZURICH

Regenerative Agriculture | Expanding the Carbon Credit Toolbox

Regenerative agriculture has traditionally generated carbon credits by increasing soil organic carbon (SOC) through cover cropping, minimal tillage, and rotational grazing. However, new frontier approaches are emerging that offer significantly longer-duration carbon removal, higher credit yields, and critical co-benefits for agricultural productivity. Among these, Enhanced Rock Weathering (ERW) and Biochar stand out for their scientific robustness, commercial scalability, and MRV advancements. Below we unpack these nature-tech hybrid solutions that can be integrated into regenerative farming systems to diversify credit income and build long-term soil resilience.

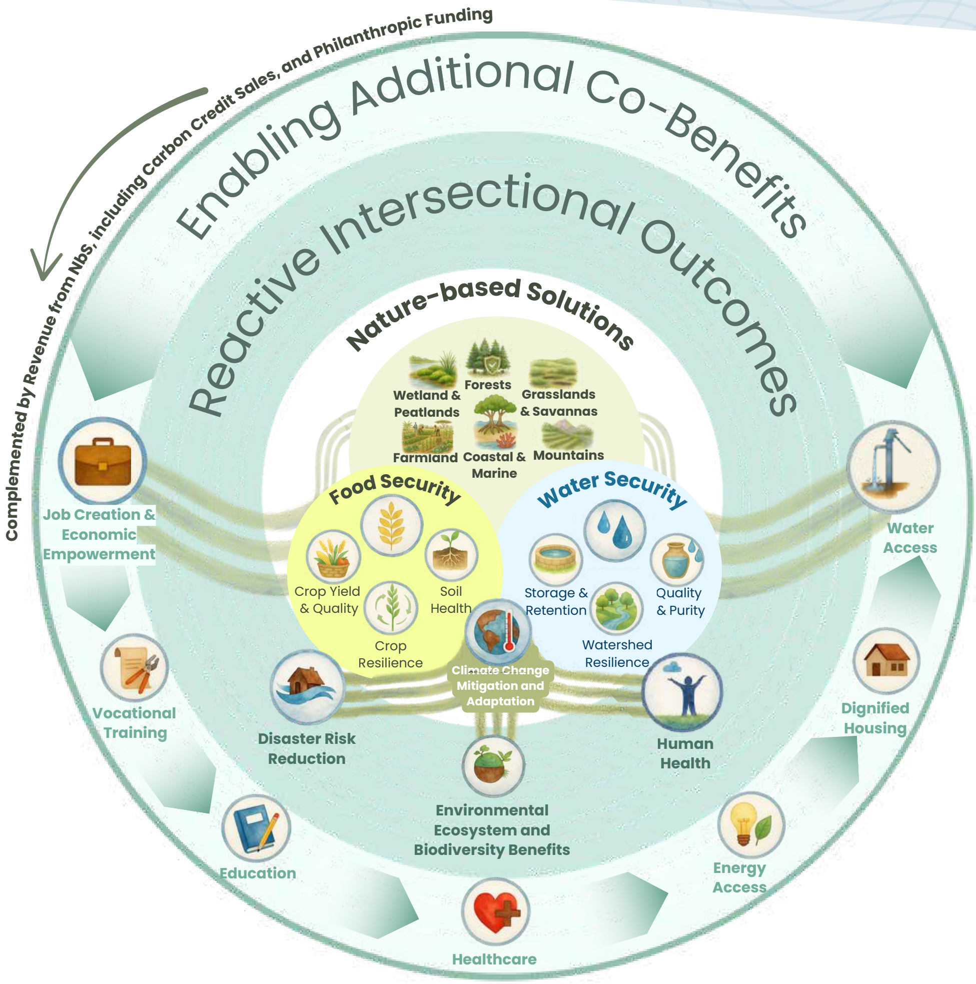


	Enhanced Rock Weathering	Biochar
What is it?	• Finely-ground silicate or basalt rock is spread on cropland; as the particles weather, they convert atmospheric CO_2e to stable bicarbonates that wash into rivers and oceans, sequestering carbon for thousands of years.	• Biomass (e.g., crop residues) is pyrolysed into a stable, carbon-rich solid that resists decomposition for hundreds of years when returned to soil.
Fits with Regen Ag	• Uses existing farm equipment, often during lime-spreading passes. Its alkalinity offsets soil acidification and may boost yields.	• Recycles on-farm waste, improves soil structure, nutrient retention, and microbial function.
Carbon Credit Mechanics	• Net CO_2 removed = (tonnes of rock × weathering rate × molar CO_2 uptake) – life-cycle emissions from mining, crushing, transport and spreading. **Protocols:** Puro.earth; Verra (under development).	• Credits issued for stable carbon content; avoided emissions from open burning excluded to prevent double counting. **Protocols:** Verra's VM0044, Puro.Earth.
MRV	○ Baseline and follow-up soil chemistry ○ Stream and runoff bicarbonate sampling ○ Remote sensing for spread area and rate	○ Feedstock-to-biochar mass balance ○ Carbon permanence via H/C ratio testing ○ Barcode and site-level stockpile tracing
Co-Benefits	• Micronutrient supply, pH regulation, potential yield boost (context-dependent).	• Faster composting, moisture retention, yield gains (often ~10% on average).
Risks	• Trace-metal contamination and particulate dust exposure, which can negatively impact certain soil sample tests used for critical certifications.	• Sustainable feedstock sourcing and PAH contamination.

Conclusion

Integrating these new CDR technologies into regenerative farming broadens both the ecological and financial impact of agricultural carbon projects. Solutions like ERW and biochar offer durable sequestration (centuries for biochar to ≥10,000 years for ERW), multiple co-benefits, and stackable credit potential—marking a shift from short-cycle SOC gains to long-term climate assets.

Sources: Puro.earth, Verra, Amaly Legacy analysis



> When Nature-based Solutions deliver quantified food and water outcomes, they unlock a cascade of co-benefits—fueling new products, generating high-value credits, enabling innovative financing, and powering transformative insurance models. Beyond economic returns, they safeguard biodiversity, strengthen climate resilience, and enhance cultural values. By ensuring the meaningful participation and leadership of Indigenous Peoples and local communities, NbS not only restore ecosystems but also restore prosperity, equity, and dignity for the people who depend most on nature.

CHARLES KARANGWA
Head of Nature-based Solutions, IUCN

IUCN International Union for Conservation of Nature

Direct Impacts of NbS on Food and Water Security

NbS transform agricultural productivity by optimising natural processes that enhance crop performance, resilience, and soil vitality, through:

Enhanced crop yields and quality by optimising nutrient cycling and providing pollinator habitat, which can increase harvest volumes while improving nutritional content and market value of agricultural products.

Robust crop resilience by diversifying farms and using natural pest control to strengthen crops against climate extremes, diseases, and pests, reducing yield losses and input costs.

Improved soil health by enhancing organic matter retention, erosion prevention, and microbial activity to create fertile growing conditions for sustainable agricultural productivity.

NbS provide comprehensive hydrological services that ensure reliable, clean water availability while protecting against extreme weather impacts, through:

Enhanced water storage and retention via wetland restoration and watershed management that enable capturing precipitation and recharging groundwater, maintaining water availability during dry periods.

Improved water quality and purification since wetlands and riparian buffers naturally filter contaminants and excess nutrients, reducing treatment costs and protecting drinking water.

Watershed resilience via floodplain restoration and green infrastructure that absorb excess flows during extreme weather while maintaining steady water supplies (adaptive capacity).

Intersectional Outcomes and Co-Benefits: Health, Biodiversity and Disaster Risk Reduction

Aside from obvious climate mitigation and adaptation benefits, NbS offers three critical intersectional outcomes:

Disaster Risk Reduction

Serving as critical components of integrated adaptation strategies that reduce the risk of major disasters that we explained briefly in this report. Please refer to pages 25, 27, and 30 for disaster risk reduction analysis for select NbS types.

Environmental ecosystem and biodiversity benefits

Multiple benefits for biodiversity such as wetland restoration that supports aquatic organisms critical to food webs, coastal vegetation conservation that provides marine habitats and native grassland protection that creates bird habitats.

Human Health

NbS' multidimensional impacts—such as cleaner air and water, beneficial plant compounds, and more nutritious foods from improved soil health—are associated with well-documented health gains, including **reductions in stroke**, **hypertension**, **asthma**, **heart disease**, **obesity**, **diabetes**, **preterm births**, and **both cardiovascular** and **overall mortality**.

Sources: IUCN, Amaly Legacy analysis

Monetising Human Health Intersectional Outcomes and Co-Benefits

NbS intersectional human health outcomes can aid carbon projects through monetisable, verifiable co-benefits that **increase revenue via price enhancement**, **offer access to financing** and **reduce risk**. They offer measurable impact that can enhance revenues and strengthen the operational and financial resilience of NbS carbon projects, in turn generating higher returns and enabling long-term capital flows.

Product Premiums via Embedded Co-Benefits

- Bundle high-integrity co-benefits (e.g., verified for social, biodiversity impact) with products, enabling premium pricing, as buyers are willing to pay more for goods with credible, verified impact attributes (carbon neutral, biodiversity-positive, women-empowering, etc.).

> **E.g: L'OCCITANE en Provence** premium skincare products made with shea butter from women-led regenerative agroforestry projects in Burkina Faso with carbon and gender co-benefit..

Premiums on Carbon Credits

- High-quality NbS credits that deliver verified social, biodiversity, or water benefits command higher prices than basic carbon credits on the voluntary market.

> Carbon credit pricing analysis demonstrates that carbon credits with co-benefit certifications and labels such as **Verra's Community, Climate and Biodiversity (CCB)** attract an average price premium of ~78%.

Unlocking New Financing (e.g., Orange Bonds, Blended Finance) and Grants

- **NbS** projects with quantifiable co-benefits can access innovative financing such as Orange bonds (see page 36) and concessional and blended finance for projects with co-benefits, which help unlock better financing terms (lower rates, longer tenors).

> **E.g: IIX Women's Livelihood Bond™ 5** demonstrates how quantifiable co-benefits—such as rural women's empowerment—can unlock innovative financing (Orange Bonds), enabling better terms - lower rates and longer tenors for impactful projects

Enhanced Financing Costs/Terms

- Robust co-benefits improve a project's risk profile, leading to lower cost of capital, improved loan or guarantee terms and greater eligibility for green or impact-linked financing.

> **E.g: L'OCCITANE Group** closed a €600 million sustainability-linked revolving credit facility with the margin indexed to sustainability KPIs (e.g., biodiversity preservation, climate and community indicators), illustrating how KPI-linked financing can improve terms.

Regulatory Compliance and Licence-to-Operate

- Projects with strong NbS co-benefits help companies meet decarbonisation mandates, biodiversity/net gain requirements, or ESG compliance standards—facilitating project approvals, licence renewals, or market entry in tightly regulated sectors. In addition, by meeting or exceeding decarbonisation and social impact thresholds (often a condition for operating permits), companies can avoid fines, trading bans, or exclusion from supply chains.

> **E.g: DSM-Firmenich**, aligns its skincare and medicinal product supply chain with EU biodiversity and carbon regulations, supporting EU regulatory compliance.

Insurance Premium Reductions

- **NbS** projects (e.g., mangrove or forest restoration for flood or fire risk mitigation) can lower the insured's risk profile, leading to reduced insurance premiums for assets, crops or supply chains.

> **E.g: In wildfire-prone areas in the US**, insurers give premium discounts for vegetation management /defensible space and Firewise USA® community actions; California's "Safer from Wildfires" regulation requires insurers to provide such discounts.

Translating Co-Benefits into Cash Flows

NbS transcend traditional impact narratives by converting health, biodiversity, and water co-benefits into tangible financial value. From commanding price premiums on consumer goods and carbon credits to unlocking Orange Bonds and concessional capital, these benefits directly enhance project bankability. Verified co-benefits also reduce cost of capital, secure regulatory approvals, and lower insurance premiums—embedding climate resilience into balance sheets and turning ecosystem services into cash flows.

Sources: Group L'OCCITANE, Senken, IIX Global, Credit Agricole, DSM-Firmenich, California Department of Insurance, Amaly Legacy analysis

Price Enhancement · Financing Access · Risk Reduction

From Intersectional Human Health Outcomes to Healthcare Investments

Investing carbon credit proceeds in healthcare is not just a co-benefit—it is foundational to building resilient, climate-adaptive communities. Climate change exacerbates health inequities by intensifying disease outbreaks, malnutrition, water scarcity, and barriers to care, particularly for remote and marginalised populations. Redirecting carbon revenue to last-mile health solutions delivers profound social returns.

A Continuum Approach: Strengthening Last-Mile Healthcare through Carbon Revenues

NbS carbon revenues can be deployed in 3 core pillars to reinforce health equity in climate-vulnerable regions:

Last-Mile Access: Direct delivery of essential health services to remote and underserved communities, overcoming barriers of distance, infrastructure, and climate disruptions.

- **Mobile Health Clinics:** Deliver primary care, maternal and child health, vaccinations, nutrition counseling, and reproductive health to remote communities—overcoming distance and disaster-related isolation.
- **Community Health Worker (CHW):** Recruit and train local CHWs to bridge trust gaps, deliver preventive and basic curative care, reduce maternal and child mortality, and combat malnutrition.

Infrastructure Equity: Building and upgrading health facilities and sanitation to ensure everyone can access safe, dignified, and inclusive care, especially in climate-vulnerable settings.

- **Menstrual and Reproductive Health Infrastructure:** Construct gender sensitive sanitation and hygiene facilities in schools and clinics. Support local production and distribution of sanitary products, supporting dignity and maternal and child health.
- **Safe Birthing Facilities:** Upgrade or build maternal care units, providing essential equipment, clean water, and skilled attendants to reduce birth-related complications and deaths.

Digital Health Enablers: Using technology—like telemedicine and mobile platforms—to extend care, improve disease tracking, and keep health services running during climate shocks.

- **Telemedicine Platforms & Data Innovation:** Use telemedicine, SMS health reminders, and digital health records to reach patients in low-resource settings, support CHWs, and enable real-time disease tracking and rapid response.
- **Community Health Data:** Map disease outbreaks and service needs across regions, using digital platforms for targeted interventions during climate shocks (e.g., flooding, rainy seasons, heatwaves).

Conclusion

By integrating ecosystem restoration with healthcare investments, NbS projects foster health equity, build resilience against climate-sensitive diseases, and enable community-led systems that improve both environmental and human wellbeing. This reinforces **positive feedback loops** where healthier communities become better environmental stewards, generating more benefits that fund more health services. It positions NbS not just as environmental interventions but as critical health infrastructure.

Source: Amaly Legacy analysis

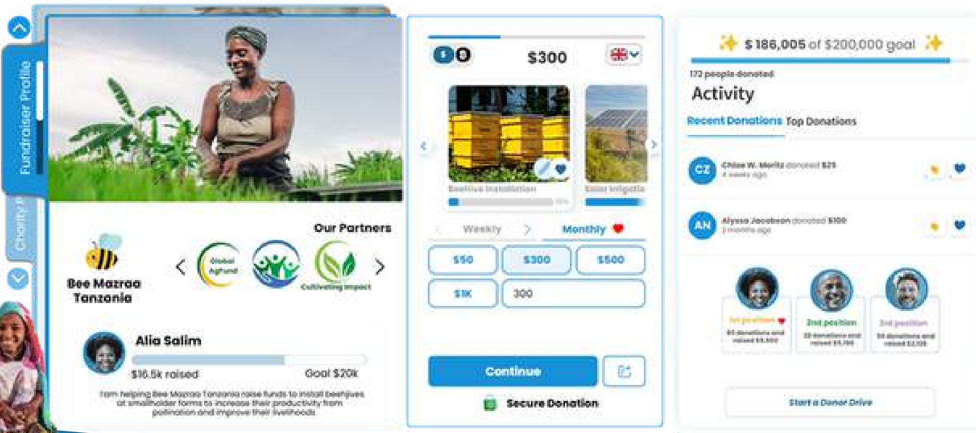
Additional Co-Benefits Enabled via Carbon Credit Revenue

A 2014 study by Imperial College London and ICROA found that **every tonne of CO_2 offset delivers about $664 in additional economic, social**, and **environmental benefits** beyond direct greenhouse gas emission reductions. This multifaceted value proposition fundamentally transforms how we design and implement NbS, shifting from narrow carbon-focused approaches to holistic development strategies that address complex challenges facing communities. Below are innovative areas where carbon-credit sales proceeds can be deployed to increase co-benefits, which can be further amplified with hybrid and innovative forms of funding.

	Examples of Co-Benefits	Innovative Hybrid Funding to Amplify Co-Benefits
Job Creation. Vocational Training & Economic Empowerment	• **Materials**, **workspace**, and **marketing support** for handicrafts sold online	• Gender-lens revolving micro-grants blended with e-commerce revenue share
	• **Capacity building** and **employing** patrol officers for forest conservation	• Forward sale of co-benefit-priced carbon credits
	• Regenerative farming **workshop** training in composting, and IPM	• Price premiums for agri commodities from certifications (e.g. Organic) bundled with TA
	• Digital literacy **bootcamp** inc. basic computer skills, online banking, and e-commerce for rural entrepreneurs	• "Rural-leapfrog" CSR grants from telcos, banks and fintechs + crowdfunding campaigns
Education	• **Upskilling teachers** using locally led, evidence-based training.	• Pay-for-results bond tied to learning gains, tying repayments to improved student outcomes.
	• **Tuition support** for school students in rural communities	• Philanthropic "last-mile" scholarship pool matched by school waiver
Water & Energy Access	• **Community well** drilling with **solar-powered pumps** providing clean water	• Grants supported by carbon credit sales proceeds to social enterprises drilling wells
	• Household **solar kit distribution** inc. **LED lights**, **phone charging** for off-grid families	• Agrivoltaics connected with the grid with verifiable carbon-credits
Healthcare	• **Medicine supply:** stocking of essential medications at local clinics	• Health-impact bond with tiered donor buy-downs and additional first-loss grant layer
	• **Mobile health clinic** with basic medical supplies and preventive care	• CSR sponsorship aided by additional crowdfunding campaigns
Dignified Housing	• **Home improvement aid** - concrete floors, metal roofing, or improved ventilation	• Green microfinance aided by in-kind grants of building materials and volunteer engineers
	• **Latrine construction materials and technical support**	• "WASH-results" blended facility (grant + output-based aid)

Leveraging Proprietary Tech to Amplify Co-Benefits

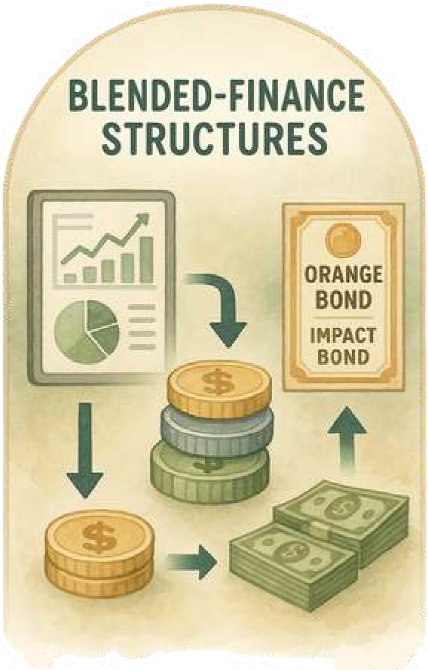
Amaly developed proprietary fintech that enables NGOs to unlock **donations via crowdfunding, philanthropic funding, and sale of rural artisan products** to **amplify and enhance the quality of co-benefits**



Source: Amaly Legacy analysis

Unlock Funding with Quantified Co-Benefits: Orange Bonds & Blended Finance

Unlocking transformational funding for climate projects increasingly depends on the ability to demonstrate measurable co-benefits—such as improved health, gender equity, and community resilience. Funders are seeking multi-dimensional impact, prompting a new wave of financing instruments designed to reward projects that deliver social and environmental outcomes together. By rigorously quantifying and verifying these co-benefits, NbS can attract larger, more diversified pools of capital and achieve sustainable, system-wide change.



De-risks Projects and Unlocks Private Equity at Premium Valuations

Co-benefits elevate a project's income profile by unlocking price premiums on carbon credits and certified commodities. These diversified revenue streams flow to local stakeholders, reducing execution risks. The result is a **de-risked, higher-margin project that unlocks new funding from private equity at more favorable valuations and conditions**.

Access to Innovative Financing and Diverse Capital Sources

Robust co-benefit metrics unlock blended-finance structures such as impact bonds or **Orange Bonds**. These **financing layers lower the overall cost of capital**, increase investment returns, and align incentives by tying incentives to verified social and climate outcomes, offering greater access to diverse capital sources.

Crowd in Co-Investments From Various Funding Sources and Stakeholders

Verified multi-dimensional co-benefits **draw in governments, corporates, and philanthropies as funding partners**. Their involvement brings concessional funding, credit enhancements, and supportive policies that distribute risk, crowd in co-investment, and embed projects within broader development agendas. This enables scaling impact well beyond what carbon revenues alone could achieve.

Case Study: Orange Bonds – Financing Gender and Climate Co-Benefits

What are Orange Bonds?

Orange Bonds are a class of sustainable debt centered on SDG 5 (Gender Equality) that channel capital to activities empowering women and girls, including projects in climate-positive sectors (e.g., clean energy, climate-smart agriculture). The Orange Bond Principles™ require clear impact intent, strong use-of-proceeds and transparency, and can sit on top of existing ICMA labels—i.e., an Orange Bond may also qualify as a Green, Social, Sustainability Bond (use-of-proceeds bonds), or Sustainability-Linked Bond (SLB) (performance-linked bonds) if it meets those standards — positioning them as a credible, scalable instrument that can finance NbS while also empowering women

Why Orange Bonds Have a Capital-Mobilisation Advantage?

- **Structural Flexibility and Advantages:** They can qualify under multiple recognised sustainable-finance umbrellas (use-of-proceeds bonds and performance-linked bonds)
  - **Use of Proceed Bonds:** Most Orange Bonds today are issued as use-of-proceeds bonds with gender-positive allocations and robust reporting/verification (e.g., second-party opinions against the Orange Bond Principles + ICMA guidelines).
  - **Performance-Linked Bonds:** An Orange Bond may also be structured as a SLB where issuers can include coupon step-ups or other economic adjustments if pre-set gender (and, where relevant, climate) performance targets are missed.
  - **De-risking:** They can also be paired with catalytic capital (e.g., first-loss, subordinated tranches) and partial credit guarantees to reduce downside for senior investors.
- **Funder Diversity:** By combining gender outcomes with (where applicable) climate or broader ESG use-of-proceeds they can tap both gender-lens and mainstream green/ESG allocators under one instrument without changing underlying standards.

By rigorously quantifying and reporting co-benefits, carbon projects can access new, blended, and outcome-linked funding sources—transforming the scale and impact of NbS. Innovative instruments such as Orange Bonds demonstrate how quantified co-benefits are integrated into concrete outcome-linked financing, unlocking premium investor demand and lowering capital costs for NbS—unlocking and channeling large-scale capital into high-integrity NbS and paving the way for the next generation of sustainable finance instruments.

Source: IIX Global, Amaly Legacy analysis

Delivery Risk of Co-Benefits

Despite co-benefits having a diverse set of benefits for carbon projects, they carry an inherent high risk of delivery. Here we examine additional co-benefits that can be enabled via revenue streams from NbS, including carbon credit revenue, and how NGOs reduced the implementation and delivery risk

Vocational Training	• Classroom-only courses miss market needs — A Ugandan study found many graduates still jobless.	**BRAC's** apprenticeship model matches trainees with local firms, boosting employment and earnings.
Education	• New classrooms but no qualified teachers — learning outcomes stay flat (teacher shortages persist even after building new schools).	**Pratham's** "Teaching at the Right Level" assesses pupils, groups them by actual skill, and retrains local teachers—dramatically raising basic literacy in 20+ countries.
Energy Access	• Millions of off-grid solar lanterns become toxic e-waste when batteries fail and are discarded.	**SolarAid** runs rural take-back and repair networks, training local technicians and creating circular value from e-waste..
Water Access	• Hand-pump boreholes break and stay offline; maintenance funds are sometimes diverted by local elites.	**charity: water** equips pumps with low-cost IoT sensors and a maintenance fund, cutting downtime from months to <24 h.
Healthcare	• NGO clinics lure ("poach") government health workers, so overall service coverage and nearby clinics suffer.	**Partners In Health Haiti** trains community health workers, expanding front-line capacity without draining state staff.
Dignified Housing	• Climate-resilient upgrades can trigger "climate gentrification," pricing out original residents.	**Habitat-linked Community Land Trusts** keep land in nonprofit ownership, capping resale prices and preserving affordability.

De-Risking Delivery, Unlocking Capital: The Co-Benefit Advantage

Co-benefits transform carbon projects into powerful vehicles for social impact, attracting larger, blended, and outcome-linked funding—exemplified by innovative instruments like Orange Bonds and co-benefit-linked debt swaps. Yet, delivering these benefits at scale means tackling real-world risks: from failed health clinics and broken water points to skills gaps and climate-driven displacement. NGOs are essential for de-risking delivery through locally rooted solutions as seen in the examples above. **The formula is clear:** implement NbS with trusted NGOs, rigorously verify co-benefits, and embed those verified outcomes in financing structures—using carbon revenues alongside tools such as debt swaps—to unlock larger, hybrid funding streams. Done right, well-designed NbS projects secure broader funding and deliver lasting, equitable climate and social outcomes.

Sources: The Business Standard, Pratham, SolarAID, Charity: Water, PIH, UN-Habitat, Interboro Community Land Trust, and Amaly Legacy analysis

Insight: Monetising Co-benefits via Debt Swaps

Bingcai Liu,
Research Fellow
International Institute of Green Finance, Central University of Finance and Economics

"Debt swaps monetize co-benefits by converting verified outcomes such as watershed protection, sustainability power construction, livelihoods and gender inclusion into hard budget savings and investable cash flows. In practice, creditors provide debt relief or restructuring while debtors commit the savings to invest in sustainable projects. For emerging creditors such as China and India, debt swap is a creative restructuring tool that preserves value, enables local-currency or in-kind repayments, and channels capital into sustainable or nature-based development. For LICs, they free fiscal space and lower blended costs of capital, so that co-benefits of projects are effectively priced, securitized, and used to unlock new liquidity for resilient, community-led development"

Engaging Local Land Stewards in NbS Projects

Engaging local land stewards – whether villages, indigenous communities, municipalities, or other local authorities – is critical to the success of NbS projects. Effective engagement not only upholds the rights and knowledge of those who manage the land, but also improves project outcomes by reducing risks and ensuring long-term sustainability. Engagement approaches differ based on the type of NbS project as seen in the contrasting examples presented between forest conservation and regenerative farming projects; this section outlines best practices for **Free, Prior, and Informed Consent** (**FPIC**) and capacity building.

Securing FPIC

FPIC is the cornerstone of ethical NbS projects, especially when working with indigenous peoples or local communities with customary land rights.

FPIC means that communities have the right to grant or withhold consent to a project that may affect their lands or livelihoods, and that this decision is made freely (without coercion), before any irreversible decisions or activities commence, and with full information.

High-quality frameworks and standards universally endorse FPIC. For example, the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) affirms Indigenous peoples' right to FPIC. The UN-REDD Programme's Operational Guidance on FPIC and numerous voluntary carbon standards (e.g. the Climate, Community & Biodiversity Standards) provide specific procedures to ensure this consent process is upheld. Today, demonstrating robust FPIC is also a requirement of credibility: the **Integrity Council for the Voluntary Carbon Markets (ICVCM)** includes FPIC in its Core Carbon Principles assessment framework, meaning any carbon credits labeled as "**high-integrity**" must show that effective FPIC has been obtained. Best Practices for FPIC: Implementing FPIC is an involved process that goes beyond a one-time consultation. Widely accepted guidelines (e.g. from UN-REDD and the Accountability Framework initiative) outline several best practices to secure FPIC in NbS projects:

1. **Determine rightful decision-makers** and establish clear agreement on who holds **negotiating authority,** whether they are traditional leaders, elected councils, or elders. This process must respect indigenous and local governance norms to ensure consent comes from appropriate sources, not just a subset of the community.

2. **Design inclusive consultation processes** aligned with community customs, including all affected groups, e.g. **women, men, youth, elders and minority voices**. Provide comprehensive project info covering **purpose, activities, risks, benefits, and alternatives in <u>accessible language and formats</u>,** with sufficient time for community discussions through their own assemblies or meetings. The **process must remain free from pressure, truly embodying "prior" and "informed" principles** that support asking questions and seeking independent advice.

3. **Clearly document FPIC process outcomes** in agreements that are shared with affected communities, detailing benefit-sharing arrangements, roles and responsibilities, and grievance mechanisms to enhance transparency and accountability. FPIC requires ongoing communication and a continuous commitment to respectful partnership.

4. **Involve NGOs as neutral facilitators** to address power imbalances between communities and project developers, enabling communities to access independent advice. **NGOs can build trust** and **help navigate complex information**, with each party retaining the right to involve experts of their choice, such as NGO advocates or forestry specialists for communities. This approach ensures communities aren't disadvantaged in understanding technical carbon project terms and creates more balanced negotiations

Securing FPIC in this rigorous manner is considered a best practice not only from a human rights perspective but also for project success. Projects that obtain genuine buy-in face far fewer conflicts, legal challenges, or delays. By involving communities in decision-making from the beginning, FPIC fosters local ownership and can integrate traditional knowledge that improves project design. Conversely, neglecting FPIC or conducting perfunctory consultations can result in protests, project cancellations, or reputational damage for investors and buyers. For these reasons, investors and carbon credit purchasers increasingly conduct due diligence on community consent.

Sources: UNDRIP, UN-REDD FPIC guidance, Verra, ICVCM, Accountability Framework, Amaly Legacy analysis

Building Capacity for Durable Outcomes and Long-Term Success

Engaging local stewards is not just about meetings and consent – it also requires building the capacity of those stakeholders to actively participate in and benefit from NbS projects. Capacity building should be tailored to the type of NbS (e.g. forest or agriculture) and the local stewardship arrangements (e.g. communal, private, or public land). Strengthening local capacity helps ensure that once a project is implemented, communities and local institutions can carry it forward, monitor progress, and adapt as needed.

Capacity Building is Context and NbS-Type Dependent

The approach to capacity building must adapt to who the "land stewards" are. If the steward is a municipal body overlapping with villages, capacity building might involve technical training for staff and creating communication channels for the community. If the stewards are an entire village on communal land, then training might target a broad cross-section of residents and focus on group organisation, conflict resolution, and participatory mapping of resources. In all cases, best practice is to partner with local knowledge institutions – such as NGOs, local universities, agricultural research stations, or indigenous knowledge holders – to co-develop culturally appropriate and relevant training content. This ensures capacity building is a mutual learning process that respects traditional practices and local innovations alongside scientific techniques.

Strong capacity building yields multiple dividends. First, it **increases local ownership**: communities and land managers who well positioned to implement NbS interventions are more likely to stay committed and feel a sense of pride in outcomes. Second, it **improves performance and permanence of carbon projects** – a community that is well trained to monitor forest health or soil carbon can catch issues early and respond adaptively, preventing reversals. Third, it **empowers local stakeholders in policy**. For example, indigenous groups that gain experience in regenerative methods can influence agricultural policy or supply chain standards in their region. For investors and carbon credit buyers, supporting capacity building helps de-risk projects by ensuring there is local expertise to maintain project activities and that benefits will endure after external actors step back. By building capacity at the local level, NbS projects empower local stewards to govern natural resources sustainably, contributing to climate goals and community well-being.

Managing Trade-offs in NbS Implementation

Nature-based carbon projects can unintentionally swap food security and traditional fuel-wood or logging rights for tree cover, degrade biodiversity through fast-growing monocultures, and expose communities to "carbon rush" land grabs and green-washing when credit prices or oversight falter.

	Examples of Trade Offs	Mitigation Strategies
Land Use 	• **Bans on wood gathering shift costs to women and youth who collect fuel.** • **Halting all timber harvesting can ignite conflict or illegal logging.**	• Ensure community-forestry plans **set fuel-wood quotas** and **reinvest royalties** – Nepal nearly doubled forest cover while meeting local energy demand. • Introduce **adaptive thinning** under Improved Forest Management (IFM) protocols to allow low-impact harvests that cut wildfire risk and still earn credits.
Ecological Resilience 	• **Fast-growing monocultures to store carbon quickly erode biodiversity.** • **Thriving biodiversity can cause human–wildlife conflict**	• Restore with **native mixed-species plantings** and **ecological buffer zones**; mixed plots lock in carbon while protecting habitats and soils. • Pair NbS with deterrent tech—**beehive fences** that monetise honey, **chilli-rope**, **solar-electric lines** that block entry, and **inaudible acoustic deterrents** (e.g., infrasound-based devices)—so communities stay safe while still reaping ecological and livelihood gains.
Market 	• **Carbon-price swings could make banned activities like commercial logging more appealing.** • **Land grabs and capture of benefits by select elites erode trust.**	• Diversify income (e.g., **eco-tourism**, **value-added crops**, **converting waste to value-added by-products**), infuse philanthropic funding, escrow part of credit sales to cushion volatility. • Hard-wire FPIC, transparent benefit-sharing, and grievance mechanisms to keep governance inclusive.

Sources: Earth Observatory, Save The Elephants, Oryx (Vol. 53, No. 1), ISTI Portal, and Amaly Legacy analysis

Maha Oda, Board Member, The Jane Goodall Institute (UAE)

Jane Goodall Institute

"As Dr. Jane Goodall says, "What you do makes a difference, and you have to decide what kind of difference you want to make." In carbon markets, that difference depends entirely on how we engage with rural communities. These communities are not just beneficiaries; they are the architects of successful land restoration and conservation interventions. Our experience has taught us that effective engagement demand codesign, localization, learning, and collaborations. Community engagement is one of the critical enablers of carbon market success because rural communities bring knowledge about local ecosystems, traditional land management practices, and the social dynamics that determine carbon project outcomes. Without genuine engagement with them, carbon projects cannot work effectively for people, animals, and planet."

Hybrid Digital-Local Facilitation Models to Build Capacity and Scale NbS

A critical challenge for scaling NbS is delivering high-quality, contextualised training at scale affordably and capturing ground-truthing data that aid premiums for commodities from these NbS. Traditional extension services, though valuable, often fall short in providing an optimal user experience for the millions who rely on them. This analysis presents a hybrid model that:

- **leverages digital platforms led by a project developer** for **knowledge delivery** and **data gathering,** and
- **utilises local Community Facilitators ("CF") - defined in this report as local cooperatives, local charities, international NGOs and local municipalities - for trust-building, local adaptation and implementation support** through personalised, continuous support and community-based implementation.

In our proposed model, we advocate the use of blockchain-based traceability and digital storytelling and engagement platforms to create additional value that benefit rural communities, enhance local facilitators' effectiveness, and attract buyers that aid scaling these NbS.

