

A Roadmap for Safe, Efficient, and Interoperable Carbon Markets Infrastructure



Acknowledgements

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The International Organization of Securities Commissions (IOSCO) Secretariat participates as an observer.

The CMI WG welcomes engagement from relevant stakeholders interested in joining and contributing to these ongoing efforts.

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1818 H Street NW, Washington, DC 20433
Telephone: 202-473-1000

Internet: www.worldbank.org

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Abbreviations and acronyms

ABC	Anti-bribery and corruption	MFA	Multi-factor authentication
AML	Anti-money laundering	MRV	Monitoring, reporting, verification
CAD Trust	Climate Action Data Trust	SBSTA	The Subsidiary Body for Scientific and Technological Advice, a subsidiary of the United Nations Framework Convention on Climate Change
CFTC	Commodity Futures Trading Commission	TC	Technical committee
CMI WG	Carbon Markets Infrastructure Working Group	TSVCM	Taskforce on Scaling Voluntary Carbon Markets
COP28	28th annual Conference of the Parties of the United Nations Framework Convention on Climate Change	UNFCCC	United Nations Framework Convention on Climate Change
COP29	29th annual Conference of the Parties of the United Nations Framework Convention on Climate Change	VVBs	Validation and verification bodies
ICVCM	Integrity Council for the Voluntary Carbon Market		
IIF	Institute of International Finance		
IOSCO	International Organization of Securities Commissions		
ISO	International Organization for Standardization		
IT	Information technology		
KYC	Know your customer		



Foreword

Carbon markets can be a crucial channel for climate finance in developing countries, where resource needs far exceed available funding. High integrity carbon markets help mobilize capital, deliver measurable emissions reductions, and bridge investment gaps. Beyond environmental benefits, these markets enable projects that generate jobs and direct financial flows to communities.

At COP28, the World Bank released its carbon markets engagement roadmap, [High Integrity, High Impact: The World Bank Engagement Roadmap for Carbon Markets](#). This roadmap outlines our ambition to unlock the potential of high-integrity carbon markets by supporting countries in generating carbon credits and by deepening partnerships to address key barriers to market expansion.

To scale effectively, carbon markets need safe, efficient, and interoperable infrastructure. This entails (1) defining the roles and responsibilities of market infrastructure players—from registries to trading venues and exchanges, (2) implementing robust systems to ensure information security and transaction integrity, thereby preventing fraud, money-laundering and double counting, and (3) establishing common data frameworks and systems interoperability to enable a globally connected market.

This nascent market is evolving rapidly and organically. The Paris Agreement gives countries flexibility in structuring their national carbon market infrastructure. What has emerged as a result is an agile yet fragmented landscape with inconsistent terminology and unclear governance over roles and responsibilities.

Building safe, efficient, and interoperable systems requires collaboration among governments, regulators, standards bodies, infrastructure providers, philanthropies, and nonprofit organizations. Following the roadmap launch, the World Bank convened the Carbon Markets Infrastructure Working Group (CMI WG) to bring diverse stakeholders together, identify critical bottlenecks, prioritize actions, and develop guidelines to inform the creation of safe, efficient, and interoperable carbon markets infrastructure. The inaugural output from this initiative is the *Roadmap for a Safe, Efficient, and Interoperable Carbon Markets Infrastructure*.

The recent UN climate negotiations in Bonn (SB60) laid the groundwork for advancing Article 6 discussions at COP29 in Baku, with parties signaling readiness to engage constructively. COP29 presents a vital opportunity to resolve remaining issues, including decisions on the international registry systems interoperability, and related technical, functional, and data requirements—key elements for operationalizing Article 6 under the Paris Agreement.

Addressing bottlenecks in carbon market infrastructure is one piece of a broader landscape that includes environmental, financial, and social integrity. However, carbon market infrastructure is the backbone and arteries of market activity. Tackling these bottlenecks head-on and early on is essential for the market to develop on strong foundations. Decisions made today will shape our capacity to scale these markets, mobilize climate finance, and achieve impactful emissions reductions.

