CMI Working Group

Technical Guidance Note

Enhancing Data and Systems Interoperability for Carbon Markets: Current Landscape and Strategic Recommendations

Carbon Markets Infrastructure

Working Group

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Acknowledgments

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Abbreviations and acronyms

AEF agreed electronic format

AF assessment framework

API application programme interface

BTR Biennial Transparency Reports

CAD Trust	Climate Action Data Trust
CDOP	Carbon Data Open Protocol
CIWP7	Continuous Work Improvement Program 7
CMI WG	Carbon Markets Infrastructure Working Group
DMRV	digital monitoring, reporting and verification
GCMU	Global Carbon Market Utility
GHG	greenhouse gas
ICVCM	Integrity Council for the Voluntary Carbon Market
ICP	independent crediting program
IETA	International Emissions Trading Association
IOSCO	International Organization of Securities Commissions
ISO	International Organization of Standardization
ITMO	Internationally Traded Mitigation Outcomes
MRV	monitoring, reporting, and verification
NDC	Nationally Determined Contributions
PACM	Paris Agreement Crediting Mechanism
RMI	Rocky Mountain Institute
SFWG	Sustainable Finance Working Group
SOC	Standards Oversight Committee
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VCM	voluntary carbon markets

Foreword

Carbon markets hold significant potential as a vehicle for channeling climate finance to developing countries, many of which face growing needs that far exceed available funding. When designed with high integrity, these markets not only unlock capital and drive verifiable emissions reductions but also help close investment gaps in critical sectors. Beyond their environmental impact, well-functioning carbon markets support job creation and deliver tangible financial benefits to local communities.

Significant progress is already underway. As highlighted in the World Bank's 2024 State and Trends Report, several key initiatives are advancing the integrity and functionality of carbon markets. The International Organization of Securities Commissions (IOSCO) is advocating for stronger oversight and market integrity; the International Institute for the Unification of Private Law (UNIDROIT) is working to harmonize the legal classification of carbon credits; and the Integrity Council for the Voluntary Carbon Market (ICVCM) is advancing transparency and scale through its Continuous Improvement Work Program. These global efforts lay essential groundwork, but further progress is needed to address persistent gaps—particularly in governance, institutional coordination, and technical integration.

As carbon markets grow in scale and strategic relevance, the need for trusted, connected and scalable infrastructure has become a global policy priority. Market infrastructure is the backbone of credibility, transparency, and efficiency. It supports the issuance, transfer, and retirement of carbon credits, and enables trust among market participants. Under South Africa's 2025 G20 Presidency, the Sustainable Finance Working Group (SFWG), highlights in its Note on Agenda Priorities that "by focusing on improving the foundational elements of market infrastructure – including data standardization and cross-border connections – the SFWG can help unlock the greater financing potential of these markets." This reflects growing recognition that robust, standardized approaches to data and infrastructure are essential for the credibility and effectiveness of carbon markets.

While carbon market infrastructure is just one part of a broader system that encompasses environmental, financial, and social integrity, it forms the backbone of effective market operations. Addressing infrastructure gaps early is critical to building a solid foundation for growth. The choices made now will shape our ability to scale, unlock climate finance, and achieve meaningful emissions reductions.

Advancing a global and decentralized market—such as for carbon credits—presents a unique opportunity to build robust, future-ready systems.

At COP28, the World Bank launched the *Engagement Roadmap for Carbon Markets* outlining how it will support countries in building high-integrity, high impact carbon markets. As part of efforts to operationalize this strategy, the World Bank launched the Carbon Markets Infrastructure Working Group (CMI WG), convening a diverse set of stakeholders to identify infrastructure-related bottlenecks and deliver actionable guidance. At COP29, the CMI WG released its flagship publication, *A Roadmap for a Safe, Efficient, and Interoperable Carbon Markets Infrastructure*, which outlined a vision for addressing foundational gaps and identified key priority areas for action.

Building on these findings and the collaborative efforts of the CMI WG, five targeted technical guidance notes were released in June 2025. These technical guidance notes aim to support countries and market actors in addressing key infrastructure challenges through practical recommendations on ecosystem governance, transaction integrity, information security, data interoperability, and digital MRV.

1 Ecosystem Governance for Carbon Markets Infrastructure: Assessment and Recommendations

2 Transaction Integrity for Carbon Markets Infrastructure: Tools and Recommendations

3 Information Security for Carbon Markets Infrastructure: Tools and Recommendations

4 Enhancing Data and Systems Interoperability for Carbon Markets: Current Landscape and Strategic Recommendations

5 Standardizing Digital MRV in Carbon Markets: System Evaluation Criteria and Hotspots Assessment

Together, these guidance notes are complementary in supporting the scale-up of safe, efficient, and interoperable carbon market infrastructure. Robust governance builds trust by clarifying institutional roles and responsibilities, integrity and security safeguards reduce risks, and interoperability enables scale by facilitating seamless data and system integration. The World Bank will integrate this guidance into ongoing capacity-building efforts to support countries in strengthening their carbon market infrastructure.

Executive summary

The *Technical Guidance Note on Enhancing Data and Systems Interoperability for Carbon Markets: Current Landscape and Strategic Recommendations* is one of five guidance notes prepared by the Carbon Markets Infrastructure Working Group (CMI WG). This note aims to inform ongoing efforts to improve data interoperability across carbon market systems—enabling consistent, transparent exchange of data between registries, programs, and jurisdictions. It outlines key challenges such as data fragmentation and inconsistent reporting; offers a stocktake of global initiatives focused on the standardization of carbon credit data; and provides targeted recommendations for aligning registry systems and data practices. Designed for modular adoption, the note aims to help stakeholders enhance comparability, support Article 6 implementation, and build connected, interoperable carbon markets infrastructure.

Carbon Markets Infrastructure Working Group

The CMI WG was established to identify key bottlenecks hindering the security, efficiency, and interoperability of carbon market infrastructure and to prioritize actions to address these challenges. As of June 2025, the CMI WG includes entities from across the carbon market ecosystem—ranging from standard setters on both the demand and supply sides, carbon crediting programs, registry operators, trading platforms, marketplaces, financial institutions, data and analytics providers, technology firms, Validation and Verification Bodies, legal and consulting firms, multilateral organizations, and regulatory authorities, among others. This broad and balanced membership brings together diverse perspectives that are essential for addressing infrastructure gaps, fostering interoperability, and supporting the integrity and scalability of global carbon markets (Table 1).

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TABLE 1
Composition of the CMI WG

CMI WG Member Organizations	
Abaxx Exchange	Integrity Council for the Voluntary Carbon Market (ICVCM)
Air Carbon Exchange	Intercontinental Exchange (ICE)
B3—Brazilian Stock Exchange	International Standards Organization (ISO)
BeZero Carbon	International Swaps and Derivatives Association (ISDA)
Climate Action Data Trust (CAD Trust)	Johannesburg Stock Exchange (JSE)
Climate Impact X	Nasdaq
CME Group	Philip Lee LLP
EcoRegistry	Puro.earth
European Bank for Reconstruction and Development (EBRD)	S&P Global Commodity Insights
Global Carbon Council (GCC)	SustainCERT
Global Carbon Market Utility (GCMU)	Sylvera
Gold Standard	Verra
Indian Energy Exchange (IEX)	World Bank
INFRAS	Xpansiv

Observers:
International Organization of Securities Commissions (IOSCO) Secretariat
Climate Data Steering Committee (CDSC) Secretariat

The CMI WG convened a series of meetings and consultations beginning in June 2024, which informed the development of A Roadmap for Safe, Efficient, and Interoperable Carbon Market Infrastructure (2024), released at COP29. The roadmap identified key infrastructure bottlenecks and outlined three priority action areas to strengthen the carbon market ecosystem: (i) ecosystem governance, (ii) information security and transaction integrity, and (iii) data and systems interoperability. It proposed the development of targeted technical guidance notes for each priority area by June 2025, intended to provide deeper analysis of existing barriers as well as practical frameworks, tools, and recommendations to guide coordinated action and system-wide improvements (Figure 1).