Rural Communities

Problem: How can I implement the required activities to earn extra income, and what data must I send to our partners to unlock payments?

Solution: Simple mobile phone voice notes, missed calls, and short videos automatically translated by AI into structured data, triggering direct payments to community members' mobile wallets for verified actions

Project Developers & Partners

Problem: How can I efficiently enable communities to execute NbS activities at scale, while cost-effectively collecting, verifying, and reporting data to justify premium prices?

Solution: Collaborate with **CFs** to deploy accessible, low-cost digital tools that streamline the process of addressing enquiries and aiding data collection, verification, and traceability, providing auditable impact proof directly to buyers.

Buyers

Problems: How do I know the extra money I'm paying for carbon-neutral impactful products is **i)** actually making a difference (**end consumers**) or **ii)** meeting the compliance requirements of our procurement division (**corporations**)?

Solution: Blockchain-backed QR codes on product packaging link to farmer-recorded voice notes, geo-tagged videos, and traceability data, providing consumers with transparent and auditable proof of impact. Accurate data entry is critical for optimal results

What Buyers Need to See: Origin and Impact, Chain-of-Custody, and Compliance

Origin and Impact

- **Info:** Country or region, farm or project location on a map; certification; and any environmental or land restoration info
- **Why Buyers Care:** Shows the source and real-world impact—helps buyers confirm the product or carbon credit is from a trusted, verifiable and reliable source.

Chain of Stakeholders and Events

- **Info:** Batch/lot IDs, product description, farmer cooperative and developer identity, chain-of-custody event history.
- **Why Buyers Care:** Facilitates end-to-end traceability, risk assessment, and transparency for corporate procurement divisions — critical for Due Diligence (DD) and supporting supply-chain integrity audits

Compliance

- **Info:** compliance certifications, audit reports, and DD checklists (downloadable PDFs).
- **Why Buyers Care:** Shows quality and commodity standards are met (e.g. food safety standards), legal checks are in place, and documents are ready for audits.

Source: Amaly Legacy Tech team

Boosting Value Using Common Digital Tools for Traceability and Premiums

Communities use everyday tools like WhatsApp and call-backs to contribute data and stories to dedicated numbers managed by CFs. Data can be added to blockchain-based traceability systems, enhancing transparency and unlocking higher value for carbon credits and products from these NbS (creating digital passports that aid export of commodities from these NbS). Verified and traceable data essentially requires collecting, formatting, and adding to the traceability platform record logs (added on blockchain) to ensure transparent, tamper-proof records—essential for audit-grade carbon credits and premiums for ethically sourced bio-assets and commodities. Our proposed model's two key utilities are:

- **Enquiries: Voice Notes and Missed Calls to Local Facilitator-Managed Number via WhatsApp or Call**

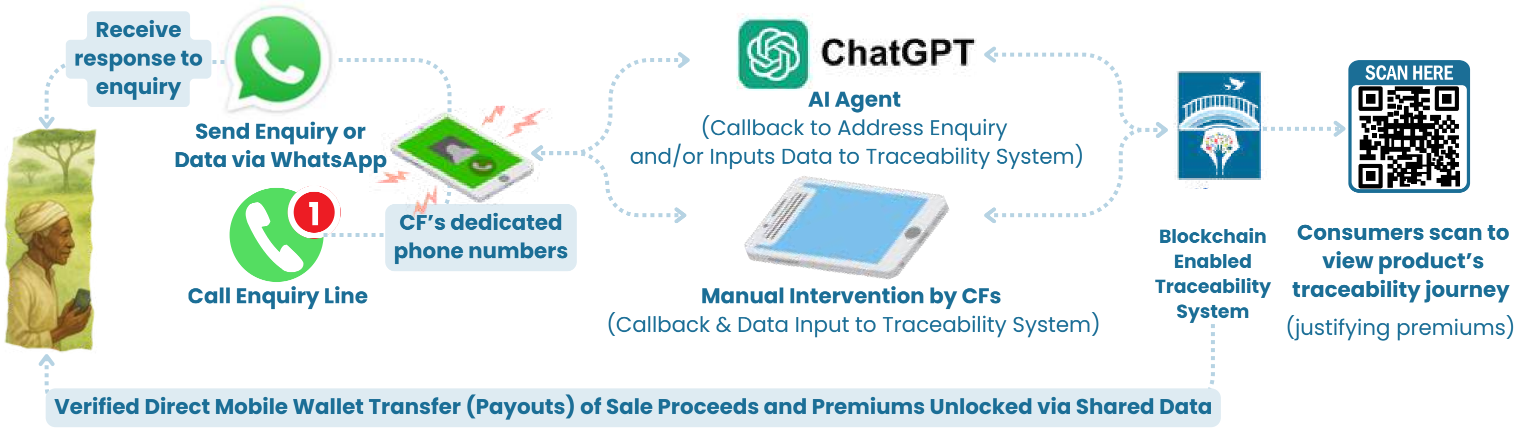
Community members involved in an NbS project send enquiries as voice notes or missed-call triggers that are responded to by human staff from CFs or AI agents. These enquiries aid the accurate implementation of NbS initiatives and reduce project implementation risks.

- **Impact Data and Stories for audit-grade premiums:**

Community members share impact data—particularly ground-truthing data, stories, and data points required to aid certification and audit requirements—to a central CF-managed number, where:

  - data is collected, formatted, and added to the traceability platform by CF manually (**manual process**), or
  - data is sent via an API to the AI agent to cleanse and add to the traceability platform (**automatic process**).

Videos and data (capturing local context, social, and ecological impact) build narrative authenticity for premium buyers seeking human connection or carbon-credit project developers requiring valuable ground-truthing data for certification of commodities and carbon credits.



Notes: ***1.*** *Agentic AI tools can automate the manual data-input process by CFs to the traceability platform.*
2. *Local facilitators can be co-ops, local charities, large international CFs, and local municipalities.*
3. *Verified mobile wallet payouts in emerging markets face compliance hurdles from payment processors.*

Digital Passport Essentials: Traceability Inputs for Credible Regenerative Ag and Carbon

Key data essential to capture via the traceability platform to establish and maintain trust with buyers of commodities from NbS, including carbon credits, through the case study of cashew nuts sourced from an NbS:

Farm and Regenerative Practices (Baseline and Activity Proof)

- **Data captured:** Farmer name, portrait photo or short video, and geolocated farm-boundary polygon, dates of regenerative practice, visual proof (short videos/photos) of practices
- **Why it matters: i)** Puts a human face on sourcing, deepening consumer trust and brand authenticity by showing exactly who and where their purchase supports; **ii)** aids in certifying origin, "additionality" required by carbon standards, and regenerative evidence and impact (Organic, Rainforest Alliance, Fairtrade, VM0042 baseline verification).

Payment and Compliance Verification (Fair Benefits and Standards)

- **Data captured:** Mobile-money receipts directly from a payment processor connected to the traceability platform confirming farmer payment or manual uploads of cash payment receipts - with records on the blockchain.
- **Why it matters:** Verifies fair payment distribution, ensures certification compliance (Fairtrade), and meets VCS Standard requirements for environmental and social safeguards.

Source: Amaly Legacy Tech team

Rural Community Challenges and Optimal Tech and CF Enabled Design Solutions

Digital platforms form the backbone of cost-efficient knowledge delivery, automating routine advisory services and leveraging economies of scale to efficiently reach thousands of practitioners at minimal marginal costs. By integrating blockchain-based verification systems, these platforms provide transparent, tamper-evident impact records, significantly reducing verification costs and building donor and buyer confidence. However, it's critical to complement this digital efficiency with **CF partnerships to inject vital human connections, leveraging deep community relationships, local trust, and cultural knowledge, to tackle trust deficits often faced by purely digital approaches**. CF expertise facilitates inclusive community mobilisation, encompassing farmer group formation, demonstration plot establishment, peer learning, local adaptation, input quality assurance, and gender-inclusive youth engagement initiatives. **An optimal CF partnership structure strategically balances centralised coordination with local, culturally attuned execution, maintaining operational consistency while ensuring relevance and responsiveness to community-specific contexts and challenges. This integrated digital and human-driven hybrid model sets the stage to address multifaceted rural community challenges** outlined next, providing tailored technology and CF-enabled solutions to scale sustainable practices.

Lorenzo Tachella, Head of Partnerships GCC

WFP United Nations World Food Programme

"Innovation is not just about technology—it's about transforming lives. Digital traceability tools, when placed in the hands of smallholder farmers and local cooperatives, become instruments of empowerment. In regions where youth unemployment is high, enabling young people and farming communities to manage their own data, track progress, and access fair markets turns digital records into pathways for dignity, resilience, and local ownership. True innovation is measured by how effectively it strengthens communities and shifts agency back to those at the heart of our food systems."

Rural Community Challenges and Optimal Tech and Human Enabled Design Solutions

Understanding and addressing the user experience challenges faced by rural communities implementing NbS is critical to the success of any digital-physical hybrid model. These challenges span technological, cultural, and practical dimensions that must be carefully navigated to ensure effective adoption of sustainable practices. **With many target beneficiaries lacking smartphones and many having limited digital exposure, the design must prioritise accessibility, simplicity, and cultural relevance while maintaining technical accuracy and impact measurement capabilities.** Effective data gathering, analysis, and presentation require integration of traceability tools, generating QR codes that link to farmer stories plus analysed and verified data to create powerful connections between communities and end consumers.

Challenge Category	Specific Issues	Design Solutions	CF's Role	Example Metrics to Gauge Performance
Digital Literacy	• No prior phone menu experience • Number-only literacy • Fear of "breaking" technology • Language/script barriers • Limited tech exposure	• Voice-first interfaces with local languages and accents • Number-based navigation (press 1 for x) • Step-wise confirmations	• **Group practice and 1-on-1 sessions** with youth • **Youth as tech helpers** (on stipends) • Adapting and iterating on services based on **user feedback measurement**.	• % completed first call • % of independent use • # of data fields accurately captured per user journey • Step where user abandoned process • % retention
Trust and Credibility	• Skepticism of "invisible" advisors • Past extension failures • Preference for human contact • Data privacy fears	• Local leader voice intros • Success stories and farmer testimonials • CF staff call-backs • Village display boards	• Community **endorsement meetings** • **Success story events** • **Redressal mechanism and grievance handling**	• <x% privacy concerns • % would recommend • % retention
Connection Issues	• 2G only coverage • Network dead zones • High airtime costs • Phone sharing needs • Power access limited	• Toll-free numbers • Callback services • Group listening sessions • Solar charging hubs	• **Coverage mapping** • **Technical assistance** • Alternative delivery: digital extension models complement and don't replace **traditional extension**.	• % call completion • % power access • % regular use
Economic Limitations	• High risk aversion • Competing time needs • Market access limited • Input costs prohibitive	• Incremental practices • Time-saving focus • Market linkage included • Input rewards	• **Reward and risk pools** • **Labour sharing groups** • **Buyer connections** • **Input distribution**	• % practice adoption • % time savings • % market access

Source: *Amaly Legacy analysis*

Structuring Human Intervention for Scalable UX Impact: A Layered Support Model

To effectively upskill rural communities in implementing NbS, a hybrid model combining digital support with human facilitation is essential. The optimal model needs to strike a balance between centralised coordination and localised implementation, ensuring both consistency and contextual responsiveness. This section outlines a **three-tiered human support framework designed to bridge digital gap while considering** user experience (UX) principles tailored to non-smartphone users and cultural nuances to support sustained adoption and impact.

Individual Tech-Savvy Youth

Digital Youth Champions Offering Household-Level Tech Support (Target Ratio: 1:30 Households)

Device: Regular phones with configured speed dials, or smartphones with common apps (WhatsApp) configured

- Device setup assistance
- Weekly check-ins
- Basic troubleshooting
- Usage encouragement
- Story capture training

Cooperatives, NGOs, Municipalities

Community Facilitators "CFs" Offering Group-level Coordination (Target Ratio: 1:500 Households)

Device: Smartphones with common apps configured for their use with access to traceability application

- Group training sessions
- Demo site management
- Data collection and ground truthing
- Impact documentation
- **Rewards distribution**

Project Developer & Asset Manager

Technical Specialists of Project Developers Offering Cluster-Level Oversight (Oversight of CFs)

Device: Smartphones, and laptops with common apps, and an analytics and traceability application (main dashboard)

- Complex problem solving
- Quality assurance
- Market linkages
- Impact measurement
- Story curation

Notes: i) Data collection and ground truthing can also aid validation and verification efforts of MRV protocols and processes for carbon credits; **ii)** Building an effective partnership structure requires careful consideration of each organisation's capabilities, geographic reach, and operational efficiency

<table>
<tr><th>Organisation</th><th>Strengths</th><th>Design Solutions</th><th>Role*</th></tr>
<tr><td>Agricultural Cooperatives</td><td>• Strong local networks.
• Trusted locally
• Ag expertise.</td><td>• May lack digital/data-handling capabilities.</td><td rowspan="4">Enquiry Handling:
• Digital Role:
◦ Automated reception of enquiries via basic digital tools (missed calls, voice notes, WhatsApp).
◦ Initial query categorisation and logging through structured digital systems.
• Human Role:
◦ Personally calling back farmers to provide detailed, culturally sensitive guidance.
◦ Manually logging interactions into traceability platforms for transparency and record-keeping.
Data Inputs and Manual Verification:
• Digital Role:
◦ Initial digital capture of data (voice notes, photos, short videos) through simplified mobile interfaces.
• Human Role (Technical Specialists and Facilitators):
◦ Conducting manual validation of digital submissions for accuracy and authenticity.
◦ Entering verified data into blockchain-backed systems manually when automation isn't feasible, maintaining data integrity and traceability.
Premium Justification and Storytelling:
• Digital Role:
◦ Automatically organising submitted content (voice/video) into structured narratives for premium products.
• Human Role (Technical Specialists):
◦ Curating high-quality impact stories and manually adding context-rich details.
◦ Ensuring data integrity and narrative quality for buyers through manual oversight (justifying premiums).</td></tr>
<tr><td>Local Charities and NGOs</td><td>• Community-centric.
• Trusted locally.
• Strong cultural alignment.</td><td>• May require capacity-building for technical skills.
• Operational scale limitations.</td></tr>
<tr><td>International NGOs</td><td>• Extensive technical expertise.
• Robust data management
• Good funding sources.</td><td>• Potentially higher overhead costs, less local cultural alignment initially.</td></tr>
<tr><td>Local Municipalities</td><td>• Established administrative systems.
• Authority-driven implementation.</td><td>• Risk of bureaucratic delays, potential political influence on operations.</td></tr>
</table>

Note: 1. Role assumes manual intervention in enquiries and data inputs by CFs instead of using AI agents;
2. Optimal partnerships may involve a blend of co-ops, NGOs, and local municipalities

Source: Amaly Legacy analysis

Critical Success Factors in Partnering with Community Facilitators

Viability of hybrid digital-human facilitation models for NbS implementation depends on several foundational elements that must be in place before implementation. These elements determine whether the model can achieve its cost reduction and impact targets. They broadly fall into the following 3 categories:

Technology Enablers

- **Basic Infrastructure:** 2G network coverage with reliable uptime; SMS and voice call capability
- **UX:** local languages/accents, toll-free numbers or use of missed calls, and use of common apps for smartphone users such as WhatsApp
- **Power Solutions:** charging stations, power access (grid, solar, or other)

Operational Pre-requisites

- **Input Supply Chains:** Reliable access to NbS inputs (native seedlings, compost tea inoculants, basic grafting, weeding, and/or farm equipment)
- **Market Linkages and Financial Infrastructure:** Established buyers for carbon credits, sustainable products, eco-tourism services with mobile money systems for CFs to transfer funds in a verified and transparent manner to communities (ideally linked to traceability system)
- **Storytelling:** Partnerships with media platforms for content post-production

Community Readiness

- **Community Organisation:** Existing groups (farmers, forest users, water committees) or willingness to form cooperatives
- **Community Buy-In and Leadership Support:** Community buy-in along with leaders endorsing technology adoption and NbS practices
- **Youth Engagement:** Young people available as digital facilitators

Rewards Mechanisms to Increase Adoption

Besides the key enabling elements to activate effective hybrid digital and human facilitation models, **having the right incentive structure is the fuel to power and ensure sustainability of such models and systems**. Below are key reward mechanisms to ensure adoption and continued usage by communities.

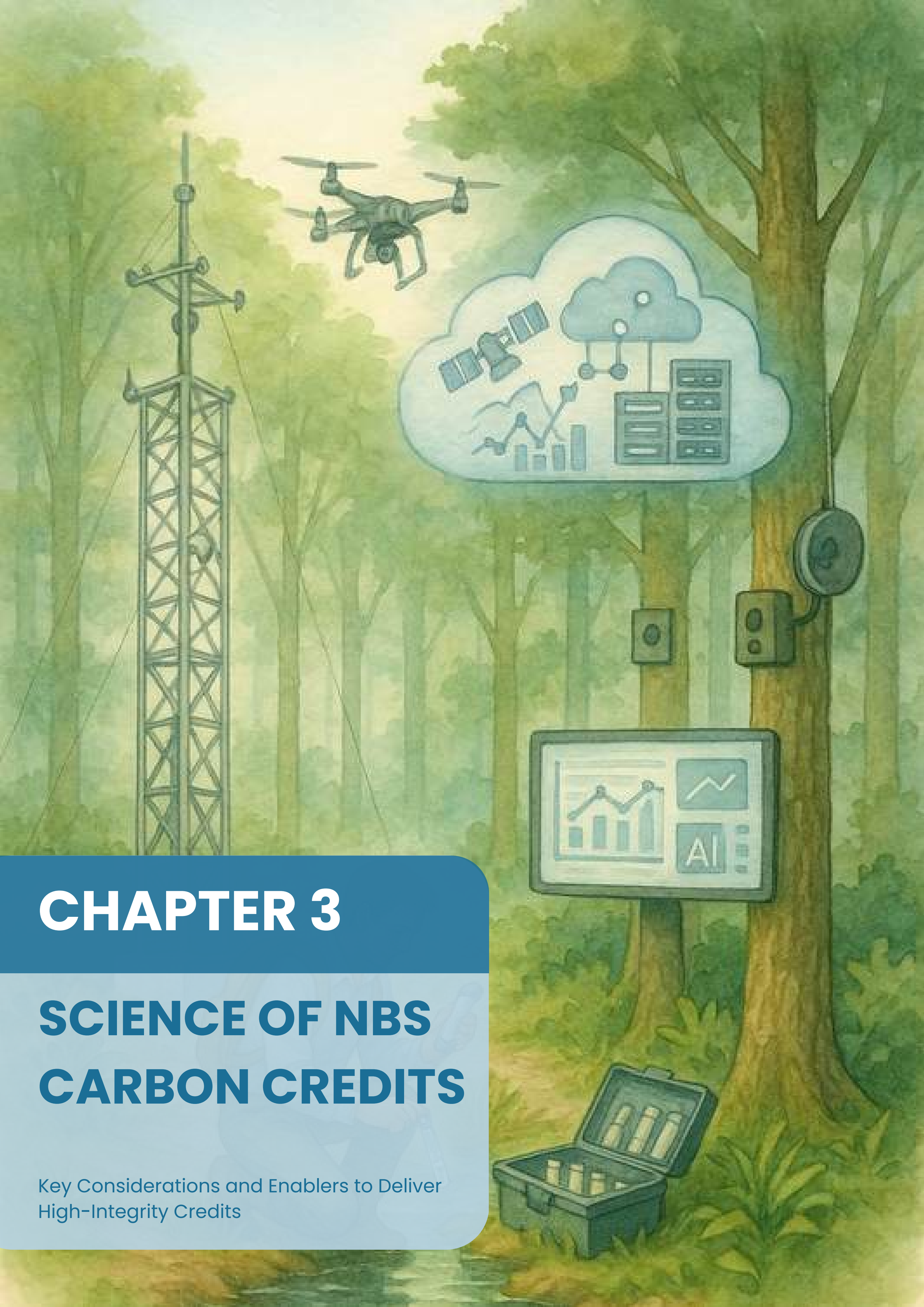
- **Access & rewards:** free access to digital platform and periodic rewards for high quality data inputs.
- **Field Visit Budgets:** fair and regular budgets allocated for field visits and activities.
- **Performance-based inputs:** access to select inputs such as bio fertilisers and pesticides based on performance.
- **Market access:** Establish and offer market linkages for ancillary products (such as honey from beehives, essential oils from forests, intercrops from farms, etc.) for communities adhering to NbS project activities.
- **Storytelling platform integration:** financial rewards for video content approved and used in story telling donor fundraising campaigns and product traceability.

The model's efficiency increases when beneficiaries begin generating revenue through carbon credits and highlighted benefits, which improve their productivity and further boost income generation.

Conclusion

Hybrid models combining digital advisory tools with strong community facilitation partnerships are essential for scaling NbS. They reduce training costs while significantly improving adoption **when implemented by capable project developers**. Success depends on thoughtful design for low-tech environments, community trust-building, and linking digital data to real-world outcomes like market access and carbon revenues. Without experienced NbS asset managers/project developers managing the ecosystem—technology, training, incentives, and verification—the model risks falling short on sustained use and

Source: Amaly Legacy analysis



CHAPTER 3

SCIENCE OF NBS CARBON CREDITS

Key Considerations and Enablers to Deliver High-Integrity Credits

SCIENCE OF CARBON CREDITS

Core Tenets of Carbon Projects

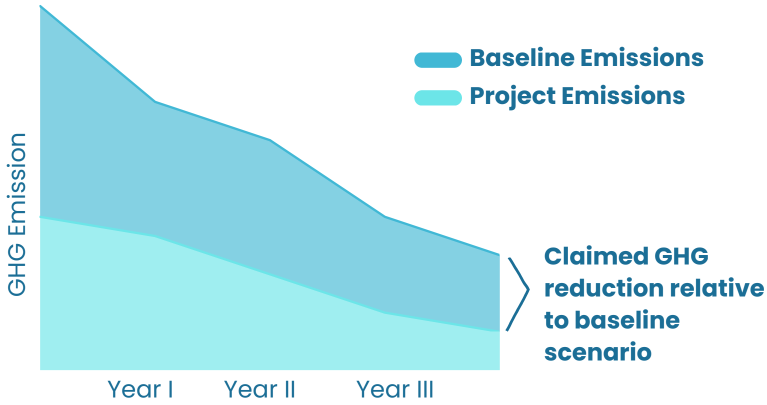
Adherence to recognised carbon credit development methodologies and protocols of standard-setting bodies for quantifying carbon reductions or removals is critical for earning corporate buyers' confidence, especially their decarbonisation divisions' buy-in when considering purchase of high-integrity carbon credits to offset their emissions. In this chapter, we consider some of the core concepts central to the development and generation of carbon credits.

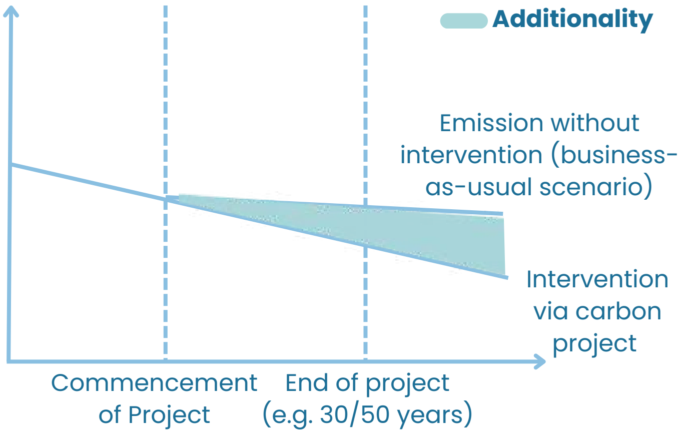
Baseline Scenario

Predicted level of GHG emissions or removals that would occur in the absence of the carbon project. It represents the "business-as-usual" scenario against which the project's impact is measured. The baseline is used to estimate how much would have been emitted without intervention, serving as a reference point for quantifying emissions reductions.

Additionality

Amount of emissions reduced by a carbon project **over and above the reductions that would occur due to other factors**; this is additionality. A project is additional if it only exists because of the carbon-credit incentive, ensuring that the reductions are genuine and would not have occurred otherwise.





Leakage

Accounting for **unintended increases in emissions** or **losses of benefits outside the project boundary** caused by project activities.

Permanence

A "permanent" carbon offset represents reductions intended not to be reversed for a defined period. However, events such as forest fires, land conversion, over-harvesting, or illegal logging can release sequestered carbon back into the atmosphere. Typical tenures of permanence include:

Typical tenures of permanence include:

- **Industry benchmark** of 100 years for "permanent" classification
- **ICVCM** 40-year minimum monitoring and compensation period from the start of the first crediting period
- **Conventional standard** of a few decades (e.g., 40 years) for practical permanence

Permanence Protection Mechanisms

- **Project-Level Buffer Pools are project-level contributions** whereby a % of issued credits is allocated to a central pool as insurance against reversals. Contributions may be risk-adjusted based on non-permanence assessments covering risk factors, or set at a flat rate

- **Registry-Level Buffer Pools** are maintained by standard-setting bodies (e.g., Verra) to aggregate these contributions. They address systemic market risks and registry-wide permanence issues.

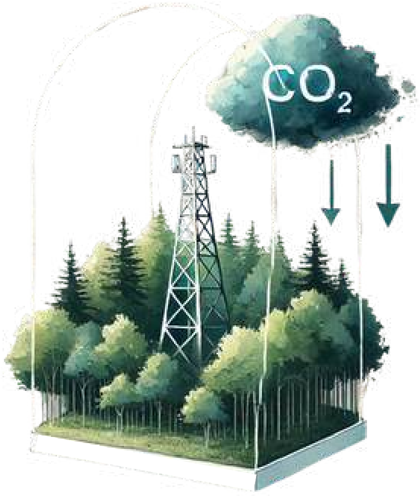
- **Insurance Products** are emerging as an effective tool covering losses at multiple layers, including permanence risks, with premiums based on project risk. Coverage terms are typically multi-year and renewable; some solutions aim to align with longer program obligations (e.g., 40 years), with a transparent, auditable manner.

- **Legal/Tenure Mechanisms** such as legally enforceable carbon rights and carbon storage agreements, and effective land tenure supported by land and carbon registries and regulatory bodies in the host nation—are critical for permanence protection.

Source: ICVCM, Climate Action Reserve, Gold Standard, CarbonPool.earth, Amaly Legacy analysis

Select Enabling Technologies That Underpin Scientific Rigour in Carbon Projects

Achieving truly high-integrity carbon credits now hinges on a new toolkit of "enabling technologies" that collect, validate, and secure field data with unprecedented precision and transparency. From dMRV (digital Measurement, Reporting and Verification) hardware—eddy covariance towers, IoT sensor networks, satellites, and real-time emission meters—to drones that capture centimetre-level imagery, and environmental DNA kits that verify biodiversity co-benefits, these innovations transform monitoring from periodic sampling to continuous, auditable evidence streams. Together, they solidify the feedback loop between project activities and measurable climate-positive outcomes, giving investors, regulators, and local stakeholders confidence that claimed emissions reductions and ecosystem benefits are real and enduring.



Eddy Covariance Towers

- **Use:** Measure the exchange of CO_2 and other greenhouse gases (e.g., CH_4) between the land (forests, grasslands, wetlands) and the atmosphere.
- **Enables High Integrity Claims** by providing continuous, high-precision data on carbon fluxes, essential for quantifying how much carbon is being sequestered or released/ emitted by natural ecosystems.

Drones (UAV)

- **Use:** Collect high-resolution aerial imagery, map restoration areas, and monitor vegetation health.
- **Enables High Integrity Claims** via rapid, cost-effective mapping and monitoring of reforestation or afforestation projects, and by delivering seed pods for planting in hard-to-reach areas.

Environmental DNA (eDNA) Sampling Kits

- **Use:** Collect and analyse genetic material from soil or water to assess biodiversity and ecosystem health.
- **Enables High Integrity Claims** by validating biodiversity co-benefits through lab-verified detection of species and community composition from soil/water samples.

Smart Camera Traps and Acoustic Monitors

- **Use:** Collect and analyse images and acoustic recordings to monitor species presence/activity, and assess biodiversity.
- **Enables High Integrity Claims** by delivering verifiable evidence of species trends, habitat use, and disturbance events that substantiate biodiversity co-benefits.

Cloud-based dMRV systems powered by Artificial Intelligence and Machine Learning algorithms ingest multiple high-quality datasets from spaceborne, airborne, and ground-based sensors and automate their processing into real-time information, providing insights into greenhouse gas emissions and removals. This provides a standardised, scalable, cost-effective, and secure avenue for project developers to identify areas of improvement, optimise project operations, and, overall, ensure the integrity of carbon accounting and trading

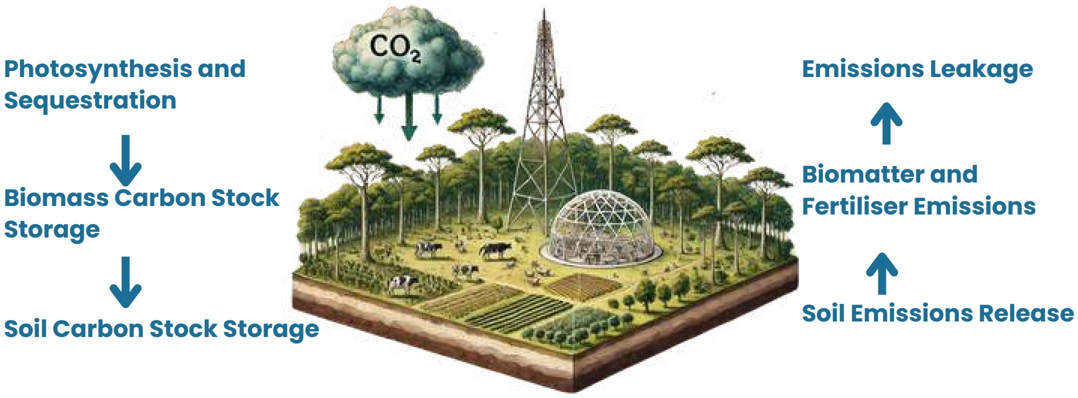
Dr. David Gwenzi
VCS Advisory Group (Verra)

> ***Credible project developers ensure scientific rigour of carbon projects by adhering to any leading standard-setting body's methodology and protocols. Additionally, utilising advanced hardware technology for MRV, enhances the accuracy and transparency of assessments. This approach guarantees robust project monitoring and data integrity, ultimately delivering real, verifiable benefits in carbon reduction, environmental impact and premiums of carbon credit price. These technologies enable automated, accurate, and transparent tracking of GHG emissions and removals, supporting the issuance of high-quality carbon credits and compliance with regulatory requirements***

Source: Amaly Legacy analysis

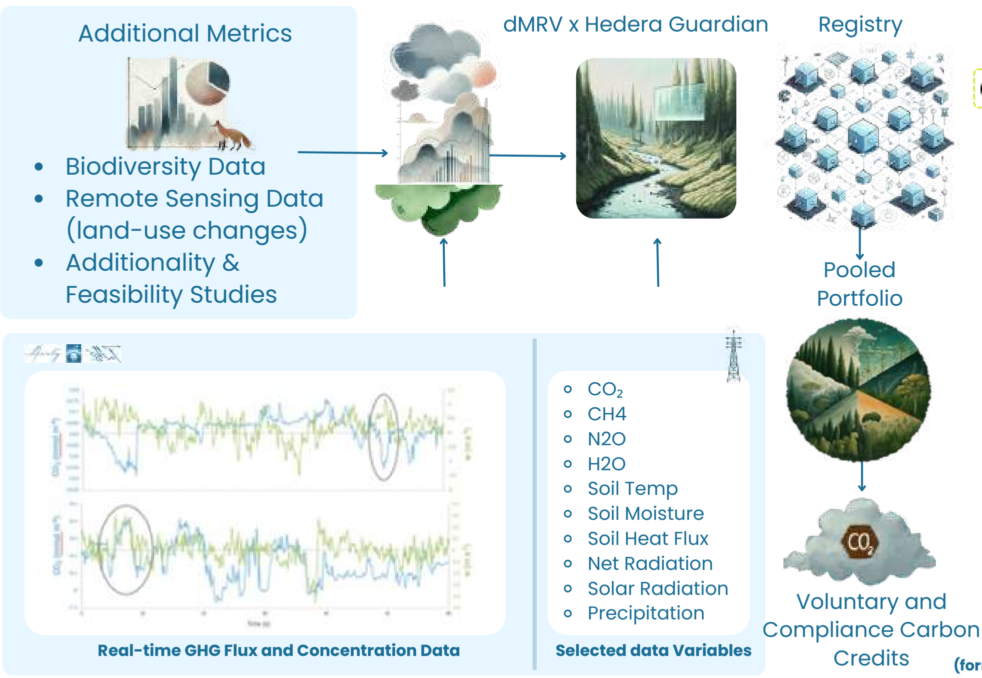
Digital Enablers: Hardware Tech and Real-Time Data Tracking

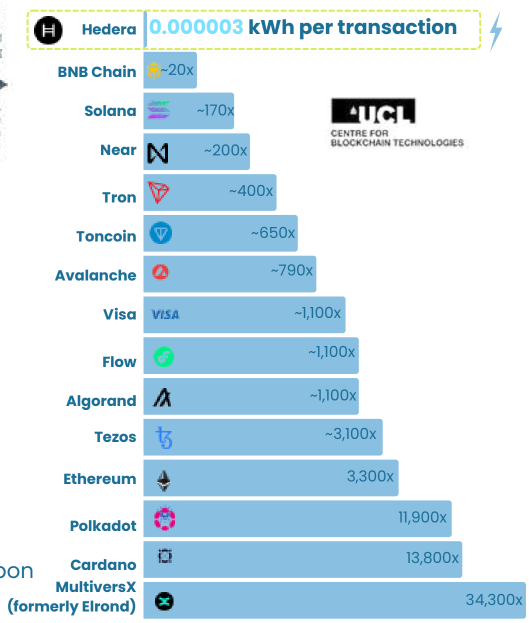
Project developers are establishing strong partnerships to track carbon sequestration in real-time, along with other data points that can be leveraged to enhance co-benefits. They also analyse, visualise, and report data to key stakeholders, including governments, communities, and buyers of our carbon credits, which translate into additional premiums for sold carbon credits and lower project risks.



Digital Enablers: Blockchain

Together with reputable dMRV partners, project developers can leverage various Blockchains such as the Hedera blockchain to track key metrics critical to the buyer of our carbon credits. **Tracking, verifying and reporting social and environmental impact of projects aids capturing additional carbon credit co-benefits price premium ...**





Sources: Hyphen.earth, UCL Centre for Blockchain Technologies (2023), “The energy consumption of Proof-of-Stake systems: Replication and expansion,” Table II. Multiples shown are relative to Hedera at 0.000003 kWh/tx and are rounded.

