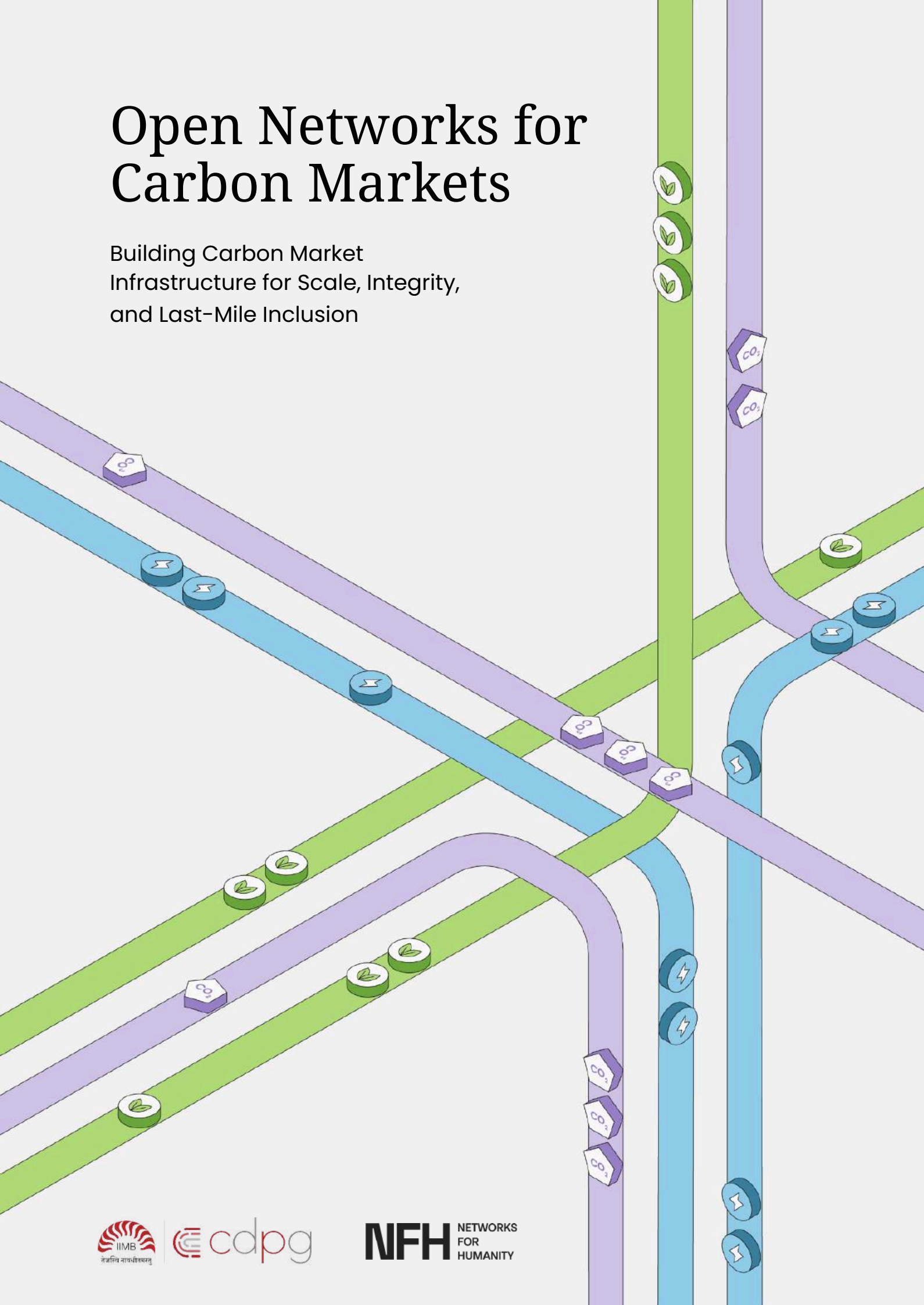
Open Networks for Carbon Markets

Building Carbon Market Infrastructure for Scale, Integrity, and Last-Mile Inclusion



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NFH NETWORKS FOR HUMANITY

Status and Intent

This paper outlines an evolving thesis and seeks to establish a shared conceptual foundation for how open networks can be implemented in the carbon market ecosystem. Realising this objective will require a series of collaborative, ecosystem wide conversations. We invite all interested stakeholders to join these discussions and help implement this vision. Please visit the IIMB Center for Digital Public Goods (CDPG), Open Network for Carbon Markets (ONCM) and Networks for Humanity websites for more information.

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About IIMB CDPG

The Center for Digital Public Goods (CDPG) at IIM Bangalore is a living lab for digital public infrastructure and digital public goods, where ideas are researched, tested, and translated into practice. It serves as a repository of knowledge, producing rigorous policy research, open-access publications, and thought leadership to advance scalable and inclusive DPI models in India and beyond. Through strategic advisory and capacity building, CDPG helps policymakers, entrepreneurs, and institutions adapt proven Indian digital systems to new contexts. It also works through collaborations with institutions such as IISc, NPCI, NFH, UIDAI, RBIH, and global partners like the World Bank and UNDP to strengthen innovation, governance, and impact. IIMB CDPG has led the inaugural "State of DPI in India 2025" report, the first annual benchmark of DPI progress across sector in India, and has also contributed to landmark national platforms such as Bharat Taxi and the Digital Address Code, studying the impact of e-commerce on small vendors for DPIIT while anchoring the Open Network for Carbon Markets (ONCM) project and convening the broader carbon market ecosystem.

About Networks for Humanity

Networks for Humanity (NFH) is an international network of labs focused on building open, interoperable, and decentralised digital infrastructure that enables trusted value exchange at scale. Its vision is a world where anyone—individuals, small businesses, AI agents and more—can participate fully in the global economy while retaining ownership of their credentials, data, context, and assets. NFH operates labs across the United States of America, Switzerland, Singapore, and India, and works across sectors including mobility (Namma Yatri), retail (ONDC), energy (DEG), data (Decentralised Data Marketplace, Climate and Sustainability Data Exchange), and water (Water Data Exchange).

Executive Summary

India's climate transition has become an economic and industrial imperative, not just an environmental one. With a Nationally Determined Contribution that commits to a carbon sink of 3.5–4 billion tonnes of CO_2 equivalent by 2035 and the Carbon Credit Trading Scheme (CCTS) launching by mid-2026, India is entering a rare policy inflection point: the rules, institutions, and digital infrastructure for its carbon markets are being shaped now.

India currently supplies approximately 17% of the world's carbon credits—the second-largest share globally—with voluntary carbon market revenue projected to reach USD 20–40 billion by 2030 and the compliance market targeting USD 10 billion by the same year (as per 2023 reports). Yet the market operates as a set of disconnected islands. Registries remain barely interoperable, voluntary trading happens opaquely over-the-counter, and Monitoring, Reporting, and Verification (MRV) is a manual, paper-based process costing thousands of dollars per project. These structural imperfections—fragmentation, opaque pricing, and high transaction costs—compound to exclude the long tail of small and medium carbon projects from a market built, in principle, to reward them. These constraints are not unique to India, they define carbon markets globally. This paper develops its argument through India's case but the infrastructure thesis is intended to generalise across jurisdictions.

This paper proposes the Open Network for Carbon Markets (ONCM): an open, interoperable digital infrastructure layer that connects every actor in the carbon credit lifecycle across the compliance and voluntary mechanisms. ONCM is structured as three interdependent layers: a neutral foundation, namely the NFH fabric, that provides shared registries, credentialing, and tokenisation infrastructure; a network layer carrying country-specific rules and methodologies; and an innovation layer where existing exchanges, platforms, and applications operate freely. The model mirrors India’s existing digital infrastructure like Aadhaar, Unified Payments Interface (UPI), Open Network for Digital Commerce (ONDC), and Digilocker to unlock value exchange at population scale.

Central to ONCM is the tokenisation and interoperability of digital MRV (dMRV) evidence across both compliance and voluntary markets, enabling independent verification from both supply- and demand-side auditors and structurally reducing the risk of double counting. The paper traces the resulting benefits across the full ecosystem—from a smallholder farmer gaining direct, broker-free access to buyers, to a regulator gaining real-time, tamper-evident records without manual reporting burdens.

This is a thesis, not a finished system. We present ONCM as an invitation for collaborative, ecosystem-wide design: inviting regulators, registries, exchanges, and market participants to co-create the network, with a minimum viable ecosystem pilot targeted for prototype readiness by September 2026.

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1. The Case for India

India's climate transition is no longer only an environmental agenda. It is now a **development, rural prosperity, and industrial competitiveness necessity**. Under the updated Nationally Determined Contribution (NDC), India has committed to reducing the emissions intensity of its GDP by **47 percent below 2005 levels** and achieving **60 percent of cumulative electric power from non-fossil sources by 2035**[1]. India's 500 GW non-fossil fuel operational target is central to this shift, framing the climate transition as a question of energy security and long-term economic resilience[2].