The objective of these notes is to offer practical tools and actionable recommendations for a broad spectrum of market participants. This includes both those designing and operating key components of carbon market infrastructure, as well as those leveraging these systems to carry out carbon market activities. All stakeholders play a critical role in developing robust, secure, and scalable market systems. The insights presented here are also intended to inform capacity-building and technical assistance efforts tailored to the unique contexts and institutional capacities of each country. This targeted support is designed to promote a cohesive, inclusive, and resilient carbon market infrastructure.

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FIGURE 1
Key challenges and recommendations of the five CMI WG technical guidance notes

Data and systems interoperability

Scope and approach

This technical guidance note outlines a coordinated strategy to improve data and systems interoperability across carbon markets. Its primary goal is to harmonize data infrastructure, reduce fragmentation, and align practices with global policy frameworks—most notably Article 6 of the Paris Agreement—so that carbon credit data can be reliably tracked, exchanged, and reported across jurisdictions and systems.

Key term: What is interoperability?

Interoperability refers to the ability of carbon market systems—such as registries, crediting program platforms, and accounting tools—to seamlessly exchange, interpret, and use data across different jurisdictions, institutions, and digital infrastructures. In this context, interoperability enables consistent tracking, validation, transfer, and reporting of carbon credits across voluntary and compliance frameworks, while preserving data integrity, minimizing duplication, and supporting scalable climate action.

This guidance is intended for a broad audience of stakeholders engaged in carbon market infrastructure. This includes crediting programs—whether independent, government-led, or affiliated with the United Nations—that are responsible for structuring carbon credit data and managing registry systems. It also targets government entities involved in developing or overseeing carbon market policy and infrastructure, as well as regulators, multi-stakeholder initiatives, and private sector actors working to advance shared data practices and enhance interoperability across carbon markets.

The recommendations presented in this note are based on a comprehensive review of existing interoperability initiatives, with the aim of mapping the landscape, identifying gaps, and avoiding duplication. They also reflect insights from technical deep dives and extensive multi-stakeholder consultations, which helped to identify key data and accounting challenges and validate the proposed approaches.

The subgroup's work was guided by three core objectives: to enhance trust in carbon market data by promoting harmonized, transparent, and verifiable data practices across the credit lifecycle; to enable robust accounting for policy-relevant use cases, including Article 6 transactions and corporate climate claims; and to reduce operational inefficiencies while improving system integration among key actors such as registries, marketplaces, verifiers, and government platforms.

Interoperability is increasingly recognized as essential to the credibility and scalability of carbon markets. However, progress remains uneven due to fragmented data standards, incompatible system architectures, and inconsistent reporting practices. This note presents a phased, practical pathway to address these challenges—from foundational data alignment to technical system integration—supporting the development of a more credible, scalable, and interconnected carbon market infrastructure.

Barriers and opportunities

Persistent barriers undermining carbon market interoperability

This guidance note responds to several persistent challenges that hinder data and systems interoperability in carbon markets. These include:

- **Systemic data fragmentation.** Carbon markets currently face significant data fragmentation, with inconsistencies and a lack of standardization across data sources, registries, and reporting standards. This fragmentation—resulting from differing data models, diverse methodologies, incompatible systems, and varying levels of technological adoption—often isolates essential data, such as verification of mitigation outcomes, ownership, and emissions reductions. Siloed information and the lack of a globally recognized common approach complicate efforts to ensure transparency and accuracy in tracking carbon credits.

- **Pre-issuance misalignment.** Data fragmentation in the early stages of the credit lifecycle stems from inconsistent standards for primary data collection and reporting across registries. Variations in validation and verification protocols—as well as differing methodologies and tools (for example, satellite imagery, remote sensing, or ground-based measurements)—create misalignment that makes it difficult to aggregate, compare, or verify project data. These inconsistencies make it difficult for stakeholders' to assess project quality using a uniform approach. They also pose significant barriers to scaling carbon market activities across regions and sectors.

- **Post-issuance interoperability gaps.** After credits are issued, fragmentation across registries creates significant barriers to transparency, traceability, and market efficiency. Incompatible registry systems prevent seamless tracking and transfer of credits, especially when moving between voluntary and compliance markets. Divergent reporting standards and timelines across registries also hinder oversight, making it difficult to conduct consistent performance assessments or reconcile data across jurisdictions.

> Siloed information and the lack of a globally recognized common approach complicate efforts to ensure transparency and accuracy in tracking carbon credits.

These challenges, identified in A Roadmap for a Safe, Efficient, and Interoperable Carbon Markets Infrastructure (2024) released at COP29, arise from two fundamental gaps:

i) Lack of common frameworks for data collection and exchange along the credit lifecycle.

Effective information exchange between systems requires aligned data structures. These are shaped both bottom-up—by how crediting programs choose to structure and present data—and top-down—by regulatory requirements for compliance reporting. While some common practices have emerged, particularly among established crediting programs, project developers, and intermediaries, carbon markets still lack standard, universally accepted data frameworks (for example, taxonomies, formats, labels) to describe activities across the credit lifecycle.

Inconsistencies in data collection—especially at the pre-issuance stage—persist across programs, even when similar methodologies are used. Project documentation is often poorly digitized, and the adoption of digital tools remains uneven. This inconsistent approach hampers interoperability and limits the ability to aggregate and compare data efficiently.

TABLE 2
Examples of pre-issuance data inconsistencies and their implications

Aspect	Observed inconsistency	Implication for interoperability
Project location data	Some registries use coordinates; others use shapefiles or textual descriptions	Inhibits automated spatial analysis and overlap detection
Methodology reference	Methodologies are named inconsistently across programs (e.g., "Afforestation v1.2" vs. "Forest_001")	Hinders automated mapping and comparison of similar project types
GHG quantification data	Varies in format (e.g., PDF reports vs. structured spreadsheets) and frequency of reporting	Limits comparability and automated validation of emissions estimates
Validation and verification records	Stored as unstructured documents with variable metadata	Complicates cross-checks and audit trail construction
Stakeholder engagement information	Often buried in narrative reports or uploaded as scanned documents	Difficult to extract or assess consistently across projects
Baseline assumptions	Documented in free-text rather than parameterized fields	Makes it difficult to compare assumptions or rerun calculations

Source: CMI WG

As new actors get involved in a growing market and scrutiny of credit integrity grows, the need for common data practices becomes increasingly urgent. A clear pathway to international standardization would support the development of high-integrity carbon markets and more interoperable infrastructure.

As new actors get involved in a growing market and scrutiny of credit integrity grows, the need for common data practices becomes increasingly urgent.

ii) Lack of coordinated guidance for carbon credits tracking and accounting

In policy-relevant use cases, carbon credits issued in one registry may need to be tracked in a higher-level registry, national inventory, or other tracking system to support transparency or compliance—such as under Article 6 of the Paris Agreement or the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). However, in the absence of common exchange protocols or consistent reporting practices, these inter-system connections often become inefficient, fragmented, or manual, leading to risks of delays, inaccuracies, and miscommunication.

A key challenge is the lack of clear, standardized approaches for determining credit eligibility under different policy schemes. Without consistent implementation of this information across registries, oversight becomes more challenging, and accurate performance assessments more difficult to achieve. Improved coordination guidance is critical to ensuring interoperability between registries and accounting systems, and enabling scalable, policy-aligned credit tracking across jurisdictions.

Opportunities created by enhancing market interoperability

Improving data and systems interoperability within carbon market infrastructure offers a strategic pathway to scale climate finance with greater transparency and confidence. By developing a shared language for carbon credit data and simplifying how information is collected and exchanged across systems, interoperability enhances data access, supports robust credit tracking and accounting, and empowers stakeholders—from regulators to investors to the public—to make better-informed decisions.