Atmospheric-Based MRV: Direct Insight into Emissions and Removals

Atmospheric-based Measurement, Reporting, and Verification (aMRV) directly and continuously measures greenhouse gas (GHG) fluxes — specifically carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) — moving between land surfaces and the atmosphere. This allows real-time quantification of both removals (negative flux) and emissions (positive flux) as they occur. These fluxes are captured using high-precision gas analysers and the eddy covariance technique — a well-established scientific method that measures the turbulent exchange of gases over a defined area. The result is a continuous, high-resolution dataset that reveals how land use, land-use change, and ecosystem processes affect atmospheric GHG levels.

Scientific Lineage

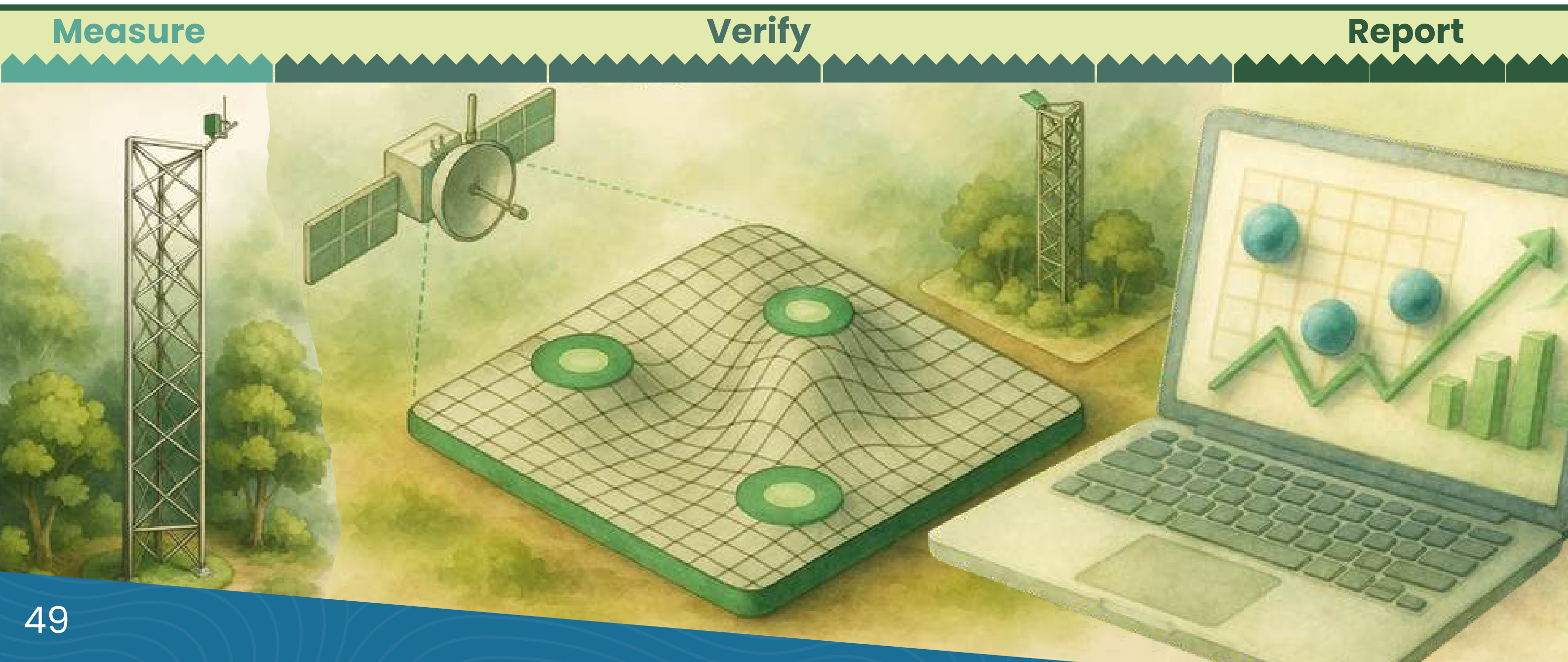
The instrumentation and flux-calculation protocols underpinning aMRV are grounded in more than five decades of field-tested, peer-reviewed research. They form part of the World Meteorological Organisation's (WMO) Global Atmosphere Watch (GAW) and are widely applied by organisations such as the U.S. National Oceanic and Atmospheric Administration (NOAA), the Integrated Carbon Observation System (ICOS), and the global FluxNet network. Eddy covariance methods have been used since the 1950s to directly monitor atmospheric GHG concentrations for climate science.

Key Advantages of aMRV

- **Direct Measurement of Outcomes:** Quantifies GHG fluxes across landscapes using analysers calibrated to global scientific standards.
- **Continuous Monitoring:** Captures data at sub-hourly intervals, tracking seasonal variation, management impacts, and reversal events year-round.
- **Clear Separation of Removals vs. Emissions:** Provides unambiguous classification, enabling precision in credit type and climate claims.
- **Ecosystem-Scale Coverage:** Generates flux measurements representative of entire project areas in real time.
- **Real-Time Quantification:** Converts continuous time-series data into carbon accounting units via validated, standards-compliant methodologies.

Atmospheric-based Measurement, Reporting, and Verification (aMRV) solution provides precise, real-time quantification of GHG emission reductions and removals for carbon projects. It integrates on-site eddy covariance flux instrumentation, advanced data analytics, and direct integration with carbon registries — enabling project developers to issue high-quality carbon credits or insetting claims grounded in verifiable, measured impact.

By measuring GHG fluxes alongside temperature, wind, and other environmental variables, the system delivers actionable insights as they happen. Its secure, user-friendly platform ensures transparency, produces audit-ready data exports, and empowers decision-makers to monitor, mitigate, and manage emissions across sectors such as agriculture, forestry, and waste management.



How aMRV Works in Practice

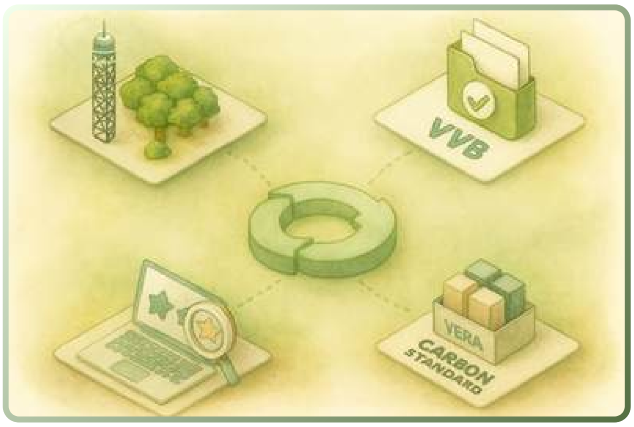
Specialised aMRV solution providers such as Hyphen provide an end-to-end service, from project-site flux instrumentation design and infrastructure installation to continuous data processing and market integration. They transform high-resolution atmospheric and environmental data into quantified emissions reductions and removals for entire project areas, with results accessible via a customisable, decision-maker-friendly dashboard. In the case of Hyphen, their patented software integrates these flux measurements with remotely sensed data to scale insights across entire project areas. The outcome is real-time quantified tonnes of removals, directly translatable into carbon credits. Unlike traditional estimation approaches, aMRV measures what ecosystems are actually doing — in physical units (tCO_2e) per hectare per day.

Step 1: Feasibility and Site Design
- GHG Flux Potential Analysis using over two decades of global flux and meteorological data
- Land Use Stratification to assess heterogeneity and determine sampling density
- Instrumentation Blueprint designed around prevailing winds, topography, and canopy height
- Baseline Evaluation using pre-intervention monitoring or paired-control sites

Step 2: On-Site Infrastructure Deployment
- Eddy Covariance Towers calibrated for CO_2, CH_4, and N_2O
- Soil Chamber Systems for soil emission-dominated landscapes
- Minimal Disruption Construction to integrate with ongoing land management

Step 3: Continuous Flux Measurement and Quantification
- Live Data Collection at 10–20Hz
- Standardised Flux Conversion into traceable tCO_2e units
- Upscaling Models integrating remote sensing for full-area coverage
- Embedded Uncertainty Quantification meeting ICVCM, VCMI, and Article 6 standards

Step 4: Registry Integration and Credit Issuance
- Verification Packages including raw data logs, Quality Assurance/Quality Control, and uncertainty analysis
- Credit Pathways via next-generation registries and compliance systems
- Data Interoperability with blockchain-based MRV platforms for tamper-proof issuance



aMRV: The Measurement Layer for Carbon Market Integrity

As carbon markets move from high-volume to high-integrity, aMRV delivers precision, standardisation, and trust at scale. It aligns with:

- **ICVCM Core Carbon Principles:** Ensuring outcomes are measurable and verifiable
- **SBTi Forest, Land and Agriculture Guidance:** Enabling quantifiable separation of agricultural removals
- **VCMI Claims Code:** Supporting credible Scope 3 and offset claims
- **Jurisdictional Nesting & Article 6:** Enabling cross-scale verification

aMRV harmonises remote sensing, land-use models, and reported activity data under a single, observable atmospheric signal. This foundation enables:

- **Outcome-Based Ecosystem Payments** – Rewarding actual atmospheric performance
- **Policy-Linked Finance** – Subsidies and taxes tied to measured fluxes
- **Standardised Verification** – A common accounting language akin to GAAP in finance

Looking ahead, aMRV is positioned to become the default MRV approach for ecosystems where legacy methods are no longer sufficient — from wetlands and savannas to regenerative agriculture and mixed forests — unlocking climate finance at the scale required to meet global targets.

Measuring Biodiversity - Rationale and Challenges

Measuring biodiversity remains complex: traditional surveys are labor-intensive, habitat-invasive, and often yield incomplete results. Many projects default to oversimplified indicators and measurements, limiting the ability of markets to reward projects with higher biodiversity value. Specialised biodiversity data analytics innovators such as Biometrio.earth address this challenge by pioneering a holistic, data-driven, AI-powered approach to biodiversity assessments and monitoring. By combining acoustic monitoring, computer vision, and remote sensing, biometrio.earth generate transparent, audit-grade biodiversity analytics that strengthen integrity in NbS projects.

Acoustic monitoring uses digital microphones to capture wildlife vocalisations and environmental soundscapes. This non-intrusive method generates vast amounts of data that help detect elusive species, provide round-the-clock coverage, and enable the assessment of ecological communities over time.

- Detects indicator species without human interference.
- Produces verifiable data (date, time, GPS) suitable for audits.
- Creates long-term acoustic archives for retrospective analysis.
- Identifies both biodiversity signals and anthropogenic pressures.

Deep learning can be applied to transform vast acoustic datasets into species-level insights that are validated by experts, while building annotated datasets to expand coverage for highly diverse tropical ecosystems.

Spotlight: Computer Vision

Wildlife cameras capture high-resolution photos and videos of fauna with 1 kg body mass and above. Deep learning models aid in processesing this visual data to identify species, estimate population densities, and track behavior, while maintaining expert validation for quality control.

- Enables independent, replicable monitoring of fauna.
- Provides transparent, expert-verified results.
- Engages stakeholders through compelling imagery and video evidence.

How It Comes Together

<biometrio.earth> integrates acoustic monitoring, computer vision, and remote sensing into a comprehensive dMRV system. Data from multiple sources is fused into spatially explicit analytics that quantify three dimensions of biodiversity:

- Species richness and composition – variety and abundance of species
- Structural diversity – habitat organization and spatial patterns
- Functional diversity – ecological roles such as pollination, predation, and nutrient cycling

These metrics are synthesised into an Ecosystem Condition Index: a robust indicator of ecosystem health. This standardised approach equips NbS developers with rigorous, audit-ready biodiversity assessments, helps buyers reward high-impact projects, and empowers communities with data that links nature conservation to economic opportunity.

MRV-Enabled for Buffer Zone Leakage Prevention & Carbon Project Integrity

Adherence to carbon credit development methodologies requires rigorous assessment and mitigation of leakage risks—unintended increases in emissions or benefit losses outside the project boundary caused by project activities. This is especially true for **buffer zones - transitional areas between core protected forests and surrounding agricultural or settlement areas that serve as critical barriers against leakage. Buffer zones represent critical transitional areas where enabling technologies and strategic management interventions address this core MRV challenge**. When carbon projects restrict forest access without providing alternative livelihoods, communities may shift deforestation pressure to adjacent unprotected areas, undermining additionality and permanence claims. Advanced monitoring technologies—from satellite imagery tracking land-use changes to IoT sensor networks detecting encroachment patterns—now enable real-time leakage detection and prevention. Strategic buffer zone management leverages this technological foundation by creating economic value from degraded edge areas, reducing encroachment incentives while maintaining ecosystem connectivity and providing continuous, auditable evidence streams that demonstrate effective leakage mitigation to standard-setting bodies.

Selected practical, cost-effective approaches that enhance landscape resilience while supporting local livelihoods without major financial outlays are provided below.

Technical Farming Support and Affordable Inputs

Provision of technical regenerative agriculture assistance to improve soil health, increase crop yields and quality while curbing deforestation and conversion of natural habitat for agriculture

- **Use objective:** Increase agricultural productivity on existing farmland to reduce encroachment pressure on forest and natural habitat edges.
- **Key benefits:** Boost crop yields through improved soil health, drought-resistant varieties, and organic matter enhancement.
- **Claims verification:** Enables high-integrity buffer zone protection by providing measurable productivity improvements that reduce deforestation and conversion drivers.
- **Implementation:** Training programmes on regenerative agriculture and provision of affordable inputs and equipment through field officers and NGO partners.

Ecotourism

Guided nature walks, birdwatching, and cultural heritage trails

- **Use objective:** Generate sustainable income from buffer zone landscapes without ecosystem disturbance.
- **Key benefits:** Create economic incentives for conservation while showcasing biodiversity and cultural value of transition areas.
- **Claims verification:** Enables high-integrity community engagement by providing alternative livelihoods that directly depend on ecosystem health.
- **Implementation:** Development of trail networks, guide training programmes, and partnerships with tour operators to market authentic nature experiences.

Biological Asset Valorisation

Assessing and supporting transitional natural habitats for **medicinal oils, resins, edible foods, and forest-product market** linkages.

- **Use objective:** Transform buffer zones into productive income-generating landscapes through sustainable harvesting of native biological resources.
- **Key benefits:** Create value from existing forest products, including essential oils from aromatic plants, tree resins, wild edibles, and medicinal plants, while maintaining ecosystem integrity.
- **Claims verification:** Enables high-integrity co-benefits measurement through quantifiable sustainable harvesting quotas and biodiversity conservation outcomes.
- **Implementation:** Species inventory and sustainable yield assessments, processing facility establishment, quality certification for organic/fair trade markets, and direct linkages to pharmaceutical, cosmetic, and specialty food buyers.

Summary

Rather than investing in costly replanting, project developers can safeguard degraded buffer zones around core forests through these practical, low-cost initiatives that deliver both conservation and livelihood value.

Source: Amaly Legacy analysis

Leakage and Permanence - NbS Versus Industrial CDR

As we delve deeper into the potential and integrity of NbS, it's insightful to benchmark against industrial CDR technologies. This comparison not only enhances our understanding of NbS's robustness and strategic advantages but also highlights why NbS stands out as a vital and holistic investment within broader climate action portfolios.

Risk Dimension	Industrial CDR	Nature-based Solutions	Why NbS Outperforms	NbS Strategic Advantage
Leakage Profile	• Single-point failure risks (wellbore, cement integrity) • Requires continuous high-tech monitoring • Binary outcome (stored or leaked) • Catastrophic failure potential	• Distributed risk across ecosystem • Self-healing biological systems • Multiple carbon pools (soil, biomass, products) • Gradual changes detectable early	**Biological systems offer inherent redundancy:** • Thousands of trees/plants per hectare vs. single injection point • Living organisms naturally regenerate • Ecosystem changes provide early warning signals • Partial disturbances rarely compromise entire system	**Lower monitoring infrastructure needs through natural distribution**
Permanence Mechanism	• Geological containment dependent • Insurance/financial guarantees often required • Passive storage requiring perpetual vigilance	• Dynamic equilibrium through regeneration • Economic value creation prevents reversal • Active management by beneficiaries	**Economic alignment enhances permanence:** • Sustainable harvesting provides ongoing income • Communities protect resources that support livelihoods • Productive land maintains higher market value • Multi-generational benefits encourage long-term thinking	**Self-reinforcing permanence through community stakes**
Protection Economics	• Primary revenue from carbon credits	• Multiple revenue streams possible ◦ Carbon as complementary income • Biological assets value appreciation over time	**Diversified economics reduce risk**: • Agricultural products, timber, NTFPs provide regular income • Carbon credits supplement rather than drive viability • Local employment creates political sustainability	**Risk mitigation through diversifying revenue**

NbS Advantage: Beyond Carbon

1. Biological Resilience > Engineered Containment

- Established forests show strong recovery capacity after natural disturbances.
- Soil carbon represents a large, stable pool that buffers against surface changes.
- Well-managed agricultural lands can increase soil organic carbon over time.

2. Value Stacking Creates Aligned Incentives

- Agroforestry systems generate food, timber, and carbon benefits simultaneously.
- Sustainable nature management provides harvests while maintaining carbon stocks.
- Ecosystem services (watershed protection, biodiversity) add unmeasured value.

3. Community-Based Monitoring Reduces Costs

- Local stakeholders can monitor forest health at lower cost than remote sensors.
- Traditional ecological knowledge complements scientific monitoring.
- Smartphone apps enable efficient data collection without expensive infrastructure.

Conclusion

Unlike industrial CDR, the distributed nature of biological carbon storage—spanning countless plants, vast soil networks, and diverse ecosystems—naturally protects against catastrophic reversals. Additionally, communities economically tied to healthy ecosystems become active guardians. While industrial CDR suits certain needs requiring geological-timescale storage, scalable and economically viable carbon removal is best delivered through nature's proven systems, operating successfully for billions of years.

Source: Amaly Legacy analysis

Aligning MRV with Jurisdictional and Nested REDD+ (JNR)

JNR represents the evolution of forestry carbon project science toward landscape-scale MRV integration, addressing core scientific concepts of additionality, baseline consistency, and leakage accounting and mitigation through coordinated monitoring systems. Under private carbon standard-setting body methodologies such Verra's VM0048 methodology for reducing emissions from unplanned deforestation, **JNR leverages enabling technologies—satellite imagery, ground-based forest inventories, and standardised forest monitoring protocols—to align project baselines with jurisdiction-level forest reference emission levels.** This technological integration ensures consistency in emission factors, deforestation risk mapping, and allocation of activity data and baselines while enhancing permanence through pooled buffer accounts determined via Verra's AFOLU Non-Permanence Risk Tool. The nested approach reduces double counting risks by anchoring individual projects to government-led emissions reference levels verified through standardised MRV protocols, creating a scientific foundation for high-integrity credits that meet institutional buyers' requirements for transparent, auditable carbon accounting. For developers, this structure can improve carbon credit quality —but it may involve more complex coordination with government entities.

Consideration	Traditional Carbon Methodology	JNR (Nested)	Hybrid: Traditional Methodology with JNR-aligned MRV
Credit Volume	Often higher due to project-level baselines.	May be lower (more conservative baseline).	**Balances optimal project-level volumes while benefiting from improved credibility via nested alignment.**
Revenue Share for Communities	Easier to maximise as projects retain control of revenue.	Negotiation with governments may limit flexibility.	**Maintains high community share while meeting government expectations**, building trust and co-benefits alignment.
Attribution of Co-benefits	Clear and direct.	Blurred in aggregate outcomes.	**Co-benefits are tracked and verified at the project level (e.g., under Verra's CCB Standards); carbon accounting is validated under JNR-aligned MRV.**
Buyer preference (VCM)	Favoured by Impact/ESG buyers.	Preferred by certain institutional and sovereign buyers.	**Appeals to broader buyer base -** credible to compliance-oriented and sovereign buyers, and transparent and traceable for ESG/impact buyers.
Sovereign/legal risk	Higher, especially in jurisdictions with regulatory uncertainty.	Lower due to alignment with government frameworks.	**Lower risk** by ensuring projects are legally aligned while retaining implementation flexibility.
Setup complexity	Simpler setup with fewer coordination points.	High due to government integration and multi-level coordination.	**Moderate setup complexity** - builds on existing project methods with structured JNR alignment, reducing future transition risk.
Long-term scalability	Moderate; may face limits if not aligned with national systems.	High, as it integrates into long-term national climate strategies.	**Highly scalable:** Ready for future jurisdictional programmes, scalable and adaptable to evolving market/registry demands.

Impact on Credit Issuance: More Accurate, Lower Volume

Under a JNR framework, projects may generate fewer credits compared to standalone projects using localised baselines, because jurisdictional baselines tend to be more conservative. However, alignment with jurisdictional data will enable premium pricing through enhanced scientific credibility, as alignment with broader-scale monitoring systems demonstrates robust additionality and permanence claims without surrendering project autonomy. The technological precision achieved through jurisdictional MRV alignment—including access to continuous satellite surveillance, standardised forest classification algorithms, and coordinated ground-truthing protocols—strengthens buyer confidence in project integrity while maintaining private ownership and direct market access. Advanced monitoring technologies from automated deforestation alerts to standardised biomass assessment protocols enable projects to demonstrate alignment with jurisdictional standards, commanding premium pricing from institutional buyers seeking verifiable compliance with corporate sustainability commitments. Therefore, strategic alignment rather than full nesting delivers enhanced scientific credibility through coordinated enabling technologies while preserving project independence and competitive per-credit values.

Source: Amaly Legacy analysis

Aligning MRV with JNR *(continued)*

Revenue Distribution: Preserving Community Benefits Through Strategic Jurisdictional Alignment

Alignment with jurisdictional MRV systems without full nesting offers an effective pathway to achieve high-integrity carbon claims while ensuring benefit distribution remains governed by direct carbon rights agreements with land stewards and forest communities. Unlike fully nested JNR structures where revenues may be retained and redistributed by subnational or national governments, projects that strategically align with jurisdictional monitoring data—using project-level methodologies such as Verra's VM0048—can maintain direct control over revenue flows to participating communities. This alignment approach leverages jurisdictional MRV infrastructure to enhance scientific credibility and demonstrate landscape-scale impact while preserving the transparent benefit-sharing frameworks that characterise successful community-based forest protection initiatives. Project developers can negotiate structured carbon rights agreements that guarantee predictable and traceable fund flows directly to local forest stewards, bypassing complex government redistribution mechanisms. This model ensures meaningful community impact through direct compensation for forest protection activities while accessing the enhanced market credibility that comes from alignment with broader jurisdictional monitoring standards, creating a win-win scenario that combines scientific rigour with community-centred benefit distribution.

Best Practice: Align Early with Jurisdictional MRV and Approval Structures

To maximise project longevity and credibility under JNR, developers should engage early with jurisdictional MRV systems. This includes adopting compatible data standards, satellite imagery sources, and forest classification models used at the regional or national level. Early alignment also ensures the project can be nested smoothly into evolving jurisdictional programmes and avoids future compliance risks. Developers should also build relationships with relevant REDD+ focal points in government and contribute to participatory processes that shape how subnational reference levels and credit allocation rules are designed—thus gaining both influence and legitimacy in the nested system.

When Full Nesting Makes Sense

Despite the benefits of a hybrid approach, there are a few cases where engaging in full nesting under JNR could make strategic sense:

Government Support is Mandatory or Critical to Receive Government Approvals: Some governments may require nesting for forest projects to avoid conflicts over carbon rights, especially as they integrate REDD+ into NDCs. Nesting may be the only legally viable path forward in certain jurisdictions, depending on national or subnational policy.

Access to Jurisdictional Credibility and Large Buyers: Large buyers (e.g., multilateral funds, sovereign-backed programmes) increasingly prefer credits from jurisdictional or JNR-aligned programs due to concerns about baseline inflation and leakage. If the target buyer pool includes institutional actors, JNR alignment can unlock credibility-based access to these buyers and even premium pricing, despite potentially fewer credits.

Long-Term Market Stability and National Registry Integration: JNR-aligned projects are often better positioned for compliance markets (e.g., Article 6.2 and 6.4 transactions), where host-Party authorisation and alignment with national carbon accounting—including the application of corresponding adjustments for NDC or other international uses—are mandatory. If the project aims to transition into compliance markets in the future, JNR may offer longer-term viability.

Summary

The hybrid approach—combining traditional carbon methodologies with JNR-aligned MRV—offers the most balanced and strategic pathway for carbon project developers. It retains the flexibility of project-based methods while enhancing credibility, reducing legal risk, and aligning with national systems through jurisdictional integration. This makes it attractive to a broader range of buyers, ensures stronger community benefit retention, and provides long-term scalability in a maturing carbon market.

Source: Amaly Legacy analysis

Practical Guidance for Developers Not Following JNR

1. Clarify Carbon Rights and Data Sovereignty Early

One of the core challenges under the JNR frameworks is the ambiguity around who holds the carbon rights—national governments, subnational authorities, or project developers. To avoid future conflicts or reallocation of credits, developers using methodologies like VM0048 should secure clear, contractual recognition of carbon rights with the appropriate land stewards. Additionally, maintain ownership and control over monitoring data and forest baselines, ensuring that while data can be shared for jurisdictional reporting, it is not absorbed into a centralised system without consent. This safeguards both the integrity of your project and its revenue streams.

To avoid future credit ownership disputes under JNR, developers using methodologies like VM0048 should secure clear agreements on carbon rights and retain control over forest monitoring data. Shared data can support jurisdictional transparency, but ownership should remain with the project.

- **Project-level control over data**
- **Supports national transparency without sacrificing autonomy**

2. Align Leakage Mitigation with District-Level Land-Use Plans

JNR places a strong emphasis on addressing inter-project leakage, which is complex without jurisdiction-wide control. Developers operating outside the JNR umbrella can still pre-empt leakage concerns by harmonising project boundaries and land-use goals with district or regional plans. By co-developing micro-zoning maps and integrating sustainable land-use corridors, developers can demonstrate jurisdictional alignment and reduce the risk of leakage in adjacent areas—one of the main value propositions claimed by JNR systems.

Rather than relying on JNR's centralised leakage management, developers can partner with district authorities to create micro-zoning and harmonised land-use plans that mitigate deforestation pressures across project-adjacent areas.

- **Proactive leakage prevention**
- **Strengthens local land governance**
- **Increases credibility with buyers**

3. Coordinate Reference Levels & MRV to Avoid Double Counting

Nested systems require consistent reference levels and MRV protocols across the jurisdiction. For non-JNR projects using VM0048, it's critical to ensure that your baseline and emission reduction calculations are harmonised with national forest monitoring systems (e.g., aligning forest classification and satellite imagery parameters) while maintaining project-level independence. This allows the project to remain additional and verifiable without being absorbed into a top-down framework, while still supporting national or regional reporting.

By aligning baseline setting and MRV protocols with national forest monitoring systems—while still following VM0048—developers avoid conflicts or double counting—a common JNR concern—while preserving project independence.

- **Prevents double counting or jurisdictional misalignment**
- **Aligns with national reporting and Article 6 pathways**

4. Replicate Benefit-Sharing Structures Without Centralisation

JNR requires a jurisdiction-defined (centralised) benefit-sharing mechanism, which can dilute local-level incentives or delay disbursements. Developers under VM0048 can replicate the equity and transparency goals of JNR by establishing locally governed revenue-sharing committees, complete with published allocation formulas, grievance redress mechanisms, and community audit processes. This maintains local trust and alignment with Article 6 readiness goals—without sacrificing project control or requiring integration into national distribution pipelines.

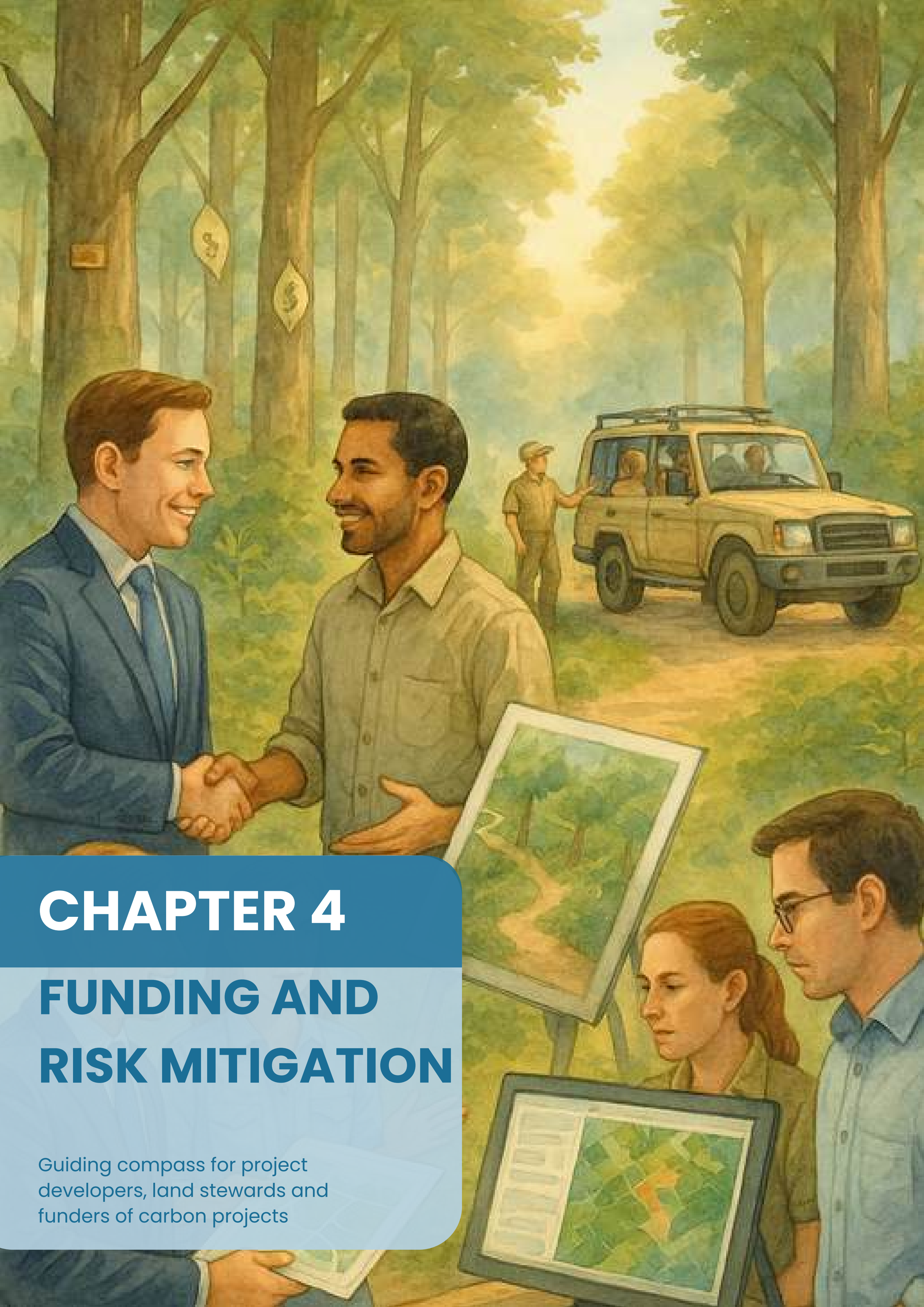
Instead of relying on centralised JNR benefit-sharing mechanisms, developers can create local, transparent structures to equitably distribute carbon revenue through committees, grievance mechanisms, and public audits.

- **Maintains local trust and buy-in**
- **Aligns with international standards and not losing control**

Summary

By using robust project-level methodologies like VM0048 instead of fully nesting into the JNR Framework, project developers retain operational control, ensure legal clarity over carbon rights, and implement transparent, locally governed benefit-sharing mechanisms. This cleaner, decentralised approach enables direct accountability, faster revenue distribution to communities, and allows projects to demonstrate high additionality and verifiability—key criteria for attracting premium carbon pricing. At the same time, by voluntarily aligning baselines, MRV systems, and data-sharing with national strategies, developers support the host country's climate goals and Article 6 readiness without compromising sovereignty or risking double counting. The result is a scalable model that delivers higher value credits, greater community impact, and full respect for national ownership of climate outcomes.

Source: Amaly Legacy analysis



CHAPTER 4

FUNDING AND RISK MITIGATION

Guiding compass for project developers, land stewards and funders of carbon projects

FUNDING LANDSCAPE

Mobilising capital at the scale required to meet global climate goals demands not only public funding but also a sophisticated mix of private finance and catalytic instruments tailored to the unique risks and opportunities of carbon project development. From forward credit purchases that bring revenue certainty, to blended finance structures that unlock risk-averse capital, to catalytic philanthropy that seeds early-stage innovation—each instrument plays a vital role in shaping a viable, investable pathway for nature-based and engineered climate solutions. This section explores the most relevant private financing mechanisms, clarifying their structure, key terms, and position within the capital stack—offering a strategic blueprint for project developers, investors, and policymakers seeking to accelerate high-integrity carbon markets.

Forward Financing

Advance purchase agreements where buyers commit to purchasing future carbon credits at a pre-agreed price and volume.

Private Equity

Equity investments by institutional or impact-focused investors into project developers or holding companies, often in exchange for a stake and governance rights.

Sustainable Finance

Loans or financial products with pricing tied to predefined environmental or social performance indicators.

Green Bonds/Sustainability Bonds

A debt instrument where the issuer raises funds for environmental or sustainability purposes by earmarking proceeds for specific eligible projects; sustainability-linked bonds instead tie the bond's financial terms to predefined sustainability targets.

Blended Finance

Combines public and philanthropic funding and de-risking instruments and mechanisms (concessional or first-loss) with private investment to improve the risk-return profile and crowd in private capital.

Technical Assistance Facilities

Non-commercial advisory support provided to governments, communities, or project developers to build capacity, enhance project design, secure finance, and align regulatory and market frameworks.

Philanthropic Funding and Charitable Donations

Non-commercial capital aimed at de-risking early-stage carbon projects, especially from foundations or donor institutions. Includes donations from individual donors leveraging innovative digital strategies.

Guarantees

A guarantee is a financial commitment to partially cover specified risks (e.g., credit, political, or performance risk), improving creditworthiness and enabling more favorable financing terms.

Development Aid and Finance

A broad spectrum of official support—grants, concessional loans, guarantees, and technical assistance—provided by bilateral donors and multilateral institutions with the goal of promoting long-term sustainable development in emerging economies.

Source: Amaly Legacy analysis

Importance of Funding Carbon Projects

"Carbon markets are no longer just about offsetting—they are about unlocking flows of capital into the very communities, ecosystems and landscapes that will determine whether we meet global climate, nature and development goals. By blending finance, risk-sharing mechanisms, and integrity standards, we can channel investment at scale into projects that restore biodiversity, build resilience, improve livelihoods and drive inclusive growth. This is how carbon markets evolve from a niche tool into a genuine engine of sustainable development."