The strategic urgency for India, given its commitment to net zero by 2070[3], to act on climate change mitigation challenges is now being shaped by power-sector decarbonization, industrial competitiveness, and land-based carbon sinks simultaneously[4]. The carbon sink dimension is especially strategic. India's NDC includes the creation of a carbon sink of **3.5 to 4 billion tonnes of CO_2 equivalent through forest and tree cover by 2035 from the 2005 levels**[5]. This commitment places land, forests, and agriculture at the heart of India's mitigation architecture, making these assets crucial to the supply-side of India's carbon markets.

Despite the many challenges surrounding integrity, demand, and credit prices around project-based offsets within the country's carbon market, India supplies ~17% of carbon credits to the world, making it the second largest supplier[6]. India's revenue from voluntary carbon credits is projected to reach **USD 20–40 billion by 2030**[7].

Globally, more than **87 carbon pricing instruments** are in operation, covering approximately **29 percent of global greenhouse gas emissions**[8]. As India prepares for the launch of the Carbon Credit Trading Scheme (CCTS) by mid-2026, it is targeting to tap a substantial market size by 2030 via compliance caps on energy-intensive sectors, and land, forests, and agriculture integration for voluntary credits.

This strengthens the case for market mechanisms that can reward restoration, agroforestry, and conservation while also supporting clean energy and industrial transition. For policymakers and regulators, this means carbon markets must be designed not only for emissions accounting, but also for equitable participation, traceable claims, and lower transaction costs, leveraging existing innovations across policy, technology and markets, aligned with the vision of Viksit Bharat @2047 and net-zero by 2070.

1.1 India's Policy Imperative

The Government of India has created a decisive policy foundation for carbon markets. The **Energy Conservation (Amendment) Act 2022**[9] empowers the Central Government to specify a Carbon Credit Trading Scheme (CCTS). The government further strengthened its

carbon market readiness by creating the National Steering Committee for the Indian Carbon Market (NSC-ICM) with the Bureau of Energy Efficiency (BEE) acting as the market administrator. The NSC-ICM brings together representatives from various ministries, state governments, and industry experts, and serves as the highest authority overseeing the establishment and functioning of India's carbon market by providing recommendations to the Bureau of Energy Efficiency on institutionalizing the carbon market (procedures, rules, and regulations)[10]. The Central Government, in consultation with the Bureau of Energy Efficiency, notified the **Carbon Credit Trading Scheme (CCTS)**[11] in June 2023, establishing both a compliance mechanism for nine energy-intensive sectors and a voluntary offset mechanism for non-obligated entities.

The Indian Carbon Market (ICM) framework positions BEE to record, issue, transfer and retire credits. The nine sectors covered by the compliance mechanism represent the backbone of India's industrial emissions with more sectors added over time. The existing PAT (Perform, Achieve and Trade) scheme and Renewable Energy Certificate (REC) mechanisms will transition progressively into this framework[12].

India has also demonstrated strong institutional capacity. It is the world's **second largest registrant of Clean Development Mechanism (CDM) projects globally**, with Indian units having conserved **106+ million tonnes of CO_2** under the PAT scheme since 2015[13].

India's carbon markets are at a rare policy inflection point.

The rules, institutions, and digital infrastructure for the Indian Carbon Market (ICM) are still being shaped. This presents a first-mover advantage to set standards before markets harden into fragmented silos.

India can bring together its compliance and voluntary carbon markets into one high-trust ecosystem. Done well, this ensures carbon value reaches not only large intermediaries but also farmers, forest dwellers, Farmer Producer Organisations (FPOs), local communities and more through transparent, low-cost participation pathways.

The ICM can, therefore, be a livelihood engine, while also positioning India as one of the world's most significant sources of high-integrity carbon credits. Restoration, agroforestry, soil carbon, renewable energy, and community-based projects can all be turned into measurable, financeable value if India pairs market design with digital infrastructure, regulatory clarity, and inclusion at scale.

1.2 The Market As It Stands Today

India's carbon ecosystem contains the necessary components: a regulatory framework, a deep project pipeline, digital monitoring tools (including e-Green Watch[14] and GIS-based forest cover mapping that generates high-resolution biomass and afforestation data),

and growing buyer demand. What it lacks is the **digital infrastructure to connect them**. Today's market operates as a set of disconnected islands—and the gaps between those islands cost the market its credibility, efficiency, and equity.

Three Structural Imperfections

Fragmentation and silos

Registries like Verra, Gold Standard, and the nascent Indian Carbon Market (ICM) registry, along with carbon markets' workflows, remain barely interoperable. In case of the ICM, all three power exchanges, Indian Energy Exchange (IEX), Power Exchange India Limited (PXIL), and Hindustan Power Exchange (HPX), will be integrated with the same ICM registry for compliance as well as voluntary mechanism under CCTS[15]. In the case of global voluntary markets, though the discovery happens through voluntary carbon market exchanges, most of the trading still happens over-the-counter (OTC) through intermediary traders rather than on exchanges. So, liquidity stays fragmented and value bilaterally negotiated[16]. Monitoring, Reporting, and Verification (MRV) compounds the fragmentation: providers deliver data in formats specific to each standard, and the process itself remains largely manual and procedural, making outcomes highly dependent on the auditor. The result is that every connection between actors requires bespoke bilateral integration, creating friction that locks out smaller participants entirely.

Opaque and arbitrary pricing

In the Indian carbon markets, under CCTS, price discovery takes place on exchanges, typically through a bidding process for compliance and voluntary mechanisms. For ICM's compliance mechanism, trades occur within a predefined price band, bounded by a floor price and a forbearance price while trading guidelines for ICM's voluntary mechanism are still being defined[17]. These limits are set by the Central Electricity Regulatory Commission (CERC), based on their consultation with NSC-ICM and the BEE, to ensure market stability[18]. On the other hand, prices in the global voluntary carbon markets are determined by buyers and sellers based on registry standards, carbon rating agencies, intermediary traders, verifiers, and valuation consultants, and most purchases occur through over-the-counter transactions. This leads to under– or overvaluation of carbon credits, with buyers unable to verify whether the price reflects the legitimacy of the underlying asset and/or the true value of the carbon credit. This creates a low trust market that increases the costs for verification and validation of Indian carbon credits.

High transaction costs, low participation, and duplication of documentation

MRV is currently a sequential, manual, largely paper-based process that sits entirely outside the transaction flow. A validation cycle can take 12–18 months and cost thousands

of dollars per project. There is no shared, machine-readable audit trail either that buyers, regulators, or civil society can independently verify.

The combination of fragmentation, opacity, and non-standardised MRV creates transaction costs so high that they exclude the long tail of small and medium carbon projects. A rural solar cooperative, a community-managed wetland, or a smallholder agroforestry group cannot justify the bureaucratic cost of engaging with a paper-heavy, intermediary-dependent market.

Many stages of the carbon markets' workflows also require certain documentation repetitively. For instance, project and project owner related documentation is required by project developers, Validation and Verification Bodies (VVBs) / Accredited Carbon Verification Agencies (ACVAs) auditors, registries, and MRV providers. The current market infrastructures lack workflows where duplication of efforts for documentation and verification could be eliminated through having a single source of truth authenticating these.

Therefore, one of the key challenges in the existing carbon markets is not the absence of willing participants or sound projects. It is the need for a shared, open infrastructure through which participants can find each other, agree on terms, verify claims, and settle transactions without rebuilding the entire chain for every new connection.

2. Our Proposal: The Open Network for Carbon Markets (ONCM)

The Open Network for Carbon Markets is an open, interoperable network that enables every actor in the carbon credit lifecycle including resource owners, project developers, VVBs, ACVAs, MRV providers, registries, exchanges, platforms, valuation consultants, and buyers to connect and transact seamlessly.

ONCM does not replace existing registries, exchanges, or platforms, nor does it compete with any regulatory actor. Instead, it leverages the NFH fabric for **shared registries, and authentication, credentialing, and transaction infrastructure on which all of these actors can discover, verify, and exchange value with each other**—the same way Unified Payments Interface (UPI)[19] did not replace banks but enabled any bank's/apps' customers to transact with any other bank's/apps' customers seamlessly. By January 2026, UPI had grown to **21.70 billion transactions per month**, handling 81% of India's digital payments[20]. This is merely one example, India has spearheaded many more shared digital infrastructures like Aadhaar[21], Open Network for Digital Commerce (ONDC)[22], Digilocker[23], etc, that enable value exchange at population scale and speed (expanded in the

annexure). ONCM aspires to create a shared digital infrastructure for the Indian carbon market, mirroring and building on existing efforts.

2.1 The Three-Layer Architecture

ONCM operates as three distinct but interdependent layers, built on the NFH fabric. The NFH fabric is an agentic-ready, programmable, decentralised infrastructure on which any actor can build without permission. The foundation is neutral, the network layer carries the rules and policies for a country's carbon market context, and the innovation layer is where users, exchanges and markets reside. This separation is what makes ONCM simultaneously open and trustworthy with no single point of failure and multiple checks and balances across the layers.