Hania Dawood
Practice Manager, Climate Finance and Economics,
World Bank



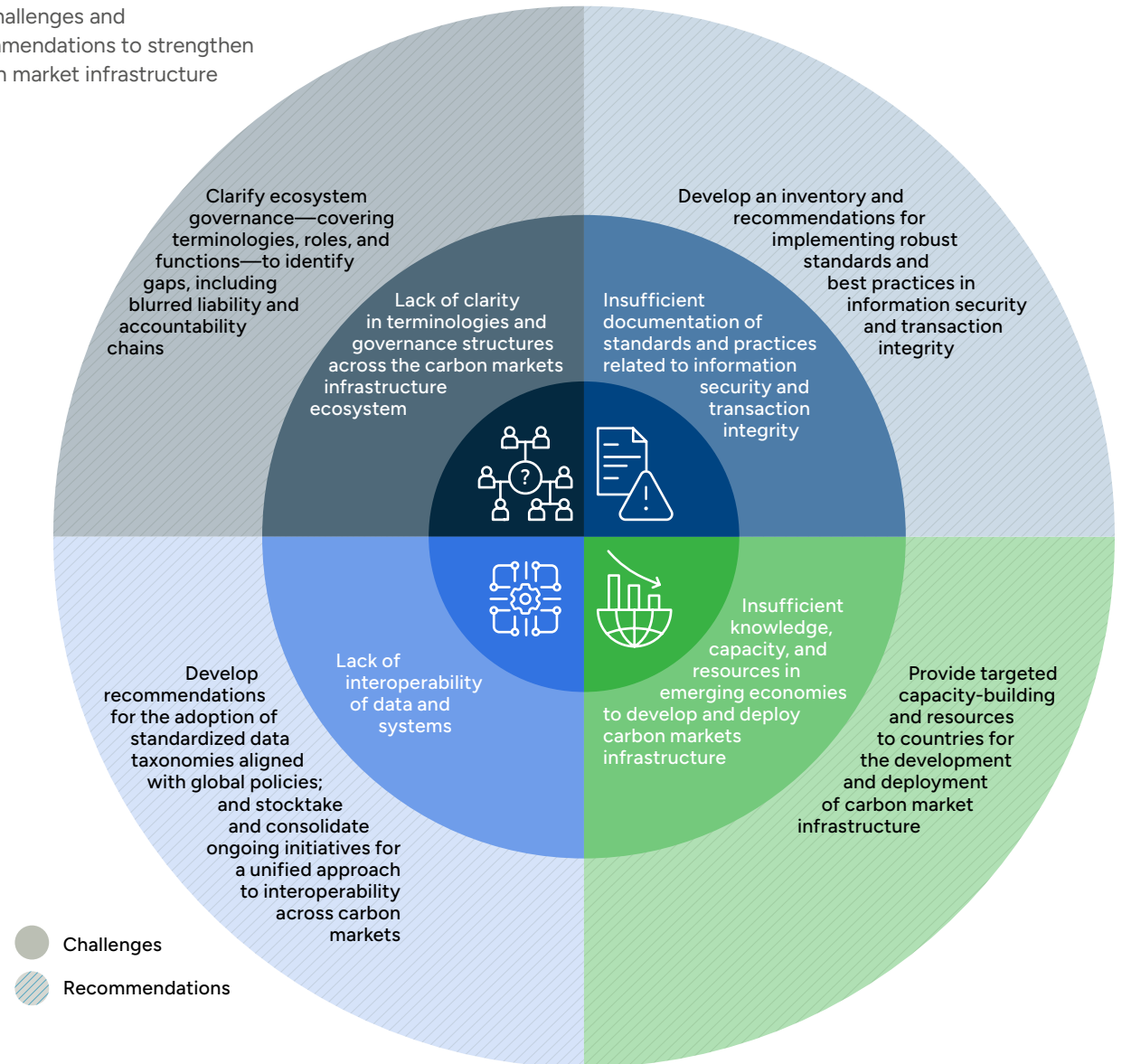
Executive summary

A well-structured and high-integrity carbon market has the potential to mobilize essential financing for climate action, especially in developing countries. Achieving scale will require secure, efficient, and interoperable infrastructure that fosters the growth and reliability of these markets.