RESHMA SHAH
Head of Sustainability & Information Governance, Zurich Middle East

fsdafrica

Funding Landscape: Closer Look at Forward Financing

Forward financing is one of the most catalytic instruments to unlock early-stage capital for carbon projects. Carbon projects often face a severe cash-flow mismatch — front-loaded development and monitoring costs precede revenue that may only materialise years later upon credit issuance. Forward financing solves this bottleneck by allowing projects to monetise future carbon credits today, providing essential liquidity to aid preliminary implementation costs and attract investors. By locking in credit prices up front, it gives investors and sponsors the pricing certainty needed to model project cash flows—thereby unlocking follow-on channels like private equity and sustainable debt, whose financial structures hinge on stable carbon-credit pricing. With structured forward sale agreements, performance-linked security measures, and pricing mechanisms that offer predictable returns for buyers, forward financing is a cornerstone for building bankable, high-integrity carbon pipelines, especially in emerging markets where traditional capital remains risk-averse. Below we illustrate key commercial, security, risk management, and performance considerations in forward financing arrangements.

Key Commercial Considerations:

Forward sales may offer price premiums or discounts depending on credit quality and delivery risk; cash can be advanced via milestone-based prepayments.

- **Pricing mechanisms:** negotiated fixed or indexed pricing. Premiums/discounts vary by rating, vintage, and methodology.
  - Ex-ante credits often trade at discounts due to delivery risk, with pre-issuance credits carrying higher discounts due to development risk.
- **Volume commitments:** Projects can forward-sell up expected credit issuance; **bulk purchases usually secure discounts** (vary by segment and structure).
- **Prepayment structures:** milestone-based (e.g., a smaller signing advance, then validation/verification-linked tranches).

Key Security Arrangements

Structured protections like parent guarantees, and revenue pledges could be structured to reduce buyer risk.

- **Performance security:** Collaterals are used in some transactions.
- **Parent guarantees:** Corporate guarantees can be structured to be capped at annual delivery obligations.
- **Revenue assignments:** Carbon credit sale proceeds and/or project cash flows are typically assigned to a secured account.

Default Provisions

Default provisions establish clear recourse in the event of delivery failures, ensuring project accountability and protecting buyers. These are essential for maintaining credit integrity and investor trust in forward purchase agreements.

- **Delivery failure remedies:** 60-90-day cure periods; replacement credit obligations at the market differential.
- **Credit quality standards:** Registry compliance, buffer-pool good standing, ongoing MRV compliance.
- **Force majeure exclusions:** Market conditions, price changes, and economic hardship are typically excluded from force majeure provisions.

WAHID A. KAMALIAN
Managing Partner
Amaly Legacy

“The power of a forward sale is that it marries demand validation with a floor price investors can credibly model. This converts volatile market outlooks into predictable cash flows, improving bankability and lowering the cost of capital. Milestone-based disbursements then increase accountability early, aligning execution with the capital at risk.”

Performance Metrics:

These metrics ensure that buyers receive high-integrity credits, while also managing and mitigating key risks.

- **Delivery targets:** Minimum 80% of contracted annual volume, quarterly reporting requirements.
- **Quality standards: e.g.** VCS or Gold Standard certification, recent vintages etc.
- **Permanence requirements:** 100-year horizon (where applicable) with buffer-pool contributions.

Source: Amaly Legacy analysis

Funding Landscape: Closer Look at Sustainable Finance

As carbon markets mature, sustainable finance is becoming a pivotal mechanism to scale high-quality carbon projects, such as renewable energy projects, by aligning financial performance with environmental outcomes. Unlike traditional debt, sustainable finance instruments incorporate ESG-linked pricing, KPI-driven covenants, and robust monitoring frameworks that reward measurable climate impact. For carbon project developers, these structures not only unlock access to larger pools of capital—often at better terms—but also validate impact through independent verification, rigorous digital MRV, and transparent reporting obligations. The following breakdown illustrates how sustainable debt instruments are tailored for carbon projects, ensuring accountability, integrity, and long-term investor confidence.

Pricing Mechanisms

Loan interest rates are determined using credit risk models and can adjust over time based on a borrower's ESG performance. Lenders use structured tools to reward or penalise based on measurable progress:

- **Margin adjustments:** Adjustments of a few basis points (bps) for ESG performance, with two-way step-up/step-down structures.
- **KPI structures:** ESG targets—like reduced emissions or verified project impact—are set in advance and tracked over time to influence pricing.
- **Margin ratchets:** Periodic assessments of performance against ESG KPIs that lead to changes in the interest margin.

Covenant Packages

Covenants are legally binding promises made by the borrower to maintain certain financial or operational standards which, if breached, may allow the lender to impose penalties, demand early repayment, and/or declare a default.

- **Financial covenants:** These ensure the borrower can repay the loan by requiring minimum Debt Service Coverage Ratio (DSCR) thresholds that are deal-specific (often between 1.2–1.4x), or by limiting debt relative to equity.
- **Operational covenants:** These include commitments to comply with project plans, environmental permits, and other performance-related requirements.
- **ESG reporting:** Borrowers are expected to provide regular sustainability updates, often verified by third parties, with periodic progress KPI reports.

Security Arrangements

To protect their investment, lenders secure claims over specific project assets and cash flows. This ensures that if the borrower fails to repay, the lender can recover funds through legal rights over the pledged assets.

- **Project cash flows:** priority access to incoming project revenues through a waterfall structure (trust and retention account) that prioritises loan repayments before other expenses.
- **Carbon receivables:** Carbon credits are often held in dedicated registry accounts; lenders may control access via account control agreements and/or assignment of offtake proceeds.
- **Equipment pledges:** Lenders may hold fixed or floating charges over project equipment and assets, which can be sold or claimed in the event of default.

IRENA
International Renewable Energy Agency

"High financing costs and rising debt put clean energy out of reach for many developing economies. International public finance, especially concessional loans and grants, is critical — yet the largely debt-based $21.6 billion provided to developing countries in 2023 was well below requirements."

Strategic contribution to our report from IRENA

Reporting Obligations

Projects are expected to maintain transparency through consistent, verifiable reporting. These obligations give funders confidence that activities are progressing as planned and that impact claims are credible, while safeguarding against misreporting and greenwashing.

- **Impact reporting:** Periodic reporting of agreed quantitative/qualitative indicators.
- **Third-party verification:** Independent audits, site visits, data cross-checking.
- **Digital MRV:** real-time data collection (e.g., satellite/IoT) with blockchain records (optional - strengthens auditability).

Source: Fitch Ratings, Amaly Legacy analysis

Sustainable Finance Best Practices

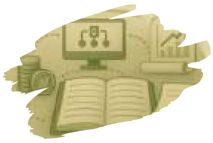
The Loan Market Association (LMA) has established comprehensive frameworks that fundamentally reshape how banks approach financing for carbon credit project developers. These frameworks, particularly the Green Loan Principles (GLP) and Sustainability-Linked Loan Principles (SLLP), create standardised pathways for sustainable finance deployment.

Core LMA Framework Components

Within the LMA's sustainable finance architecture, the Green Loan Principles (GLP) comprise four critical pillars that directly impact carbon credit project financing:

- **Use of Proceeds:** Under GLP, proceeds must exclusively finance eligible green projects. For carbon project developers, this means clear categorisation requirements for NbS, renewable energy, and CDR projects.

- **Process for Project Evaluation and Selection:** LMA frameworks mandate robust due diligence processes that extend beyond traditional financial metrics. Carbon project developers must demonstrate clear environmental objectives, quantifiable carbon sequestration or avoidance targets, and alignment with GLP, SLLP and, where relevant, SBTi for corporate targets.



- **Management of Proceeds:** Dedicated tracking systems are required to ensure transparency in fund allocation. Project developers must establish segregated accounts or portfolio approaches that enable clear traceability from financing to specific carbon credit generating activities. This includes at least annual reporting (many borrowers provide semi-annual or quarterly reports) on fund deployment and project milestone achievements.

- **Reporting Requirements:** Annual impact reporting is a core component of LMA frameworks and is typically required under loan agreements, requiring project developers to provide detailed metrics on carbon credits generated, co-benefits achieved, and progress against predetermined KPIs.

SLLs often include two-way ratchets tied to KPI performance, creating tangible financial incentives for robust project design and implementation.

Emissions Score Metrics Impact on Financing Terms

The integration of LMA frameworks with ESG rating methodologies has created a sophisticated evaluation matrix for corporate bankability. Banks now employ a multi-dimensional assessment approach where primary emission metrics include evaluating Scope 1, 2, and 3 emissions intensity against sector-specific benchmarks, ensuring carbon reduction and removal trajectories align with **1.5°C pathway targets**, assessing transition risk exposure such as stranded asset risks and adaptation strategies, and conducting climate scenario analyses using NGFS climate scenarios. Additionally, disclosure quality is measured through indicators like TCFD alignment scores, CDP ratings and response completeness, SBTi validation status, and the extent of third-party assurance on sustainability data. There is an increasingly clear relationship between strong emission performance and lower financing costs. Companies demonstrating robust emission profiles—typically reflected in high CDP ratings (A or B) and validated Science-Based Targets—benefit from sustainability-linked loans featuring margin reductions per KPI achieved. Such companies may achieve marginally lower yields ("greenium") on green bond issuance relative to comparable conventional bonds, gain preferred access to transition finance facilities with longer tenors, and may experience reduced collateral requirements for sustainability-linked financing.

Companies with Poor Emission Profiles:
Stricter terms are imposed on high-emitters, including:

- **Premium pricing** above baseline rates
- **Shortened loan tenors** and increased **covenants**
- Transition requirements as **conditions precedent**
- Potential **exclusion from certain bank portfolios** due to climate risk policies

Margin Adjustments
Banks link SLL margins to the borrower's performance against agreed sustainability KPIs including step-up features—where the margin increases if the borrower fails to meet the targets—and step-down features—where the margin decreases if the targets are achieved or exceeded. Adjustments serve as a financial incentive to improve their ESG performance over the life of the loan.

The quality of disclosure directly impacts financing terms, with companies providing assured, comprehensive sustainability data accessing the most favourable terms. Banks increasingly require external verification of KPIs by approved sustainability auditors as a condition for margin benefits.

Source: LMA, ICMA, Baker McKenzie, EBA, ECB, IFRS, CDP, NGFS, KPMG, Amaly Legacy analysis

Funding Landscape: Closer Look at Philanthropy and Charitable Donations

Philanthropic funding and charitable donations—ranging from major grants to grassroots crowdfunding—play a critical role in enabling the foundational steps of high-integrity carbon projects. These early, risk-tolerant contributions are often the only viable source of capital to fund essential pre-commercial activities such as conducting FPIC, signing MOUs with local communities, and formally registering carbon rights. By absorbing early-stage risk that deters traditional investors, philanthropic capital helps unlock the entire carbon finance value chain, laying the groundwork for future private equity, debt, and carbon credit-based revenue streams. Here we illustrate key terms and considerations for philanthropic instruments preferred by donors, such as recoverable grants.

Recoverable Grants

Blending catalytic intent with financial rigour, recoverable grants enable donors to achieve impact with accountability. These instruments offer patient, risk-tolerant capital that is repayable only upon achieving pre-agreed success thresholds, allowing funders to recycle capital and scale outcomes over time. Key structuring features include:

- **Repayment triggers:** Revenue and profitability targets, other financial KPIs.
- **Revenue-sharing:** Carbon credit revenue integration with donations.
- **Concessional terms:** Tenors set case-by-case (often multi-year).

Legal Documentation

Some common documentation and clauses that grantors use to ensure accountability and recovery terms, and to mitigate risks, include:

- **Accountability and Risk Mitigation Clauses within Grant Agreements:** Non-assignability clauses, detailed project milestones, performance timelines etc.
- **Clawback:** Revenue-based recovery and compliance violation remedies.

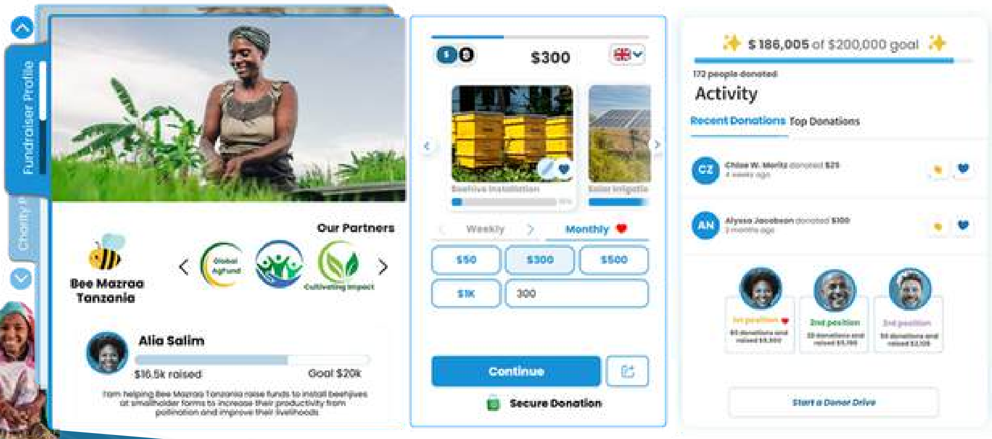
Performance Metrics

Impact-linked funding now demands more than narrative reports—donors expect quantifiable, verifiable results. Performance metrics have evolved to encompass end-to-end measurement of environmental and social outcomes, embedded within project design and delivery cycles to guide disbursement, reporting, and validation. Core performance expectations include:

- **Carbon delivery:** MRV compliance, lifecycle accounting, real-time IoT monitoring and digital MRV automation.
- **Community benefits:** Benefit-sharing plans, FPIC, livelihood co-design, gender and youth inclusion, and local governance alignment.
- **Impact frameworks:** Theory of change documentation, standardised metrics, and evidence-based practices.

Charitable Donations to Derisk Projects & Unlock Grants

Amaly's proprietary fintech enables NGOs to unlock **instant donations, philanthropic funding, and sale of products** for **near-term funding** that reduces project risks and gives comfort to grantors



Source: Amaly Legacy analysis

Institutional-grade Accountability Frameworks by Philanthropic Funds

Philanthropic institutions are increasingly leveraging well-structured sustainable finance and accountability frameworks to not only the enhance efficacy of their grantmaking but also de-risk climate-related funding and transition grantees to bankable organisations that can operate without reliance on grants. By aligning with best practices drawn from and inspired by the LMA, the SBTi, etc., we will be witnessing:

- Greater funder and investor confidence through measurable, verified outcomes from grantees,
- Mobilisation of blended capital, attracting private equity alongside philanthropic funds, and
- Scalability of projects through rigorous governance, monitoring and reporting frameworks.

Ultimately, these factors help transition philanthropic capital from isolated, impact-driven funding to strategic, institutional-grade catalytic investments that unlock funding from the wider financial ecosystem.

Transitioning Grantees to Climate-Aligned, Bankable Organisations

Philanthropic entities are increasingly positioning their grantees as mission-aligned climate funding targets by

Alignment of Grantees with Bankability Best Practices

- Philanthropic institutions are steadily more structuring their grant portfolios as climate-aligned investments—funding organisations who are well-structured for subsequent access to private equity, blended finance, and sustainable finance.

Applying Negative & Positive Screening

- **Negative screening:** Exclusion of grantees involved in environmentally harmful practices
- **Positive screening:** prioritisation of organisations producing measurable and verifiable positive outcomes

SBT

- Endowments and foundations are actively encouraging or requiring grantees to adopt science-based targets. This adoption significantly enhances grantee credibility and positions them favourably for subsequent financing rounds and funding opportunities from private equity and sustainable finance actors.

Beyond Grants: How Strategic Philanthropy Enhances Bankability of Grantees

Philanthropic institutions play a crucial role in enhancing bankability of grantees via strategic philanthropy that embeds accountability measures and bankability criteria into grant disbursement processes This ensures transparency, credibility, and effectiveness, significantly reducing risk perceptions for subsequent investors and financiers, enabling grantees to access broader funding opportunities. Below we describe three core benefits of institutional-grade accountability frameworks adopted by grantees.

- **Multi-Stakeholder Partnerships Enhancing Governance & Reporting:** Well-structured grants that are co-designed with grantees, local communities, and technical partners **solidify grantees' governance and reporting structures, create broader institutional buy-in and reduce perceived investment risk, enhancing the bankability of grantees.**
- **Results-Based Grant Disbursement to Improve Bankability:** Linking grant disbursement to verifiable milestones such as hectares protected, carbon credits issued, and biodiversity indicators accustoms grantees to accountability and achieving results, mirroring frameworks used by institutional and private-sector investors, directly enhancing grantee bankability and alignment with future investors and financiers.
- **Testing Financial and Operational Capability:** Well structured grants with robust accountability frameworks enable grantees to **demonstrate financial management and operational capabilities** — critical factors for attracting private-sector investment.

These benefits highlight how well-structured accountability frameworks by philanthropic institutions paves the way for grants to be strategic - transitioning grantees to bankable entities ripe for private capital to scale.

Source: Amaly Legacy analysis

Philanthropy's Role in Mobilising Climate Capital

"When philanthropy embraces institutional-grade accountability, it transforms from an act of giving into an instrument of capital mobilisation. This convergence of ethical purpose and financial discipline attracts blended and private capital, creating scalable pathways where climate-positive outcomes are no longer peripheral to investment logic but central to it."

RALPH CHOUEIRI
Executive Director
Pearl Initiative

Funding Landscape: Closer Look at Private Equity

Private equity provides risk-tolerant capital in return for shareholding in a company. Beyond capital, most private equity investors instill governance discipline and contribute strategic expertise and relationships that enable their portfolio companies to pursue their business plan while adhering to rigorous reporting standards. In this section, we examine how these principles apply to a carbon project developer to illustrate the mechanics of this critical layer in the funding stack.

Investment Terms

Private equity in carbon projects involves capital commitments, structured to align investor returns with risk exposure and project milestones. Terms by private equity funds ensure disciplined capital deployment while offering upside via carried interest, with step-ups tied to LP IRR, for the General Partners.

- **Carbon Project Target IRRs:** 20% gross IRR, 15% net IRR; 2.5x MOIC.
- **Carried interest:** 20% structure (80/20 LP/GP split) with 7-9% hurdle rates.
- **Management fees:** 2% annually on committed capital.

Security Arrangements

To mitigate downside risk, investors secure enforceable rights over assets, revenues, and carbon receivables. These protections ensure lenders or equity holders can recover value in the event of project failure or underperformance. Key security instruments include:

- **Share pledges:** Share pledges/charges over equity; founder share pledges where applicable.
- **Project-level security:** First lien on assets (land, equipment, carbon rights), carbon credit sale proceeds assignment.
- **Insurance requirements:** key person life insurance, wildfire/natural disaster risk insurance (AFOLU), political risk, carbon credit delivery risk insurance etc.

Governance Rights:

Governance frameworks protect investor interests by embedding oversight rights into board composition, major decision-making, and access to financial and impact data negotiated by Investors to ensure strategic alignment and risk oversight to enforce accountability on credit issuance, revenue use, and adherence to environmental integrity standards. Common provisions are:

- **Board composition:** Investor-nominated directors, independent oversight.
- **Consent rights:** Veto over debt issuance above thresholds, management changes.
- **Information rights:** financials, carbon impact assessments, registry verification access.

Performance Metrics

Robust KPIs underpin investor confidence, linking financial performance and environmental delivery to capital disbursement and upside sharing, tracking credit integrity, project execution, and climate outcomes. Investors track KPIs and embed these in monitoring dashboards and link them to milestone-based disbursements or earn-outs. Common KPIs include:

- **Carbon targets:** Annual delivery targets (e.g. No. of VCUs), vintage requirements, buffer pool reserves.
- **Development milestones:** development timelines, regulatory approvals, 3rd party verification.
- **Revenue targets:** Carbon pricing assumptions with floor-price protections, EBITDA-linked to sales.

SANSRITI PANDEY
Private Equity Investor,
Econ Climate Fund

> ***"Private equity in carbon projects goes beyond funding—it strategically aligns capital, governance, and safeguards to ensure climate impact and investor returns scale together with precision and resilience. By embedding rigorous oversight and measurable performance metrics, it transforms climate ambition into long-term value for stakeholders."***

Source: Amaly Legacy analysis

Economic Feasibility of NbS Projects

Core feasibility factors that determine whether a nature-based carbon credit project can attract institutional capital and long-term offtake agreements cover technical, legal, policy, and market considerations that influence the project's ability to generate high-integrity, tradeable carbon credits at scale. Each feasibility pillar reflects common expectations and best practices expected by serious investors and buyers, serving as both a diagnostic framework and a readiness checklist for project developers. **We explore these core feasibility factors below in the context of a REDD+ forest conservation carbon project.**

Project Scale
- Adequate scale and carbon stock to generate sufficient high-integrity carbon credits, ideally complemented with additional revenue sources besides carbon credits such as sale of biological assets, to absorb costs effectively and meet target returns
- Expansion development pipeline to further dilute fixed costs.

Carbon Integrity & Net-Deliverable Volume
- Conservative, accurate and scientifically rigorous carbon credit volume forecasts.
- Proven additionality.
- 100 year+ permanence horizon with 10-20% buffer pool contribution (typical for REDD+)
- Leakage < 20%.

MRV Readiness & Cost
- Satellite/LiDAR/IoT + field plots.
- Aligned with leading carbon credit development methodologies.

Land & Carbon Title Security
- Clear land tenure and carbon rights.
- FPIC
- No overlapping claims.

Supportive Policy & Investment Climate
- National carbon registry (weak registry/authorisations materially impair bankability)
- Host-country Article 6 readiness.
- FDI-friendly laws, repatriation of profits.
- Tax incentives.

Carbon-Market Fundamentals
- Spot and forward price outlook.
- Voluntary carbon credits, CORSIA, Article 6 buyer interest.
- SDG, Co-benefit or jurisdictional premiums.

Co-benefits & Premium Pathways
- CCB, biodiversity, gender, SDG layers.
- Agroforestry, clean cooking, water.
- Monetisable via credit stacking or differentiated pricing.

Financing, Tax, Legal & Currency Hedging Structure
- Bridge funding for 3–5 yr pre-issuance phase with stable capital structure
- Effective tax, legal and currency hedging structure.

Project Costs
- Granular opex costing budgeting backed by relevant supporting documents for these costs.
- Clear capex investment schedule including dMRV technologies.

Investors' Due Diligence and Investment Readiness Checklist

Core due-diligence requirements that institutional investors and corporate buyers use in practice are multifaceted and incorporate various factors, as provided below.

Financial Viability needs to be demonstrated with a robust, granular financial model with different scenarios and sensitivity analyses incorporating various project- and market-associated risks.

Investment Readiness encompasses various info such as KMZ/KML shape files, land tenure info, village land-use plans, concept notes with robust implementation plan, Project Design Document (PDD), impact assessment, proof of compliance with FPIC, MOUs and carbon rights agreements, NGO partner MOUs, legal documentation, financial model, LOIs from prospective buyers, etc.

Legal, tax and regulatory compliance ensuring accurate documentation of compliance with relevant laws, regulations and government procedures, inc. national carbon registry criteria.

MRV compliance framework and protocols ensuring alignment with international best practices and standards, and digital MRV integration (satellite monitoring, IoT sensors).

Comprehensive risk assessment matrix inc. technical, market, operational, natural, financial, and reputational risks, with appropriate legal, governance, and commercial risk mitigants, including but not limited to carbon credit delivery and co-benefits insurance. Permanence risk with buffer pools.

- **Required by Buyers:** Independent third-party project ratings (e.g. BeZero)

Source: Verra, Sylvera, UC Berkeley (Goldman School of Public Policy), Amaly Legacy analysis

Mechanics to Offset Carbon Emissions

"Companies seeking to offset emissions prefer standardised large-scale projects to limit due-diligence costs and ensure a steady supply with appropriate co-benefits — both carbon credits and insetting are viable as long as projects meet scale and quality criteria."

HEMANGI SARMA
Strategy Manager
Amaly Legacy

Differentiating Between Insetting and Offsetting

A **carbon offset** is a reduction or removal of emissions of CO_2e made in order to compensate for emissions made elsewhere.

This can be achieved **by either i) investing directly in a carbon avoidance or removal project (<u>insetting</u>), or ii) purchasing and retiring carbon credits,** to "offset" the emissions associated with their chosen carbon footprint.

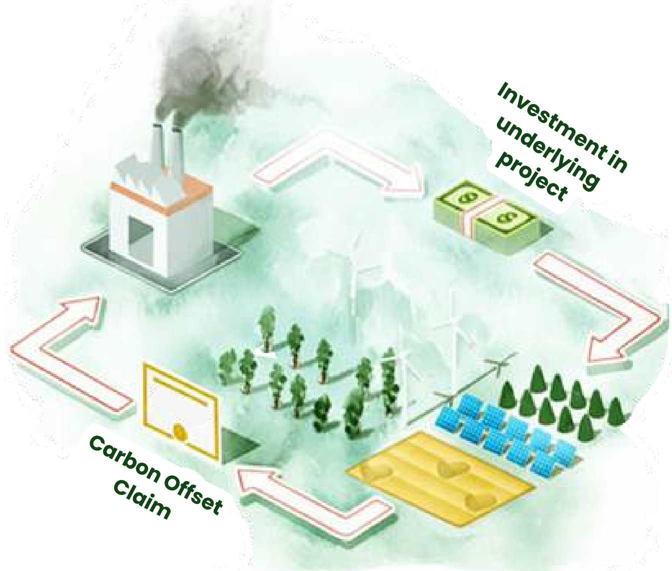
This distinction in terminology is important because it clarifies that carbon credits are financial instruments that facilitate market transactions, while offsets describe broadly the environmental claim or action taken by the purchaser or direct investor in carbon projects.

1 Buying and Retiring (Offsetting) Carbon Credits

Compensation for an individual's or corporation's emissions **by purchasing and retiring carbon credits** to **offset CO_2e emissions**

- **Pros:**
  - Market liquidity,
  - standardised verification, and
  - Portfolio diversification capability
- **Cons:**
  - Less direct control over specific projects,
  - Quality variation if sourcing from different projects (lack of large scale projects)
  - Market price volatility

2 Insetting (Direct Investments, Value-Chain Projects)



Compensation for an individual's or a corporation's emissions by **funding a carbon removal or avoidance project to offset CO_2e emissions within the value chain**

- **Pros:**
  - Full control over project details,
  - Additional benefits tied to supply chain
  - Cost certainty
- **Cons:**
  - Exposed to Inherent project and delivery risk,
  - Potentially weaker verification protocols (lower incentive for project developers)
  - Quality risks

Sources: ForestTrends.org, WEF, Ecosystem Marketplace, Sylvera, Amaly Legacy analysis

Notes: 1. Credits sold from these projects can take the form of ex-post credits, ex-ante credits and pre-purchase agreements. **2. Ex-Post Credits:** Credits issued after carbon reductions/removals have already occurred and been verified which can be immediately retired upon purchase, providing instant environmental benefit. **3. Ex-Ante Credits:** Credits issued for future expected carbon reductions/removals before they occur and they cannot be retired until the carbon benefit actually takes place. **4. Pre-Purchase Agreements:** Payments made today for credits not yet issued, representing a commitment to buy credits once generated.

Carbon Registries

The rise of national carbon registries is reshaping the carbon-credit landscape, giving governments a sovereign tool to track, authorise and retire credits and—crucially—anchor carbon rights in domestic law. For investors, financiers, land stewards and project developers, a registry is fast becoming the single source of truth that decides who can legally issue, transfer and monetise a tonne of CO_2. Operational registry mechanics vary —from Vietnam's ETS-ready platform to Zimbabwe's blockchain registry— however, they all signal that Article 6-ready infrastructure is moving from concept to reality.

Defining a Carbon Registry

A national carbon registry is a government-mandated database that issues, serialises, tracks and authorises the export of carbon credits (or "mitigation outcomes") generated inside the country. The registry acts as a domestic ledger that reconciles with voluntary standards (e.g. Verra) and, where relevant, with the UNFCCC's Article 6.2 international registry and Article 6 database via the Centralised Accounting and Reporting Platform (CARP).

Whom Does a Carbon Registry Protect

Buyers & Investors

- **Transparency** allows investors to conduct due diligence, verify the legitimacy of carbon credits, and ensure their investments represent real environmental benefits.
- **Eliminates double issuance/claiming** by providing a single, state-controlled ledger.
- **Records authorisation and corresponding-adjustment status**, where applicable, helping buyers understand eligibility for compliance or voluntary claims.

Project Developers

- **Confers legal title to underlying rights** that the carbon credits are generated from, which speeds up due-diligence and financing.
- **Standardises interface** for MRV data feeds inc. digital MRV, lowering transaction costs.
- **Protects condifential project data and development investments while** providing developers with standardised pathways to bring projects to market.

Land Stewards

- **Carbon rights**, similar to mineral rights, are separate from the estate, so projects can develop on a property without affecting ownership. This separation ensures landowners can participate in carbon markets without transferring underlying property rights.
- **Links carbon rights to underlying land tenure records**, making benefit-sharing agreements enforceable.
- **Long-term security for** land stewards through standardised contracts and monitoring requirements (giving communities transparency on carbon credits issued).

Operationalising Article 6

Under Article 6 of the Paris Agreement, countries that export or import internationally Transferred Mitigation Outcomes (ITMOs) must:

- **Authorise use of ITMOs and track transfers in a registry;**
- **Apply corresponding adjustments** to their NDCs;
- **Report required Article 6.2 information via the UNFCCC's Centralised Accounting and Reporting Platform** (CARP).

A well designed national registry serves three roles simultaneously: **domestic issuance ledger**, **Article 6 transaction gateway**, and **reporting engine feeding into biennial transparency reports**. Without it, a host country cannot credibly certify ITMOs—or protect its own NDC from double counting.

Source: ETP, Bloomberg, Norton Rose Fullbright, Amaly Legacy analysis

DR. DEO SHIRIMA
National Carbon Monitoring Centre, Government of Tanzania

"A well-functioning national registry is the sovereign hinge on which credible, Article 6–compliant carbon trading turns. By embedding authorisation, corresponding adjustments and transparent reporting in one system, governments convert mitigation outcomes into investable, internationally recognised assets while shielding their own NDCs from double counting. For project developers, investors and land stewards, this "**single source of truth**" reduces legal risk, lowers transaction costs and unlocks cross-border demand for high-integrity carbon credits—turning Paris Agreement text into bankable climate action."

Public Equity Investments and Decarbonisation

Unlike private equity transactions where capital directly funds specific projects with traceable decarbonisation outcomes, public equity investments operate through indirect transmission mechanisms in the secondary market. Asset managers trading on secondary markets don't provide new capital to companies—they purchase existing shares from other investors. This fundamental difference creates an attribution gap: **how can we measure the impact of buying a publicly listed company's shares on its decarbonisation efforts?**

Comparison Private Equity & Pubic Equity

Compared to private equity, where the flow of capital and impact is direct and traceable, understanding the decarbonisation impact of public equity investing requires unpacking the indirect mechanisms through which asset managers can influence real-world emissions and carbon credit demand.

Private Equity:

Clear sources and uses table tracking exactly how investment dollars fund decarbonisation initiatives and purchase of carbon credits

LPs can require KPI-linked clauses; reporting often audited.

PE owners typically set strategy and capital-budgeting decisions.

Public Equity:

Capital injection is indirect; impact must be inferred from market signals (cost-of-capital shifts), disclosure milestones, and stewardship outcomes.

Reliant on third-party ratings (MSCI, CDP), voluntary frameworks (SBTi, TCFD) and shareholders' ability to pass resolutions.

Influence proportional to shareholding; minority positions must collaborate (e.g., Climate Action 100+) to move the needle.

Four Mechanisms of Influence

Based on the evidence from sustainable investing practices, public equity managers influence decarbonisation via:

1. Cost of Capital Effects

Asset managers' preference for low-carbon companies (through index design, fund flows, and ESG mandates) increases demand for these companies' shares, which raises their valuation and share prices and lowers their cost of equity. A lower cost of capital makes it cheaper for sustainable companies to raise additional funds—through secondary equity offerings or issuing green bonds—for new decarbonisation projects. Over time, a higher cost of capital incentivises companies to improve sustainability practices to

- **Insight:** Companies with top ESG ratings can access equity and debt at 70–100 BP lower than industry averages. Higher valuations and lower cost of capital incentivise companies to maintain/improve ESG KPIs

How to Measure:

- Track changes in Weighted Average Cost of Capital (WACC) for high- vs. low-carbon companies.
- Analyse the spread between green and non-green bond yields for the same issuer.

2. Market Signalling and Liquidity

Sustained demand for green equities boosts trading volumes and tightens bid-ask spreads, making these stocks more attractive to investors. This greater liquidity enables green companies to issue new shares or bonds more efficiently in primary markets, directly supporting future decarbonisation investments.

- **Insight:** Large flows into ESG or climate-focused funds which is a signal to the broader market that sustainability matters to capital allocators.

How to Measure:

- Monitor trading volumes and bid-ask spreads for ESG vs. non-ESG stocks.
- Assess primary market issuance success (frequency, size, pricing) following major ESG inflows.

Source: MSCI, ECB, Morningstar, Amaly Legacy analysis

3. Active Ownership

Asset managers with significant shareholdings use their voting rights and direct engagement to influence corporate climate policy and capital allocation decisions. Stewardship teams and coalitions press companies to set SBT, improve emissions disclosure or tie executive compensation to sustainability milestones.

- **Insight:** BlackRock, Vanguard, and State Street are the largest shareholders in ~88% of S&P 500 companies and together hold >20% of voting power. Their stewardship and voting power have coincided with broader climate disclosure across large companies and the adoption of Scope 3 targets by some firms.

How to Measure:

- Track engagement outcomes: e.g., number of companies adopting new emissions targets.
- Review proxy voting records on climate resolutions.
- Monitor the share of portfolio companies with SBTi-validated targets.

4. Allocation Shifts

Asset managers shift portfolio allocations away from high-carbon sectors (oil, coal, etc.) toward low-carbon sectors either by exclusions or sector reweighting. These allocation choices send a strong market signal, increasing the cost of capital for excluded companies and lowering it for beneficiaries. Large and coordinated capital outflows can depress valuations and raise capital costs for targeted sectors.

- **Insight:** The exclusion of thermal coal companies from leading European pension funds coincided with underperformance in their share valuations relative to market benchmarks over time.

How to Measure:

- Analyse sector allocation shifts in major ESG funds over time.
- Compare relative performance of high-carbon vs. low-carbon sectors before and after major sustainable fund reweightings.
- Track AUM in exclusion-based vs. integration-based ESG strategies.