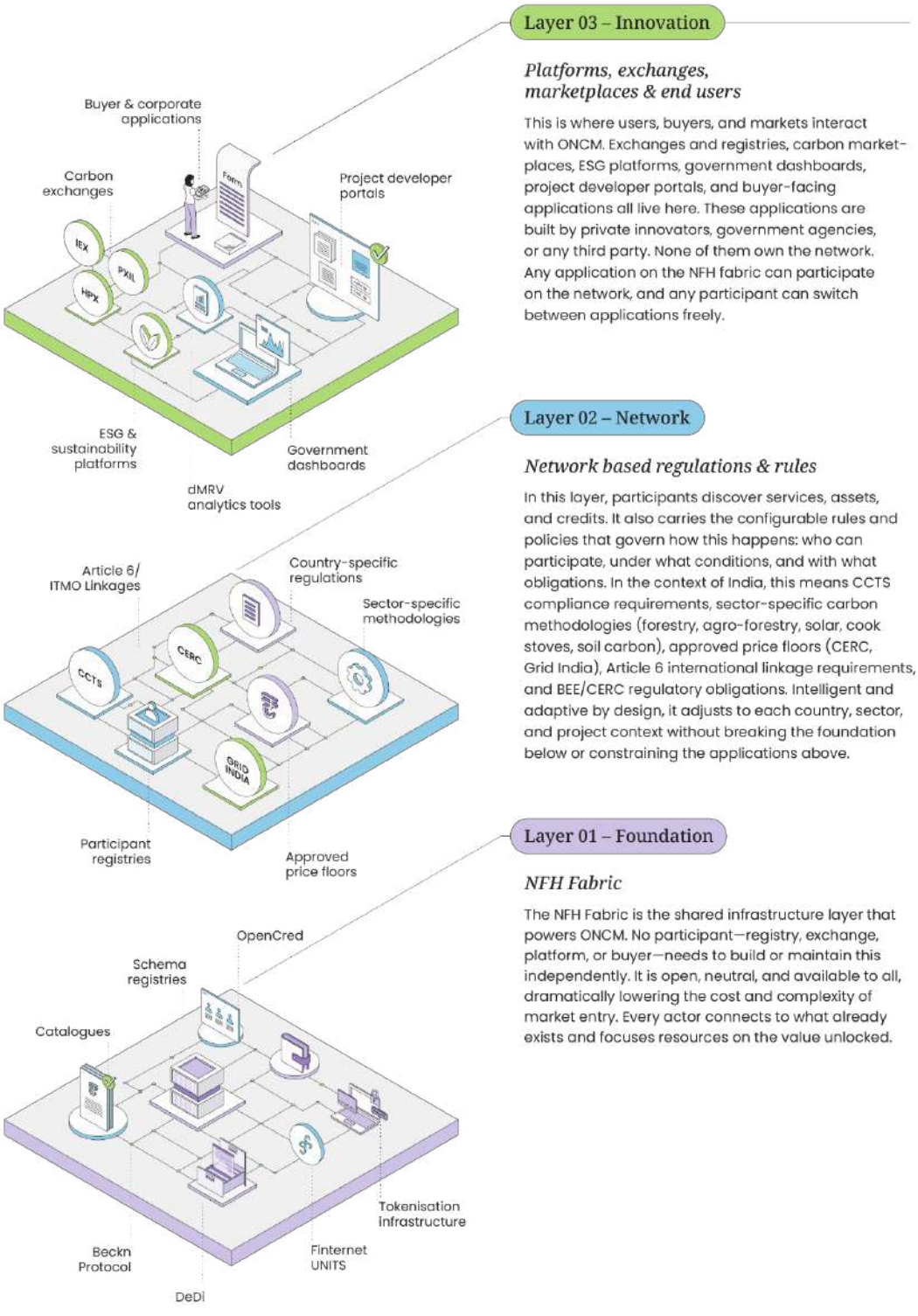

Illustration 1: ONCM's three-layer architecture combines a neutral NFH foundation, policy-driven network governance, and an innovation layer to enable open, trusted carbon markets.

2.2 The Building Blocks of ONCM

ONCM is built on proven building blocks—each solving a distinct function, each interoperable with the others, and each designed to be reusable across sectors and jurisdictions. These components together constitute the NFH fabric.

Registries. Every participant on an open network—a farmer, a project developer, a verifier, a registry, a government—needs a discoverable, verifiable identity recognised across the entire network. Registries are the universal address book: a common reference layer that any application can query and any participant can be found through, without separate integration on every system they wish to interact with. In ONCM, this extends to carbon project registries—the ICM registry, Verra, Gold Standard, RenewCred, or any new registry—each maintaining sovereignty over their own data while interoperating through the network.

Catalogue and discovery services. Fragmented, invisible supply becomes a searchable, real-time open marketplace. A buyer who wants high-integrity forestry credits from Odisha, a corporate seeking solar energy credits from Rajasthan, or an exchange seeking to price agroforestry offsets from the Northeast—all can query the full ecosystem through a single interface, enabling discovery across projects and registries.

Trust, credentialing, and tokenisation. On an open network, verified identities, ratings, and transaction histories accumulate over time, and travel with the participant across every context, creating a verifiable audit trail that builds a high-trust transaction environment. Carbon credits—as verifiable, transferable digital assets—can also be tokenised, enabling new economic primitives: fractional credit participation for smallholders, programmable incentive structures, and collateral that travels with the participant.

Transaction protocols and schemas. Open protocols provide the common grammar through which the network operates—from search and selection through ordering, fulfilment, and post-fulfilment. These protocols define a shared language that any system can speak, enabling end-to-end transactions across boundaries without bespoke integration at every step. The schemas form the backbone of interoperability, as they offer the shared grammar and semantics for any transaction on the network.

Consent and data ownership. Every data-sharing interaction is governed by permissions that are purpose-bound, time-bound, and revocable. Participants determine what is shared, with whom, and for how long. This is not a compliance layer—it is the mechanism through which user-centricity is operationalised at every transaction, including for farmers who may be sharing land data, soil measurements, or satellite imagery for the first time.

Secure data infrastructure. Encrypted tunnels, transaction proof ledgers, immutable audit trails, and non-repudiation receipts ensure that what was agreed cannot be denied, what

was recorded cannot be altered, and what was exchanged cannot be disputed. In a carbon market where a single fraudulent credit can undermine an entire programme's credibility, tamper-evident infrastructure builds trust, reducing concerns around fraudulent claims.

Policy and governance layers. Participation rules, audit trails, and compliance conditions are built into the network's protocols. Governance travels with the value flows: programmable, composable, and specific to each use case. ONCM's governance layer coordinates ontology updates, version control, and protocol evolution across all participants without requiring centralised control.

Agentic-readiness. When every participant has a verifiable identity, every credential is portable, and every exchange is tamper-evident, the structured data that results turns every transaction into a signal for intelligence. AI agents operating on ONCM have access to grounded, verifiable information, the foundation they need to act reliably, at scale, on behalf of any user, enabling anomaly detection in dMRV data to real-time credit pricing signals.

3. What ONCM Solves For: Five Dimensions That Compound

ONCM brings together transaction complexity, transparency and provenance, dMRV auditability, trust, and scale in a single architecture so that their benefits reinforce and compound across the entire carbon credit lifecycle.