This Roadmap for a Safe, Efficient, and Interoperable Carbon Market Infrastructure 2024 identifies critical bottlenecks relating to market infrastructure. Left unaddressed, these bottlenecks will impede scalability. These consist of i) lack of clarity in ecosystem governance structures emerging out of ambiguity in roles, liabilities, and governance structures, which may cause confusion and inefficiencies, ii) lack of documentation of current standards and market practices related to information security and transaction integrity measures, which undermines stakeholder trust in the market, and iii) insufficient data and systems interoperability, which hinders exchange of information.

This roadmap outlines the bottlenecks and priority action areas identified by the CMI WG. These action areas will be developed into three guidance notes and released by June 2025 to coincide with the 62nd sessions of United Nations Framework Convention on Climate Change (UNFCCC) Subsidiary Body for Scientific and Technological Advice (SBSTA).

FIGURE 1
Key challenges and recommendations to strengthen carbon market infrastructure



Carbon Markets Infrastructure Working Group

Objectives and members

For carbon markets to be effective in increasing decarbonization, they must operate with transparency, integrity, stability, accountability, and principles of orderly functioning. [High Integrity, High Impact: The World Bank Engagement Roadmap for Carbon Markets](#) released by the World Bank in December 2023 called for **common frameworks** shaping governance across the ecosystem of principles-setters, independent standards, registries, validation and verification bodies (VVBs), and rating agencies; **connecting markets through interoperability** between different registries and trading platforms along with transparent and integrated market-level data; **harnessing digital technologies and scaling their use**, for example in measuring, reporting, and verifying emissions and reductions, which could provide a much-needed boost to the market; and **building capacity through robust policy frameworks** for carbon market infrastructure which in turn are matched with better technical and institutional capacity at the country level.¹

The CMI WG was established to address these goals: to identify key bottlenecks that hinder the security, efficiency, and interoperability of carbon market infrastructure, as well as outlining priority areas for action to address these challenges in the medium and long term. The entities listed in Table 1 participated in the series of meetings and consultations beginning in June 2024, which contributed to the development of this report; the CMI WG welcomes new members who wish to join and contribute to the ongoing discussions and workstreams.

TABLE 1
CMI WG Member Organizations

CMI WG Member Organizations	
Air Carbon Exchange	International Swaps and Derivatives Association (ISDA)
B3 – Brazilian Stock Exchange	International Standards Organization (ISO)
Climate Action Data Trust (CAD Trust)	Johannesburg Stock Exchange (JSE)
CME Group	Nasdaq
Climate Market Strategy & Infrastructure group (CMSI)	Philip Lee LLP
Ecoregistry	Puro Earth
Global Carbon Council (GCC)	S&P Global
Global Carbon Market Utility (GCMU)	Sylvera
Gold Standard	US Treasury
Indian Energy Exchange (IEX)	Verra
Integrity Council for the Voluntary Carbon Market (ICVCM)	World Bank
Intercontinental Exchange	Xpansiv
Observer: International Organization of Securities Commissions (IOSCO) Secretariat	



Scope of work

CMI WG discussions and contributions draw on key principles and standards from leading reports and frameworks—such as those produced by ICVCM, IOSCO, the Commodity Futures Trading Commission (CFTC), and the Institute of International Finance (IIF). For instance, the report of the IIF’s Taskforce on Scaling Voluntary Carbon Markets (TSVCM) called for robust data infrastructure to scale voluntary markets, prevent double counting, and ensure seamless data exchange, particularly by achieving interoperability between carbon registries and trading platforms.² The IOSCO Consultation Report 2023 (CR0623) outlines crucial considerations for building resilient voluntary carbon markets, focusing on open access, market integrity, transparency through publicly available data, interoperability, and strong governance frameworks.³ Additionally, the CFTC’s Call for Inputs 2024 (RIN 3038-AF40) proposes standards for voluntary carbon credit derivative contracts, aimed at establishing a regulated market with clear requirements for transparency and market integrity.⁴

These existing initiatives are foundational to the work of the CMI WG.