Impact on Carbon Credit Purchases

Public equity investments influence corporate carbon credit strategies through:

- **Board and Management Pressure:** As more asset managers pursue credible decarbonisation strategies, the quality and integrity of carbon credits demanded by public companies are rising. This pressure has evolved discussions to cover credit quality, permanence, additionality, verification methodologies, etc. This scrutiny has driven companies to reconsider their approach. Firms with high ESG fund ownership are investing in higher-quality projects that can withstand investor due diligence. Notable among these are next-generation REDD+ projects that go beyond avoided deforestation to deliver measurable carbon removal through innovative approaches, while offering lower implementation costs.
- **Reporting Requirements:** SFDR imposes disclosure obligations on funds; in practice, Article 9 managers increasingly seek transparency on whether portfolio companies use credits for 'neutrality' claims or as part of credible net-zero pathways. Companies are increasingly expected to disclose not just the quantity of credits purchased, but also their characteristics—project type, vintage, registry, and whether they represent avoidance or removals. This transparency requirement has revealed quality variations across corporate portfolios. The disclosure pressure is influencing companies to move toward credits with clearer methodologies and more robust verification while ensuring high decarbonisation ROI.
- **Capital Allocation:** Engaged investors advocate for strategic thinking about the role of credits in decarbonisation pathways. The message from major asset managers is consistent: prioritise direct emissions reductions, but where offsets are necessary for residual emissions, invest in genuine removal rather than avoidance. The focus has moved from cost minimisation to value optimisation. Companies increasingly recognise that investing in innovative forest-based removal projects can provide better long-term value than lower-quality offsets. These approaches can deliver verified removals cost-effectively, making them economically viable while meeting investor expectations for quality.

Conclusion:

While public equity investments lack the direct attribution of private markets, their collective influence operates through market mechanisms that can accelerate corporate decarbonisation. The key lies not in individual transactions but in coordinated ownership strategies that align market incentives with climate goals. Asset managers are focusing on engagement quality over exclusion quantity, and investors are demanding evidence of real-world outcomes beyond portfolio carbon metrics. While public equity investments lack the direct traceability of private deals, coordinated stewardship and allocation strategies by asset managers—if scaled and substantiated by engagement outcomes—can shift incentives, drive capital to decarbonising companies, and raise standards in carbon credit markets.

Sources: Business and Politics, Vol. 19, Bettermarkets.org, Norges Bank Investment Manage
Investopedia, Amaly Legacy analysis

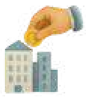
Sovereign-Linked Institutional Funders Powering & Shaping Carbon Markets

In the race to decarbonise the global economy, sovereign-linked institutional funders have quietly become the most consequential funders of carbon markets. From UAE's Mubdala and Singapore's GIC to Canada's pension giants, and Europe's public development banks, these sovereign-linked funders are allocating and deploying funds across the "soil to screen" continuum from underlying projects and LP allocations in funds to related infrastructure—MRV platforms and regulated trading hubs. Their capacity to underwrite long term hotizon investments and large transaction tickets, absorb risk and align capital with national climate mandates positions them as architects of the emerging carbon-credit ecosystem—establishing price signals, integrity standards and diplomatic corridors that commercial capital alone could never build.

Carbon Project Exposures

Private Equity Investments In Project Developers

Equity stakes in project developers that develop carbon credits, such as Temasek's GenZero investment in South Pole, and CDPQ's investment in Chinook Forest Partners.



Limited Partner (LP) Commitments to Institutional Asset Managers and Funds

LP stakes in asset managers that originate credits directly and/or invest in project developers, securing influence over quality and deal flow such as BII, Norfund and Finnfund's cornerstone role in New Forests' Africa Forestry Impact Platform, and Proparco's investment in Mirova Sustainable Land Fund II.

Joint Ventures with Project Developers + international NGOs

Joint ventures with project developers and international NGOs such as CPP Investments' JV with Conservation International prototype private-capital models for forest-credit generation.

These long-dated positions offer a first-call on high-integrity credits while providing developers with capital.

Industry and Infrastructure Exposures

MRV

Digital measurement, reporting and verification (MRV) start-ups use satellites, AI and DLT to track forest cover, calculate emissions and verify credits. Controlling these pipes gives first-hand project data and a slice of transaction fees.

Rating & assurance agencies

Independent ratings translate raw MRV data into simple letter-grade scores (e.g., AAA–D) that buyers and exchanges rely on for pricing. Funding these firms locks in an information edge and potential revenue-sharing on data subscriptions, ***E.g.*** *Temasek's GenZero leading $32m Series C of global ratings agency, BeZero Carbon.*

Standard-setting bodies

Global rule-makers such as ICVCM define what counts as "high-integrity" credit. Early sponsorship lets sovereign-linked funders help write the playbook—and ensure their portfolio projects qualify; ***E.g.,*** *sovereign-linked funders sponsorships of policy round-tables and events shapes and cements influence over future standards.*

Trading & FinTech

Trading venues, clearing houses, tokenisation platforms and enabling fintech that increase carbon-credit liquidity, and co-benefits giving sovereign-linked funders stable, utility-like cash flows—platform fees, data subscriptions and transaction fees. ***E.g.,*** *Mubadala bought a stake in AirCarbon Exchange, supporting the establishment of the first fully regulated carbon trading exchange and clearing house.*

Positions in these layers— MRV and fintech pipes, rule books and quality signals—give sovereign funders first-call on credit supply (early sight of projects that pass MRV and ratings screens), policy voice (dialogues and influence on standards) and recurring data and platform revenues (infrastructure cash-flows).

Sources: Pestalozzi, Mubadala, CDPQ, NewForest, Proparco, GenZero, CPPI, Amaly Legacy analysis

MASSIMILIANO RIVA
Principal, EBRD
Green Climate Fund

European Bank
for Reconstruction and Development

"By anchoring blended finance structures and carbon and biodiversity credits within nature-positive investment projects, multilateral development banks and development finance institutions can mobilize deeper capital stacks for climate adaptation and nature. Junior and impact investors can take first-loss positions and address structural risks—unlocking larger financing volumes and enabling project developers in frontier markets to scale. Carbon and biodiversity markets can further diversify revenues across regenerative agriculture, sustainable forestry, and emerging blue carbon opportunities. We are not there yet: many DFIs remain in pilot mode. But with effective partnerships, more mature credit markets, and stronger origination pipelines, DFIs can evolve from boutique philanthropic approaches into investment-grade platforms driving systemic change."

Role of Sovereign Funds on Carbon Markets

Nations have emerged as major global players in carbon markets, deploying billions through Sovereign Wealth Funds (SWFs) holding assets from soils to screens—owning NbS sinks, equity in developers, MRV tech that supports verification and issuance of carbon credits and the trading platforms that monetise them. Their investments are balanced by shorter-duration, fee-generating exchange stakes and longer-term investments in projects, developers, and enabling technology infrastructures mirroring traditional upstream, midstream and downstream energy investing logic. Their transaction reinforce national initiatives (Saudi Green Initiative, UAE Net-Zero, Oman 2050) while creating soft-power linkages with host countries supplying credits. To these governments and their sovereign funds, carbon markets are seen as a cornerstone of economic diversification, creating new revenue streams worth billions annually while supporting international development through innovative climate finance mechanisms.

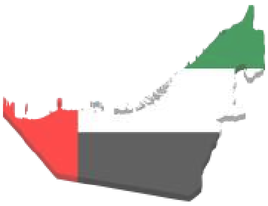
Why Carbon Markets Matter to SWFs?

“Carbon projects double as foreign policy and development finance— for SWFs they're diversification engines and diplomacy assets. SWF-linked carbon investments create jobs, transfer technology, and secure a steady supply of high-integrity credits that unlock far more value than traditional aid, while generating investment returns and diplomatic goodwill..”

WAHID A. KAMALIAN
Managing Partner
Amaly Legacy

Outward Investments: Strategic Development Finance Through Carbon Projects

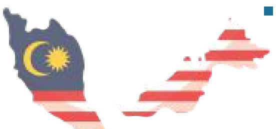
Major acquisitions and partnerships demonstrate the scale of nations' outward ambitions in nature-based solutions and broadly carbon projects.



- KSA-based **NEOM's energy and water subsidiary, ENOWA**, has signed a long-term agreement with Voluntary Carbon Market Company (VCM Co; formerly RVCMC) to **deliver more than 30 mn tonnes of high-integrity credits by 2030 from projects worldwide—mostly in the Global South**—providing predictable offtake that helps developers raise finance.
- In parallel, the UAE is deploying outward climate capital—**ALTÉRRA, a $30 bn vehicle launched at COP28, aims to mobilize up to $250 bn by 2030** (including a $5 bn arm focused on the Global South)—and, through the **Mangrove Alliance for Climate co-founded with Indonesia**, supports partner countries to design blue-carbon programs and access carbon finance. This outward model pairs long-term demand with technology transfer—satellite monitoring, AI-enabled forest management, and drone planting—delivered with partners in host countries.

Investing in Carbon Project Developers

Sovereign wealth funds are taking direct positions in carbon project developers abroad, moving beyond simple credit purchases.



- **Singapore's Temasek** via its wholly owned platform GenZero, backs developers such as Imperative (reforestation and mangroves across Africa, Asia, and Latin America), C-Quest Capital (clean-cooking programmes in Southeast Asia), and AJA Climate Solutions (multi-country nature-based projects in Africa), and has also committed capital to New Forests' Tropical Asia Forest Fund 2; in 2024 GenZero also participated as a shareholder in South Pole's investment round.
- **Malaysia — Khazanah Nasional** formed Camco South East Asia as a joint venture with carbon-project developer Camco, capitalized at up to $30mn, to invest in emission-to-energy projects and deliver carbon credit development and related advisory services across Southeast Asia—an explicit sovereign investment into a carbon project developer.

Collectively, these SWF investments strengthen developers' balance sheets, crowd in private finance, and accelerate a pipeline of high-integrity credits—especially in the Global South.

Source: UAE Government, Saudi Government, Oman Government, VCM SA, Alterra, Mangrove Alliance, Yahoo Finance, GenZero, NewForests, Khazanah Nasional, Amaly Legacy analysis

Carbon Finance Becomes Development Diplomacy

Nations are pioneering a new model of development finance that leverages carbon markets to support friendly nations while meeting domestic decarbonisation commitments. The **UAE Carbon Alliance's $450 mn commitment to African carbon credits by 2030 exemplifies this approach**, establishing the UAE as a leading purchaser in the **African Carbon Markets Initiative** while supporting the continent's goal to increase carbon credit retirements from 16 mn tonnes annually to 300 mn by 2030.

Saudi Arabia's VCM Co has conducted the world's two largest voluntary carbon credit auctions, selling over 6.1 mn tonnes to-date. In recent auctions, about three-quarters of credits originated from Global South projects, creating direct revenue streams for developing countries while enabling Saudi companies like Aramco to meet climate commitments. This model could generate approximately $337 mn in revenue for Rwanda under its bilateral agreement with Singapore. Rwanda has also signed a separate cooperation agreement with Kuwait under Article 6.

The strategic advantages extend beyond traditional development aid by creating market-based partnerships that generate returns rather than dependency.

Investment Scale Demonstrates Serious Commitment by Nations, Esp. Gulf Countries

The financial commitments across many nations, especially Gulf countries, for carbon market development indicate genuine strategic prioritisation rather than token climate action. Gulf sovereign wealth funds alone deployed $82 bn in 2023 and $55 bn through Q3 2024, with the latter representing **nearly two-thirds of global sovereign wealth fund investment activity** and an increasing focus on climate technologies and carbon market infrastructure. Specific project investments demonstrate scale and technological ambition. NEOM's $8.4 bn green hydrogen project is expected to avoid up to 5 mn tonnes of CO2 emissions annually, while ADNOC's $23 bn decarbonisation investment by 2030 encompasses major carbon capture and utilisation facilities. Qatar's 2,000 MW Dukhan solar project and Oman's $49+ bn green hydrogen commitments through Hydrom indicate region-wide transformation toward decarbonising carbon-intensive industries.

Market projections indicate transformational economic impact. The global voluntary carbon market's projected growth positions nations with active investment arms, especially Gulf states, to capture significant market share through their trading platforms and credit generation projects. Under optimal scenarios, carbon markets could reach $1.1 tn annually by 2050, representing a major new economic sector for nations, especially Gulf countries, as part of diversification strategies.

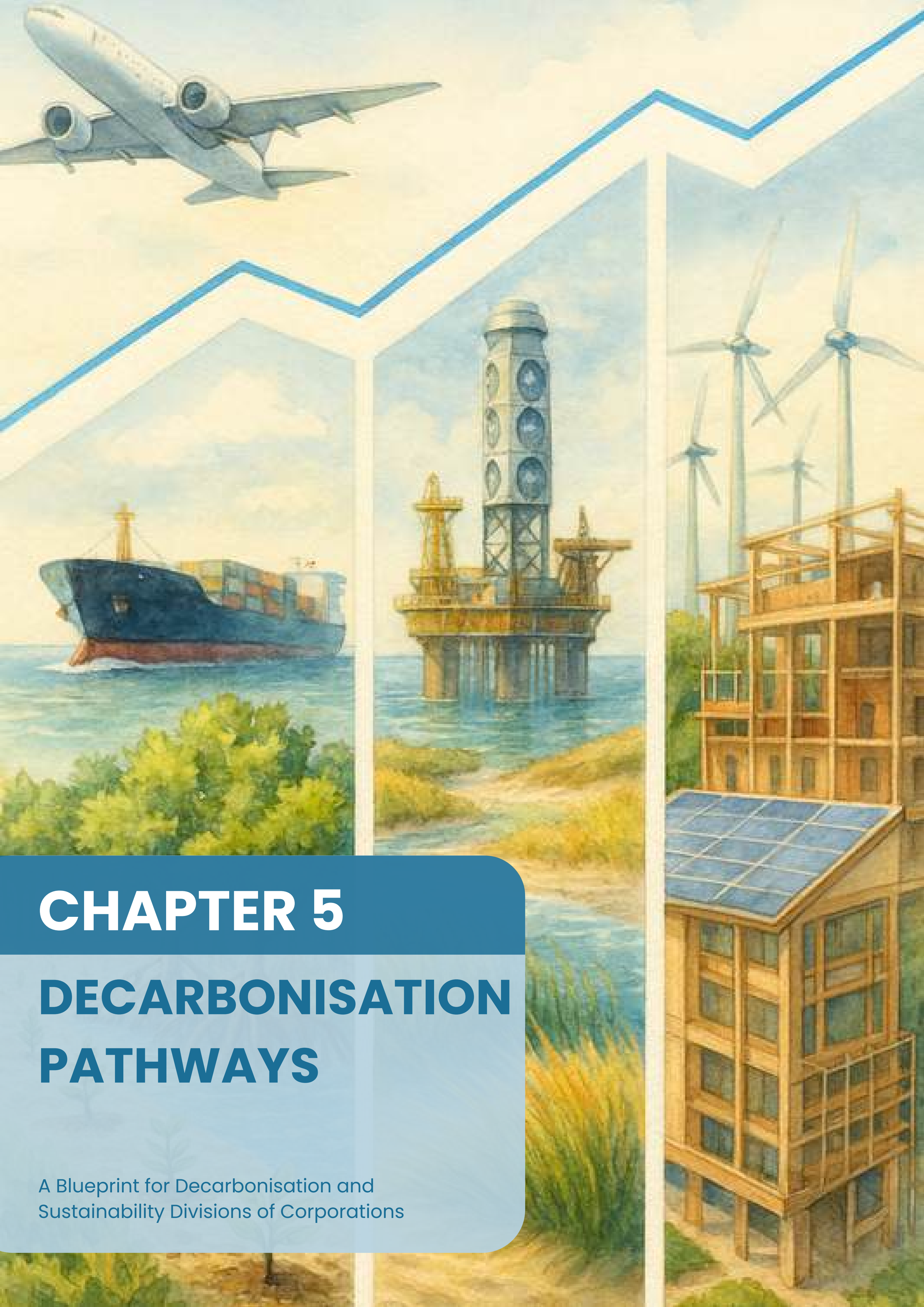
Conclusion

Nations have positioned carbon markets as a central component of economic diversification and diplomatic strategy, combining substantial financial resources with existing energy expertise to create new industries and international partnerships. The dual approach of investing in carbon credit generation while simultaneously investing in trading platforms and enabling technologies creates both robust infrastructure and outward development finance mechanisms that strengthen strategic relationships with developing nations.

The integration with their national transformation visions, massive investment commitments, and innovative finance mechanisms demonstrate genuine strategic commitment beyond conventional climate rhetoric. Success will ultimately depend on maintaining high environmental integrity standards, ensuring equitable benefit-sharing with international partners, and developing robust regulatory frameworks that support long-term market confidence.

Nations are emerging as major carbon market players, with potential to create entirely new industries while positioning themselves as constructive leaders in global climate action. The convergence of financial capacity, existing infrastructure, diplomatic networks, and growing international carbon demand creates unprecedented opportunities for these countries to establish leadership in carbon trading while achieving meaningful economic transformation beyond dependency on traditional sectors.

Sources: Ministry of Environment Rwanda, Deloitte, NEOM, OECD, Reuters, Qatar Energy, AllAfrica, VCM Saudi, SPA.gov, WEF, ACMI, Amaly Legacy analysis



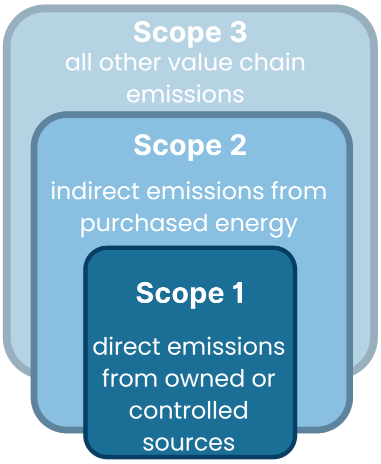
CHAPTER 5

DECARBONISATION PATHWAYS

A Blueprint for Decarbonisation and Sustainability Divisions of Corporations

DECARBONISATION PATHWAYS

As organisations increasingly commit to net-zero targets, a systematic approach to emissions reduction becomes indispensable. Critical to this journey is understanding the emissions reporting framework - **Scope 1** (**direct emissions from owned or controlled sources**), **Scope 2** (**indirect emissions from purchased energy**), and **Scope 3** (**all other value chain emissions**)—and where these emissions originate within business operations. While many companies focus primarily on internal optimisation to address Scope 1 and on renewable energy transitions to address Scope 2, achieving true net-zero requires a more comprehensive strategy that addresses emissions across all three scopes, progressing from foundational efficiency improvements through circular economy initiatives, supply chain transformation, and technological breakthroughs. Critically, our analysis shows that even after implementing all feasible reduction measures, residual emissions—typically representing 5-30% of baseline emissions—remain unavoidable, particularly in hard-to-abate sectors. High-integrity carbon credits therefore emerge not as an alternative to direct decarbonisation efforts, but as an indispensable final step in any credible net-zero strategy.



Pathway 1: Internal Optimisation inc. Circular Economy

- Process efficiency improvements
- Energy management systems
- Waste-to-resource conversion
- Industrial symbiosis and byproduct valorisation
- Tech upgrades and optimising operations

Mainly Scope 1 emissions

Short term gross abatement potential of **30-50%** and ~**90–95%** by 2050

Pathway 2: Energy Transition

- Direct renewable installations
- Electrification of processes
- Strategic Sourcing including Power Purchase Agreements (PPAs)

Scope 2 emissions + some Scope 1 (fuel switching)

Short term gross abatement potential of **10-30%** and **~90–100%** by 2050

Pathway 3: Sustainable Supply Chains and Sourcing

- Green procurement policies
- Supplier engagement and targets
- Logistics optimisation
- Sustainable raw material sourcing
- Product lifecycle management

Scope 3 emissions (upstream and downstream)

Short term gross abatement potential of **20-30%** and ~**90–95%** by 2050

Carbon Credits & Offsets

While internal optimisation, energy transition and efficient supply chains are essential first steps, **carbon credits remain indispensable** for achieving net-zero targets, particularly for hard-to-abate sectors where complete elimination of emissions is unfeasible.

Sources: SBTi, GHG Protocol, Amaly Legacy analysis

Note: Scope ranges - Figures are indicative gross abatement ranges (excluding PPAs and carbon credits) derived from cross-sector, cross-region evidence and scenarios; they are guiding, not definitive. They align with broad frameworks on long-term decarbonisation and residuals (SBTi), Scope 2 accounting (GHG Protocol), and sector roadmaps (IEA, U.S. DOE, IPCC). Actual feasibility varies materially by sector, process chemistry, asset age, grid/fuel mix, geography, and policy—company-specific engineering and operational analysis is required to set definitive targets.

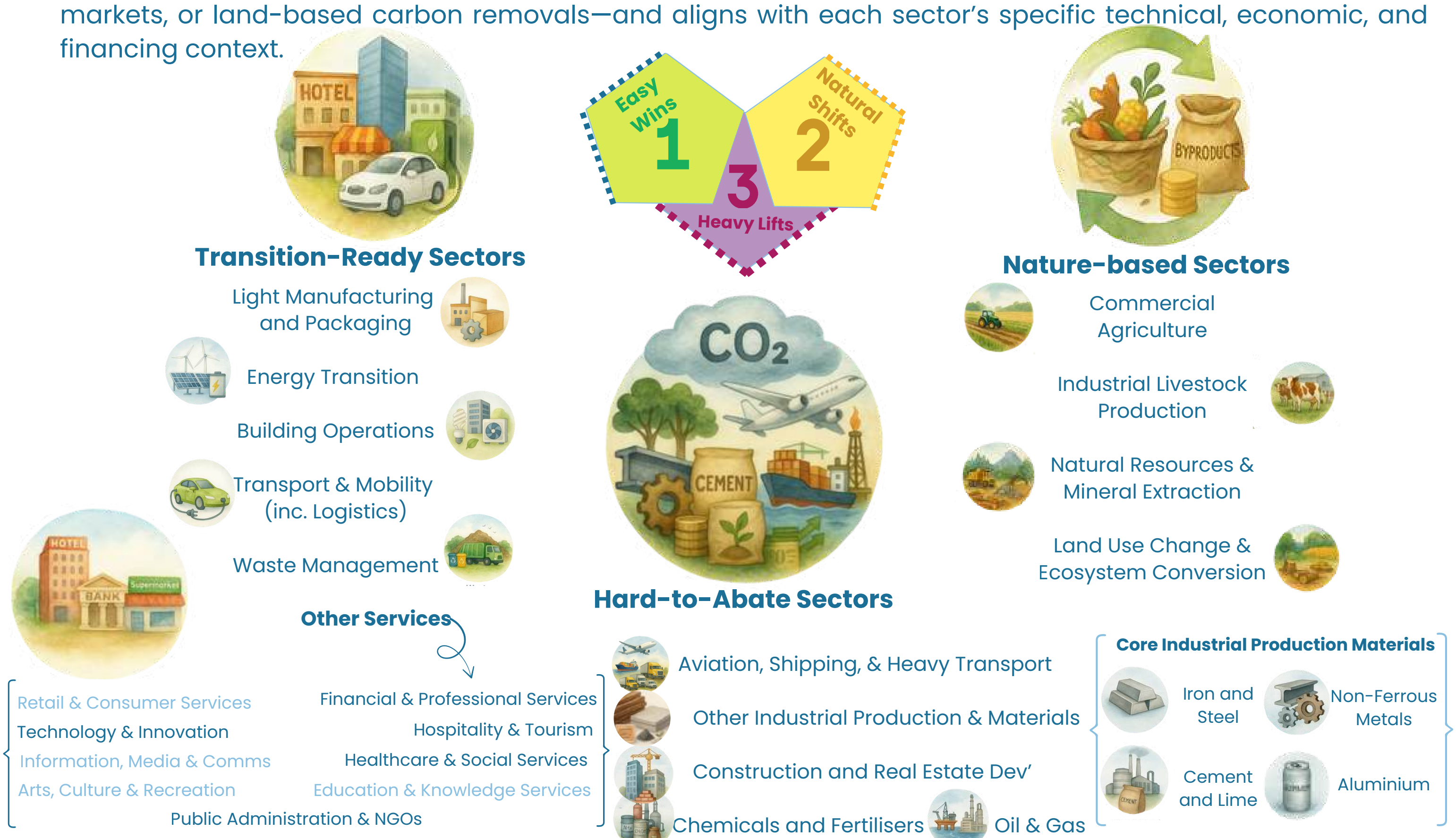
Illustrative Case Study: Scope 1, 2 and 3 Emissions from Different Vantage Points

Cashew Processing Plant	VS	Supermarket (GreenMart)
• Biogas combustion emissions from an on-site CNS biogas facility (renewable but still Scope 1 if combusted on-site). • Processing emissions (steam, drying, etc.) from any direct combustion or machinery (if any residual fossil source exists). • On-site handling and packaging activities (fuel used in internal forklifts, generators, etc., if non-electric).	SCOPE 1	• Emissions from supermarket-owned delivery vehicles (green vans and bikes—even if electric, there may be some emissions in maintenance/fleet operation). • Refrigerant leaks or other minor in-store equipment emissions.
• Zero Scope 2 emissions if electricity is fully sourced from on-site solar panels, making this category renewable and effectively emissions-free. This directly reduces the supermarket's upstream Scope 3 emissions from purchased cashew products.	SCOPE 2	• Electricity used to charge electric vehicles. • Indirect Emissions from Purchased Energy: Zero Scope 2 emissions if all store electricity needs met with solar energy. • Scope 2 can be zero under the market-based method if on-site generation and/or credible contractual instruments (PPAs/EACs) fully cover consumption; still disclose location-based Scope 2.
Upstream: • Farming input emissions (cashew sourced from regenerative farms, which minimises but doesn't eliminate Scope 3). • Transport of raw cashews from farms to the processing site (if the fleet is not owned). **Downstream:** • Shipping to the supermarket using a partner with sustainable fuel—still Scope 3 even if low-carbon. • End-of-life treatment of packaging (if any).	SCOPE 3	**Upstream:** • Procurement of cashew products from the processing plant (includes the **products' cradle-to-gate footprint**—the processing plant's Scope 1 and 2 and relevant upstream Scope 3—embedded in the sourced cashews). • Embodied emissions in capital goods and equipment (e.g., refrigerators). **Downstream:** • Outsourced home deliveries. • Consumer use and end-of-life disposal of packaging and products.

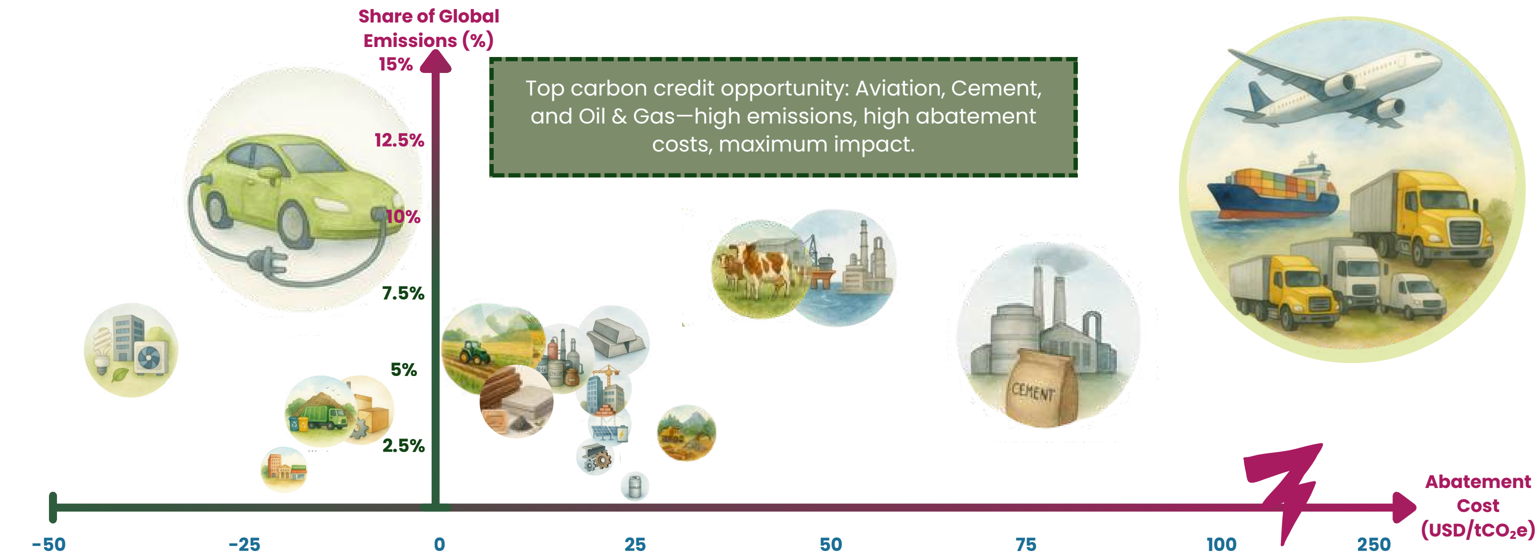
Source: Amaly Legacy analysis

Decarbonisation Industry Taxonomy

To drive climate mitigation at scale, it's essential to understand diverse emissions profiles and decarbonisation pathways across sectors with a clear, logical and easy-to-understand taxonomy conceptually aligned with other financing frameworks. Broadly, we grouped industries into three categories: **hard-to-abate sectors**, where emissions are chemically embedded in materials or tied to high-temperature industrial processes and large-scale infrastructure (e.g., cement, steel, aviation); **nature-based sectors**, which include land- and resource-intensive industries such as commercial agriculture, livestock, and logging—sectors that are often major emitters due to deforestation, soil degradation, or methane release, but also have the unique potential to act as carbon sinks through ecosystem restoration, regenerative land use, and the conversion of waste into byproducts that enhance project viability and sustainability; and **transition ready sectors**, where emissions—though significant—can often be reduced using commercially available solutions such as electrification, clean energy, and efficiency upgrades. This taxonomy enables more targeted interventions—whether through industrial byproduct valorisation, carbon markets, or land-based carbon removals—and aligns with each sector's specific technical, economic, and financing context.



Decarbonisation Industry Taxonomy: Carbon Credit Investment Potential



Legend

X-Axis (Abatement Cost): Measures the cost per ton of CO_2e reduced — left is low-cost, right is high-cost.
Y-Axis (Emission Volume): Represents the sector's total share of global emissions — higher means more emissions.
Note: Abatement costs differ significantly across granular segments within these classifications. These classifications are merely meant as a high-level assessment of decarbonisation opportunities and not a definitive guide. Emphasis and weight given to certain segments of a classification might be more than others due to emission potential and due to lack of available data which renders this analysis indicative guide and not definitive.
Source: Amaly Legacy analysis (2024)

Decarbonisation Pathway 1: Internal Optimisation

Across the hardest-to-abate sectors—real estate development and construction, shipping, aviation, and oil & gas—the most immediate emission-cutting "**big levers**" sit squarely inside **Pathway 1: Internal Optimisation**. Here, process tweaks, waste-to-resource conversions and on-site energy recovery can deliver cost-effective Scope 1 gains while nudging Scopes 2 and 3. This page gives a high-level snapshot of Pathway 1's major optimisation levers, outlines the resulting waste profile, and highlights the most promising by-product opportunities— followed by a closer look, analysis, and industry insights on the big levers to cut emissions and residue revolutionaries who convert liabilities into scalable climate and revenue wins

	Industry	3 Big Levers to Cut Emissions	Residues and Byproducts	Analysis
	**Construction and Real Estate Development**	• **Adopt circular, low-carbon materials** across the supply chain (alternative cement, recycled metals, and mass timber). • **Net-zero-ready operations – on-site electric equipment**, on-site **solar + storage**, and **digital-twin energy management.** • **Design for modular assembly, prefabrication and disassembly** to minimise waste and enable easy reuse.	• **Turn leftover concrete and soil from excavations** into building materials that trap carbon. • **Recycle scrap steel and aluminium** by melting them down using renewable electricity to create new metals. • **Transform salvaged wood and drywall** into new building panels, soil-boosting biochar, or gypsum for cement production.	**pages:** 80, 81
	**Oil & Gas**	• **Use renewable energy** to power wells, pipelines and refineries. • **Eliminate methane leaks and routine flaring** through LDAR, vapour-recovery and low-bleed equipment. • **Deploy CCUS and low-carbon hydrogen** across processing sites.	• **Associated / flare gas:** Capture and convert to LNG, power, or petrochemical feedstock. • **Produced-water brine:** Recover lithium and other critical minerals; treat and reuse water for EOR or local agriculture. • **Recovered sulphur:** Turn sulphur from sour-gas treatment and refining into sulphuric acid, fertilisers, and asphalt binders.	**pages:** 82, 83
	**Shipping**	• **Shift to zero-/low-carbon fuels.** • **Energy-efficiency, wind-assist and electric engines** to make ships use less fuel and pollute less. • **Operational optimisation** - slow steaming, just-in-time port calls, smart routing.	• **Oily Bilge Water and fuel oil sludge ›** separate valuable fuel oil from the waste mixture of oily water and sludge collected in a ship's bilge. • **Cargo-hold washings ›** Sell cargo residues (e.g., animal feed) and reuse cleaning water.	**pages:** 84, 85
	**Aviation**	• **Switch to zero or low-carbon fuels**, and increase use of **Sustainable Aviation Fuels (SAF), biofuels, and synthetic fuels.** • **Leverage next-gen plane designs for efficient plane propulsion (how planes are powered)** & **airframes** (how they are built) to reduce aircraft weight and in turn its fuel/energy consumption. • **Operational and fleet efficiency** – weight reduction, optimised routing, continuous-descent and single-engine taxi.	• **Cabin and catering waste ›** convert food/oil fractions to SAF feedstock; recycle plastics & cans back into inflight service ware. • **De-icing/anti-icing glycol runoff ›** Recover used aircraft glycol from runoff, vacuum-collect and distill it so it can be reused or sold — dramatically cutting the need to buy new (virgin) glycol and reducing pollution. • **Maintenance and end-of-life aircraft scrap ›** Re-melt aluminium and recover recycled carbon-fibre for cabin interiors or auto parts.	**pages:** 78, 79

Mainly Scope 1 emissions

30-50% reduction potential depending on sector

Carbon Credits & Offsets

While internal optimisation, energy transition and efficient supply chains are essential first steps, **carbon credits remain indispensable** for achieving net-zero targets, particularly for hard-to-abate sectors where complete elimination of emissions is unfeasible.

Notes: 1. Shipping: Bilge is the lowest point of a ship, typically in the engine room, where liquids and waste accumulate. **2. Shipping:** slow steaming is operating ships at reduced speeds to lower fuel consumption and cut emissions while just-in-time port calls is a scheduling approach that coordinates ship arrivals with docking spot availability to minimise waiting time and reduce fuel use and emissions. **3. Oil & Gas:** When oil and gas are extracted, large volumes of salty water (brine) also come up from underground. This is called produced water. It often contains salts, metals, and sometimes valuable minerals. Technologies can extract valuable elements like lithium, cobalt, or rare earths from this brine. Lithium, for example, is in high demand for electronic vehicles batteries. After removing the minerals, the leftover water can be treated so it's no longer toxic. Once cleaned, it can be reused for Enhanced Oil Recovery → reinjected into oil reservoirs to help push out more oil. Local agriculture → if treated to safe levels, it can be used for irrigation, helping reduce water scarcity. **4. LNG** means liquified natural gas - natural gas that's been cooled into a liquid form so it can be easily stored and transported. **5. Aviation:** Glycol liquid is used for de-icing planes before takeoff. The residual glycol is recovered and distilled/purified to create safe, high-quality glycol used again to remove ice from aircraft before takeoff.