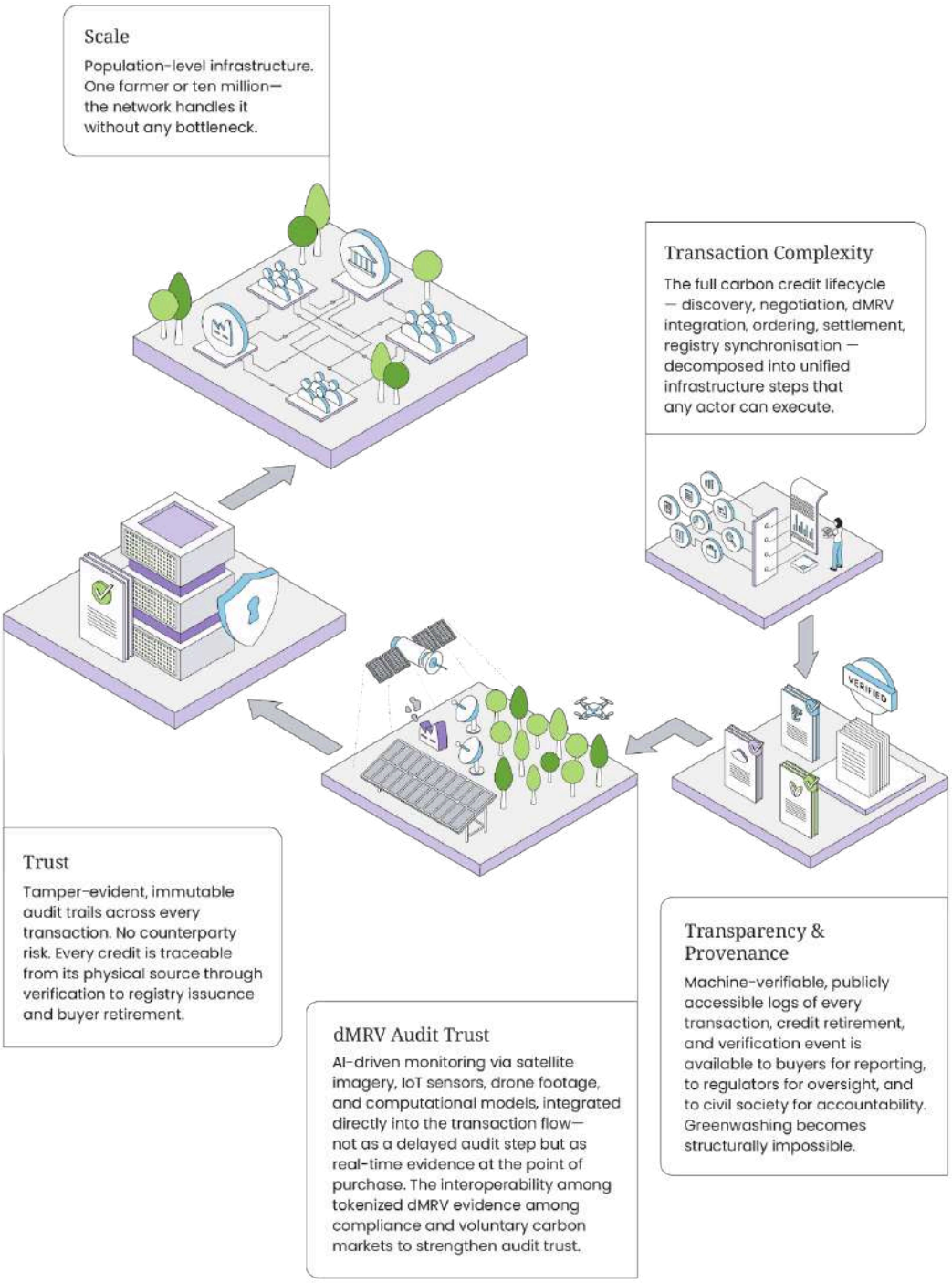

Illustration 2: Rather than isolated capabilities, ONCM creates a virtuous cycle where unifying the entire carbon credit lifecycle on a shared infrastructure layer enables provenance across the chain, building transparency, transparency strengthens auditability and trust, and trust enables population-scale adoption.

4. How ONCM Works: The Carbon Credit Lifecycle on an Open Network

A resilient carbon market operates as a transaction network, with carbon credits flowing between independent systems through unified interactions. NFH fabric, with its

decentralised design, enables carbon credits to be **published, discovered, confirmed, exchanged, and retired** without a centralised registry or intermediary.

4.1 Shared Digital Infrastructure Design Principles

The following principles govern how ONCM achieves scalability, multi-country operability, and the conditions for carbon as a globally tradeable digital asset.

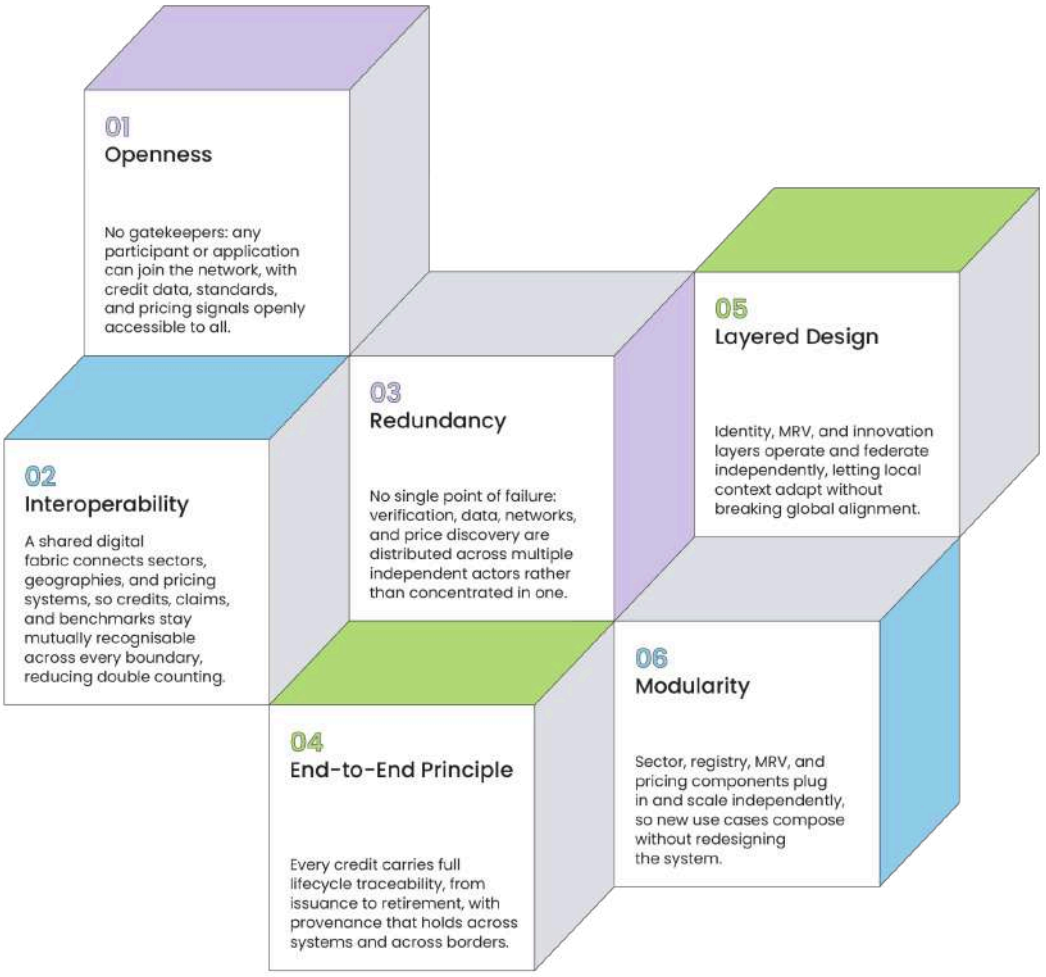

Illustration 3: These six design principles—openness, interoperability, redundancy, end-to-end principle, layered design, modularity—underpin ONCM's ability to operate across sectors, registries, and geographies to enable trust at scale in the carbon ecosystem.

4.2 The Carbon Credit User Journey on ONCM

From the moment a project developer lists their first credit to the moment a buyer's retirement is confirmed on-chain, the following four phases describe the end-to-end journey on ONCM. Prior to this transaction flow, the demand for carbon credits is estimated in the market.

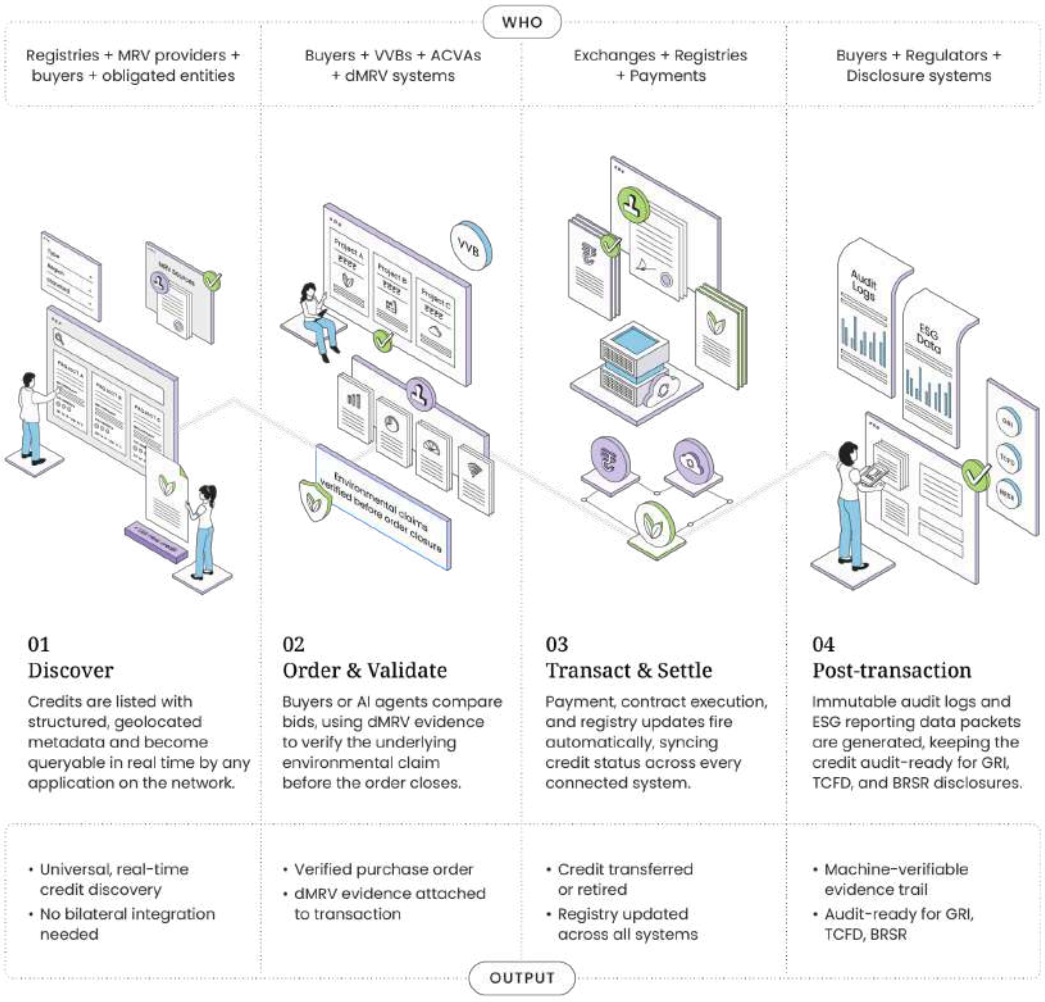

Illustration 4: The end-to-end ONCM transaction journey orchestrates every stage of the carbon credit lifecycle from credit discovery to retirement on a shared digital infrastructure.