Further, the CMI WG recognizes that public policy is crucial in defining the market architecture of carbon markets and therefore CMI WG aims to cover developments across both compliance and voluntary carbon markets. The CMI WG has engaged and continues to have planned engagements with relevant government counterparts across several emerging economies to capture the challenges and necessary solutions to strengthen infrastructure across national carbon markets. These considerations ensure that the group’s efforts build on and align with other efforts to establish best practices and support the creation of a secure, transparent, and efficient carbon market infrastructure ecosystem through multistakeholder dialogue and collaboration.

CMI WG discussions and contributions draw on key guidelines and standards such as those developed by ICVCM, IOSCO, CFTC, and IIF.

FIGURE 2
Scope of the Carbon Markets Infrastructure Working Group

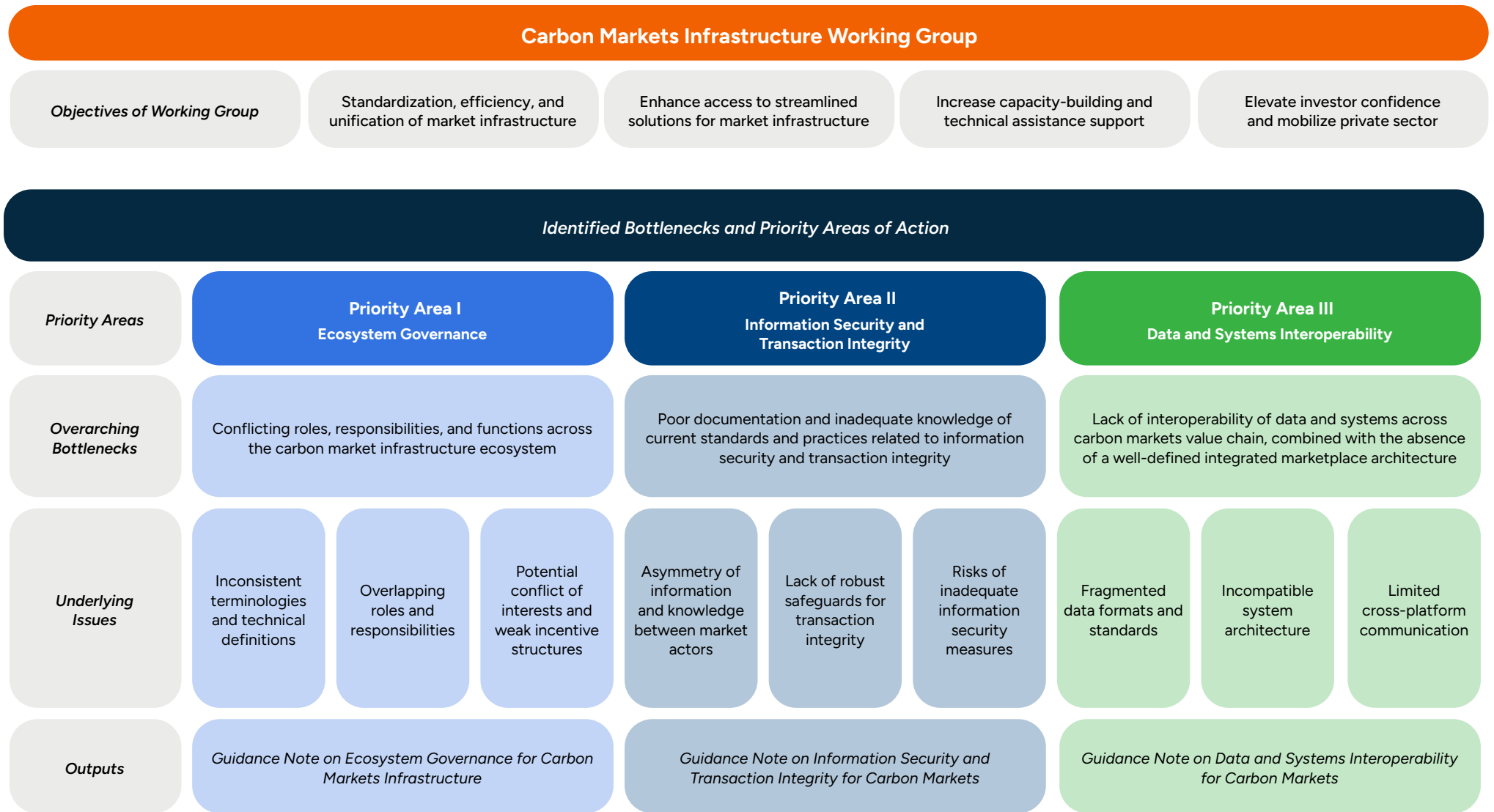


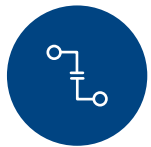
FIGURE 3

Priority areas identified by the Carbon Markets Infrastructure Working Group

The CMI WG identified and prioritized three critical areas for action, targeting key bottlenecks across the carbon market value chain:



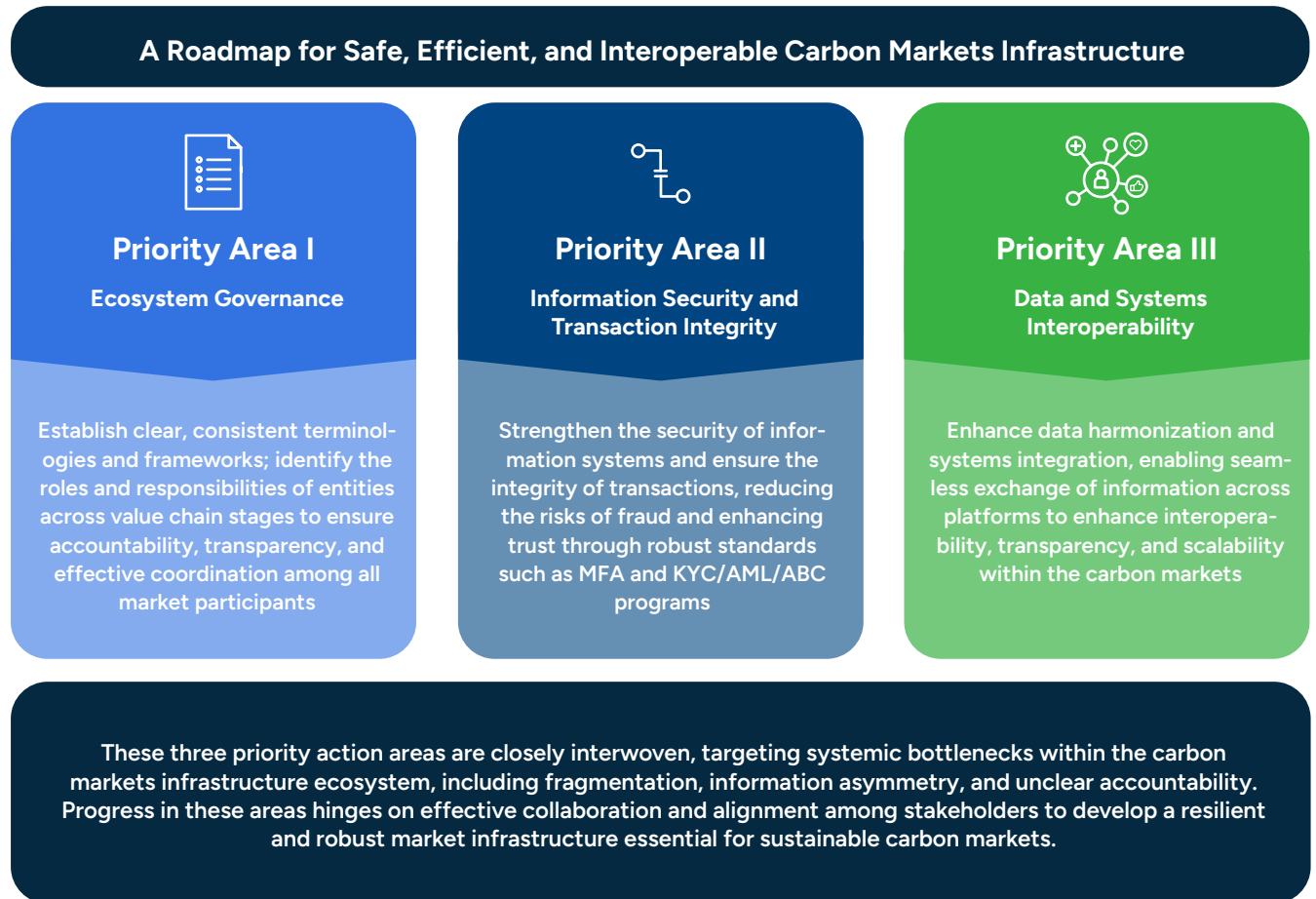
Priority Area I:
Ecosystem Governance



Priority Area II:
Information Security and
Transaction Integrity



Priority Area III:
Data and Systems
Interoperability



MFA-multifactor authentication; KYC-know your customer; AML-anti-money laundering; ABC-anti-bribery and corruption



Outputs and outcomes

This roadmap is the first output of the CMI WG. It lays out the critical bottlenecks and priority areas and recommendations for building safe, efficient, and interoperable carbon market infrastructure identified in discussions. It also features a dynamic, evolving mapping of the carbon markets ecosystem, which will be updated throughout the work on priority area I.

The bottlenecks outlined in this roadmap focus on highlighting priority areas that demand the stakeholder community's attention within the market infrastructure space. It establishes a foundation for the CMI WG's future agenda, which consists of developing comprehensive guidance notes that delve deeper into each identified priority area. These detailed guidance notes are scheduled for release in June 2025, when the 62nd sessions of the UNFCCC SBSTA will occur.

- Guidance Note on Ecosystem Governance for Carbon Markets Infrastructure
- Guidance Note on Transaction Integrity and Information Security for Carbon Markets
- Guidance Note on Interoperability of Data and Systems for Carbon Markets

The CMI WG seeks to offer practical, actionable guidance to accelerate progress in building a reliable, high-impact carbon market infrastructure capable of delivering meaningful climate outcomes.





Priority area I

Ecosystem governance

Scope

Priority area I of the CMI WG centers on mapping and clarifying current ecosystem governance within carbon markets, with an emphasis on identifying key entities and functions within market infrastructure.