As carbon markets expand globally, they are likely to remain decentralized, involving a diverse range of actors in credit issuance, trading, and end use. Rather than aiming for centralized control, this guidance note supports the scaling of common data practices to foster interoperability between systems, enabling more efficient, liquid, and trusted carbon markets.

The following sections explore three key opportunities where improved interoperability can directly support market integrity and growth: (i) enabling project analysis and comparison, (ii) ensuring transparent credit use and accounting in policy schemes, and (iii) reducing the risks of double counting.

This guidance note supports the scaling of common data practices to foster interoperability between systems, enabling more efficient, liquid, and trusted carbon markets.

i) Enhancing project comparability to streamline market participation

Projects developed under similar methodologies are often comparable in scope but vary significantly in the type and depth of data they provide. Crediting standards differ in their requirements from project developers and the methods used for data collection—often relying on analog exchanges such as project documents or email correspondence. This inconsistency makes it difficult for stakeholders to analyze or compare projects across standards, increasing time, cost, and complexity.

The adoption of common data practices across the carbon credit value chain, along with digital workflows, can significantly reduce these burdens. For project developers, this would streamline the path to market regardless of the certification framework. For researchers, regulators, and ratings agencies, standardized data would improve the accuracy and efficiency of quality assessments. For buyers, it would lower due diligence costs and reduce reputational risk from overestimating a project's impact. A globally recognized baseline for data standardization would also support more seamless trading across different market types and jurisdictions, facilitating international cooperation.

ii) Transparent credit use and accounting toward policy objectives

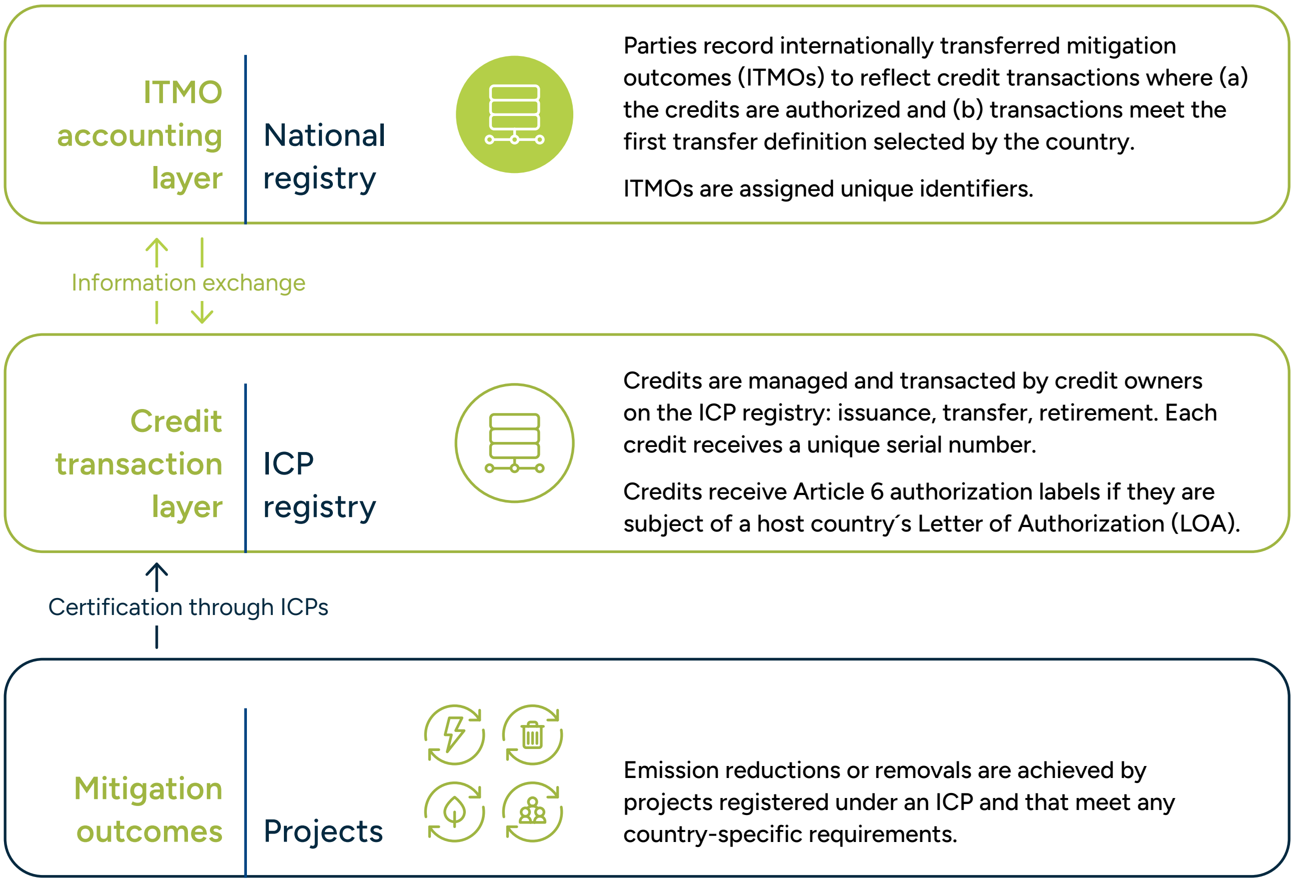
Carbon market infrastructure underpins the full life cycle of verified carbon credits and supports their multiple, and increasingly overlapping, uses. For instance, credits issued by independent crediting programs (ICPs) may be purchased by companies to meet voluntary climate commitments within the voluntary carbon market (VCM)or used to fulfill compliance obligations under a range of domestic and international policy schemes. Many carbon pricing mechanisms, such as emissions trading systems in California and South Africa or carbon taxes in Singapore and Colombia, allow the use of credits from a variety of crediting mechanisms.

Carbon credits are increasingly used across multiple regulatory and voluntary frameworks. Governments may establish their own crediting frameworks or authorize credits from other programs based on eligibility criteria such as project activity, methodology, or geographic location. In some cases, the same crediting program may certify credits that are eligible across several unconnected regulatory frameworks—whether as an ICP or as part of a global platform like the Paris Agreement Crediting Mechanism. Ultimately, a range of crediting schemes will support broader policy frameworks such as CORSIA or bilateral cooperation under Article 6.2 of the Paris Agreement.

Verified carbon crediting systems are becoming increasingly interconnected. As frameworks governing the use of verified carbon credits continue to evolve—and as domestic carbon pricing instruments expand and begin integrating into cross-border trade—the once-clear boundaries between compliance and VCMs are becoming increasingly blurred. This convergence heightens the need for efficient information exchange between systems, particularly between registries that manage credit transactions and those responsible for broader accounting and reporting. As these interactions become more complex, so too does the need for robust systems interoperability to ensure transparency, traceability, and alignment across market layers. The following figure (Figure 2) illustrates the information flows between project development, transactional registries, and accounting in national regiries for Article 6.2 cooperation underpinned by independent crediting program (ICP) credits.

FIGURE 2

Illustrative architecture of information flows under Article 6.2 cooperation underpinned by ICP credits



Source: Article 6.2 Crediting Protocol

Clarifying the roles of registries and broader market infrastructure is critical to scaling carbon markets. Years of negotiations on Article 6 have highlighted the importance of robust systems for governance, trading, and accounting—culminating in the finalization of guidance at COP29. As countries take varied approaches to developing carbon markets, achieving global interoperability between credit registries and compliance tracking systems will be essential to ensure transparent accounting of credit contributions to climate goals.