While the preceding illustration presents the universal transaction journey on ONCM, its implementation varies for compliance carbon markets. Jurisdictions differ in how emission obligations are assigned, how compliance is measured, the role of regulated entities, and the mechanisms through which carbon credits are issued, traded, and surrendered. Despite these differences, the core digital transaction flow remains consistent. ONCM

provides a common digital infrastructure that can adapt to diverse regulatory models while preserving interoperability, transparency, and verifiable execution.

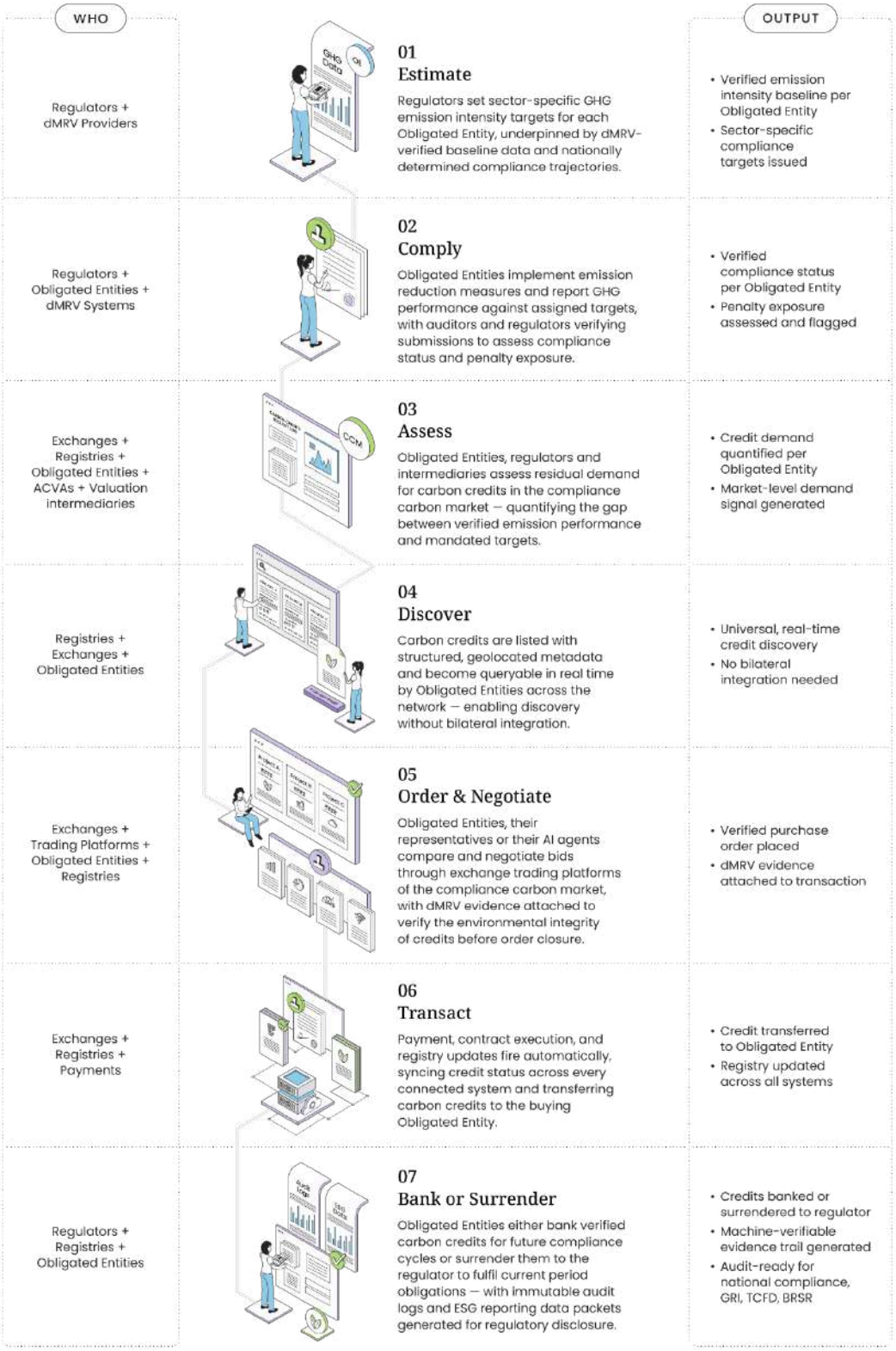

Illustration 5: The ONCM transaction journey adapted across major global compliance carbon market models, depicts how a common digital infrastructure can interoperate with diverse regulatory frameworks.

5. Envisioning the Global dMRV Framework

Globally, there have been conversations highlighting the need for digital Monitoring, Reporting and Verification frameworks to strengthen trust within carbon markets. This presents an opportune moment for India to take pioneering action in establishing a nationally determined standard framework for dMRV architecture.

A dMRV architecture extendable to global scale should be designed as a trusted, interoperable, auditable, and scalable system that can support carbon markets, compliance reporting, ecosystem restoration, and wider climate-finance use cases. The architecture should not be treated as a single software platform, but as a layered digital infrastructure stack that combines field data capture, digital processing, verification workflows, observability, and standardised outputs[24]. This framework is not conceived in isolation. Global integrity bodies—including the Integrity Council for the Voluntary Carbon Market (ICVCM) and the Voluntary Carbon Markets Integrity Initiative (VCMI)—have already established the quality thresholds and claims guidance that any credible MRV system must be built to serve. ONCM's dMRV architecture is designed to operationalise these existing standards digitally, not to define new ones.

At the core of the architecture is the idea that carbon credit project's dMRV are continuous digital processes, not one-time project tasks. This means field applications, IoT sensors, remote sensing, GIS, enterprise datasets, and third-party data sources should all feed into a common data network through secure ingestion and open integration APIs. The architecture should therefore allow multiple actors to participate while preserving traceability, version control, and data quality across the full lifecycle of a project[25].

The resulting dMRV evidence can be tokenised and rendered interoperable across both compliance and voluntary carbon market registries[26]. Instead of dMRV data existing as static files attached to a project folder, each discrete unit of evidence—a satellite pass confirming canopy cover, an IoT soil-carbon reading, a verified activity record—is issued as a uniquely serialised, cryptographically signed digital token, bound to the project's registry identity and timestamped at the point of capture.

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[26]The granular, credit-linked tokenization model proposed here parallels reference architectures being developed for adjacent carbon-accounting systems, such as the E-ledgers Finternet architecture, which specifies analogous invariants (counted-once recording, transfer-linked movement, conservation) for emissions data moving across enterprise and jurisdictional boundaries.

This granularity changes what is possible in four concrete ways:

5.1 First, it makes provenance traceable at the evidence level, not just the credit level: an auditor or buyer can trace a single issued credit back through the specific tokens that substantiated it, rather than trusting a registry's summary claim.

5.2 Second, it structurally reduces double counting because a token is uniquely serialised and its consumption toward a specific credit issuance is recorded immutably, the same

underlying evidence cannot be silently reused to justify claims in two registries or two markets.

5.3 Third, tokenised evidence becomes programmable: verification thresholds can trigger automatic downstream actions—release of a government subsidy, disbursement of upfront financing to a resource owner, or initiation of credit issuance—without a human re-checking each milestone manually.

5.4 Fourth, because tokens are machine-readable and portable, they become the raw material for agentic and financial innovation: AI agents can query them for real-time anomaly detection or dynamic pricing, and financiers can extend working capital against verified-but-not-yet-issued evidence as a form of collateral, moving dMRV from a cost center to a source of liquidity for smallholders and small project developers.

ONCM will have domestic enforcement with activity level regulation in its governance layer. Therefore, the dMRV framework's country-specific adaptation should be governed by a national regulatory authority (like the Bureau of Energy Efficiency in India) that authorises dMRV entities, sets standards and policies, and oversees audit and compliance. In this design, the authority does not need to perform all monitoring; instead, it defines the rules, approves methodologies, and ensures consistency, independence, accountability, and trust across the ecosystem. This governance model is important because it creates a common regulatory and technical baseline that can support both market-linked and public-good climate applications. Aligning this national baseline to global frameworks will ensure that credits verified through India's dMRV architecture retain credibility with international buyers, rather than creating a parallel, India-only integrity standard.

A strong dMRV framework should also include an observability and trust layer that captures audit logs, change history, privacy controls, security safeguards, and data-quality management. This creates a robust layer for carbon-credit issuance, compliance reporting, and future integration. Without this layer, digital monitoring may exist, but it will not be sufficiently credible for national standards or cross-border use.