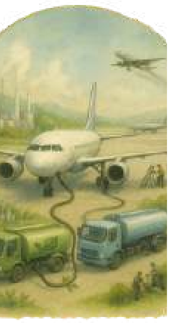
Source: Amaly Legacy analysis

Decarbonisation Pathway 1: Aviation Industry's Levers to Cut Emissions

Three hard-hitting levers now dominate the race to slash aviation's climate burden. First, switching fossil jet fuel (jet-A) for or greener, "drop-in" fuels like SAF or synthetic [e-kerosene]. These fuels work in existing engines but deliver their climate benefit through lifecycle CO_2 reductions by up to 80% compared with fossil jet, depending on feedstock and production process. Second, build the next wave of planes with more sustainable designs which need less fuel. Third, operational optimisations —from AI flight planning to single-engine taxi—unlock additional emission cuts with relatively low costs. Together these moves drive down tail-pipe (Scope 1) emissions, limit upstream energy needs (Scope 2), and shrink the refinery and distribution footprint of jet fuel (Scope 3), giving airlines the clearest pathway to IATA and ICAO net-zero goals.

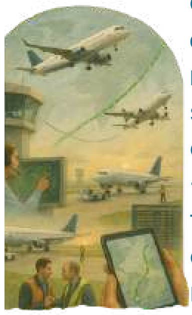
	Impact Category	How It Works	Impact on Emissions
	**Shift to zero or low-carbon fuels** (SAF from used-cooking-oil, ag-residues and forestry waste; e-kerosene made with green H_2 + captured CO_2; hydrogen-rich bio-fuel blends; ATJ fuels (ethanol/methanol))	**Swap fossil jet fuel for SAF,** which cuts lifecycle (production-to-flight) GHG emissions by up to ~80% (pathway-dependent). Newer fuels— e-kerosene and hydrogen-based synthetic fuels—made in a lab using clean electricity to turn water and captured CO_2e into fuel not relying on oil- are almost carbon-free once produced at scale.	• **Scope 1:** Drop-in SAF cuts lifecycle CO_2 and makes less engine exhaust that turns into heat-trapping clouds (contrails). • **Scope 2:** Producing e-fuels with 100 % renewable power shifts emissions to a clean electricity ledger. • **Scope 3:** Each tonne of SAF avoids the refinery and crude extraction footprint counted in an airline's upstream Scope 3.
	**Airframe and propulsion efficiency** (laminar-flow wings, blended-wing bodies, sharklets, lighter composite fuselages, geared-turbofan/open-fan engines)	**Smarter aircraft designs** reduce fuel use with lighter, streamlined structures and more efficient engines that power planes. Small upgrades—like winglets or cleaner engines—also help save fuel. Advanced propulsion systems and lightweight materials can further lower fuel consumption.	• **Scope 1:** Every % fuel saved directly lowers CO_2, NO_x and contrail-forming particulates. • **Scope 2:** Marginal—mainly ground power for lighter-weight MRO[1]. • **Scope 3:** Less fuel refined and shipped › refinery and bunkering Scope 3 drops in parallel.
	**Operational optimisation** (AI flight planning, continuous-descent, single-engine taxi, dynamic load-factor/ weight reduction, contrail-avoidance routing)	**Software and policies** reduce extra engine use, aircraft weight, and delays. Smarter speeds, better routes, fewer contrails, and carefully managed cargo loads cut emissions, amplified by fleet-wide eco-dashboards.	• **Scope 1:** Digital tools use almost no extra electricity yet clip Scope 1 immediately. • **Scope 2:** Marginal—very low electricity for tools clips Scope 2 right away. • **Scope 3:** Every tonne of fuel not uplifted removes refinery and logistics emissions from owner's ledger.

Why these three dominate emission-reduction potential



Fuel choice overwhelms everything else: SAF and newer fuels like e-kerosene deliver significant well-to-wake (production-to-flight) cuts in an order of magnitude larger than any single technical tweak.

Efficiency and design deliver near-term gains: Airframe/ engine upgrades are retrofit-friendly, cash-positive at today's fuel prices, and bridge the gap while green-fuel supply scales.



Operational measures are instant with minimal costs: just smarter routing and commercial alignment —make them the fastest and most affordable path to to net-zero 2050.

Sources: IATA, ICAO, Transportenvironment.org, Amaly Legacy analysis

Note: 1. Lighter-weight MRO refers to Maintenance, Repair, and Overhaul practices that use lightweight materials, components, and repair methods to reduce aircraft weight → improving fuel efficiency and cutting emissions. **2.** Please refer to the report's glossary for definitions of technical terms.

Andrew Sweeney, Boeing sustainability lead for the Middle East, Türkiye, Africa and Central Asia:

BOEING

"Boeing is committed to resilient, sustainable growth in aerospace and to supporting customers in meeting their sustainability goals. To do so, we continue to invest in a multi-faceted approach to improve the civil aviation sector's energy efficiency including developing and delivering more fuel-efficient airplanes, exploring advanced technologies, improving operational efficiency, and advancing sustainable aviation fuels (SAF). Boeing is supporting SAF feedstock and technology assessment, policy and financing in the UAE and in the region working together with our long-standing partners including the UAE Ministry of Energy and Infrastructure, Etihad, Emirates, Masdar and others."

Aviation Industry's Waste and Value Added Products

Around 1–1.5 kg of waste is generated for every passenger carried, and three waste streams—cabin and catering waste, de-icing/anti-icing run-off and end-of-life aircraft scrap—make up aviation's biggest material footprint in flight and on the ground. Instead of paying to landfill or incinerate them, progressive operators now spin each into a sellable by-product: Recovered glycol from de-/anti-icing can be reprocessed. End-of-life metals and some carbon-fibre can be recycled into non-critical components. Catering waste is often subject to strict biosecurity rules (e.g., 'international catering waste'), limiting reuse; where permitted, only separated oils/fats may qualify as SAF feedstock. This turns compliance costs into revenue, reduce disposal cost, contamination and critically slashes emissions across the aerospace value chain.

Waste	Waste Description	Emissions	Byproducts	Impact on Emissions
 **Cabin and catering waste**	Leftover food, drinks, plastic items, cans, and single-use items from flights	If waste isn't recycled, it is burned or put in landfill, causing pollution and greenhouse gases.	**SAF Feedstock & Recycled Materials:** Where permitted, separated used cooking oils/fats can be turned into SAF feedstock (HEFA pathway). Cans and plastics can be recycled to make new products for planes.	Large reduction in emissions by diverting from landfill/incineration and avoiding virgin materials; where permitted, separated used cooking oils/fats can become SAF feedstock that displaces fossil jet fuel.
 **De-icing / anti-icing glycol run-off**	Glycol-based fluids sprayed on aircraft to remove and prevent ice.	If used glycol isn't recycled, treating the wastewater takes more energy and chemicals, and producing new glycol adds even more emissions.	**Cleaned Glycol for Plane De-icing:** recover, purify and filter glycol (safe, high-quality fluid used to remove ice from aircraft before takeoff) for reuse.	Large decrease in emissions because recycled glycol displaces virgin glycol production
 **Maintenance and end-of-life aircraft scrap**	Old planes and leftover parts—most can be recycled	If parts aren't recycled, new materials must be made, which causes more pollution.	**Recycled Metal and Fibre:** Old plane parts are turned into new products like car parts, plane parts, and sports equipment.	If parts aren't recycled, new materials must be made and waste is disposed, which causes more pollution.

Summary

- **$ value unlocked** from turning used food oils, recovered glycol, and high-quality recycled aluminium and carbon fibre into useful products help pay for equipment, lowering emissions both during flights and on ground.
- **Massive emission reductions** where every recycled product replaces a material that normally causes a lot of pollution — like fossil jet fuel and new (petroleum-based) glycol.
- **Circular infrastructure** matters because on-site digesters, glycol recovery units and electric smelters powered by renewables can trasnlate into additional savings, magnifying end-to-end. reductions.

Source: IATA, UK Gov, Amaly Legacy analysis

Dr. Shaurya mohan
Chief Executive Officer, EarthSaathi, and Fellow, Institute Of Chemical Technology, India

Airports are sitting on a biogas field. Each passenger leaves ~1–15 kg of energy-rich waste, and CNSbiogas turns those cabin leftovers into on-site renewable gas and power—flipping waste from expense to clean supply while shrinking landfill methane and displacing fossil fuels. Combined with glycol recovery and materials recycling, the airport's dirtiest streams become a circular utility that runs terminals and ground fleets, cuts opex, and creates auditable carbon reductions airlines can claim.

Decarbonisation Pathway 1: O&G Industry's Levers to Cut Emissions

Three fast-acting levers now dominate the drive to decarbonise upstream, mid-stream and downstream oil & gas assets. First, deep electrification powered by renewables can wipe out signifcant stationary combustion[1] CO_2e in producing fields and refineries. Second, methane-management and flare elimination[2] tackle the sector's most potent, low-hanging climate pollutant—often at negative cost. Third, CCUS for process units and fuel-switching to low-carbon H_2 address residual, high-temperature emissions in heaters, reformers, and crackers (technology- and site-dependent). Together they slash on-site (Scope 1) emissions, shift emissions from Scope 1 to Scope 2 (total emissions decrease only if electricity is low-carbon), and curb upstream component of customer-facing Scope 3 barrels—giving operators a clear pathway to net-zero targets.

Impact Category	How It Works	Impact on Emissions
Power wells, pipelines, and refineries with renewable energy 	Replacing gas turbines, diesel generators, and fired boilers with smart electric motors and renewable electric heat cuts emissions and boosts efficiency. Upgrading pumps and compressors to variable-speed electric motors further reduces energy use and costs.	• **Scope 1:** Eliminates fuel combustion for compression, lifting and refinery utilities. • **Scope 2:** If electricity is 100 % renewable, Scope 2 drops to near-zero. • **Scope 3:** Every barrel produced with lower upstream intensity marginally cuts end-user life-cycle emissions.
Eliminate methane leaks and routine flaring 	Detecting and repairing methane leaks, capturing associated gas for sale or on-site power, and ending routine flaring cut emissions. Replacing gas-powered control devices (pneumatic devices) with electric alternatives further reduces methane release, improving operational efficiency.	• **Scope 1:** Methane has greater overall warming impact than carbon dioxide over time—each tonne avoided is a high-impact Scope 1 win. • **Scope 2:** Minimal. • **Scope 3:** Captured gas displaces higher-carbon fuels in operations, trimming customers' upstream intensity.[3]
Carbon Capture, Utilisation and Storage + low-carbon hydrogen 	Installing systems to capture CO_2 from exhaust gases and storing it underground or using it to help extract more oil (enhanced oil recovery) reduces overall emissions. Replacing conventional hydrogen with cleaner hydrogen in refinery equipment and turbines further cuts the carbon footprint of operations.	• **Scope 1:** Capture typically removes majority of CO_2 from treated streams; when stored, captured CO_2 is prevented from reaching atmosphere (residual emissions remain) • **Scope 2:** Green-H_2 produced with renewables is nearly zero-carbon power-to-molecule. • **Scope 3:** Hydrogen-derived e-fuels and CCS credits can offset a slice of the downstream barrel's life-cycle.

Sources: Official Journal of EU, Energy Intelligence, IEA, Global CCS Institute, World Bank, Amaly Legacy analysis

Notes: 1. Stationary combustion refers to Burning gas or diesel on-site (e.g. in pumps, compressors, refineries) to generate power or heat and replacing gas or diesel with renewable electricity significantly cuts CO_2 emissions. **2.** Methane (from leaks or burning excess gas, called flaring) is highly potent for climate and fixing leaks and stopping flaring directly reduces GHG. **3.** Using captured gas instead of higher-carbon fuels (e.g. diesel) in oil and gas operations or LNG production cuts overall emissions from those activities.

Why these three dominate emission-reduction potential

Electrification swaps combustion for clean electrons: Removing gas turbines and boilers slashes the lion's share of on-site CO_2e in one stroke where renewable power is available

Methane cuts are cheap, quick and potent: Leak-repair and flare-capture projects often pay back in months, delivering the biggest near-term climate bang per dollar in the sector.

CCUS + H_2 tackles residual emissions: High-temperature process heat, hydrogen production and residual combustion CO_2 cannot be fully electrified today — capture-and-hydrogen provide the only scalable, technology-ready solution to reach net-zero.

Decarbonisation Pathway 1: O&G Industry's Waste & Value Added Products

Oil and gas operations create different types of waste, like extra gas that gets burned, salty water from drilling, and sulphur from cleaning natural gas. Instead of just throwing these wastes away or burning them, new solutions let companies turn them into useful products—such as fuel, battery materials, or fertiliser. This not only saves resources but also helps lower pollution and greenhouse gas emissions across the whole industry.

Waste	Waste Description	Current Situation	Byproducts	Impact on Environment
Associated / flare gas 	Extra gas burned off at oil & gas sites	Burning (flaring) releases CO_2; unlit or inefficient flares also emit methane and black carbon.	**Energy Products:** The gas can be captured and turned into LNG, compressed natural gas, electricity, or chemicals like hydrogen — reducing waste, lowering emissions, and creating additional economic value.	Big emission cuts—capturing gas means less CO_2e and methane go into the air. Power for compression and treatment raises electricity use, however with low-carbon power, net cuts remain large
Produced-water brine 	Salty wastewater brought up during oil & gas production	Moving and treating produced water uses energy; if it's just disposed of, minerals are lost and extra transport increases emissions.	**Battery Materials and Reuse:** In certain areas where the water from O&G production contains valuable minerals, that water can be treated to extract the minerals for use in batteries; elsewhere it's reused in oil recovery or irrigation.	Potential large system-wide cuts —recovering lithium can displace mined lithium (energy- and carbon-intensive). However, treatment and mineral recovery adds energy demand, so the net impact depends on technology and the power mix (best with renewable electricity).
Recovered sulphur 	Sulphur removed from gas at refineries and plants	Burning off H_2S (sour gas) releases SO_2 pollution if not captured. In addition, if not reused, more new sulphur must be mined.	**Industrial Products:** Recovered sulphur is used to make acids, fertilisers, asphalt, and concrete additives.	Large cuts in emissions - avoided pollution from burning H_2S (sour gas) and recycling sulphur means less mining > less pollution.

Summary

$ value unlocked by monetising flare gas, lithium and sulphur funds the capture and treatment kit that trims operational emissions.

Significant emission reductions because each by-product replaces carbon and resource-intensive virgin materials like mined lithium and sulphur.

On-site circular infrastructure matters: Electrified compressors, direct lithium extraction units and sulphur recovery plants powered by renewables can flip Scope 2 from a cost to a further saving, amplifying end-to-end reductions.

Sources: World Bank, US Department of Energy, Essential Chemicals Industry, Amaly Legacy analysis

Decarbonisation Pathway 1: Construction and Real Estate Development Industry's Levers to Cut Emissions

Three high-impact levers dominate the race to decarbonise buildings and infrastructure. First, specifying circular, low-carbon materials—green cement, recycled steel, mass-timber—slashes embodied CO_2e by as much as 70% before a project even breaks ground. Second, electrifying the job-site and building operations replaces diesel gensets and gas boilers with renewably powered equipment, wiping out on-site (Scope 1) fuel burn. Third, modular, prefabricated and design-for-disassembly (DfD) practices curb material waste by up to 90%, enable component reuse, and lock in circular-economy value for the building's end of life. Combined, these moves flatten cradle-to-grave emissions profiles, pushing developers toward net-zero pathways aligned with SBTi-Built Environment and leading green-building certifications.

Impact Category	How It Works	Impact on Emissions
Circular, low-carbon materials  	Replacing Portland cement[1] and virgin metals with renewable alternatives, and reusing formwork and aggregates reclaimed from demolition can greatly reduce waste and embodied CO_2e in construction.	• **Scope 1:** Biogenic carbon in mass timber stores CO_2e in-building. • **Scope 2:** Minimal. • **Scope 3 – Upstream:** Major drop in raw-material extraction and clinker production.
All-electric, net-zero-ready operations 	All-electric, net-zero-ready operations cut emissions by replacing diesel machinery and fossil-fuel HVAC with electric systems powered by renewables. IoT sensors and digital twins[3] further optimise energy use and performance.	• **Scope 1:** Eliminates job-site diesel and ongoing boiler/gas burn. • **Scope 2:** Falls toward zero when renewable PPAs[3] or on-site solar-generated electricity. • **Scope 3:** Each kWh not derived from fossil fuels trims upstream fuel extraction/refining.
Modular, prefabrication and DfD 	Modular and prefabricated construction shifts much of the building work to factories, where parts are made efficiently with less waste. Designing these parts for easy disassembly and reuse, along with take-back agreements, allows materials to be recovered and reused in future projects.	• **Scope 1:** Fewer on-site cuts/welds reduce fuel and generator runtime. • **Scope 2:** Factory lines can run on renewables. • **Scope 3:** Reusing elements slashes future virgin-material demand and demolition waste.

Sources: McKinsey, WRAP, Modular.org, Amaly Legacy analysis

Notes: 1. Portland Cement is the most common type of cement used in construction - a fine powder made primarily from limestone and clay, which, when mixed with water, forms a hard, stone-like material — concrete or mortar **2. HVAC** stands for Heating, Ventilation, and Air Conditioning. **3. PPA** is power purchase agreements. **4. IoT and digital twins** optimise energy use by tracking performance in real time and adjusting systems for maximum efficiency.

Why these three dominate emission-reduction potential

Material choice sets the carbon floor: Embodied emissions occur up-front—it's now or never to cut them; low-carbon cement and recycled metals deliver the biggest single-line item reduction.

Electrification wipes out diesel and gas pain-points: Switching to clean electricity tackles the largest the largest controllable Scope 1 emissions in construction while future-proofing buildings as the grid gets greener.

Modular and DfD close the loop: Factory precision and planned disassembly transform waste into assets, creating new revenue streams from reclaimed materials and making circularity the default.

Decarbonisation Pathway 1: Construction and Real Estate Development Waste and Value Added Products

Building and demolition sites already dump well over two billion tonnes of contruction and demolision waste every year—mostly broken concrete, scrap metal, wood and drywall. Forward-thinking builders now flip that waste into new building ingredients: crushed concrete that locks in CO_2, recycled steel and aluminium, and re-used wood and gypsum where uncontaminated. The result? Lower disposal fees, extra revenue and major cuts to carbon emissions.

Waste	Waste Description	Current Situation	Byproducts	Impact on Environment
Concrete and excavation spoil 	Left-over ready-mix, demolition rubble and surplus dug-out soil.	Waste is typically hauled off-site; projects buy virgin aggregate and cement/clinker—making fresh cement is very carbon-intensive.	**CO_2-locking recycled aggregate and engineered fill:** rubble is crushed and blended with carbon-mineralising additives or used as a aggregate substitute and in some applications, CO_2-treated fine materials can partly replace cement in concrete.	Large emission cuts as each tonne reused avoids virgin aggregate and new clinker. There might be slight increase in emissions from processing however this can be mostly mitigated with renewable power.
Steel and aluminium scrap 	Leftover metal pieces from reinforcing bars, façade panels (outer panels of a building's exterior), formwork, and window frames.	Projects typically purchase primary steel and aluminium; producing new metal is energy- and carbon-intensive (mining, refining and smelting).	**New steel and aluminium billets** made from scraps melted down in electric furnaces, cutting the need for virgin metal production and lowering emissions from mining and smelting.	Huge decrease in emissions as recycled steel and recycled aluminium displace primary production and save significant energy ompared with producing metal from virgin raw materials.
Salvaged timber and drywall 	De-nailed joists, plywood off-cuts, cross-laminated timber scraps and gypsum boards.	Landfilled wood can generate methane while virgin gypsum extraction and board manufacture emit CO_2e.	**Engineered-wood panels, bio-char and recycled gypsum** (if uncontaminated) used in cement or as soil conditioner.	Moderate decrease in emissions as wood used in long-lived products stores biogenic CO_2e and can displace higher-impact materials (e.g., steel or concrete) while recycled gypsum avoids quarrying.

Sources: Act Initiative, Fast Markets, epa.gov, Cembureau, International Journal of Steel Structures, Level.org.nz, Sustainability (Vol. 16, No. 8, Article 3494), Environmental Engineering Research, Global Alliance for Buildings & Construction, Amaly Legacy analysis

Summary

$value unlocked by selling crushed concrete, recycled metal billets and reclaimed gypsum can pay for onsite sorting gear and renewable-powered crushers and balers.

Significant carbon emission reduction because every recycled product replaces a carbon-heavy virgin material —cement, steel, aluminium or mined gypsum.

Site-level sorting really matters: electric crushers, balers and kilns powered by green electricity can turn translate into extra saving, magnifying total carbon cuts across the whole building life-cycle.

Decarbonisation Pathway 1: Shipping Industry's Levers to Cut Emissions

Three hard-hitting levers now dominate the race to slash maritime carbon. First, swapping heavy fuel oil to low-carbon fuels (e.g., methanol, ammonia, advanced biofuels, e-fuels) that requires newbuilds or retrofits to deliver lifecycle (well-to-wake) reductions that vary by fuel and supply chain. Second, retrofit-friendly efficiency tech—rotor sails, air-lubrication, optimised hulls—cuts every voyage's fuel burn. Third, pure operational smarts—slow steaming, just-in-time port calls, AI routing—deliver instant, minimal capex, savings. Together, these moves cut Scope 1 emissions from fuel combustion and Scope 3 upstream impacts from fuel production and bunkering while Scope 2 changes only when shore power is used (the net effect depends on the carbon intensity of the local grid)

Impact Category	How It Works	Impact on Emissions
Shift to zero-/low-carbon fuels (green ammonia, e-methanol, advanced bio-fuel blends) 	Replace heavy fuel oil with fuels made from renewable power or sustainable biomass. From production to use, GHG emissions can drop significantly with truly green fuels. Burning methanol still releases CO_2, while ammonia gives almost none but needs strict N_2O control.	• **Scope 2:** Battery-hybrid or shore-charging vessels may lift Scope 2 slightly, e-fuel production itself is counted upstream (Scope 3), not to the ship. • **Scope 3:** Making fuel with wind- or solar-derived electricity slashes well-to-wake emissions; each tonne of green ammonia or e-methanol avoids the refinery and crude-extraction footprint carried in the owner's Scope 3.
Energy-efficiency, wind-assist and electric DC propulsion tech (rotor sails, rigid wings, air-lubrication, hull retrofits, advanced 	Devices cut hydrodynamic drag or let wind deliver part of the propulsion load. Rotor sails, kites and air-lubrication save fuel on typical routes while DC power systems let generators operate at optimal load or run on battery/e-fuels, trimming fuel consumption	• **Scope 1:** Devices draw only a small fraction of main-engine power—reducing Scope 1 emissions; most systems draw only small auxiliary power on board. • **Scope 2:** Unchanged (systems run on onboard power; purchased electricity is not material). • **Scope 3:** Less fuel burned means less crude refined and shipped—so upstream Scope 3 drops in parallel.
Operational optimisation (slow steaming, just-in-time port calls, smart routing**)** 	Software and policies reduce unnecessary ship speeds and waiting times. Slowing ships down during voyages greatly reduces their total CO_2 emissions.	• **Scope 1:** Software and data-driven optimisation reduces fuel use directly—reducing Scope 1 emissions. • **Scope 2:** Typically unchanged unless shore power/charging is used at berth. • **Scope 3:** Every tonne of fuel not ordered removes refinery and bunkering emissions from the owner's Scope 3 ledger.

Sources: International Maritime Organisation, Official Journal of EU, European Maritime Safety Agency, WEF, Amaly Legacy analysis

Why these three dominate emission-reduction potential

Fuel choice overwhelms everything else: Switching to genuinely green fuels can deliver >90 % well-to-wake cuts—an order of magnitude larger than any single technical tweak.

Efficiency and wind give near-term gains: They are retrofit-friendly, cash-positive at today's fuel prices, and bridge the gap until green-fuel supply scales.

Operational measures are instant and free: They need no new kit, just smarter routing and commercial alignment—making them the fastest way to hit interim IMO checkpoints.

Decarbonisation Pathway 1: Shipping Industry's Waste and Byproducts

Around 80% of world trade moves by sea, and managing waste streams is part of shipping's environmental compliance. Two key regulated categories—bilge water and sludge (MARPOL Annex I)[1,2], and cargo residues/hold washings (MARPOL Annex V)[3]—account for a significant share. With the use of modern separators oil can be recovered from bilge or sludge as reusable low-grade bunker oil while cargo residues can be sold and suitably treated wash water can be reused (while complying with MARPOL and port-state rules). Although resale and reuse of byproducts are rare and tightly regulated, when adequately managed they may be viable turning compliance costs into value while lowering lifecycle emissions through avoided waste handling and reduced fuel purchases.

Waste	Waste Description	Current Situation	Byproducts	Impact on Environment
Oily bilge water and fuel oil sludge 	Dirty water that leaks into the engine room and mixes with oil.	Bilge water is treated to remove oil (separating oil from water) before it's released, and the leftover sludge is either incinerated on the ship or handled safely at the port - burning it releases emissions.	**Recover bunker oil from bilge:** Modern separators can recover a portion of the ship's original fuel as reusable low-grade bunker oil, cutting waste sludge volumes.	Reduced as sludge landings and onboard incineration fall. However there will be a small increase in emissions from recovery-equipment power. Overall lifecycle emissions fall where recovered fuel displaces purchases.
Cargo-hold (storage areas inside ships) **washings** 	Wastewater and residues when cargo holds are cleaned after transporting bulk goods like grains, animal feed, minerals, or other loose materials.	If residues or cleaning agents are classified as harmful to the marine environment (HME), the washwater and residues must be taken ashore for treatment. This prevents marine pollution but increases emissions from waste handling/transport.	**Sell cargo residues and reuse wash water:** The solid residue can be sold (e.g., animal feed, metal fines), and suitably treated washwater reused for deck washing.	Emissions are moderately reduced because this approach avoids port waste disposal and, where allowed, can replace the use of virgin crops or mined materials. Additional savings come from washwater reuse, which reduces freshwater and energy demand.

Sources: Alfalaval, UNCTAD, International Maritime Organisation, MARPOL Annex I, MARPOL Annex V, Amaly Legacy analysis
Notes: 1. MARPOL is an international agreement that helps keep the oceans clean by preventing pollution from ships. It sets rules for handling oil, chemicals, sewage, garbage, and air emissions. If ships break MARPOL rules they can face heavy fines, detentions, or criminal charges. Enforcement of penalties is carried out by Flag states (the country where the ship is registered), and Port states (countries where the ship docks). **2. MARPOL Annex 1** covers rules to stop oil spills and control oily waste from ships (like bilge water and sludge). **3. MARPOL Annex 5** covers rules on how ships manage and dispose of waste.

Summary

$ value unlocked by monetising oil, gypsum, and cargo fines which funds the kit that reduces shipboard energy.

Scope 3 dominates the upside because each by-product directly substitutes a carbon-intensive virgin material.

Port-state infrastructure matters because shore-power from renewables can flip Scope 2 from a cost to an additional saving, magnifying end-to-end reductions.

Pathway 2: Energy Transition

Energy transition represents the most capital-efficient decarbonisation pathway for organisations seeking to eliminate Scope 2 emissions while positioning themselves for long-term energy security. We've present three strategic levers that can achieve significant Scope 2 reductions while delivering energy cost savings.

Strategic Framework: The 3R Energy Transition Model

The 3R Framework provides a comprehensive approach for organisations to accelerate their energy transition and decarbonisation strategies. Each "R" represents a distinct lever for action, enabling companies to address both direct and indirect emissions, enhance resilience, and create long-term value.

REPLACE - Direct Renewable Installations

The deployment of renewable energy generation assets directly on company-owned or leased properties, converting organisations from pure energy consumers to energy producers.

REINVENT - Process Electrification

The systematic conversion of fossil fuel-dependent processes to electric alternatives, enabling organisations to leverage clean electricity for operations previously reliant on direct combustion.

RELOCATE - Strategic Sourcing via Power Purchase Agreements

Long-term contractual arrangements to procure renewable energy from off-site generation facilities, enabling access to clean energy without capital investment or operational responsibility.

> "Attracting large volumes of private investment towards climate-resilient renewable energy projects requires well structured transactions with attractive risk-return profiles. Blended finance is a viable financial structuring approach that provides adequate risk buffers and risk premiums to strengthen the commercial viability of projects that deliver strong environmental and social returns. It is a compelling approach that can unlock the billions of dollars required to achieve sustainable development globally."

LADÉ A. ARABA
Chairperson

REPP
Renewable Energy Performance Platform

1 REPLACE - Direct Renewable Installations (On-site Generation)

To accelerate the shift from energy consumers to energy prosumers, organisations are increasingly deploying on-site renewable installations—strategically leveraging existing assets to enhance energy security, reduce costs, and unlock new revenue streams through four key value levers.

- **Asset Optimisation:** Utilise existing real estate footprint (rooftops, parking, unused land) to generate facility energy needs. Every 10,000 sqm of roof space can host approximately 1.5–2 MWp of solar capacity, depending on panel efficiency and layout, transforming dead assets into revenue generators while reducing grid dependence and exposure to peak pricing.
- **Energy Arbitrage:** Store excess generation for peak demand periods when **electricity prices can be higher than base rates**. Advanced battery systems enable load shifting, capturing price differentials while ensuring operational continuity.
- **Grid Services:** Monetise flexibility through demand response programmes where utilities pay for load reduction during grid stress events. Renewable installations with smart inverters can provide frequency regulation, voltage support, and other ancillary services, generating additional revenue.
- **Resilience Premium:** Quantify and capture the value of energy independence through reduced downtime risk and insurance premium reductions. Facilities with on-site generation experience fewer outages, translating to annual savings for critical operations through avoided production losses and lower business interruption insurance costs. Using advanced, IOT and AI-enabled technologies—such as sensors aiding predictive maintenance, anomaly detection, and outage forecasting—further improves reliability, reduces downtime, and lowers interruption.

Sources: SEIA, NREL, Amaly Legacy analysis

REINVENT - Process Electrification

Electrifying fossil-fuel-based operations eliminates on-site combustion, cutting Scope 1 emissions and, when powered by renewables, drives Scope 2 emissions toward zero—supporting climate targets, improving efficiency, and reducing fuel price risk.

High-Impact Value Levers

These five levers capture the breadth of industrial electrification—spanning low- and high-temperature heat, feedstock transformation, and digitally enabled load flexibility—delivering material decarbonisation and value-creation in a coherent framework that **reduces energy waste and ensures energy efficiency**.

		What it Delivers?	Why it Counts?
	**Zero-Carbon Heat and Steam**	Electric boilers, heat pumps, resistance heaters, and induction systems replace fossil-fired heating	Enables electrification of low- to mid-temperature processes, cutting direct CO_2e and NO_x emissions while boosting thermal efficiency
	**High-Temp' Conversion**	Electric arc furnaces, plasma torches, and e-crackers electrify high-temperature processes	Makes decarbonisation feasible for high-heat industries (steel, cement, chemicals) while preparing assets for green premiums and regulatory alignment
	**Power-to-Molecules**	Produces green hydrogen, e-ammonia, and e-methanol via electrolysis and synthetic pathways	Replaces fossil-derived chemical feedstocks, enabling circular production loops in chemicals, fuels, fertilisers, and maritime shipping
	**Motion and Compression**	Electrifies pumps, compressors, conveyors, fans, and other mechanical systems	Applies across most industries—enabling significant Scope 1 reductions through efficient, electrified motion and reducing maintenance and energy losses
	**Digital Operations**	Advanced controls, smart inverters, variable-speed drives, and on-site storage	Unlocks participation in grid services, load shifting, and demand response—adding resilience and new revenue streams

Key Strategies to REINVENT

Three strategies below offer a practical toolkit applicable across most industries. Whether an organisation is electrifying its heating systems, mechanical processes, or digital operations, these strategies help cut energy waste via efficient electrification to maximise return throughout the transition.

- **Modular Retrofits and Phased Roll-outs:**
  - **Quick Installations:** Prioritise plug-and-play electrification solutions (e.g., heat pumps, electric boilers).
  - **Scale:** Use modular clean-energy units that can be added in stages, expanding as energy needs grow.
- **Cross-Technology Integration and Hybridisation**
  - **Balancing:** Pair electric heat with thermal storage or waste heat to lower peaks and balance load.
  - **Smoothing:** Use energy storage systems to manage power spikes, and minimise grid stress.
- **Grid-Interactive Orchestration**
  - **Shift Usage:** Implement real-time energy-management systems that shift high-load processes to periods of excess renewable generation.
  - **Earn from Grid:** Get paid by grid operators helping the grid stay balanced by using flexible equipment that can join programs like frequency regulation or backup power.

Outcome

A deliberate, phased electrification roadmap allows companies to drive Scope 2 decarbonisation of hard-to-abate processes, stabilise energy costs, and turn operational flexibility into a profit centre—all while future-proofing assets against tightening climate regulations and investor scrutiny.

Source: Amaly Legacy analysis

Note: 1. Electrifying fossil-fired processes slashes direct emissions, shields operations from fuel-price swings, opens access to green-premium markets, and positions plants to benefit as renewable electricity costs keep falling. Yet the **business case must absorb: i) high retrofit CAPEX**, **ii) today's often pricier power**, **iii)immature high-temperature electric options**, **iv)uneven renewable supply**, **v) redesign and safety upgrades**, **vi) workforce retraining costs,** and **vii) transition-period productivity hits**. **2.** Low/medium-temperature (< 600 °C) electric heaters are commercially available today, whereas > 1000 °C options (e-kilns, plasma/arc systems) remain early-stage and need further R&D to scale.

3 RELOCATE - Strategic Sourcing via Power Purchase Agreements

Organisations are embedding long-term renewable sourcing into their energy transition plans—shifting from passive energy buyers to active clean energy participants by securing off-site supply through PPAs, enabling decarbonisation and cost stability without upfront capital or operational complexity.

Physical PPAs

A direct contract for the physical delivery of renewable electricity from a generator to an organisation's facility[1] usually through the grid. You take ownership of the electricity (in MWh) at the delivery point to meet consumption needs.