The bottom-up nature of carbon markets under the Paris Agreement has created complexity and allowed for a diverse set of requirements for policy and regulatory frameworks and carbon market infrastructure at both national and international levels. This has led to a fragmented ecosystem, marked by inconsistencies in terminologies and ambiguous governance over stakeholder roles, responsibilities, and functions. As a result, the chain of liability and accountability across the carbon market value chain has become unclear. Additionally, the growing number of participants has heightened the risk of errors and fraud, underscoring the urgent need for transparent, reliable infrastructure and standardized digital systems to support the effective functioning of carbon markets.

The CMI WG conducted a preliminary ecosystem mapping, which can be found [here](#) as a living and evolving resource. It includes a comprehensive list of terminologies, technical definitions, functionalities, and entities, covering all stages of the carbon cycle process (both pre- and post-issuance). This mapping effort is a first step to establishing a common understanding of the components of the carbon market infrastructure ecosystem, and will help stakeholders assess potential inconsistencies, overlaps, and conflicts of interest across the value chain. Figure 4 provides a visual representation of the framework and mapping.

The following infographic (Figure 4) maps the main entities in the carbon markets infrastructure and their respective functionalities. Entities are categorized by their roles in pre-issuance, post-issuance, and regulatory and governance functions. The top row of the infographic displays a sequential list of functionalities progressing from pre-issuance to post-issuance. Each functionality is associated with a set of entities classified by their roles and degree of involvement, whether direct or indirect, in implementing each function. For detailed information and specific examples, please refer to the aforementioned [preliminary ecosystem mapping](#).