Credit labels are a key enabling tool for interoperability. These labels allow for the identification and tracking of credits eligible for specific policy uses across systems. Standards bodies and public agencies define the eligibility criteria and data requirements for labels, which must be consistently reflected in credit registries. While criteria will vary depending on the policy context, adopting a uniform technical approach to issuing and managing labels can support seamless cross-registry integration. In turn, this would enhance transparency and facilitate the scaling of high-integrity credit use across compliance and voluntary frameworks alike.

iii) Reducing risks of double counting

As carbon markets scale and multiple systems operate in parallel, improved data and systems interoperability is essential to reduce the risk of double counting. Double counting occurs if the same greenhouse gas (GHG) emission reduction or removal is claimed more than once, undermining the environmental integrity of carbon credits. There are three primary forms of double counting risks:[2]

- **Double issuance** occurs if two or more carbon credits are issued for the same GHG reduction or removal, either within the same or across different crediting programs. It can also arise when multiple mitigation activities overlap in their accounting boundaries.
- **Double use** refers to the use of a single carbon credit to meet more than one target or objective—such as applying it to separate corporate, national, or regulatory commitments—resulting in multiple claims on the same credit.
- **Double claiming** happens if a carbon credit is issued for a GHG reduction or removal that is also accounted for under a mandatory domestic mitigation scheme, or when a similar environmental credit (for example, a Renewable Energy Certificate) is issued and traded for the same activity. Considering this issue in the context of international cooperation under Article 6 of the Paris Agreement led to the adoption of rules on corresponding adjustments

Within their own systems, crediting programs and exchanges have established practices to mitigate double counting risks and uphold the integrity of the credits they issue or trade. However, global credit issuance remains decentralized and, as the market expands, multiple systems are likely to continue operating in parallel. Currently, no one centralized platform comprehensively tracks all carbon credit issuances, claims on credit use, or interactions across schemes worldwide. This fragmentation creates potential for errors, particularly given the growing number of crediting programs, national frameworks, and the evolving implementation of Article 6.

Harmonizing data practices and governance across programs and jurisdictions is critical to improving system interoperability and enabling large-scale detection and prevention of double counting using publicly available information. Concrete steps could include standardizing the provision of project location data (for example, shapefiles) to reduce the risk of project overlaps—especially in remote areas—and establishing consistent requirements for disclosing ultimate beneficiary information to enhance transparency and support robust evaluations of credit use.

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Stocktaking of global initiatives

Improved data and systems interoperability depends on the adoption of common frameworks that enable seamless tracking and accounting of carbon credits across platforms. At the **pre-issuance stage,** greater digitization of project documentation and MRV processes can enhance both data quality and accessibility across crediting systems. At the **post-issuance stage**, crediting programs, registries, and other market actors are increasingly expected to anticipate downstream system connections and policy-related uses of credits. Establishing interoperable data structures from the outset will be essential to enabling robust, automated information exchanges as markets evolve.

To inform the recommendations presented in this note, a stocktaking of major data standardization and interoperability initiatives in carbon markets was undertaken. Table 2 provides a summary of key initiatives and tools, outlining their governance arrangements, development timelines, and anticipated contributions to improving transparency, comparability, and system integration (for further details see Annex B). The initiatives span international frameworks, emerging technical protocols, and infrastructure efforts across both voluntary and compliance carbon markets—with particular emphasis on alignment with Article 6 of the Paris Agreement. Recent developments—including the launch of the Carbon Data Open Protocol (CDOP), the Article 6.2 Crediting Protocol, and ongoing work under the International Organization of Standardization (ISO) and the G20 Sustainable Finance Working Group (SFWG)—build upon earlier efforts such as the Climate Warehouse, the Climate Action Data Trust (CAD Trust), and multilateral negotiations under Article 6.

Establishing interoperable data structures from the outset will be essential to enabling robust, automated information exchanges as markets evolve.

These efforts reflect a growing international movement to define and harmonize the data architecture underpinning carbon markets. While many initiatives operate independently, they increasingly rely on shared building blocks. In particular, the open-source data model developed by the CAD Trust and guidance from the UNFCCC inform ongoing efforts under CDOP, the ISO Working Group on Sustainable Finance, and the G20 SFWG's development of a Common Carbon Credit Data Model. Figure 3 provides an overview of these initiatives, highlighting their scope, governance structures, and areas of complementarity across the carbon credit lifecycle. This stocktaking forms the analytical foundation for the practitioner-oriented recommendations presented in the next section.

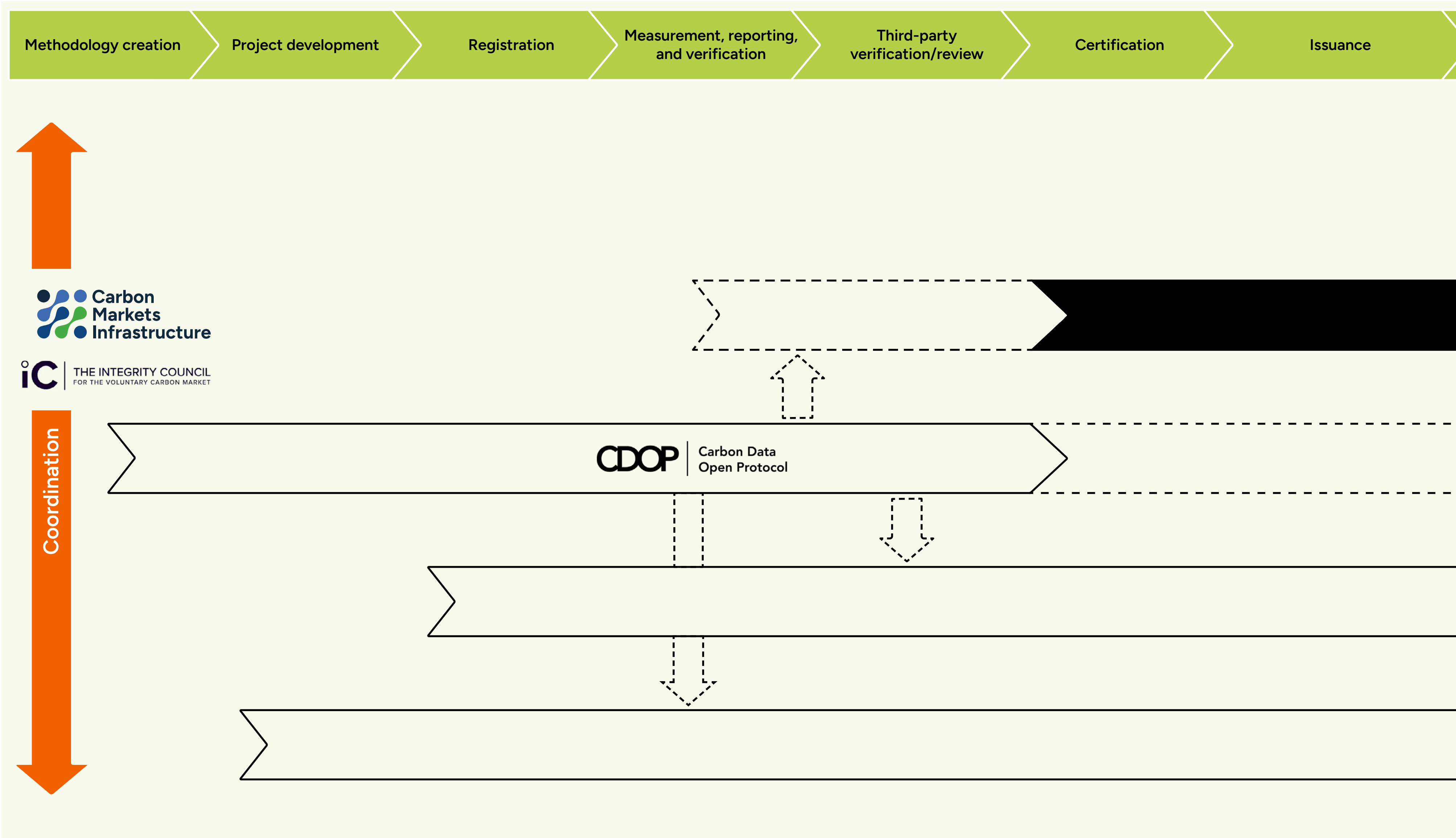
TABLE 3
Overview of data standardization and interoperability initiatives in carbon markets