Benefits:

- **Price Stability:** Locks in a long-term fixed or indexed price, shielding operational costs from wholesale swings (avoiding risk of future market price fluctuations).
- **Local Impact:** Creates visible local "additionality" by underwriting new renewable capacity on the same grid.
- **Compliance:** Lets the buyer earn local renewable energy certificates (RECs) or meet compliance requirements.[2]

Virtual (Financial, Synthetic) PPAs

A financial contract (often a contract-for-difference) between the organisation and a generator. No physical electricity delivery occurs; instead, price difference is settled between the agreed strike price and the market price.

Benefits:

- **Geographic Arbitrage:** Lets buyers tap the best wind/solar resource zones/pricing regardless of where they consume power.
- **Stable Forecasting:** Works as a contract-for-difference hedge that settles whenever market. prices differ from the strike price.
- **Scalable Volume:** Scales easily in tranches, enabling scaling over time without restructuring grid connections.

Green Tariffs

A utility-run programme where renewable energy and certificates are bundled into the electricity bill. Organisation buys clean energy indirectly through the utility, without a separate contract with a generator.

Benefits:

- **Turnkey Setup:** The utility folds renewable energy & RECs into your bill—no need to negotiate with generators.
- **Speed:** Smaller or leased sites can claim renewable supply within a single billing cycle.
- **Fully transfers counterparty, balancing, and scheduling risks** to the utility, freeing internal resources.

Key Strategies to RELOCATE

- **Scale and Structure - Aggregation and Virtual Flexibility:** Aggregate demand across multiple facilities—or in partnership with peers—to access utility-scale wind and solar projects at reduced cost while securing bankable offtake commitments[3]. Use virtual PPA structures to flexibly add or remove sites under a single contract, cutting administrative complexity compared to individual agreements.
- **Geographic Optimisation: Cross-Border and REC Supplementation:** Structure cross-border PPAs that align with your operational footprint and capture regional price arbitrage. For smaller sites or variable loads not covered by the main agreement, use regionally bundled RECs with underlying energy to meet compliance requirements and reinforce environmental claims.
- **Generation-Load Fit: Hybrid and 24/7 Portfolio Approaches:** Combine baseload resources (hydro, geothermal) with variable generation (solar, wind) to closely match load profiles. Go further by building a geographically and technologically diversified portfolio that enables hourly, 24/7 matching—enhancing resilience and carbon credibility while mitigating intermittency risks.

Note: 1. Scaling up off-site renewables via PPAs and feeding a greatly electrified system requires robust grid infrastructure. In reality, many regions face delays and challenges connecting new wind/solar farms due to limited transmission lines or grid congestion. **2.** Implement a robust process (or rely on third-party platforms) to ensure transparent issuance, transfer and retirement of RECs once purchased to prevent double counting and aligning with RE100, CDP, and SBTi disclosure rules. **3.** A common strategy here is Group Captive Power which is a collaborative energy model where multiple organisations co-invest in a power generation facility, often renewable (solar, wind, hydro), to meet their own electricity needs. In a Group Captive Model, 60% to 80% of electricity-related CO_2e emissions can be abated - depending on how much of the electricity demand is replaced by group captive renewable energy.

Source: Amaly Legacy

Sector-Specific Accelerators

To accelerate the decarbonisation of hard-to-abate sectors, tailored interventions must align with each industry's unique operational footprint, infrastructure constraints, and emissions profile. The following sector-specific accelerators showcase high-impact strategies—ranging from renewable integration and electrification to waste-to-energy conversion—that unlock emissions reductions and operational efficiencies.

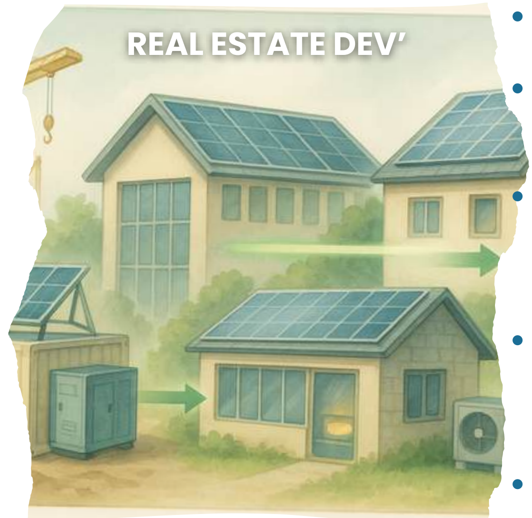
Hard-to-Abate Sector Strategies

- **Airport Solar Microgrids:** Vast roof areas, parking structures, and unused land host solar-PV arrays paired with battery storage and energy-management systems. Onsite microgrid powers terminals, air-side facilities, and electric vehicle chargers.
- **Electric Ground Support Equipment:** Diesel tugs, baggage tractors, and service vehicles are replaced with electric models. Dedicated charging hubs draw from the airport's renewable microgrid.
- **Waste-to-Energy Biogas:** Catering scraps, deplaned food, and other organic streams are processed in anaerobic digesters to create renewable electricity and heat for airport operations, reducing waste-handling burdens, and supplying steady clean power to the microgrid.

Note: Given current energy-storage limits, full battery-electric propulsion is not yet feasible for most deep-sea/long-haul vessels. Near term, we prioritise port-side electrification (shore power/cold-ironing), efficiency, and transitional low-carbon fuels.

- **Renewable Shore-Power Microgrids:** Solar-PV canopies on roofs, yards, and berths combined with batteries and smart controls create a clean microgrid that powers cold-ironing for vessels, cargo-handling equipment, and port lighting—displacing purchased grid electricity.
- **Near-Port Wind Supply:** Offshore or coastal wind arrays feed the same microgrid via direct high-voltage links. Steady wind output covers port loads, charges electric yard equipment, and reduces transmission losses while locking in predictable renewable pricing.
- **Waste-to-Power Biogas:** Anaerobic digestion of galley waste, cargo spoilage, and other organics produces baseload renewable electricity and heat for the microgrid.

- **Offshore Wind-Powered Platforms:** Connect offshore installations to nearby wind arrays, replacing on-board gas turbines with renewable electricity delivered via subsea cables and existing infrastructure.
- **Solar Heat and Power for Refineries:** Combine concentrated solar thermal for process heat with PV arrays for electrical loads; pair both with thermal storage to power operations round-the-clock.
- **Green Hydrogen Supply:** Convert surplus renewable power to electrolytic hydrogen, substituting grey hydrogen in refining; integrate with on-site renewables, reducing fossil-fuel use for heat and feedstock.
- **Hybrid Renewable Microgrids for Remote Sites:** Combine solar, wind, and battery storage into modular microgrids that supply clean, stable electricity to off-grid or remote oil & gas installations.



- **Modular Solar-Battery Sets:** Deploy relocatable PV + battery units to meet construction electricity needs, eliminating diesel generators.
- **Building-Integrated Photovoltaics (BIPV):** Replace conventional façades, roofs, and canopies with solar-active materials that generate onsite electricity while serving as the building envelope.
- **Advanced Building Management Systems (BMS) and AI enablement:** Use IoT-connected sensors to simulate, monitor, and optimise building energy flows in real time to continuously adapt lighting, HVAC, and plug loads based on occupancy and weather forecasts, improving efficiency.
- **All-Electric Buildings with Thermal Storage:** Use heat pumps for HVAC and hot water, induction for cooking, and incorporate thermal mass or phase-change materials to shift loads; the system draws from onsite renewables where available and avoids gas infrastructure entirely.
- **Low-GWP Refrigerants in HVAC:** Replace harmful chemicals used in air conditioning systems with safer, eco-friendly alternatives. Regularly check for leaks to reduce pollution and stay within environmental rules.

Sources: AECOM, ACRP, GE Vernova, Sustainability (Vol. 15, No. 4, Article 3860), IEA Bioenergy, SIA Partners, ARAS Energy, IRENA, Anern, BCC Research, Burohappold, ACEEE, Amaly Legacy analysis.

Clean Energy Project Deployment Matrix for Hard-to-Abate Sectors

Transition from conventional energy sources to clean alternatives requires careful matching of technology capabilities with sector-specific operational requirements. The optimal technology mix varies significantly based on operational patterns, geographic constraints, and process requirements. This analysis demonstrates how each clean energy project type creates unique value propositions across our four hard-to-abate sectors, enabling near-zero market-based Scope 2 emissions.

Strategic Technology-Sector Alignment.

AVIATION	Solar PV Biogas	★★ ★½	• Solar PV on rooftops and parking areas. • Electrified ground support equipment with renewable-powered charging hubs. • Biogas digesters converting waste to energy.

SHIPPING	Wind Solar PV Biogas	★★½ ★★ ★½	• Shore power from solar + battery microgrids. • Offshore wind directly powering port operations. • Biogas digesters for organic port waste. • Solar PV on warehouse and parking rooftops.

OIL & GAS	Wind Solar PV	★★½ ★★	• Offshore wind direct to platforms (50-200 MW). • Solar thermal for refinery process heat. • Hybrid renewable microgrids for remote sites.

CONSTRUCTION AND REAL ESTATE	Solar PV Geothermal	★★ ★★½	• Solar-battery units for construction sites. • Integrated solar (BIPV) on new developments. • All-electric building systems with heat pumps and induction appliances. • Thermal storage for load shifting + peak shaving. • AI-enabled BMS to increase energy efficiency.

> "Advanced economies and China captured more than 80% of global energy transition investments in 2024, while LDCs accounted for less than 2% — a stark imbalance that only more concessional and grant-based financing can begin to address"

Strategic contribution to our report from IRENA

IRENA
International Renewable Energy Agency

Technology Selection Criteria by Sector

Technology selection based on sector-specific fit, crediting potential, and operational benefits has the ability to displace fossil fuels, scale modularly, and support long-term emission reduction and energy cost savings.

- **Solar PV (All Sectors)**
  - **Credit mechanism:** Grid-emission displacement per CDM methodology ACM0002 (grid-connected electricity generation from renewable sources); can be eligible under Verra VCS and Gold Standard.
  - **Sector advantage:** Modular deployment allows rightsizing to available space. Proven long lifespan with minimal maintenance provides predictable long-term emissions reductions. Costs have declined significantly since 2010, making solar PV cost-competitive in many markets without subsidies.
- **Wind (Shipping, Oil/Gas, Aviation)**
  - **Credit mechanism:** Fossil fuel displacement following CDM methodology ACM0002 (grid-connected electricity generation from renewable sources); can be eligible under Verra VCS and Gold Standard.
  - **Sector advantage:** Offshore wind can support 24/7 operations when paired with storage or grid balancing. Direct connection to offshore platforms reduces long-distance transmission losses.
- **Energy Storage and Heat Pumps (Construction and Real Estate)**
  - **Credit mechanism:** Energy-efficiency emissions reductions and heating fuel substitution under Verra methodology VM0008 (Building Weatherisation and Energy Efficiency) or AMS-II.E (for energy efficiency and fuel switching in buildings reactivated by Verra on 4 April 2025).
  - **Sector advantage:** Appropriately sized battery storage can materially increase on-site renewable self-consumption in buildings (site-specific). Heat pumps are more efficient than gas heating; emissions depend on refrigerant choice and grid carbon intensity, with larger gains as grids decarbonise. Combined deployment creates all-electric buildings aligned for grid decarbonisation.

Sources: Verra Amaly Legacy analysis

Pathway 3: Sustainable Sourcing and Circular Supply Chains

Supply chain transformation represents the highest-leverage decarbonisation pathway, with Scope 3 emissions accounting for 70-90% of total corporate carbon footprint in certain industries. We've identified five strategic interventions that, when orchestrated systemically, can achieve significant Scope 3 reduction while unlocking procurement cost savings through waste elimination, risk mitigation, and value chain innovation.

Strategic Framework: The SCALE Supply Chain Transformation Model

Supply chain decarbonisation demands a systematic approach that transforms traditional linear procurement into regenerative value networks. The SCALE model provides executives with an integrated framework that addresses every critical touchpoint where emissions are embedded, costs are incurred, and value can be captured. Unlike piecemeal initiatives that deliver marginal improvements, SCALE orchestrates five interdependent interventions that compound in impact—turning the complexity of Scope 3 emissions into a structured opportunity for competitive advantage.

SELECT - Green Procurement Policies

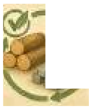
The systematic integration of environmental criteria into purchasing decisions, transforming procurement from cost-only optimisation to total value creation through supplier qualification, category strategies, and contract mechanisms.

COLLABORATE - Supplier Engagement and Targets

The activation of upstream partners through capability building, performance management, and shared value creation to achieve science-based emission reductions across the extended enterprise.

ACCELERATE - Logistics Optimisation

The redesign of transportation networks, modal shifts, and last-mile delivery systems to minimise carbon intensity while enhancing service levels and reducing total logistics costs.



LEVERAGE - Sustainable Raw Material Sourcing

The transition from extractive to regenerative material flows through alternative inputs, certified sources, and closed-loop systems that decouple growth from resource depletion.

EXTEND - Product Lifecycle Management

The evolution from linear take-make-dispose models to circular value retention through design for sustainability, service transformation, and end-of-life value recovery.

Insight on EXTEND

"The circular economy is critical to corporate net-zero pathways because it tackles the material intensity of growth, where the majority of value-chain emissions reside. By designing products and systems for extended use, repair, and remanufacture, companies can decouple revenue from virgin resource extraction and the associated carbon load. This approach delivers durable emissions reductions that compound over time, complementing energy transition measures and enhancing long-term resilience"

RANA HAJIRASOULI
Chief Executive Officer
The Surpluss

Framework Summary: From Theory to Execution

The SCALE model transforms abstract sustainability commitments into concrete business actions. Each element builds upon the previous, creating a reinforcing cycle: SELECT establishes the foundation through procurement policies, COLLABORATE activates the supply base, ACCELERATE optimises physical flows, LEVERAGE transforms material inputs, and EXTEND captures value across multiple lifecycles. This systematic progression ensures that investments in one area amplify returns in others—procurement policies enable supplier collaboration, which unlocks material innovation, which enables circular design. The following implementation architecture translates this strategic framework into actionable programmes with measurable outcomes.

Sources: Carbon Trust, Amaly Legacy analysis

SELECT - Green Procurement Policies

SELECT – Green Procurement Policies puts sustainability on equal footing with cost, quality and delivery by embedding carbon considerations directly into purchasing decisions. By mandating supplier emissions disclosure, applying carbon-weighted total-cost-of-ownership, and setting green-procurement thresholds, organisations can systematically steer spend toward lower-carbon inputs. In short, SELECT transforms procurement from a compliance checkbox into a strategic accelerator of decarbonisation and competitive advantage.

Strategic Imperative: Embed sustainability as core procurement criterion alongside cost, quality, and delivery

Sector	Priority Categories	Procurement Levers
All Industries	Energy, logistics, materials, services	• Mandatory carbon disclosure in RFPs • Total Cost of Ownership (TCO) with carbon pricing • Supplier sustainability scorecards • Green procurement thresholds by category
Aviation	Aircraft, fuel, catering, ground equipment	• Evaluate suppliers using TCO that includes a shadow carbon price aligned with CORSIA-eligible carbon credit benchmarks and SAF emission-reduction values.
Shipping	Vessels, fuel, port services, containers	• Prioritise the procurement of low-carbon fuels, energy-efficient vessels, and green-certified port and logistics services that comply with "green corridor" emission-intensity standards and clean-fuel mandates.
Oil & Gas	Steel, chemicals, equipment, services	• Adopt low-carbon procurement standards by sourcing certified low-emission materials, equipment, and services, and by requiring suppliers and EPC contractors to meet defined process-emission caps and methane-reduction standards.
Construction and Real Estate Development	Concrete, steel, fit-out, MEP systems	• Set maximum allowable "embodied carbon" (the CO_2 emitted in producing materials like steel and concrete) for building projects, and require Environmental Product Declarations (EPDs) from suppliers to verify those carbon footprints.

Importance of Green Procurement Policies

"Procurement is a powerful climate lever that companies already control, delivering tangible, near-term returns. By embedding sustainability criteria into RFPs, organizations send a clear and credible signal of commitment to both the market and stakeholders. Specify cleaner options with the same rigor applied to price and quality. Additionally, implementing a Supplier Code of Conduct and sharing sustainability guidance ensures alignment with environmental and social targets, including human and labour rights."

NADIA BOUMEZIOUT
Head of Sustainability & Information Governance, Zurich Middle East
ZURICH

Value Creation Mechanisms:

- **Carbon-Adjusted Bid Evaluation:** Weight carbon profile of bidding suppliers/vendors at 15–30% of the total evaluation score, translating their emissions to financial equivalents using an internal carbon price. Incorporating a carbon price into bid evaluations often alters the TCO — suppliers that appear least expensive on initial price can become costlier once their carbon impacts are factored.
- **Category-Specific Decarbonisation Roadmaps:** Develop 2030/2040 emission-reduction glidepaths for priority spend categories representing the majority of procurement emissions. **Example:** Aviation catering vendor must achieve 50% reduction by 2040 through zero-waste operations, and renewable-powered facilities.
- **Preferred Supplier Programmes:** Create tiered supplier status with preferential terms (payment, volume guarantees) for sustainability leaders. Top-tier suppliers can receive price premiums, justified by reduced risk, innovation value, and carbon savings. **Example:** American retail giant "TARGET Corporation" reports suppliers covering 71% of spend had set science-based targets (2023).

Sources: Target Corporation, Amaly Legacy analysis

COLLABORATE - Supplier Engagement and Targets

Translating strategic intent into operational reality requires more than frameworks—it demands specific interventions tailored to industry realities while maintaining universal principles. The following implementation architecture provides both the common foundation applicable across sectors and the nuanced applications that respect the unique challenges of aviation, shipping, oil & gas, and real estate. Each pillar includes quantified targets, proven methodologies, and real-world examples that demonstrate feasibility at scale.

Strategic Imperative: Shift suppliers from "checkbox compliance" to value-creating co-innovators.

We designed an **Engagement Maturity Model** to provide a clear, strategic pathway to transform supplier decarbonisation from a compliance-driven exercise into a source of measurable competitive advantage. **Level 1 (MEASURE),** establishes transparency and trust by **capturing reliable baseline emissions data**, **identifying high-impact reduction opportunities across supply chains**. **Transitioning to Level 2 (MOBILISE)** shifts focus from visibility to action, strategically **guiding suppliers to set credible, science-based targets aligned with business outcomes**, backed by targeted support and incentives to ensure successful execution. Ultimately, at **Level 3 (MONETISE)**, sustainability becomes self-reinforcing as **emissions performance is directly linked to commercial benefits—unlocking preferential pricing, innovative financing mechanisms, and shared gains** through joint decarbonisation investments. Progressing through this model secures immediate cost and risk reductions as well as strategically positions the organisation and its supply chain to capture long-term value.

1 MEASURE: Data Collection

Objective: Establish baseline emissions data and create visibility across the supply chain

Best Practices

- **Unified Platform Approach:** Deploy a single data collection system to reduce supplier burden
- **Tiered Requirements:** Risk-based approach - detailed data for top spend tiers, simplified for long tail
- **Capability Building:** Provide free carbon accounting tools and training
- **Incentive Alignment:** Link data quality to preferred supplier status and payment terms

2 MOBILISE: Target Setting (SBTI)

Objective: Activate suppliers to set science-based targets and develop reduction roadmaps

Best Practices

- **Supplier Academies:** Cohort-based learning that reduces per-supplier costs
- **Target Financing:** Offer 0% loans for suppliers committing to the SBTi
- **Peer Benchmarking:** Anonymous performance dashboards that drive competitive improvement
- **Long-term Commitments:** multi-year minimum contracts for suppliers with validated targets

3 MONETISE: Value Sharing (Green Premiums)

Objectives: Establish financial mechanisms that make decarbonisation profitable for suppliers

Best Practices

- **Dynamic Pricing Models:** % price increase per % emissions reduction achieved
- **Innovation Funds:** Joint funds for breakthrough technology deployment
- **Carbon Credit Sharing:** Split verified emission reductions between supplier and buyer (e.g. 70/30 split)
- **Performance Guarantees:** Suppliers guarantee emissions reductions or face penalties

Sources: Amaly Legacy analysis, including primary interviews

COLLABORATE - Supplier Engagement and Targets by Relevant Protocols

This slide maps the end-to-end "Measure → Mobilise → Monetise" journey of our Scale Framework, showing how each reporting layer underpins Pathway 3: Sustainable Sourcing and Supply Chain in our report. By first establishing rigorous data collection and verification (Measure), then equipping suppliers with clear, science-based targets (Mobilise), and finally embedding verified carbon credits into product pricing and financing instruments (Monetise), organisations can systematically drive decarbonisation, align procurement with net-zero goals, and unlock shared commercial value across their entire supply chain.

Reporting Stack Layer	Purpose	Protocols	Relationship to GHG numbers
Measurement and Accounting	Establish how tonnes of CO_2e are calculated	• **GHG Protocol Corporate Standard:** Provides the global accounting rulebook for organisational GHG inventories	Source data are compiled strictly to these rules.
Verification and Assurance	Provide confidence that numbers are correct	• **ISO 14064-1 and 14064-3:** Offer independently certifiable requirements for quantifying and verifying emissions	Auditors certify that emissions follow Layer 1 protocols.
Buyers and Stakeholder Disclosures	Create a single disclosure channel for buyers to capture supplier ESG data	• **GRI 305: Emissions —** Buyers disclose their own and their suppliers' greenhouse gas emissions (Scopes 1, 2 and 3) • **CDP Supply Chain:** Buyers use the CDP Supply Chain questionnaire to request and score standardised environmental data from suppliers, enabling transparent supply chain emissions reporting and informed procurement decisions	Import same GHG inventory, then add topic-specific KPIs.
FP&A and Risk Management	Integrate climate risk and opportunity into financial reporting and decisions	• **IFRS S1/S2:** Top of the stack - same rigour as financial IFRS, but for sustainability data. They replace TCFD as the investor-facing climate template. • **TCFD Recommendations:** Four-pillar framework (Governance, Strategy, Risk Management, Metrics and Targets) to translate emissions into risks and opportunities	IFRS S2 has absorbed TCFD's four-pillar architecture.
Supplier Engagement and Target Setting	Activate suppliers to set **science-based targets** and draft reduction road-maps	• **SBTi Corporate Standard:** Companies set clear, science-based emissions-cutting goals aligned with limiting warming to 1.5°C—either as a total emissions reduction or per unit of output. • **SBTi FLAG (Forest, Land and Agriculture):** Tailored guidance for forest, land and agriculture; companies set targets for land-related emissions and removals. • **ISO 50001 and ISO 14001:** Companies establish ongoing improvement systems for energy use (ISO 50001) and wider environmental impacts (ISO 14001) to regularly track and reduce emissions.	Baseline inventory from Layers 1–2 is used to set 5–10 yr supplier targets; annual progress re-feeds GHG ledger

Value Sharing and Green Premiums	Link emission reductions to commercial benefits and financing	• **Verra, Gold Standard, Plan Vivo Carbon Credit protocols and methodologies**
		  ◦ ***Internal Carbon Pricing:*** *Companies can use pricing of these credits to assign an internal monetary value per tonne of CO_2e, integrating carbon costs into business decisions and product pricing.*
		  ◦ ***Green-Premium Pricing:*** *Suppliers can attach verified carbon credits directly to products or services, enabling buyers to transparently pay a premium for guaranteed emission reductions.*
		• ***Sustainability-Linked Loan Principles (LMA/APLMA/LSTA) and ICMA Sustainability-Linked Bond Principles:*** KPI-linked ratchets adjust the cost of financing (step-up/step-down for loans)
			Each tCO_2e reduced or avoided is monetised through: embedded carbon credits/price differentials, KPI ratchets in financial instruments

Relevant to LEVEL 1: MEASURE - Data Collection from Suppliers

Relevant to LEVEL 2: MOBILISE - Target Setting by Suppliers

Relevant to LEVEL 3: MONETISE - Value Sharing with Suppliers

Sources: GHG Protocol, ISO, Global Reporting (GRI 305), SBTi, CDP, IFRS, ICMA, Mayer Brown, Amaly Legacy analysis

ACCELERATE - Logistics Optimisation

Decarbonising logistics follows a clear, proven sequence: first optimise existing operations, then shift to cleaner transport modes, electrify fleets when ready, and use digital tools throughout. Each step supports the next—improving efficiency makes cleaner transport options possible, and adopting cleaner transport modes sets the stage for electrifying vehicles. This structured approach maximises carbon reductions while minimising costs across global supply chains.

Network Design

Redesign distribution networks for minimum distance and maximum consolidation through hub optimisation, cross-docking, and milk runs

Modal Shift

Transition from high-carbon (air, road) to low-carbon transport modes (rail, maritime, pipeline) for suitable routes and cargo types

Fleet Transition

Replace fossil-fuel vehicles with electric, hydrogen, or biofuel alternatives across owned and contracted fleets

Digital Twins Optimisation

Deploy AI-powered route optimisation, load matching, and predictive analytics to maximise asset utilisation and minimise empty miles

Detailed cost-benefit analysis is critical for optimal profitability

Strategic use of carbon credits to be considered to enhance ROI

Notes: 1. Milk Run: A milk run is a logistics route where a single vehicle makes multiple pickups or deliveries from/to several suppliers or customers in one trip, following a fixed schedule and route. **2. Cross-docking:** Cross-docking is a logistics strategy where incoming goods are unloaded from supplier trucks and directly loaded onto outbound vehicles with little or no storage in between.

Breakthrough Strategies by Transport Mode:

It's imperative to explore breakthrough strategies by mode when exploring logistics optimisations. A few notable examples within the context of some of the hard to abate sectors we explored earlier in this report include:

- **Maritime:** Slow-steaming protocols (e.g., 10% speed reduction ≈ ~13–20% CO_2/fuel reduction; exact values vary by ship and route) combined with AI route optimisation considering weather, currents, and port congestion. Green shipping corridors with guaranteed clean fuel availability enable first-mover advantage on zero-emission vessels.

- **Aviation:** SAF procurement at scale through long-term offtake agreements. Book-and-claim systems (SAF certificates) let buyers claim the lifecycle emissions-reduction attributes of SAF even when physical SAF isn't available at specific airports. Optimise flight planning for fuel efficiency (continuous descent/optimised profile descent reduces fuel use)

- **Ground:** Electric or hydrogen fleets for last-mile delivery with strategically located charging and refuelling infrastructure. Urban consolidation centres reduce delivery mileage while enabling night-time deliveries with quiet electric vehicles. Intermodal shifts from road to rail achieve significant emission reduction for long-haul routes.

Sources: Penske, Netsuite, Seas at Risk, CE Delft, RSB, SABA, McKinsey, EEA, IATA, WEF, NAPA, Amaly Legacy analysis

LEVERAGE - Sustainable Raw Material Sourcing

The transition from linear extraction to circular material flows represents the most fundamental shift in industrial strategy since the advent of mass production. Current material systems—built on assumptions of infinite resources and zero-cost disposal—face physical, regulatory, and market constraints that make transformation inevitable. The following roadmap eases the journey from an extractive baseline to a circular target state, identifying the technologies that will enable each sector to maintain growth while dramatically reducing virgin material dependence. Success requires reimagining materials not as consumables but as assets cycling through multiple value loops.

Strategic Imperative: Decouple value creation from virgin resource extraction

	Material Type	Transition Target	Transition Description	Tech Enabler
	**Fossil-Based**	• ↓virgin petroleum/gas derived • ↑ recycled/bio-based	Shift from extraction to circular feedstocks and renewable alternatives	• Chemical recycling • Biorefinery systems • Separation and purification
	**Metals**	• ↓ virgin ore extraction • ↑ recycled	Maximise urban mining and infinite recycling loops	• Urban mining, • Sorting and separation • Hydrometallurgical recycling
	**Biomaterials**	• ↑ certified	Ensure all biological inputs meet ecological and social standards	• Blockchain traceability • Satellite monitoring
	**Minerals**	• ↓ virgin mining • ↑recycled	Reduce absolute consumption while maximising recovery	• Material substitution • Efficiency tech

Shifting from extraction to circularity requires more than intent — it requires scalable tech

- **Biorefinery systems (TRL 4-6):** Convert biomass into chemical building blocks that can replace petroleum-derived materials
- **Chemical recycling technologies (TRL 5-7):** Breaks down plastics into reusable chemicals
- **Advanced separation and purification (TRL 6-8):** Enable efficient recovery and processing of recycled materials to meet quality standards

- **AI-powered urban mining tech (TRL 4-6):** Extract valuable metals from electronic waste using automated disassembly
- **Advanced sorting and separation (TRL 5-7):** auto-identification, sorting and separation of metals
- **Hydrometallurgical processing (TRL 7-9):** Water-based extraction methods that are more environmentally friendly than traditional smelting

- **Material substitution technologies (TRL 3-6):** Develop alternative materials or reduce critical mineral dependence through engineered composites
- **Precision extraction techniques (TRL 5-7):** Precision mining with reduced environmental impact
- **Efficiency optimisation systems (TRL 6-8):** Process automation and AI-driven optimisation to minimise waste and maximise production yield

Sources: IEA, US DoE, NIST, Fraunhofer, Closed Loop Partners, EU Commission, Eunomia Research & Consulting, French Ministry of Higher Education, Research and Space, NETL, Amaly Legacy analysis

EXTEND - Product Lifecycle Management

The shift from linear to circular economics fundamentally redefines value creation. Traditional models extract maximum profit from single-use products, externalising disposal costs and environmental impacts. The circular model captures value repeatedly through multiple use cycles, turning end-of-life liabilities into next-cycle assets. This framework highlights the impact: products designed for disassembly, durability, and biological cycles can generate higher lifetime value while reducing emissions (results vary by sector and design). The results are compelling when a product can generate value through multiple lifecycles instead of a single use, circular design becomes a competitive imperative rather than a sustainability nice-to-have.

Strategic Imperative: Design out waste and emissions through circular business models

- **Traditional Linear Model:** Extract → Make → Use → Dispose **Value:** $X **Emissions:** 100%
- **Circular Value Model:** Design → Make → Use → Recover → Regenerate **Value:** often lower manufacturing cost vs new **Emissions:** lower (varies by sector)

Circular Business Model Innovation: Design for X Framework

Product lifecycle management transformation requires three integrated strategies that work synergistically - **The Design for X framework.** This framework transforms product development from a linear engineering exercise into a strategic value creation process. Each design principle addresses specific lifecycle stages while creating compounding benefits across the value chain. **Design for Disassembly** reduces end-of-life costs while enabling component reuse. **Design for Durability** extends asset life through enhanced maintenance, digital tracking, and refurbishment, significantly reducing lifecycle costs. **Design for Dematerialisation** eliminates and cuts material inputs while delivering required utility via innovative models. When combined with capturing value at the end of the product life, these strategies create products that generate value continuously rather than depleting it through use.

Design for X Strategies:

- **Design for Disassembly:** Modular product designs enabling material recovery.
  - ***E.g.*** *Arup's guidance recommends prefabricated, bolted steel connections that allows components to be disassembled and reused (unlike conventional structures sent to landfill).*
- **Design for Durability:** Extends asset life through advanced materials, predictive maintenance, and lifecycle traceability (digital traceability).
  - ***E.g.*** *Emirates' aircraft interior refresh initiative extends cabin life while reducing waste.*
- **Design for Utility:** Service-based models replacing physical products.
  - ***E.g.*** *Airbus' Flight Hour Services provides airlines with access to spare parts, maintenance, and technical support on a fixed hourly-rate basis. By outsourcing fleet support, airlines avoid stockpiling parts, cut inventory costs, and improve aircraft availability.*

End-of-Life Value Capture:

- **Take-Back Programmes:** Contractual mechanisms ensuring material recovery.
  - ***E.g.*** *Apple's device return initiative recovers materials, reducing virgin material demand.*
- **Component Harvesting:** Systematic recovery of high-value components for remanufacturing.
  - ***E.g.*** *Instead of sending decommissioned planes to scrap - Lufthansa Technik's aircraft teardown operations systematically recover high-value components.*
- **Biological Cycles:** Compostable materials for short-lifecycle products.
  - ***E.g.*** *Dubai Airports' waste management initiative diverts **more than 2,000 tonnes** of food waste from landfill annually through composting.*

Conclusion: SCALE Transformation's Compounding Effect

The power of the SCALE implementation lies not in individual pillars but in their orchestrated deployment. **SELECT** creates the market signals that make **COLLABORATE** profitable for suppliers. **ACCELERATE** reduces the carbon intensity of what cannot be eliminated. **LEVERAGE** transforms remaining inputs from extractive to regenerative. **EXTEND** ensures materials maintain value across multiple cycles. Together, these pillars create a self-reinforcing system where each intervention amplifies the others—green procurement policies drive supplier innovation, which enables sustainable materials, which facilitate circular design, which justifies premium pricing. Org's implementing all five pillars can translate to greater emission reductions and higher cost savings than those pursuing selective initiatives (supply chain decarbonisation thus becomes one integrated strategic transformation).

Sources: Arup, Bloomberg, Collins Aerospace, Emirates Airline, Airbus, Apple, Lufthansa, Dubai Airports, Amaly Legacy analysis

Optimising PPA and Carbon Credit Portfolios: Portfolio Score

Traditional PPA portfolio optimisation frameworks have often prioritised cost minimisation and risk hedging at the expense of emergent value drivers like carbon credit monetisation. Our analysis, demonstrates that integrating carbon credit revenue streams—particularly from high-integrity NbS—can significantly offset PPA costs, reshaping the economic calculus of renewable procurement. Our framework aims to offer a data-centric lens, distilling multifaceted trade-offs into a unified, comparable score that harmonises fiscal prudence with environmental stewardship ensuring portfolios achieve net-zero alignment and long-term ecosystem value.

The Enhanced Portfolio Optimisation Formula

To ensure precision and comparability across diverse metrics, we normalise each factor on a 0–1 scale—where 0 represents values for penalties (e.g., cost, volatility) and 1 for benefits (e.g., additionality, revenue). This enables a penalty-oriented scoring model that encourages decarbonisation impact.

$$\textbf{Portfolio Score} = (\text{Cost} \times w_1) + (\text{Volatility} \times w_2) + ((1 - \text{Additionality}) \times w_3) + ((1 - \text{24/7\_Coverage}) \times w_4) + ((1 - \text{Diversity}) \times w_5) + ((1 - \text{Carbon\_Income}) \times w_6)$$

OBJECTIVE: optimise and assess portfolio quality to balance financial, environmental, and operational KPIs.