The final output layer should produce verified carbon reports[27], dashboards, APIs, and compliance disclosure outputs. These outputs should be unified such that the same

underlying evidence can serve multiple use cases: project reporting, carbon market issuance, ESG disclosure, policy monitoring, and ecosystem management. In effect, this dMRV architecture should create a common evidence fabric that allows different sectors and institutions to reuse the same data rather than repeatedly building separate systems.

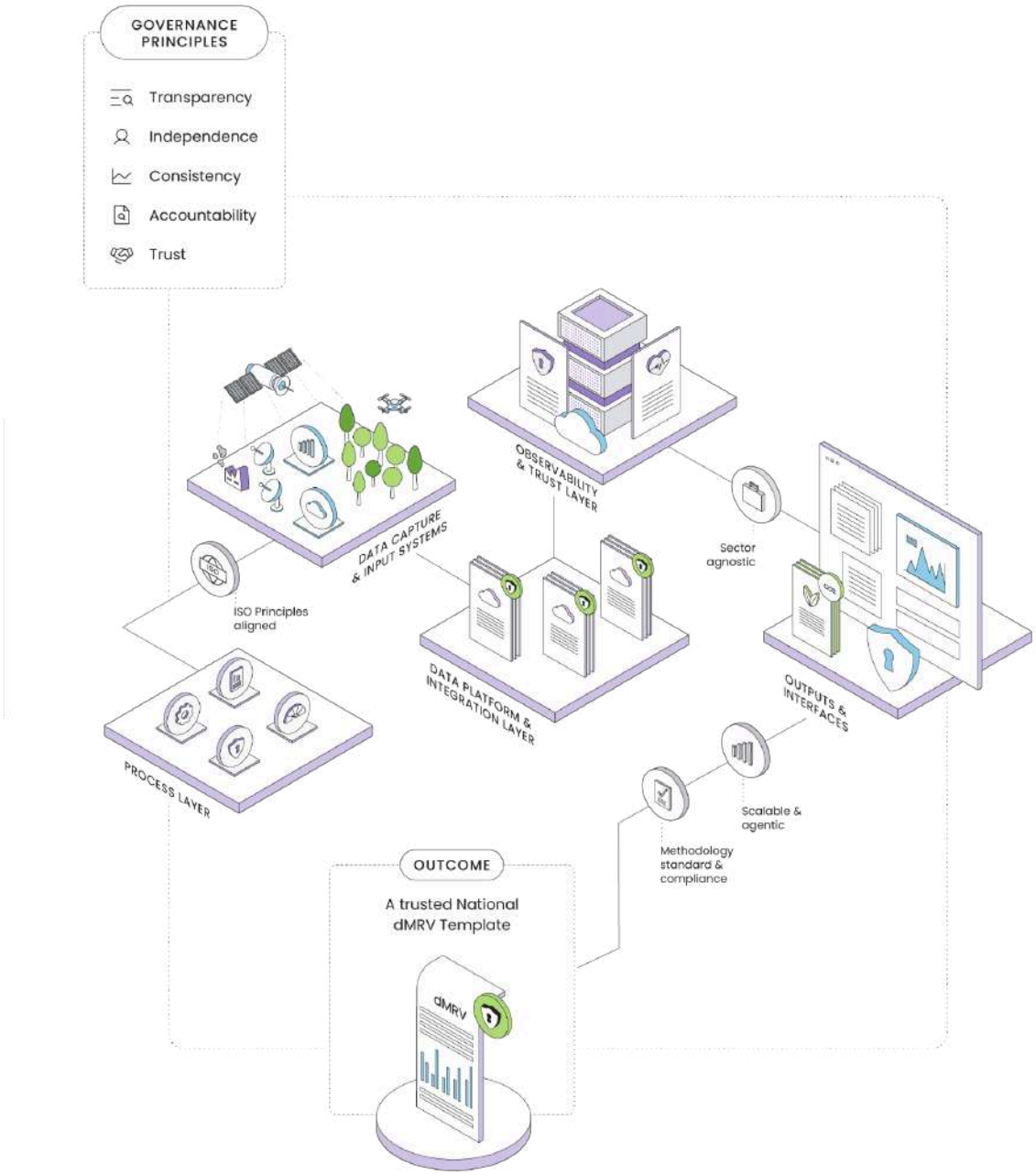

Illustration 6: A layered dMRV architecture that combines governance, data, verification, and observability outputs to create trusted, interoperable climate evidence, aligned to national or international standards.

6. Benefits of ONCM Across The Carbon Market Ecosystem

ONCM is designed to work for everyone in the carbon market ecosystem—from the smallholder farmer generating her first credit to the institutional buyer retiring credits

against a net-zero commitment. Inclusion is not a feature added on top of the architecture; it is a consequence of lowering the cost of participation at every layer. The table below maps each role's responsibilities to the concrete benefits that ONCM delivers.

Benefit Table: Voluntary Carbon Markets		
As a..	**Responsibility — what I do & what I need..**	**Through ONCM, I benefit because..**
Resource owner *Farmer, agro-forestry project owner, solar plant owner, landholder*	1. Provide land, forests, or physical assets that generate carbon sequestration or emission avoidance; maintain the resource and manage risks from climate events, wildlife conflict, or crop failure. 2. Receive carbon credit income tied to actual project performance and navigate relationships with project developers, insurers, and government bodies.	1. A single source of truth for the holdings via dMRV evidence allows project developers to discover them directly on the network—no broker intermediaries, more competition, better compensation. 2. Transparent, auditable credit trail can track every credit generated and price fetched, with access to upfront credit deposits and standardised insurance products through marketplace integrations.
Project developer *Agro-forestry developers, cookstove programme managers*	1. Design and implement carbon projects, manage the full credit lifecycle from issuance to sale, onboard resource owners, and prepare all project documentation—Project Design Descriptions (PDD), MRV plans, and baseline studies. 2. Engage a Validation & Verification Body, onboard onto a registry, and access initial	1. A single standardised onboarding onto a registry supported by tokenised dMRV evidence, leads to cross-listing and discovery across registries, exchanges and platforms through interoperable rails, ensuring no duplication and reduces intermediation cost for MRV efforts 2. Open pricing engine with real-time baseline pricing, simultaneous negotiation with multiple buyers, and programmatic

	financing to bridge to first credit issuance.	government subsidy release on verified milestones.
Validation & Verification Body (VVB) *Accredited third-party auditors*	1. Validate project eligibility, approve the PDD and MRV methodology after 30-day public consultation; periodically verify actual emissions reductions against the approved plan. 2. Issue verification statements authorising credit issuance, maintain accreditation across multiple standards and uphold market integrity.	1. Standardised digital evidence collection and automated 30-day consultation tracking—one agentic workflow across all registries, no manual deadline management. 2. Immutable audit trails and tamper-evident records makes reports instantly accessible to any registry or buyer; dMRV data reduces on-site audit costs significantly. 3. Interoperable tokens linked to dMRV evidence prevents double counting and facilitates accelerated verification.
dMRV service provider *Satellite analytics firms, IoT sensor providers, digital audit companies*	1. Collect, process, and report monitoring data across satellite imagery, IoT sensors, and ground-truth surveys; maintain chain of custody from sensor to carbon registry. 2. Deliver standardised outputs meeting registry methodology requirements to comply with species-specific carbon calculation models for forestry, soil carbon, agro-forestry, and energy.	1. MRV outputs plug directly into any registry or VVB workflow, discoverable on the network so project developers and VVBs can procure services without bilateral arrangements while generating tokenized dMRV evidence. 2. Shared methodology and formula library reduces duplicated research; data provenance recorded on the network builds a verifiable track record over time.

Carbon Registry *For example, Verra, Gold Standard, American Carbon Registry, ICM Registry*	1. Issue carbon credits based on VVB verification, maintain the authoritative credit ledger, enable transfers and retirements, and prevent double-counting across registries. 2. Develop and maintain standard methodologies, connect to national compliance infrastructure, and enforce listing standards and price floors.	1. Credits listed once, become discoverable and tradeable across all connected exchanges and platforms; unified issuance protocols and automated public disclosure eliminate manual administration overhead; instant retirement signals across all connected platforms eliminate post-retirement disputes. 2. Collaborative standard development; access to tokenized dMRV evidence that provides a single shared source of truth, enabling auditors on the supply- and demand-side to verify credits.
Exchange *Dedicated carbon credit exchanges*	1. Facilitate price discovery and matching across carbon credit registries; manage clearing, settlement, and regulatory compliance 2. Connect to national compliance grid, enforce approved pricing, enable interoperable carbon credit issuance and settlement across both market types	1. Single integration gives access to standardised, verified credits from all registries; transparent network-level pricing reduces the information asymmetry that currently inflates intermediary margins. 2. Seamless cross-market settlement and discovery of carbon credits through interoperable registries and exchanges, backed by tokenized dMRV evidence.
Platform / marketplace *Digital sustainability marketplaces, ESG platforms, B2B*	1. Aggregate demand from corporate and institutional buyers and connect them to credit supply across registries and exchanges 2. Offer value-added services including ESG analytics, reporting	1. The fabric handles trust, provenance, and settlement so platforms focus entirely on UX and services; new entrants join the full ecosystem without negotiating individually with every registry or exchange