Initiative/tool and description	Governance and timeline	Current/envisioned adoption
Common Carbon Credit Data Model Delivered by the G20 Sustainable Finance Working Group Intends "to serve as a globally recognised reference point, enhancing the transparency, comparability, and interoperability of carbon credit data across different markets. It will define the minimum key data attributes required from the beginning stages of project development and validation through to credit issuance, trading, and finally retirement."[25]	The G20 Sustainable Finance Working Group is seeking to deliver this Data Model in Q4 2025 under South Africa's G20 Presidency.	The Data Model will make recommendations for how standardised data fields are defined and incorporated into new and existing market infrastructures. Work on the Data Model is still ongoing. Once delivered, it will be made available as a public good for voluntary adoption. The Data Model is intended to offer a minimum floor for data standardization in carbon credit markets, upon which policymakers and market participants can build and/or innovate.
ISO TC/322 new work item on Data Model for Carbon Credit Markets Standard data model for integrating carbon credits into financial markets, building on the CAD (Climate Action Data) Trust model.	Proposed standard and working group undergoing ballot in ISO TC/322 (Sustainable Finance) in May-July 2025 to be followed by a 24-month anticipated consultation process	The first publication is expected in early 2027 and may inform registry design and financial integration. Broad consultation via ISO processes is anticipated.
CAD Trust Open-source registry data model and decentralized infrastructure for transparent carbon credit tracking and accounting across registries.	Multi-stakeholder governance since 2022, building on 2020-2021 Climate Warehouse prototypes.	It has 10 registries sharing data using a common schema and API links. Data model is used in 10+ national registries, being adapted to Article 6 data requirements, and informs ISO, G20 SFWG, CDOP efforts. Infrastructure is used by Digital4Climate tools and envisioned for supporting global double counting identification.
CDOP Standardized schema for carbon credit data (project definitions, methodologies, DMRV formats) with governance and update mechanisms.	Currently co-chaired by Sylvera; Global Carbon Market Utility (GCMU), Rocky Mountain Institute (RMI), and S&P Global. Future governance aims to ensure openness and extensibility.	The first version (pre-issuance data fields) expected September 2025. Will aim to support transparency and system interoperability with broad adoption. Guidance expected in 2025.
Article 6.2 Crediting Protocol Inter-registry guidance to track ITMO (internationally traded mitigation outcomes) and enable cross-registry alignment (labels, IDs, reporting templates). United Nations Framework Convention on Climate Change	Co-developed by Singapore, Verra, and Gold Standard.	It supports registry alignment for bilateral Article 6 transactions. Expected integration with CAD Trust in 2025.
Guidance on Registry Interoperability (UNFCCC) Frameworks and templates to facilitate Article 6 tracking and global registry alignment.	Driven by CMA decisions (COP26–29) and implemented by UNFCCC Secretariat.	Implementation is ongoing. Use of the Agreed Electronic Format (AEF) for reporting is encouraged but remains optional at this stage.
ICVCM CIWP7 (Continuous Improvement Work Program 7) Addresses infrastructure, standardization, and transparency challenges in the VCM.	Led by ICVCM experts, Standards Oversight Committee, and market participants; findings to be published in 2025.	The work has not yet been adopted but will inform future revisions to the ICVCM Assessment Framework to enhance scalability and credibility.

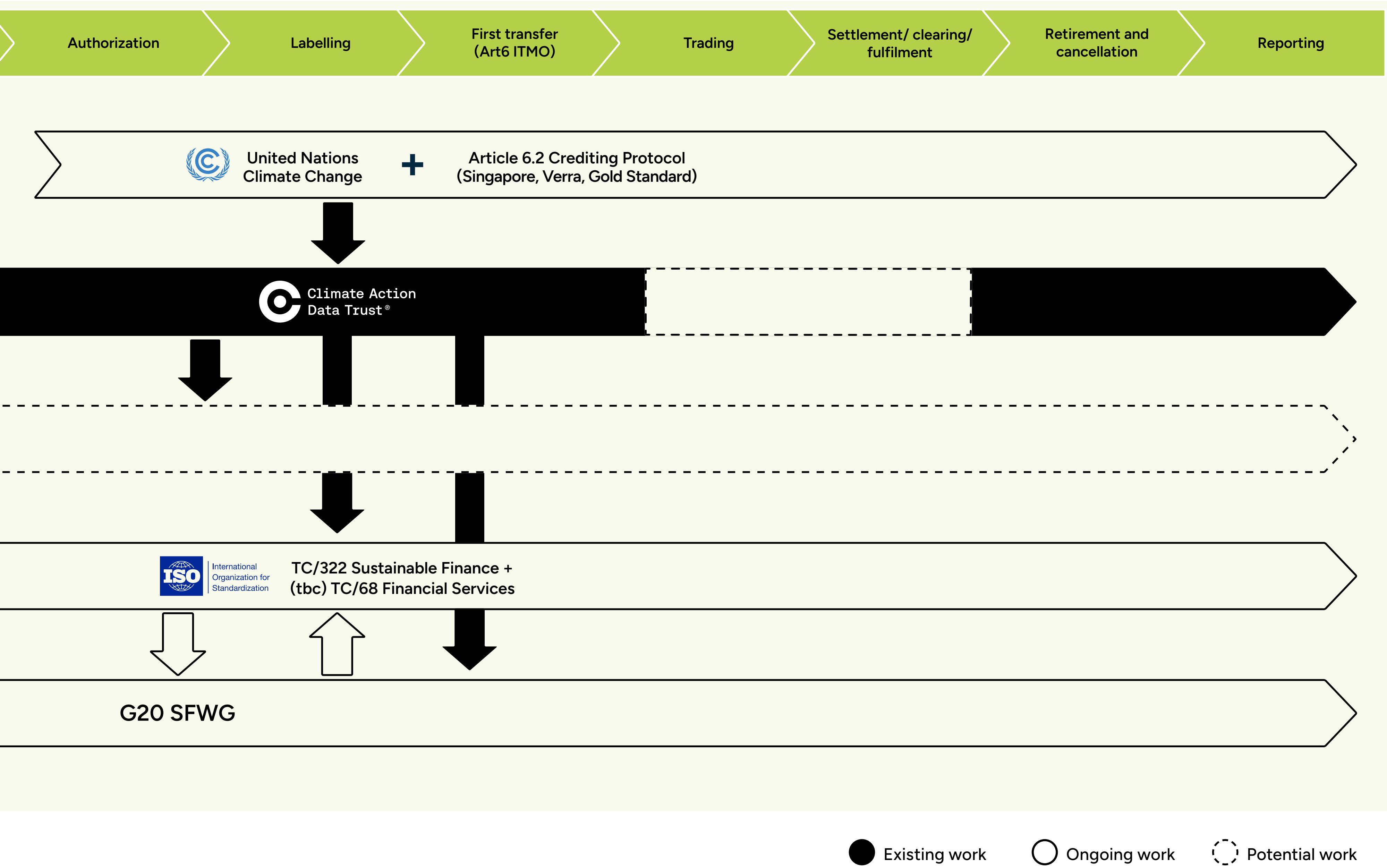
Source: CMI WG

FIGURE 3

Mapping of global interoperability efforts along the carbon credit lifecycle



Source: CMI WG


Authorization
Labelling
First transfer (Art6 ITMO)
Trading
Settlement/ clearing/ fulfilment
Retirement and cancellation
Reporting
United Nations Climate Change
+
Article 6.2 Crediting Protocol (Singapore, Verra, Gold Standard)
Climate Action Data Trust®
ISO International Organization for Standardization
TC/322 Sustainable Finance + (tbc) TC/68 Financial Services
G20 SFWG
Existing work
Ongoing work
Potential work

Recommendations

This guidance note presents two overarching recommendations to improve data interoperability in carbon markets:

1. Adopt and enhance common data practices across the credit value chain
2. Adopt and enhance registry infrastructure to support global credit accounting and reporting.