Legend and Notes:

- **Cost =** Adjusted LCOE / MaxLCOE (MaxLCOE = the highest observed Adjusted LCOE across all PPA + Carbon Credit ("**CC**") options).
  - ***Note:*** *This Adjusted LCOE is the average cost of electricity (Contract price + RECs + regular fees) plus net CC spend (converted to \$/MWh). Lower Adjusted LCOE means cheaper energy + carbon, which improves the project's overall score.*
  - ***Factor in:*** *grid savings vs. grid (%), credit cost efficiency (\$/t CO_2e = net dollars per verified tonne vs. the PPA alternative).*
- **Volatility =** Volatility/MaxVolatility (MaxVolatility= highest expected or historical standard deviation (\$/MWh) among candidate PPAs & CC)
  - ***Note:*** *score close to 1 means unstable prices (risky); a score near 0 means stable, predictable costs (safe).*
- **Additionality =** Binary value (1 for new-build, 0 otherwise)
  - ***Note:*** *New-build = you're helping create new renewable projects, not just buying from old ones. Where a score of 1 means you're adding clean power to the grid (climate-positive) and Score of 0 = you're just shifting ownership (no real climate benefit).*
- **24/7_Coverage =** Coverage percentage / 100 (shows the share of hourly demand matched by clean energy).
- **Diversity =** Inverse Herfindahl-Hirschman Index (HHI) (0-1);
  - ***Note:*** *The regular HHI gives a higher score for more concentration (which is worse for energy portfolios). The inverse flips it so a higher score = better diversity. If all your power comes from just one source, your score is 0 (very risky). If your power comes from many different sources, your score moves closer to 1 (more balanced and less risky).*
- **Carbon_Income =** Income / MaxCarbonIncome (MaxCarbonIncome = highest projected average income per ton of CO_2e for carbon credit sales in addition to respective income from the monetised co-benefit)
  - ***Note:*** *Carbon_Income represents the average* ***income received from each carbon credit sold*** *(usually per ton of CO_2e emissions avoided or removed),* ***including net income from monetised co-benefits****. Projects generating more valuable credits—meaning sold at higher prices, operate with a lower cost base, and derive higher net income from co-benefits—receive a higher score in the model.*

Weights (w_1 to w_6) must sum to 1.0 and reflect the strategic priorities of the buyer (e.g., cost efficiency, impact, risk aversion). Tailor via materiality: Cost-focused (w_1=0.30, w_6=0.20); Impact-focused (w_3=0.25, w_6=0.20); Balanced (equal).

Calibration steps:

- Conduct materiality analysis (stakeholder or board-aligned).
- Assign initial values (e.g., equal weighting, or emphasise Cost and Carbon Income).
- Validate via scenario testing (±10%) to assess sensitivity of final scores.
- Rebalance annually or when carbon markets or load profiles materially shift.

** Additionality, Diversity, Carbon_Income assume proper credit and REC issuance, transfer and retirement systems and mechanisms to avoid double counting and validate high-integrity claims under registries/standards like Verra (VCS), Gold Standard, ACR, or I-REC.*
*** This structure accommodates sensitivity testing and aligns with advanced linear programming for scalable optimisation.*
****** Co-benefits and Brand Enhancement:*** *Projects with verified biodiversity, water security, livelihood impacts and other co-benefits directly align with ESG goals, enhancing stakeholder resonance and social licence (raising Strategic Fit score).*
***** NbS should be used as a bridge within a diversified mix to maximise impact and reduce risk of greenwashing.*

Optimised Implementation

Portfolio Score represents a bespoke scoring mechanism, distinct from conventional portfolio optimisation methodologies. Its utility lies in assessing portfolios through a wider lens than solely financial risk and return. However, the efficacy of this approach hinges on the precise definition of its constituent metrics and the judicious allocation of their corresponding weights. The implementation framework begins with a baseline analysis assessing hourly loads, grid intensities, and operational tolerances, then calibrates weightings aligned with organisational priorities around cost-efficiency, impact maximisation, or balanced approaches. Using linear programming, portfolios are optimised by minimising the composite score while adhering to constraints on volume, market concentration, and counterparty exposure, with scenario-based sensitivity to varying carbon prices. Regular recalibration ensures adaptation to market developments, particularly rising demand for high-integrity credits like NbS. Leveraging these credits provides the lowest cost route to compliance with certain regulatory requirements, fosters government and public support through extensive co-benefits, unlocks preferential financing terms or entirely new financing channels and enables the decarbonisation division to **transition from a cost centre into a profit-generating unit** by accessing new revenue streams, enhancing portfolio resilience and accelerating decarbonisation objectives.

Sources: Amaly Legacy analysis

Optimising PPA and Carbon Credit Portfolios: Total Incremental Financial Benefit (TIB)

The Portfolio Score helps in selecting the right mix of decarbonisation assets by balancing cost, risk, and impact — in short, it **guides where to invest**. But **decision-makers still need to know: What's the actual financial upside?** That's where the **Total Incremental Financial Benefit (TIB)** comes in. TIB directly quantifies how much value decarbonisation actually creates in dollar terms — from new revenue streams, operational savings, and monetised byproducts. It translates high-level portfolio decisions into tangible cash flow gains.

$$TIB = \sum_{i=1}^{n} (\Delta R_i + S_i + NBI_i)$$

$$\text{Decarbonisation ROI} = \frac{TIB}{\text{Total Investment Cost}} \times 100$$

OBJECTIVE: assess decarbonisation financial ROI aiding project selection to form part of portfolio.

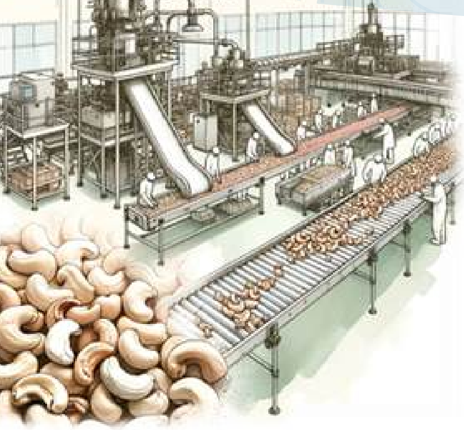
Legend & Notes:

- **TIB** = Total Incremental Financial Benefit (in currency units, e.g., $/portfolio/year).
- n = Number of projects in the portfolio.
- $\Delta R_i = R_{post,i} - R_{base,i}$ incremental revenue for project **i** (e.g., carbon credit sales at market price × tonnes avoided).
- $S_i = C_{base,i} - C_{post,i}$ Cost savings for project **i** (e.g., energy bill reduction from efficiency upgrades).
- $NBI_i = R_{bp,i} - C_{bp,i}$ Net byproduct income for project **i**:
  - $R_{bp,i}$: Revenue from byproducts (e.g., sales of CO_2-derived methanol at $X/tonne × volume produced, or resins from NbS projects).
  - $C_{bp,i}$: Costs of byproduct generation/sale (e.g., processing equipment, logistics; often lower in NbS due to natural processes).
- **Incremental Revenue Increase (ΔR):** captures additional income generated from decarbonisation activities like selling carbon credits, or revenue from certified low-carbon products - difference between post-implementation revenue and baseline revenue (pre-decarbonisation).
- **Cost Reduction (S):** Measures savings from lower operational expenses, like reduced energy consumption, maintenance costs, or risk-hedging benefits (e.g., avoiding carbon taxes or fuel price volatility) calculated as baseline costs minus post-implementation costs.
- **Net Byproduct Income (NBI):** This is a refinement to account for value created from waste or byproducts in carbon projects. Examples include:
  - ***e.g.* CDR/CCU projects:** converting captured CO_2 into sellable products like synthetic fuels, chemicals, or polymers.
  - **e.g. In bioenergy or waste-to-energy projects:** generating electricity, biogas, or fertilisers from organic waste.
  - **e.g. EOR projects:** using CO_2e (though controversial), additional oil production revenue.
  - **e.g. NbS:** byproducts such as sustainable timber, non-timber forest products (e.g., nuts, resins), bio-materials from managed habitats.
  - These byproducts turn "waste" (e.g., CO_2 streams, biomass residues, or ecosystem outputs) into revenue, but we must subtract associated costs (e.g., processing, transportation, or compliance). **NBI = Byproduct Revenue - Byproduct Costs.**
  - ***Note:*** *Our report encourages NbS as they often excel due to* ***i) relatively lower cost while achieving compliance requirements****; **ii)*** *ability to* ***generate superior revenue from products****;* ***iii)*** *significant co-benefits to communities that* ***aid public & government support.***
- **Ensure Precision and Incrementality:**
  - All terms are "incremental," comparing post-decarbonisation outcomes to a baseline scenario.
  - Use time-discounted values if evaluating over multiple years (e.g., net present value) accounting for long-term decarbonisation ROI.
  - Exclude sunk costs or non-incremental items to avoid double-counting with the original Portfolio Score.
- **Combine into a Single Metric:**
  - Sum the components to get TIB, which represents the net positive cash flow contribution from decarbonisation. This can be used standalone or to compute ROI (e.g., TIB / Total Investment).
  - Formula assumes positive values for increases/savings; negative values would indicate adverse impacts.
- **Investment gate:** accept only projects where **TIB ≥ Project Cost + (Hurdle Rate × Capital).**
  - **Hurdle rate =** minimum return for projects that exclude carbon-price revenue.
- **Relevance to Portfolio Score:** TIB can feed back into the score's optimisation loop. For example, if TIB reveals high NBI from NbS projects, you could adjust the Portfolio Score's diversity or carbon revenue weights upward to favour NbS, reducing overall volatility while amplifying financial returns—creating a virtuous cycle for sustainable portfolios.

Portfolio Score + TIB to Achieve Optimal Decarbonisation ROI

TIB ties directly back to the Portfolio Score by serving as a complementary metric assessing decarbonisation financial ROI aiding project selection to form part of the portfolio. While the Portfolio Score optimises for overall portfolio health—emphasising decarbonisation ROI through weighted factors like cost minimisation, volatility reduction, diversity, carbon revenue enhancement, and coverage—it primarily hedges risks and ensures long-term sustainability. TIB, in contrast, zooms in on the quantifiable financial upsides (revenue growth and cost savings) that arise post-optimisation, providing a clearer picture of how Portfolio Score-driven decisions translate into bottom-line gains. By integrating TIB, you can iteratively refine the Portfolio Score's weights (e.g., boosting the carbon revenue or diversity factors) to prioritise projects with superior incremental benefits, ultimately enhancing net-zero alignment and ROI. Higher Portfolio Scores signal deeper decarbonisation that may require higher upfront costs, but by translating long-term savings and revenues into cash-flow gains, TIB bridges ambition with financial return—enabling a clear flow from Portfolio Score to TIB to final investment decision.

Sources: Amaly Legacy analysis



Cashew Processing Plant Case Study

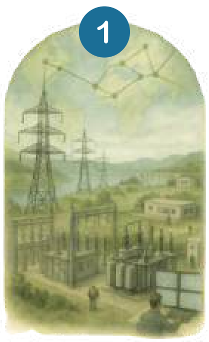
This analysis applies the Portfolio Score and TIB models, previously explored in the report, to a cashew processing plant in **Tanzania**. This facility's processing capacity is **45,000 metric tonnes of raw cashew nuts** annually, producing high-quality **cashew kernels** and **cashew nut shell liquid (CNSL)** used in industrial applications. The residual waste—deoiled cashew shells—offers an additional resource for energy generation and agricultural fertiliser production, thus furthering circular economy principles.

Objective: Reducing Scope 3 Emissions for Premium Pricing of Cashews

Clients (large supermarkets) of such cashew processors increasingly require low-carbon products, offering premium prices for cashews with lower emissions to ensure scope 3 emissions are not negatively impacted.

Real Impact on Financing: Besides voluntary net zero targets, some of these clients are portfolio companies of public listed funds or are listed with significant pressure from ESG analysts and ESG trackers/indices that could impact their share price; while others have debt financing considerations where their cost of financing could be negatively impacted with higher emissions.

Using Portfolio Score and TIB to Chose Optimal Decarbonisation Option



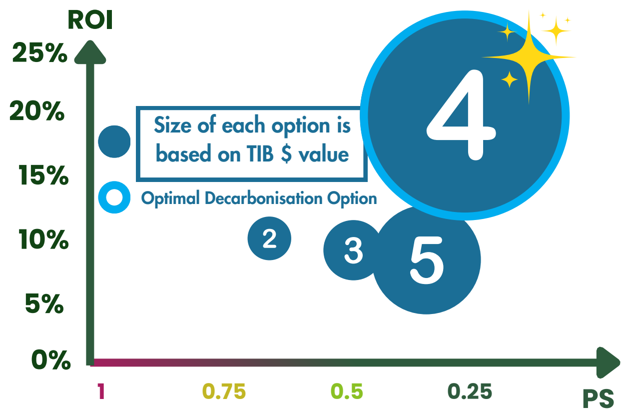
Option 1: Grid Only
Relying solely on Tanzania's national grid.

Option 2: Grid + Solar
Supplementing grid electricity with solar PV.

Option 3: Grid + Solar + Biogas
Integrating grid with solar PV and biogas (powered by deoiled cashew shells)

Option 4: Grid + Solar + Biogas + Forest Carbon Project
Same as Scenario 3 with an additional Investment in an external large-scale forestry carbon project generating high-integrity carbon credits.

Option 5: Grid + Solar + Biogas + Regen Ag
Same as Scenario 3 with additional regenerative farming carbon project development with farmers they source from



Assumptions	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
S ($/yr)	-	290,672	507,172	507,172	507,172
ΔR ($/yr)	-	350,011	350,011	3,434,418	491,611
Total investment ($)	-	6,200,000	9,800,000	18,700,000	10,900,000
TIB ($/yr)	-	640,683	857,183	**3,941,590**	998,783
Return on Investment (ROI)	-	10.33%	8.75%	**21.1%**	9.16%
Portfolio Score (PS)	1.000	0.667	0.464	**0.297**	0.357

Portfolio Score, TIB, and ROI are calculated under equal weighting (1/6 each) for Cost, Volatility, Additionality, 24/7 Coverage, Diversity, and Carbon Income. The annual electricity load is constant at 10,850 MWh, with a baseline grid price of $82.10/MWh and a solar export rate of $83.40/MWh (TANESCO tariff). Energy costs (Adj. LCOE) calculations explicitly exclude carbon revenue to avoid double-counting in the Cost metric, as carbon revenues are separately accounted for under the Carbon Income metric. Volatility incorporates fuel (40%), FX (20%), regulatory (20%), and generation profile risks (20%). Carbon Income assumes investor net proceeds after distributing 70% of net carbon revenue to local stakeholders. Byproduct value was excluded from this analysis.

Using Portfolio Score and TIB/ROI provides clear insights for decarbonisation strategies. Scenario 4 is the best option offering optimal balance of financial returns (**ROI of 21%** and **TIB of $4M annually**) and superior environmental performance (**lowest Portfolio Score of 0.297**). This scenario leverages high-integrity carbon credits, significantly reducing net emissions while providing robust economic benefits. Additionally, the inclusion of biogas from cashew shell waste ensures stable renewable energy generation and further enhances sustainability by producing organic fertilisers for local farmers they source raw cashew nuts from.

Sources: Amaly Legacy analysis

Charting the Course to Net Zero with An Integrated Decarbonisation Architecture

We approach decarbonisation as a profound opportunity to reshape business models, creating sustainable competitive advantage. In concluding the Decarbonisation Pathways section of our report, we synthesise insights from Pathways 1 (Internal optimisation and Circular Economy), 2 (Energy Transition), and 3 (Sustainable Sourcing and Circular Supply Chains) into a cohesive "**core engine**". At its core lies the recognition that while internal levers drive most emissions reductions, external instruments—particularly PPAs and carbon credits—act as critical accelerators "**acceleration layer**", enabling organisations to achieve net-zero goals cost-effectively. We emphasise the strategic use of carbon credits, particularly NbS, as essential tools for addressing residual emissions, strengthening ecosystem resilience, and delivering broad-based stakeholder value. The Integrated decarbonisation architecture we laid out in this report positions organisations to achieve net-zero where the core engine provides fundamental direct control and innovation, while the acceleration layer harmonises the approach while amplifying impact.

Core Engine: 3 Pathways to Decarbonisation

Our approach to emission reduction harnesses 3 pathways: **Pathway 1 –** Internal **optimisation and Circular Flows**, which uses internal levers to reduce emissions and creates closed-loop systems by converting waste into value-added products; **Pathway 2 – Energy Transition**, which reduces emissions by electrifying processes and optimising energy systems; and **Pathway 3 – Sustainable Sourcing and Circular Supply Chains**, which embeds sustainability across supply networks. Together, these pathways deliver the majority of emissions reductions, embedding decarbonisation into operations while driving efficiency and resilience.

Acceleration Layer: Outsourcing for Scalable Impact

Even the best internal measures hit limits—residual emissions that are costly or impractical to eliminate. PPAs and carbon credits provide an acceleration layer, turning these hard-to-abate emissions into opportunities for leveraged impact.

- **PPAs** function as a strategic hedge, securing renewable energy flows without asset ownership. Whether physical (for direct grid integration) or virtual (for financial stabilisation), they elegantly address energy-related residuals, particularly in Pathway 2. Deploy them judiciously as a supporting element in your mix, ensuring energy sovereignty amid fluctuating markets.
- **Carbon Credits** offer flexibility for residuals across all scopes, especially low-cost yet impactful high-integrity NbS which go beyond offsetting, delivering benefits like biodiversity enhancement and community empowerment. At significantly lower costs than technological alternatives, NbS credits align with evolving regulatory landscapes and stakeholder expectations, while generating co-benefits that unlock attractive financing terms and channels, and generating additional revenues from byproducts, making them a preferred instrument for outsourced portfolios.

A calibrated blend where PPAs anchor energy-specific needs, while carbon credits cover the residual emissions that cannot be abated on plan, **delivering immediate, cost-effective decarbonisation at scale—crucial for hard-to-abate sectors facing rising regulatory pressure**. **Beyond compliance, they unlock monetisable assets that turn climate action into a strategic revenue stream**, minimise capital outlay, accelerate timelines, and reduce the cost of financing. Such a blend allows organisations to rebalance in real time based on evolving regulations, market prices, and financing mechanisms, while maximising both financial returns (via TIB) and operational resilience (via Portfolio Score).

Conclusion:

To operationalise this integrated decarbonisation architecture, organisations should begin with a **diagnostic audit to quantify residual emissions** following core engine deployment. This step should **assess post-decarbonisation energy loads, emissions across all scopes, and opportunities for credit generation and byproduct monetisation**.

Once the audit is complete, allocate a defined portion of annual capital or operating expenditure to the acceleration layer, deploying PPAs and carbon credits not just for compliance, but for ROI. Use the **TIB formula to calculate the financial upside—via revenue increases, cost reductions, and byproduct income**—and the **enhanced Portfolio Score to assess asset quality across risk, cost, and impact dimensions**. This dual-metric approach allows finance and sustainability teams to jointly test and refine their asset mix, striking an optimal balance between climate performance and commercial viability. Ultimately, by integrating TIB and Portfolio Score into portfolio decisions, organisations can transform decarbonisation from a cost centre into a scalable, revenue-generating strategy—one that aligns fiduciary responsibility with planetary stewardship.

Sources: Amaly Legacy analysis

CONCLUSION

CHALLENGES, OPPORTUNITIES AND OUTLOOK

Our perspective on where we stand and what comes next ...

CURRENT SITUATION & WHAT'S NEXT

Carbon markets have reached a pivotal moment, presenting a transformative avenue to channel substantial funding toward solving global climate, social, and economic challenges. Successfully unlocking this potential depends on navigating several critical market dynamics—addressing persistent hurdles, seizing emerging opportunities, and anticipating long-term shifts to secure resilient, high-integrity growth.

Challenges

Integrity at Scale

1 Proving defensible baselines, additionality, permanence, and leakage remains uneven. Buffer obligations and fragmented dMRV slow bankability and keep high-integrity supply structurally scarce, even as prices command durable premiums.

Policy fragmentation & registry maturity

2 Article 6, CORSIA, and national registries are converging but not yet harmonised. Policy uncertainty and cross-market fungibility constraints create friction and deter liquidity.

Liquidity & price discovery for quality

3 Secondary-market depth is thin with relatively limited application of filters by corporations to identify and incentivise purchase of high-integrity credits excarcebated by weak procurement capabilities and inconsistent third-party ratings, raising financing costs for early-stage projects.

Opportunities

Deepening corporate demand & compliance pull

1 Corporate action is rising (2,983 companies had set SBTI targets in 2023 with a further 2,431 companies committed to set SBTi targets by 2025), while CORSIA and Article 6 expand compliant use cases—supporting long-dated, premium demand for high-integrity units.

NbS with measurable co-benefits

2 Each tonne of CO_2 offset can yield up to $664 in additional economic, social, and environmental value—unlocking blended revenue stacks (carbon credit sales + philanthropic funding) and stronger community outcomes.

Tech-enabled trust

3 AI and ML-driven dMRV complemented by creative use of eddy-covariance towers, drones, eDNA, and/or acoustic monitoring—anchored by blockchain traceability and third-party ratings—standardise data flow, strengthen assurance, and improve pricing and access to capital.

Future Outlook

Price bifurcation persists

1 2024 CORSIA-eligible units averaged $21.7/MT with an up-cycle flagged toward ~$51/MT; high-integrity credits are modeled at ~$203/MT by 2040 and ~$238/MT by 2050 as quality demand outstrips supply.

Market convergence accelerates

2 Article 6 operationalisation and CORSIA adoption push the voluntary and compliance segments closer, with national registries and ratings becoming part of standard due diligence.

Capital scales with tighter governance

3 Results-based grants de-risk early execution; private equity targets 15–20% gross IRR (10–15% net; 7–9% hurdles); insurers and forward sale proceed assignments become baseline protections.

What Wins: Projects that embed community benefit-sharing, rigorous dMRV + third-party ratings, and Article 6-ready traceability from day one will capture premium pricing, mobilise blended finance, and deliver resilient climate and development outcomes.

By proactively addressing these dynamics, investors, corporations, policymakers, and frontline communities can collectively drive a sustainable carbon market, unlocking meaningful impact and transformative economic growth for decades ahead.

Sources: Amaly Legacy analysis and sources referred to in this report

Note: This conclusion section is a synthesis of key findings and insights derived from various sections of this report. To avoid duplication and maintain readability, individual sources and references are not cited here. Readers seeking detailed citations or source materials are encouraged to refer to the corresponding sections of the report where each topic is discussed in detail and appropriately referenced.

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GLOSSARY

- **Abatement cost:** Cost to avoid or remove one tonne of CO_2e, usually expressed as $/t$CO_2e$.
- **AFOLU:** Agriculture, Forestry, and Other Land Use sector for GHG accounting and methodologies.
- **Ag:** Abbreviation for agriculture.
- **AI (Artificial Intelligence):** Computational methods (including machine learning) for perception, prediction, and decision-making.
- **Agrivoltaics:** Co-locating agriculture and elevated solar PV so land produces food and electricity simultaneously.
- **Alkalinity:** Capacity of a water-based solution to neutralize acids to buffer acidification.
- **APLMA (Asia Pacific Loan Market Association):** Regional loan market body; co-authors GLP and SLLP.
- **API (Application Programming Interface):** Interface enabling software systems to exchange data.
- **Baseline:** The "business-as-usual" scenario of predicted GHG emissions or removals without the carbon project, used to measure project impact.
- **Bilge:** Lowest point of a ship, typically in the engine room, where liquids and waste accumulate.
- **Blue NbS (Blue Nature-based Solutions):** NbS in coastal/marine ecosystems (e.g., mangroves, seagrasses, salt marshes) that sequester "blue carbon."
- **bn:** Billions.
- **bps (Basis Points):** One-hundredth of a percentage point (1 bps = 0.01%).
- **Carbon Credit:** Carbon credits are transferable and tradeable instruments certified and issued by independent carbon registries to represent an emission reduction or removal of one metric tonne of CO_2e
- **CAR Certificate (CRT):** Carbon credit issued by the Climate Action Reserve, representing 1 tCO_2e.
- **CCB (Climate, Community & Biodiversity Standards):** Verra co-benefit standards verifying social and biodiversity outcomes.
- **CDP Ratings:** Corporate climate, water, and forest disclosure scores issued by CDP.
- **CM (Commercial Maturity):** Degree to which a solution is ready to compete at scale (bankability, cost, supply, demand).
- **Community Facilitators:** Local cooperatives, charities, NGOs, and municipalities supporting project delivery.
- **Continuous Descent:** Smooth, gradual aircraft landing approach minimizing thrust, fuel burn, and noise.
- **Contrails:** Heat-trapping trails formed by aircraft exhaust in cold, humid air.
- **CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation):** ICAO scheme requiring airlines to offset CO_2 growth above 2019 levels with SAF and carbon credits.
- **CO_2e (Carbon Dioxide Equivalent):** Standard metric representing all GHGs' warming effect in terms of CO_2.
- **Cross-docking:** Logistics strategy where incoming goods are directly re-loaded onto outbound vehicles with minimal storage.
- **dMRV (Digital MRV):** Use of digital tech (satellite, IoT, AI) to automate MRV.
- **DD (Due Diligence):** Appraisal of legal, technical, financial, and ESG factors before investment.
- **DfD (Design-for-Disassembly):** Design approach enabling products/buildings to be dismantled for reuse or recycling.
- **Double Counting:** When the same emission reduction or carbon credit is claimed more than once. It leads to inflated climate results — making it look like more emissions were reduced than actually happened — and undermines trust in carbon markets.
- **Downstream Emissions:** Scope 3 emissions from product use and end-of-life stages.
- **Drag:** Aerodynamic resistance acting against aircraft motion, increasing fuel use.
- **DSCR (Debt Service Coverage Ratio):** Cash flow available for debt ÷ debt service (interest + principal).
- **EPD (Environmental Product Declaration):** Verified disclosure of life-cycle environmental impacts.
- **ERW (Enhanced Rock Weathering):** Spreading crushed silicate rocks on land to absorb CO_2 through chemical reactions.
- **ESG (Environmental, Social, Governance):** Non-financial performance criteria for sustainability and ethics.

GLOSSARY

- **ETS (Emission Trading System):** Cap-and-trade market allowing companies to buy/sell emission allowances.
- **Ex-Ante Credits:** Credits issued for future expected carbon reductions/removals before they occur and they cannot be retired until the carbon benefit actually takes place.
- **Ex-Post Credits:** Credits issued after carbon reductions/removals have already occurred and been verified which can be immediately retired upon purchase, providing instant environmental benefit.
- **Force Majeure:** Clause excusing performance due to extraordinary, uncontrollable events.
- **FPIC (Free, Prior, and Informed Consent):** Communities' right to consent before activities affecting their lands/resources.
- **FSC (Forest Stewardship Council):** Certification for responsible forest management and traceable timber.
- **Fuselage:** Main body of an aircraft carrying passengers and cargo.
- **GHG (Greenhouse Gases):** Atmospheric gases (CO_2, CH_4, N_2O, etc.) trapping heat and driving climate change. These gases are released through human activities such as deforestation and burning fossil fuels, as well as natural processes such as volcanic eruptions. They directly and indirectly affect Earth's systems by influencing climate, ecosystems and the atmospheric balance. Gases that trap heat in the atmosphere and warm the planet
- **GLP (Green Loan Principles):** Voluntary framework for green lending.
- **GP (General Partner):** Manager of an investment fund, earning carried interest and management fees.
- **GT (Gigatonne):** One billion metric tonnes.
- **ha (Hectare):** 10,000 m^2 (≈ 2.47 acres).
- **Hurdle Rate:** Minimum return threshold before a GP earns carry.
- **ICAO (International Civil Aviation Organization):** UN agency overseeing global civil aviation standards.
- **ICJ (International Court of Justice):** UN's principal judicial organ resolving disputes between states.
- **ICMA (International Capital Market Association):** Publishes Green, Social, Sustainability and Linked Bond Principles.
- **ICROA (International Carbon Reduction & Offsetting Alliance):** Industry body promoting high-integrity offsetting.
- **ICVCM (Integrity Council for the Voluntary Carbon Market):** Governing body defining Core Carbon Principles.
- **IFM (Improved Forest Management):** Practices that enhance carbon stocks vs. baseline forest management.
- **Insetting:** Offsetting GHG emissions within one's own supply value chain.
- **IoT (Internet of Things):** Connected devices and sensors exchanging data over networks.
- **IRR (Internal Rate of Return):** Indicates the annualised rate of return a project or investment is expected to generate. In simple terms, it tells you how much profit (as a yearly percentage) you can expect from an investment after considering the time value of money — meaning that money today is worth more than the same amount in the future because it can be invested to earn returns. The IRR calculates the exact discount rate at which the present value of all expected future cash inflows equals the amount of money initially invested. In other words, it's the break-even interest rate that makes the investment's net present value (NPV) equal to zero. A higher IRR generally means a more attractive investment, as it suggests the project generates stronger returns per year after adjusting for the timing and value of cash flows.
- **ISO (International Organization for Standardization):** Develops global standards (e.g., ISO 14064 for GHG accounting).
- **JNR (Jurisdictional and Nested REDD+):** Aligns project-level REDD+ with jurisdictional programs to prevent double-counting.
- **KML/KMZ (Shape Files):** Geospatial file formats for Google Earth mapping and data layers.
- **KPI (Key Performance Indicator):** Quantified metric tracking progress toward a target.

GLOSSARY

- **Lighter-weight MRO:** Maintenance using lightweight materials to improve aircraft efficiency.
- **LP (Limited Partner):** An investor in a fund who provides capital but has limited liability and no role in day-to-day management, sharing in the profits while their losses are capped at the amount they invested.
- **LMA (Loan Market Association):** A non-regulatory industry body that publishes guidance, model documentation, and best-practice standards for loan and debt markets, including syndicated, sustainability-linked, and green loans.
- **LNG (Liquefied Natural Gas):** Natural gas cooled to liquid for storage or shipping.
- **LOA (Letter of Authorisation):** Formal project or Article 6 authorization document.
- **LP (Limited Partner):** Investor providing capital to a private fund managed by a GP.
- **LSTA (Loan Syndications & Trading Association):** US loan market body; co-authors GLP/SLLP.
- **Management Fees:** Fees paid by LPs to GPs for operating an investment fund.
- **Margin Ratchets:** Interest-rate adjustments in SLLs/SLBs based on KPI achievement.
- **Milk Run:** Logistics route making multiple pickups/deliveries in one scheduled trip.
- **MOIC (Multiple on Invested Capital):** Value returned ÷ invested capital.
- **MoU (Memorandum of Understanding):** Non-binding agreement outlining intent and roles.
- **MRV (Measurement, Reporting & Verification):** Processes for quantifying and verifying climate outcomes.
- **mt (Metric Tonne):** 1,000 kg of mass.
- **NbS (Nature-based Solutions):** Actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges such as climate change, human health, food and water security, and disaster risk reduction effectively and adaptively, simultaneously providing biodiversity benefits.
- **NDC (Nationally Determined Contribution):** Each country's Paris Agreement climate action plan.
- **Net Zero:** Greenhouse gas emissions reduced, avoided, or removed to balance those produced.
- **NGFS (Network for Greening the Financial System):** Central banks and regulators integrating climate risk.
- **OAE (Ocean Alkalinity Enhancement):** Adding alkaline substances to seawater to absorb CO_2.
- **O&G (Oil and Gas):** Sector covering exploration, production, refining, and transport of hydrocarbons.
- **OF (Ocean Fertilisation):** Adding nutrients to ocean waters to promote CO_2-absorbing phytoplankton.
- **Offsetting:** Buying and retiring carbon credits to compensate for emissions.
- **Organic Certification:** Verification that farming avoids prohibited synthetic inputs.
- **Permanence:** Longevity of emission removals or reductions (risk of reversal).
- **PEFC (Programme for the Endorsement of Forest Certification):** Umbrella for national forest certification schemes.
- **PPA (Power Purchase Agreement):** Long-term contract to buy electricity at a fixed rate.
- **Pre-purchase Agreements:** Payments made today for credits not yet issued, representing a commitment to buy credits once generated.Fair Trade Certification: Ensures minimum prices/premiums and ethical labor standards in trade.
- **Produced Water:** Saline water brought up during oil/gas extraction, often containing metals/minerals.
- **Propulsion:** System generating thrust in aircraft or vessels.
- **QR Code (Quick Response Code):** Two-dimensional barcode scannable by smartphones.
- **Rainforest Certification:** Rainforest Alliance standard for sustainable agriculture/forestry.
- **REC (Renewable Energy Certificate):** A tradable certificate that proves one megawatt-hour (MWh) of electricity was generated from a renewable energy source, allowing buyers to claim the environmental benefits of clean power even if they don't use the electricity directly.
- **REDD+ (Reducing Emissions from Deforestation and Degradation):** Framework including conservation and enhancement of forest carbon stocks.
- **R&D:** Research & Development
- **ROI (Return on Investment):** Net gain relative to investment cost.

GLOSSARY

- **S&T (Scope 1, 2, 3 Emissions):** 1 = direct; 2 = purchased energy; 3 = value-chain emissions.
- **SAF (Sustainable Aviation Fuel):** Jet fuel reducing lifecycle emissions vs. fossil jet.
- **Scope 1 Emissions:** Direct emissions from owned/controlled sources.
- **Scope 2 Emissions:** Indirect emissions from purchased energy.
- **Scope 3 Emissions:** All other value-chain emissions.
- **SBT (Science-Based Target):** Emission-reduction goal aligned with 1.5 °C pathway.
- **SBTi (Science-Based Targets initiative):** Body validating corporate SBTs.
- Sharklets: Aircraft wingtip extensions reducing drag.
- **Single Engine Taxi:** Taxiing aircraft using one engine to cut fuel use and noise.
- **SLB (Sustainability-Linked Bond):** Bond with coupon linked to sustainability KPIs.
- **SLL (Sustainability-Linked Loan):** Loan with margin linked to sustainability KPIs.
- **SLLP (Sustainability-Linked Loan Principles):** Global framework governing SLLs.
- **Smartphone:** Internet-enabled mobile device with sensors and apps.
- **Slow Steaming:** Operating ships at reduced speeds to lower fuel and emissions.
- **SWF (Sovereign Wealth Fund):** State-owned investment fund.
- **Synthetic e-kerosene:** Electro-fuel made from green H_2 and captured CO_2 for aviation.
- **TA (Technical Assistance):** Grant-funded support for design, capacity building, and de-risking projects.
- **Taxonomy (Sustainable Finance):** Classification defining environmentally sustainable activities.
- **TCO (Total Cost of Ownership):** Life-cycle cost of acquiring, operating, and disposing of an asset.
- **TCFD (Task Force on Climate-related Financial Disclosures):** Framework for climate-risk reporting.
- **tCO_2e:** One metric tonne of CO_2 equivalent.
- **Temp':** Abbreviation for temperature.
- **tn:** Trillions.
- **Upstream Emissions:** Scope 3 emissions before a company's operations (supply inputs).
- **UX (User Experience):** user interaction journey with a digital product.
- **VCM (Voluntary Carbon Market):** Market for trading non-compliance carbon credits.
- **VCMI (Voluntary Carbon Markets Integrity Initiative):** Guidance for credible corporate claims in VCMs.
- **VCS (Verified Carbon Standard):** Verra's GHG crediting program.
- **VCU (Verified Carbon Unit):** 1 tCO_2e credit issued under VCS.

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