carbon aggregators	support, and audit-ready documentation	2. Standardised credit metadata enables rich search and filtering without bespoke integrations; and cross-registry discoverability enables diversified portfolios without bilateral relationships with every registry or intermediary 3. Interoperable tokenized dMRV evidence strengthens the buyer trust and provides access to real time data of carbon credit projects
Demand-side consultant *Carbon advisory firms, ESG consultants, sustainability advisors, net-zero strategy teams*	1. Advise corporate clients on credit procurement strategy, conduct due diligence on credit quality and registry standing, and structure multi-year offset portfolios	1. Standardised credit metadata across all registries eliminates weeks of manual research; transparent network-wide pricing replaces opaque broker quotes with defensible, comparable benchmarks 2. Cross-registry discoverability enables diversified portfolios without bilateral relationships with every registry or intermediary 3. Interoperable tokenized dMRV evidence strengthens the buyer trust and provides access to real time data of carbon credit projects
Buyer *Corporates, institutional investors, compliance entities, voluntary offsetters*	1. Discover, evaluate, and purchase high-integrity carbon credits to meet net-zero commitments, ESG targets, or compliance obligations; retire credits and report offset positions across disclosure frameworks 2. Navigate a fragmented market where prices are currently set	1. Discover and compare credits across all registries directly on the network with agentic real-time pricing signals and tokenized dMRV, providing a single source of truth—no opaque pricing and full provenance from resource owner to retirement

	arbitrarily with no transparent, comparable baseline	
Regulator / government *MoEFCC, BEE, CAMPA, Grid India, CERC, carbon market policy bodies, standard setting bodies*	1. Set carbon market rules, approve methodologies, establish price floors, oversee the market, and ensure integrity by preventing double-counting, greenwashing, and fraudulent claims 2. Interface with international bodies under Article 6, authorise ITMOs, authorise cross-border carbon adjustments where applicable, and build stakeholder trust to attract institutional finance	1. Real-time, tamper-evident dMRV data across all projects and transactions enables full regulatory oversight without manual reporting burdens; easy to integrate with ONCM and disburse benefits / subsidies programmatically on verified milestones 2. Government sets standards without building every component; private innovation runs on top of public infrastructure; Article 6 interoperability is built into the network 3. Obligated and non-obligated entities are enabled to comply with the nationally determined standards and leverage the digital infrastructure to either purchase carbon credits or build service solutions on top of it

Additionally, for stakeholders participating in compliance carbon markets across jurisdictions, the table below maps the specific benefits accrued through participation in the Open Network for Carbon Markets (ONCM). Given the growing heterogeneity of national carbon pricing frameworks—spanning emissions trading systems, baseline-and-credit mechanisms, and intensity-based targets—interoperability has emerged as a structural necessity rather than an optional feature. ONCM's open network architecture is designed to complement, rather than replace, existing compliance infrastructure, offering participating entities tangible operational and strategic advantages regardless of the regulatory regime they operate under.

Benefit Table: Compliance Carbon Markets		
As a…	**Responsibility — what I do & what I need…**	**Through ONCM, I benefit because…**
Obligated Entity	1. Large, energy-intensive industrial facilities notified by the national regulator; comply with GHG emission targets, submit monitoring plans and reports, undergo verification, and buy/surrender carbon credits.	1. Clear, rule-based digital pathway to comply with mandates through emissions tracking, banking, and trading, with transparent obligations create a market mechanism for managing shortfalls. 2. The burden of repetitive documentation and verification is eliminated.
Facility Operator of an Obligated Entity	1. Maintain gate-to-gate boundary data, activity records, fuel and power data, production data, sampling logs, and annual GHG reporting evidence.	1. Standardized digital reporting structure reduces ambiguity, improves audit readiness, and makes compliance evidence easier to assemble and verify. 2. Seamless generation of reliable and error free data supported by GHG emissions accounting and reporting firms / technology solutions.
dMRV team of an Obligated Entity	1. Build and maintain the monitoring plan, track emission sources, apply approved methods, and keep quarterly and annual records ready for verification.	1. Consistent emissions accounting across compliance years is ensured and duplication is reduced. 2. High-trust, high-integrity tokenized dMRV evidence can be accessed and verified by auditors, regulators, buyers, financiers and more.

dMRV Service Provider	1. Provide metering, digital reporting, lab analysis, data platforms, and emissions calculation support for obligated entities.	1. Demand for dMRV services from obligated entities, regulators, and auditors creates a consolidated data environment that eliminates duplicated documentation efforts across the compliance value chain, reducing siloed, point-to-point exchanges. 2. Globally interoperable dMRV standards can be adapted to meet country-specific regulatory requirements, while simultaneously simplifying technical integration and enabling seamless adoption within existing compliance mechanism workflows.
Industry Consultant	1. Advise on target planning, emissions reduction pathways, compliance strategy, and verification preparedness.	1. Digital, standardised workflows make analysis and advisory outputs more comparable, defensible, and scalable across client engagements, raising the overall quality and credibility of carbon market advisory services. 2. By consolidating documentation and verification into a single source of truth, ONCM eliminates redundant processes and reduces the risk of data inconsistencies across reporting cycles.

Accredited Carbon Verification Agency (ACVA)	1. Independently verify emissions data, assess monitoring plans, review calculations, and certify compliance evidence for compliance submission.	1. Standardised digital verification workflows, combined with traceable, tokenised evidence linked to a single source of truth improves audit quality and reduces the incidence of disputes, giving auditors a more defensible and efficient basis for review 2. Data inconsistencies become faster to identify and easier to resolve, enabling real-time redressal of objections raised against submissions by obligated entities and reducing the administrative burden associated with dispute resolution.
Regulator	1. Review monitoring plans, assess reports, evaluate verification outputs, and support issuance of carbon credits through country-specific compliance mechanisms. 2. Set GHG emission trajectories, define covered sectors, issue rules, and enforce compliance and penalties.	1. Structured digital oversight, delivering standardised and reliable data flows provide enhanced visibility into entity-level compliance performance and sector-wide emission trends. 2. By linking industrial emission reductions to national climate goals and Nationally Determined Contributions (NDCs), ONCM strengthens the evidentiary basis for compliance tracking and improves the overall enforceability of regulatory mandates. 3. High-integrity, traceable evidentiary infrastructure to support cross-border regulatory negotiations—particularly in addressing the risk of double accounting of carbon prices for

		exporting entities that are already fulfilling compliance obligations under the regulatory framework of their country of origin.
National Compliance Registry	1. Record issuance, holdings, banking, transfer, and retirement of carbon credits, and maintain the authoritative ledger for these allowances.	1. A digitally governed carbon credit issuance lifecycle—characterised by robust traceability, tamper-resistant retirement records, and significantly reduced risk of double counting—enhances the integrity and market credibility of registry operations. 2. By functioning as a foundational node within ONCM's shared infrastructure, registries become an integral component of the single source of truth—streamlining data access workflows for the full spectrum of ecosystem actors, including auditors, buyers, industry consultants, and regulators.
Exchange / Trading Platform	1. Facilitate trading, price discovery, settlement, and compliance-related market transactions for carbon credits.	1. Increased transaction efficiency, reduced friction in credit trading, and transparent price discovery mechanisms.
Buyer (Obligated Entity purchasing carbon credits to avoid penalty)	1. Purchase carbon credits to cover shortfalls or to participate in compliance-linked trading where it is permitted.	1. Opaque bilateral arrangements are replaced by transparent, standardised compliance instruments—enabling trusted price discovery, reliable credit banking, and end-to-end traceability that obligated entities can depend on across reporting cycles. 2. Seamless discovery and engagement of auditors, dMRV

		providers, exchanges, and specialised carbon accounting and reporting firms. 3. Embedded emissions accounting, dMRV evidence, and digital traceability infrastructure is available to meet cross-border trade-related regulatory disclosure requirements—including those mandated under frameworks such as the EU Carbon Border Adjustment Mechanism (CBAM).
Analytical GHG Emission Accounting and Reporting Service Providers	1. Assist Obligated Entities in accounting and reporting of their GHG emission for Scope 1, 2 and 3.	1. Facilitate efficient, structured sharing of GHG emissions data between obligated entities, regulators, and auditors; eliminating redundant rework cycles and ensuring that reporting outputs meet the evidentiary standards required across all compliance touchpoints.

7. The Multiplier Effect

By lowering discovery, transaction, and verification costs, ONCM enables small and marginal resource providers like smallholder farmers, community forestry managers, MSMEs, and distributed clean-energy operators, to participate directly in carbon markets that have historically been inaccessible to them. This inclusion is not merely additive; it produces a powerful multiplier effect.

As these providers monetize carbon outcomes, ancillary digital, financial, and service ecosystems emerge around MRV, asset aggregation, and risk mitigation, amplifying incomes, local employment, and climate-positive behaviours across regions and value chains. Central to this impact is a strong digital provenance framework and robust, interoperable registries of carbon assets and claims. ONCM ensures the integrity, traceability, and uniqueness of credits, while binding emission reduction to verifiable underlying assets and activities. This transparency transforms carbon credits from one-off

transactions into durable digital assets, enabling providers to use verified credits as instruments of leverage, unlocking advance financing, collateralized loans, insurance products, and longer-term offtake commitments.