1 Adopt and enhance common data practices across the credit value chain

Open-source, public-good data models can serve as the foundation for scaling decentralized but interoperable carbon markets. Initiatives outlined in this note have the potential to inform formal international standards across the digital carbon market ecosystem. Building on recent momentum, this recommendation aims to help establish a globally recognized data foundation for high-integrity, secure, and interoperable carbon markets.

Harmonized and complementary standardization initiatives are critical to prevent fragmentation. Success depends on consultative, inclusive processes that account for diverse perspectives and lead to durable governance models. Stakeholders—including crediting programs, governments, and infrastructure providers—are encouraged to actively engage in shaping and testing these efforts.

Recommendations for data standardization initiatives

- Involve practitioners, particularly crediting program operators, registry developers, and project developers with expertise in data collection.
- Assess the resource implications for adopting new tools and processes, including phased rollouts or transitional support.
- Establish a robust baseline standard supported by credible governance for long-term updates.
- Consider staged adoption based on project or credit status (for example, active vs. retired credits).
- Recognize the diversity of market maturity; new crediting programs or infrastructure operators may find it easier to adopt harmonized practices than mature ones with legacy systems.

2 Adopt and enhance registry infrastructure to support global credit accounting and reporting

As credits from ICPs become increasingly eligible for policy-related uses, robust interoperability between registry systems is critical to support transparent accounting and reporting. Credits from the same programme may be recognized by multiple compliance schemes across jurisdictions—such as certain Verra-issued credits eligible in both California's and South Africa's systems—and may also contribute to international mechanisms like CORSIA or Article 6.2 of the Paris Agreement.

These cross-system intersections make it essential to improve data exchange between registries, whether operated by crediting programs, governments, or multilateral bodies. Without interoperability, credit tracking can become fragmented, undermining confidence in claims and slowing market operations.

To support the scaling of carbon markets with high-integrity tracking and reporting, regulators and registry operators must evaluate their infrastructure and anticipate future system integration needs. This includes identifying how registry systems will interface with crediting programs, the UNFCCC infrastructure, and third-party data aggregators.

This section offers practical recommendations to support enhanced registry interoperability—particularly in the context of Article 6 transactions and global reporting requirements. Recommendations are structured around actionable decisions and are supported by Figure 4, which organizes them into key themes and guiding questions.

Governments. For governments, the recommendations are grouped based on whether or not a registry is currently in place, recognizing different stages of system development and integration:

- Governments with a registry
- Governments without a registry

Crediting Programs. Recommendations for crediting programs focus on aligning registry infrastructure with interoperability requirements, data standards, and Article 6 readiness.

Recommendations for governments

Decisions around registry development will depend on national priorities, technical capacity, and policy context. Key considerations include:

- **Policy complexity.** What types of instruments (for example, emissions trading systems, carbon taxes, or domestic crediting mechanisms) will the registry support?
- **Scale of participation.** Will the country primarily generate or use credits, and to what extent?
- **Registry function.** Will an accounting registry—used solely to track and report carbon credits—be sufficient, or is a full transactional registry needed?

Because registry infrastructure takes time to develop, countries may begin using carbon credits toward Nationally Determined Contributions (NDCs) or authorize credits for international transfer before their registry is fully operational. Interim solutions may need to support tracking projects across multiple registries and using other data management approaches to assign authorization IDs, and consolidating reporting for Article 6 or Biennial Transparency Reports. This guidance note does not prescribe a single approach but outlines practical considerations to help governments anticipate interoperability needs and lay the foundation for effective systems.

→ Governments developing or operating a national registry for Article 6 or other policies

To enhance data interoperability —particularly for Article 6 and similar policy frameworks— governments and registry developers should:

- **Align with international formats.** Structure registry data according to the AEF to enable seamless UN reporting and the evolving common data practices described above.
- **Consider for API connectivity** with crediting program registries and relevant UN systems to enable transparent, automated, and real-time data exchange.
  - If developing a national registry, consult UNFCCC guidance on registry interoperability to ensure compatibility.
  - If using the International Registry for tracking, assess where credits will be issued. The International Registry will help seamlessly consolidate information from the Paris Agreement Crediting Mechanism (PACM) and other UNFCCC-supported issuance platforms. If the intention is to authorize credits from non-UNFCCC mechanisms, review the interoperability guidance to ensure those connections are supported.
- **Adopt a standardized approach to labeling credit eligibility for policy schemes, assigning labels at the unit level regardless of where the eligibility criteria are applied (project, methodology, or program level).** For example, if operating a pull-and-view registry that aggregates data from multiple crediting programs, incorporate a "label" field in the data model and define a standardized text string describing policy eligibility to be shared with and displayed at the unit level across all contributing registries. Although internal processes for applying these labels may vary by program, this approach will enable seamless, machine-readable retrieval of eligible credits, both within the system and across others.
- **Consider establishing a connection with the CAD Trust or other global aggregator platforms, especially if the registry is designed to be transactional and issue units.** These connections can enable cross-registry visibility, support transparent tracking of credit issuances, and help mitigate the risk of double counting across systems and jurisdictions.

For more details on how to implement this recommendation—including tools, platforms, and technical guidance—see the Table A1, Annex A: Checklist and resources for registry interoperability and Article 6 participation.

→ Governments planning to participate in Article 6 before having or having access to access to a registry

Governments may wish to engage in Article 6 activities—such as authorizing ITMOs—before having a national registry in place. In such cases, existing systems that aggregate project and credit data can serve as interim solutions to support transparent information exchange, enable traceability, and ensure a smooth transition to future national infrastructure. Options to consider include the following:

- **Using a crediting program registry.** Partnering with crediting programs already issuing credits can provide access to existing registries and data interpretation support.
- **Using the CAD Trust.** Governments can leverage the CAD Trust's infrastructure and seek support from capacity-building partners to track credit information publicly and transparently.
- **Using third-party aggregation platforms.** Vendors offering carbon portfolio management, market intelligence, or trading infrastructure may provide tools to consolidate and interpret registry data from multiple sources.

For more details on how to implement this recommendation—including tools, platforms, and technical guidance—see the Table A2, Annex A: Checklist and resources for registry interoperability and Article 6 participation.

Recommendations for crediting program registry operators

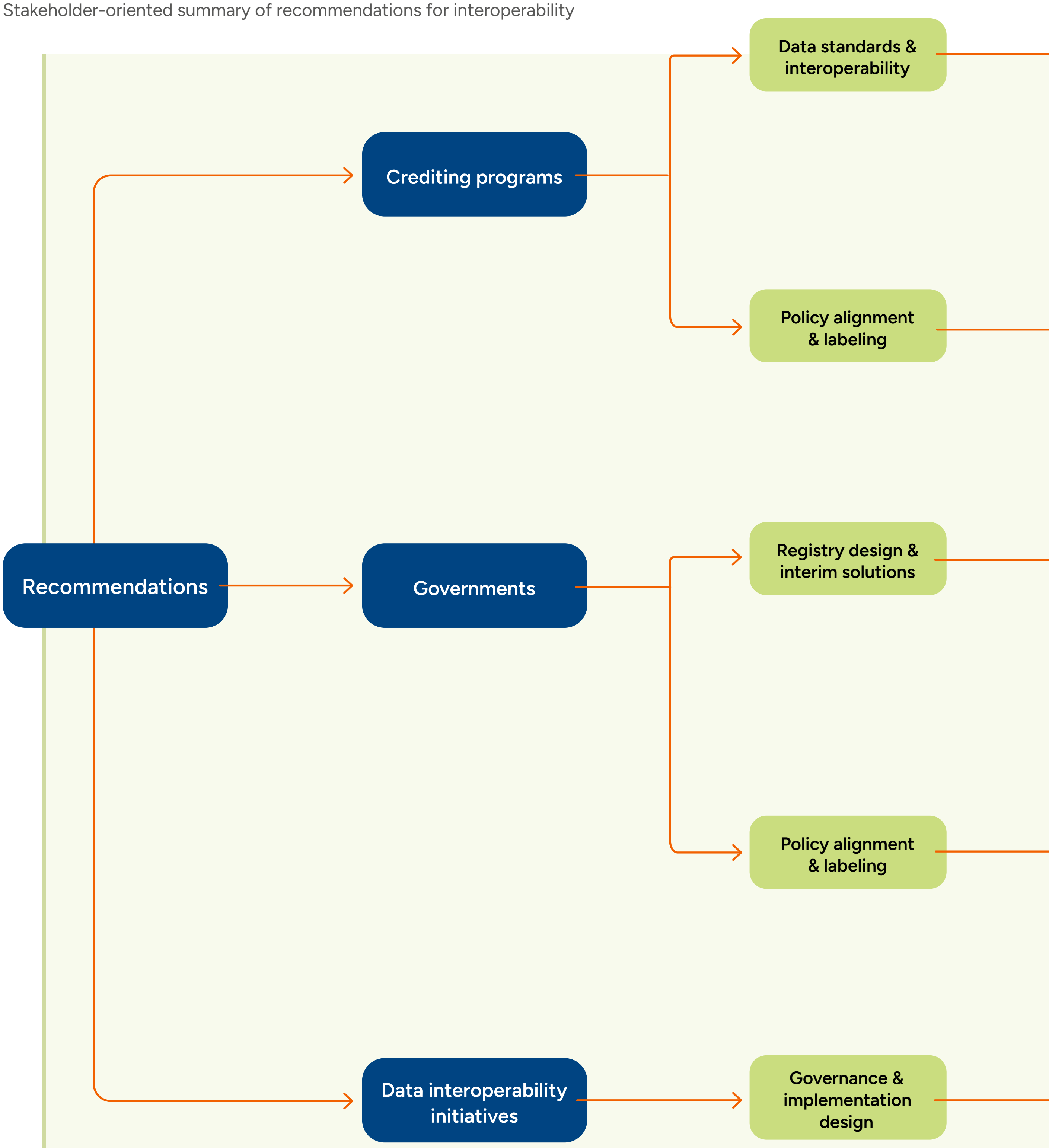
To ensure their systems support regulatory integration and interoperability for accounting and reporting purposes, crediting program registry operators are advised to:

- **Adopt the Article 6.2 Crediting Protocol** (once finalized) to enable standardized data exchange and labeling for tracking ITMOs in national and UN registries and reports.
- **Follow UN guidance on registry interoperability** to ensure compatibility with the international registry and other reporting systems.
- **Apply credit eligibility labels at the unit level**, regardless of how eligibility criteria are determined. Doing so enables automated data aggregation and reduces the risk of errors in downstream accounting systems.
- **Connect with the CAD Trust or other global aggregator platforms** to enhance cross-registry traceability of credit issuances and reduce double counting risks.

For more details on how to implement this recommendation—including tools, platforms, and technical guidance—see the Table A3, Annex A: Checklist and resources for registry interoperability and Article 6 participation.

Figure 4 provides a stakeholder-oriented action framework to support the implementation of interoperability recommendations across crediting programs, governments, and data standardization initiatives. It is structured around four key areas—data standards, registry infrastructure, policy alignment, and governance—and presents targeted questions and corresponding actions tailored to each stakeholder type and readiness level. The framework distinguishes between governments with and without registries and emphasizes the importance of aligning with global platforms such as the CAD Trust and the forthcoming Article 6.2 Crediting Protocol. These recommended actions aim to support data harmonization, consistent unit-level policy labeling, and secure, machine-readable data exchange—laying the foundation for scalable, transparent, and interoperable carbon market systems.

FIGURE 4
Stakeholder-oriented summary of recommendations for interoperability



Source: CMI WG

Is our data model aligned with emerging standards?	Engage in standardization efforts and apply data model recommendations
Are we integrating with the International Registry?	Follow UNFCCC guidance on registry interoperability
Can our system share data in machine-readable formats?	Align with emerging common practices for structuring data Connect to CAD Trust or comparable global aggregator platforms to facilitate transparency
Will our program support Article 6 or CORSIA?	Adopt the Article 6.2 Crediting Protocol for identifying authorized credits
Do we label policy eligibility at the unit level?	Streamline application of policy and scheme labels to units to enable tracking in higher-level registries
Is our registry model designed for transactional, accounting, or hybrid use?	Clarify the technical scope and assess institutional capacity to support and maintain the selected registry model Align national registry data models with AEF and evolving common practices Establish API connections to program registries and UN systems, as needed
Can interim systems or public aggregator platforms support our tracking needs before registry development?	Identify roles and responsibilities when selecting the appropriate digital tool or partner Transition any information obtained or decisions taken using from external systems to your registry once it is ready
How are we contributing to global transparency and accounting processes?	Connect to CAD Trust or similar platforms to support traceability and help avoid double counting of credits across systems
Is eligibility labeling consistent across underlying systems?	Require unit-level labels for scheme eligibility in all connected registries
Are stakeholder efforts coordinated and complementary?	Prioritize coordination to avoid duplication and promote adoption
Are key practitioners included in the design process?	Ensure strong practitioner involvement to reflect real-world needs and feasibility of implementation
Do users need support for transitioning to new data standards?	Plan transitional support tools and flexible timelines
Who will update and maintain the data standards long-term?	Build strong and trusted governance and maintenance processes

Way forward

This technical guidance note contributes to ongoing efforts to improve data and systems interoperability in carbon markets. Interoperability refers to the ability of systems, platforms, and data formats to communicate, exchange, and use information consistently and effectively. In the context of carbon markets, interoperability enables seamless, accurate, and transparent tracking of carbon credits across different programs, jurisdictions, and use cases, reducing duplication, improving efficiency, and enhancing trust in market operations.

The scope of the note includes:

- **An overview of challenges to interoperability**, including data fragmentation, incompatible system architectures, and inconsistent reporting practices.
- **A stocktaking of global initiatives** working toward standardized data models, technical protocols, and registry alignment—highlighting areas of convergence and complementarity.
- **Targeted recommendations** for crediting programs, governments (with and without registries), and data standardization bodies to align systems and practices for transparent, policy-ready credit tracking.

These contributions aim to support ongoing efforts to align registry systems and data practices across the carbon market ecosystem. They support the adoption of common data standards and registry improvements that enhance comparability, reduce duplication, and enable cross-market alignment—especially in the context of Article 6 implementation. The guidance is intended to be modular and adaptable, allowing for incremental improvements based on each stakeholder's capacity and readiness. Whether developing new systems or retrofitting existing ones, actors can use this note to:

- Identify areas where harmonization is most needed;
- Inform system design and guide strategic decisions on the allocation of financial, technical, and institutional resources toward registry infrastructure and data architecture;
- Enable integration with global platforms such as the Climate Action Data Trust or application of interoperability practices such as the Article 6.2 Crediting Protocol.

As carbon markets continue to evolve and the boundaries between voluntary and compliance applications converge, interoperability must shift from a technical aspiration to a design imperative. Embedding interoperability in system architecture and governance from the outset will be essential to ensuring transparency, avoiding double counting, and unlocking the full potential of high-integrity, connected carbon markets.

Annexes: Checklist, resources and stocktake

Annex A:
Checklist and resources for registry interoperability

This checklist is designed to support governments and crediting program registry operators to implement key interoperability recommendations. Each item includes practical steps and links to key guidance documents and tools.