Over time, as liquidity, confidence, and price discovery improve across voluntary and compliance markets, ONCM would help catalyse a transition from fragmented credit trading to mature climate finance markets. Unified digital assets, interoperable market access, and network-level trust will enable conditions for structured products, blended finance, tokenization/ securitization, and institutional participation at scale. In doing so, ONCM would shift carbon markets from niche environmental mechanisms to foundational financial infrastructure for climate action.

8. What ONCM opens is an impact aperture

This is the moment when technology readiness, policy mandate, and market demand converge to create non-linear impact. Every actor that joins expands the network's value. Every new project developer or resource owner who connects reduces the per-unit cost of participation. These are compounding effects that fragmented systems cannot replicate.

India built Aadhaar, UPI, and ONDC. The architecture for an Open Network for Carbon Markets is the same architecture India already knows to build and scale.

ONCM is, therefore, India's opportunity to transform the carbon market ecosystem, today.

Call to action

We invite the **Government of India**, **institutional partners, regulatory bodies, and market participants** to join us in co-creating ONCM. We are actively seeking project developers, VVBs, MRV providers, registries, exchanges, and corporate buyers for the minimum viable ecosystem pilot targeted for prototype readiness by September 2026.

Contact: **IIMB Centre for Digital Public Goods (CDPG)** · **Networks for Humanity**

ONCM community: discord.gg/84RKvR6HGA

Annexure

Lessons from Population-Scale Digital Infrastructure

Population-scale digital infrastructure demonstrates how interoperability, universality, user-centricity, and modularity can transform economies and enhance inclusion. These global examples showcase the impact of innovative, scalable systems on financial services, welfare delivery, and economic growth.

Unified Payments Interface (UPI)

UPI revolutionised digital payments by enabling micro-level transactions with values as low as one cent. Growing from 0.8 billion transactions in January 2018 to 21.70 billion in January 2026, UPI now handles 81% of India's digital payments. Its success stems from design principles such as interoperability, low cost, and ease of access, demonstrating how scalable infrastructure can drive financial inclusion and economic participation.

Aadhaar: Digital Identity at Population Scale

Aadhaar is the world's largest biometric digital identity system, with over 1.4 billion enrolments. It provides every resident of India with a unique, verifiable 12-digit identity number backed by biometric and demographic data—accessible via a single open API. Aadhaar has become the foundational identity layer for India's digital public infrastructure stack, enabling instant KYC, direct benefit transfers, and seamless onboarding across financial, health, and government services.

DigiLocker: Verifiable Credentials for Citizens

DigiLocker is a digital document wallet that allows citizens to store, access, and share verified copies of official documents like educational certificates, vehicle registrations, land records, and more, without physical paperwork. With over 700 million registered users and more than 9 billion documents issued, DigiLocker demonstrates how verifiable credentials can replace paper-based proof systems at scale. In the context of ONCM, the same principle applies to carbon market credentials: project registrations, VVB accreditation certificates, MRV evidence packets, and credit retirement receipts should

all be issuable as verifiable digital credentials—portable, tamper-evident, and instantly shareable across any connected system.

DigiPin: Standardised Location Identity[28]

DigiPin is India's nationally standardised digital location code system, assigning a unique 10-character alphanumeric code to every 4×4 metre plot of land across the country. Developed by the Department of Posts in collaboration with the Survey of India, DigiPin creates a precise, machine-readable location identity for addresses that may not have a formal postal address—rural farms, forest plots, tribal land, and peri-urban areas. For ONCM, DigiPin is a critical building block: carbon projects depend on precise geolocation of land parcels for MRV baselines, satellite monitoring, and registry registration. DigiPin provides the common location grammar through which any carbon project—from a one-hectare agroforestry plot in Jharkhand to a large forestry programme in the Northeast—can be uniquely identified, monitored, and verified on the open network.

Brazil's Pix Payment System[29]

Pix, launched in November 2020, rapidly expanded digital payment adoption in Brazil, adding 71.5 million users by December 2022 and serving 200 million individuals and 15 million businesses by June 2026. By focusing on speed, flexibility, and interface standardisation, Pix enabled small merchants and startups to thrive, highlighting how infrastructure thinking can bridge financial and technological divides.

Open Networks for Digital Commerce

The implementation of open transaction networks for commerce, mobility and other sectors—particularly through the Open Network for Digital Commerce (ONDC)—is pioneering a significant shift in the transaction economy. ONDC exemplifies the lowering of transaction costs and barriers to entry, thereby cultivating an environment ripe for innovation, competition and market expansion. It demonstrates how open, infrastructure-based systems can fundamentally alter market dynamics and foster inclusive growth.

Direct Benefit Transfers[30]

Welfare programmes leveraging digital infrastructure, such as India's PAHAL for LPG subsidies, showcase how direct benefit transfers reduce inefficiencies, optimise targeting, and enhance transparency. These systems provide valuable models for subsidy reforms in other sectors, such as energy.

Together, these initiatives highlight the profound potential of population-scale digital infrastructure to drive innovation, improve efficiency, and foster inclusion across global economies—offering policymakers actionable insights for designing transformative systems in diverse contexts.

Glossary

Key terms and abbreviations used in this paper, ordered alphabetically.

Abbreviation	Full term	Definition
ACVA	Accredited Carbon Verification Agency	A body accredited to conduct third-party carbon verification of project-based emission reductions.
Article 6	Article 6 of the Paris Agreement	The article of the Paris Agreement that enables international cooperation through carbon markets to help countries meet their climate targets, featuring market mechanisms under Articles 6.2 (bilateral cooperative approaches) and 6.4 (the international carbon crediting mechanism).
BEE	Bureau of Energy Efficiency	Statutory body under the Ministry of Power, Government of India. Serves as the administrator of the Carbon Credit Trading Scheme (CCTS) and the Indian Carbon Market (ICM).
Carbon Credit	—	One tonne of CO_2 equivalent (tCO_2e) reduction or removal from the atmosphere. (As per BEE, Government of India.)
Carbon Reduction	Decarbonization	Directly lowering greenhouse gas emissions by improving energy efficiency, transitioning to renewable energy sources (solar, wind), and optimising supply chains.
Carbon Removal	Carbon Dioxide Removal (CDR)	Methods that actively remove CO_2 from the atmosphere and store it durably in trees, soil, geological formations, or products.
Carbon Sequestration	—	The process of capturing and storing atmospheric carbon dioxide (CO_2) to reduce global warming. Involves removing CO_2 from

		the atmosphere and storing it in solid or liquid forms via natural sinks (forests, oceans, soil) or engineered technologies.
CCTS	Carbon Credit Trading Scheme	Notified by the Government of India in June 2023. Establishes a formal Indian Carbon Market (ICM) to facilitate trading of Carbon Credit Certificates, covering both a compliance mechanism for obligated industrial entities and a voluntary offset mechanism for non-obligated participants.
CDM	Clean Development Mechanism	Defined in Article 12 of the Kyoto Protocol (1997). Allows countries with emission-reduction commitments under the Kyoto Protocol to implement emission-reduction projects in developing countries and earn certified emission reduction (CER) credits.
Compliance Carbon Markets	—	Mandatory, government-regulated market systems in which entities are legally required to account for their greenhouse gas emissions, typically through cap-and-trade or rate-based emissions trading schemes.
GHG	Greenhouse Gases	Gases that trap heat in the atmosphere, primarily CO_2, CH_4 (methane), and N_2O (nitrous oxide). The GHG Protocol is the world's most widely used international accounting standard for quantifying and managing greenhouse gas emissions from organisations, supply chains, and products.
GIS	Geographic Information System	Technology used to create, manage, analyse, and map spatial data. Widely used in carbon project boundary delineation,

		satellite-based MRV, and land-use monitoring.
ICM	Indian Carbon Market	India's formal carbon market established under the CCTS. Administered by BEE under the Ministry of Power. (As per BEE, Government of India.)
ITMO	Internationally Transferred Mitigation Outcome	A unit of greenhouse gas reduction or removal that is transferred between countries under Article 6.2 of the Paris Agreement to count toward one country's NDC. Requires corresponding adjustment to avoid double counting.
MRV	Monitoring, Reporting, and Verification	The process of measuring greenhouse gas emissions or removals (monitoring), documenting and communicating those measurements (reporting), and having them checked by an independent third party (verification). In carbon markets, MRV underpins credit integrity.
NDC	Nationally Determined Contribution	A country's self-defined climate action plan submitted under the Paris Agreement, setting out targets for emissions reductions, energy transitions, and adaptation measures.
UNFCCC	United Nations Framework Convention on Climate Change	The international treaty governing global climate action. The Paris Agreement operates under the UNFCCC, which oversees NDC submissions, Article 6 carbon market rules, and international climate cooperation.
VCM	Voluntary Carbon Market	A market in which companies, individuals, and organisations voluntarily purchase carbon credits to offset their emissions, outside of regulatory compliance

		requirements. Credits are generated by projects that reduce or remove greenhouse gas emissions.

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