TABLE A1
Governments developing or operating a national registry for Article 6 or other policies

Action item	Description	Key resources
1. Align with the AEF	Structure your registry data model according to the Agreed Electronic Format to enable seamless Article 6 reporting.	AEF Guidance (COP29); COP26 Reporting Guidance 2/CMA.3
2. Consider establishing API connectivity	Consider enabling automated, real-time data exchange with crediting programs, UN systems, and third-party registries.	CARP and Interoperability; COP27 Interoperability Guidance (6/CMA.4 & 7/CMA.4)
3. Define issuance strategy and international registry compatibility	Assess whether credits will be issued through PACM or other systems and their integration with the international registry.	UNFCCC International Registry Overview
4. Integrate standardized credit eligibility labels	Apply consistent policy labels (e.g., Article 6, CORSIA) at the unit level across registries using structured formats.	Article 6.2 Crediting Protocol (Pending); CAD Trust Schema Documentation
5. Connect to global data aggregators	Establish connections with platforms like CAD Trust to improve transparency, traceability, and double counting prevention.	CAD Trust; Digital4Climate Tools

Source: CMI WG

TABLE A2
Governments participating in Article 6 without a registry

Action item	Description	Key resources
1. Use crediting program registries	Partner with recognized crediting programs to track issuance and transfer of authorized credits.	Verra Registry; Gold Standard Registry; ACR (American Carbon Registry); CAR (Climate Action Reserve); GCC (Global Carbon Council Registry); ART TREES Registry
2. Leverage CAD Trust infrastructure	Use open infrastructure to track credits publicly and transparently.	Climate Action Data Trust
3. Use third-party aggregation tools	Use tools from portfolio managers or data providers to consolidate and interpret registry data.	Sylvera; S&P Global Commodity Insights; Open Carbon Protocol (OCP), Xpansiv Connect

Source: CMI WG

TABLE A3
Crediting program registry operators

Action item	Description	Key resources
1. Adopt the Article 6.2 Crediting Protocol	Enable standardized data exchange and ITMO tracking aligned with national and UN registries.	Article 6.2 Protocol (Pending); COP29 Systems Guidance
2. Ensure registry compatibility with UN systems	Align your system architecture with UNFCCC interoperability guidance for seamless data exchange.	COP27 Guidance (6/CMA.4 & 7/CMA.4)
3. Apply unit-level policy eligibility labels	Consistently tag credits with eligibility information to support integration with government and international systems.	CAD Trust data model
4. Connect with global data aggregators	Enhance cross-registry traceability and support transparency by integrating with CAD Trust or similar platforms.	CAD Trust

Source: CMI WG

Annex B: Detailed stocktaking of data standardization and interoperability initiatives in carbon markets

	Initiative, tool, and description	Governance and timeline	Current/envisioned adoption
Multilateral initiatives to standardize carbon credit data in the context of sustainable finance	**Common Carbon Credit Data Model delivered by the G20 Sustainable Finance Working Group.** Intended "to serve as a globally recognised reference point, enhancing the transparency, comparability, and interoperability of carbon credit data across different markets. It will define the minimum key data attributes required from the beginning stages of project development and validation through to credit issuance, trading, and finally retirement."[1]	The G20 Sustainable Finance Working Group is seeking to deliver this data model under South Africa's G20 presidency in Q4 2025.	The data model will make recommendations for "how standardised data fields are defined and incorporated into new and existing market infrastructures"[2] Work on the data model is still ongoing. Once delivered, it will be made available as a public good for voluntary adoption. The data model is intended to offer a minimum floor for data standardization in carbon credit markets, upon which policymakers and market participants can build and/or innovate.
	ISO Working Group on Carbon Data Models. Will aim to deliver a standard Data Model for Carbon Markets, intended to facilitate interoperable infrastructure and potential standardized integration of carbon markets into global financial markets.	In Q3 2025, a new working group addressing a standard data model for carbon credits is expected to formally launch. The proposal has been submitted by the Singapore Standards Council to ISO TC/322[3] (Sustainable Finance), building on the CAD Trust data model. ISO processes involve opportunities for broad consultations with market participants or other initiatives as appropriate.	Work is expected to start mid-2025, with the first pathway to adoption from early 2027. Potential applications include registry infrastructure and carbon credit integration into financial markets.

	Initiative, tool, and description	Governance and timeline	Current/envisioned adoption
Multi-stakeholder carbon market data and systems interoperability initiatives	**The Climate Action Data Trust**[4] Open-source registry data model and decentralized infrastructure for transparent carbon credit tracking and accounting across registries. • Data dashboard[5] • Open-source data model[6]	Jointly founded by the World Bank, IETA (International Emissions Trading Association),[7] and the Singaporean government. It operates through a multi-stakeholder governance process led by the Council and Board, with support from the Technical Committee, User Forum, and Secretariat. The technical prototypes were developed by the World Bank's Climate Warehouse program in 2020–2021 through simulations with governments, crediting programs, and market participants. Changes have since been governed by the CAD Trust governance structure, designed through a multi-stakeholder consultation in 2021.	Data from 10 carbon registries are integrated via an extract-transform-load (ETL) process, where each crediting program maps its registry fields to a common schema before connecting through an API. No changes to internal registry data structure are needed. The open-source data model supports open source registry tools from Digital4Climate (World Bank,[8] UNDP[9]), underpins the proposal for the forthcoming ISO[10] standard, and is used to inform G20 SFWG Common Carbon Credit Data Model and CDOP development. Near-term extension priorities include alignment with Article 6 reporting.
	Carbon Data Open Protocol (CDOP)[11] Initiative to create a standardized data schema for carbon crediting projects, covering definitions, methodologies, and DMRV. The work will also cover guiding principles for CDOP purpose and use and a governance framework for maintenance and updates.	Founded by Sylvera[12] and co-chaired on a rotating basis with GCMU,[13] RMI,[14] and S&P Global Commodity Insights[15]. Governance will be defined to keep the protocol open, extensible, and up to date.	Not yet in use. The first version of the protocol, focusing on pre-issuance data, is expected in September 2025.
	Article 6.2 Crediting Protocol[16] Launched at COP29 by the Singaporean government, Verra, and Gold Standard, the Article 6.2 Crediting Protocol is developing standard guidance for inter-registry information flows to support governments in authorizing independent crediting program credits for bilateral Article 6 trades. It aims to help identify the credits underlying ITMO in a standard way to increase interoperability between transactional and ITMO accounting registries, addressing authorization labels, ITMO identities, and standard reporting templates.	Currently being jointly developed by Singapore, Verra, and Gold Standard.[17] Guidance expected in H2 2025.	Adoption efforts at Verra and Gold Standard. Data field and labeling requirements are expected to be integrated into the CAD Trust data model in 2025.

	Initiative, tool, and description	Governance and timeline	Current/envisioned adoption
Further guidance on systems interoperability	**UNFCCC**[18] Intended to increase systems interoperability, transparent accounting, and reporting of Article 6 activities and credit contribution to NDCs. Relevant decisions and guidance: • COP26—describes functions of the international registry, guidance for recording and tracking; 2/CMA.3.[19] • COP27—Guidance on registry interoperability arrangements between international and PACM registries and the Centralized Accounting and Reporting Platform (CARP)[20]; 6/CMA.4 and 7/CMA.4.[21] • COP29 guidance on the international registry, request use of the AEF and latest template, further guidance relating to tracking; 4/CMA.6.[22]	Decisions agreed by the CMA,[23] guidance and implementation driven by the UNFCCC Secretariat.	The implementation of registry and transparency infrastructure to support the guidance adopted in COP29 is in progress. The use of the AEF for annual Article 6 reporting is requested but remains optional.
	ICVCM CIWP7[24] CIWP7 brings together experts and market players to tackle transparency, standardization, and scalability challenges in the VCM. It is one of 13 work programs supporting the evolution of the assessment framework (AF) to reflect new science, technologies, and high-integrity standards, and to explore provisions for scaling carbon credits as a financial asset class.	Each CIWP working group includes ICVCM experts, SOC and Board members, Secretariat staff, and market players, and is facilitated by an SOC or Expert Panel member. The CIWP7 public learnings report will be published in mid-2025.	Not yet adopted, as work is ongoing. The CIWP will address market infrastructure, pricing transparency, integrity, and structured finance. The findings will inform a revised AF to help accelerate VCMs' role in the net-zero transition.

Source: CMI WG

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