FIGURE 4
Preliminary framework for ecosystem mapping

Clustering Functionalities and Entities

Functionalities

Functionalities: Pre-issuance/primary

- Methodology creation
- Project design and development
- Validation
- Due diligence/KYC & AML verification
- Information security
- Registration
- Project implementation
- Measurement, reporting, and verification
- Third-party verification/review
- Certification

Functionalities: Post-issuance/post-trade/secondary

- Issuance
- Authorization
- Labeling
- First transfer
- Trading
- Settlement/clearing/fulfilment
- Retirement/cancellation
- Reporting
- Post trade infrastructure

Entities

Entities: Pre-issuance

1. Project developer
2. Register/Accounting and tracking registry
3. Registry with transaction functionality
4. Infrastructure providers
5. Multilateral organizations
6. Carbon crediting program/standard setters
7. Verification and validation body/certification bodies/
third party auditors
8. Methodology validator

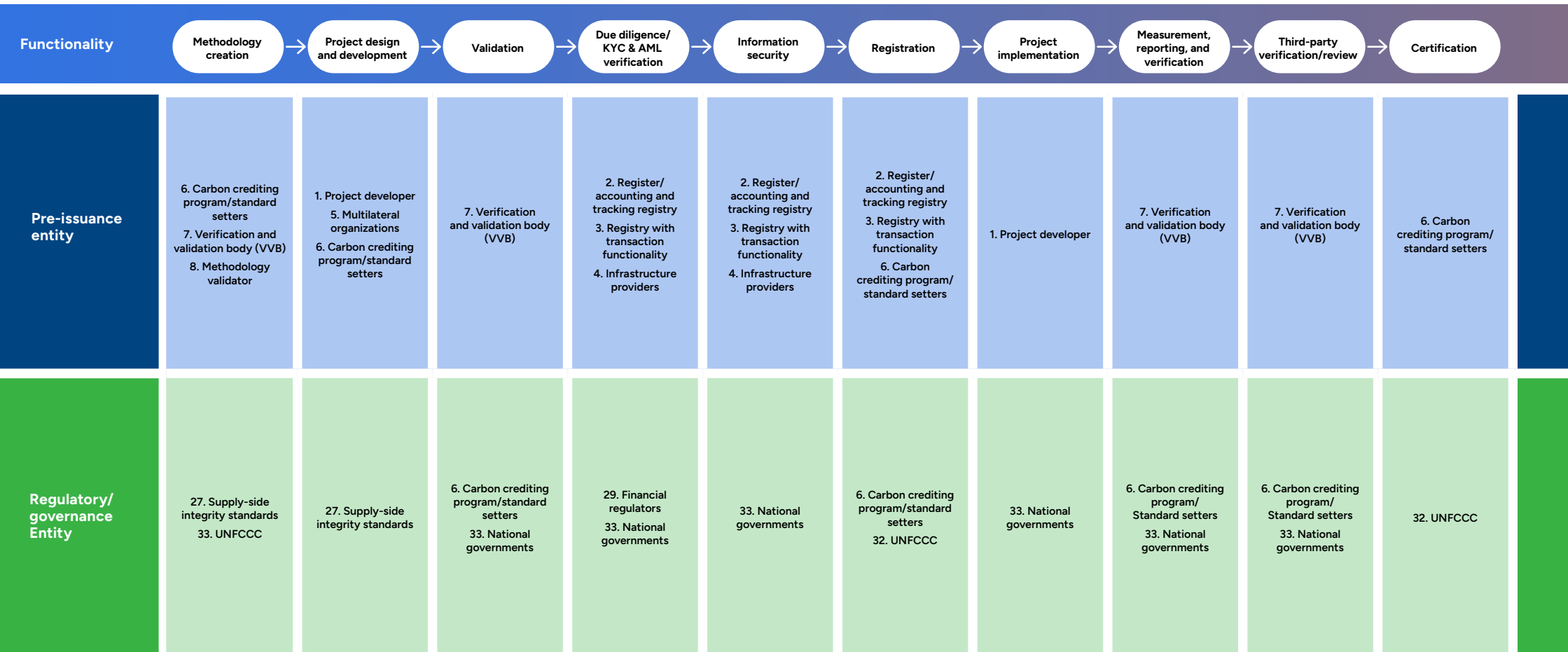
Entities: Regulatory/governance

25. Standardized contract hosts
26. Demand-side integrity standards
27. Supply-side integrity standards
28. Carbon accounting standard setters
29. Financial regulators
30. Market regulators
31. Financial accounting standard setters
32. UNFCCC
33. National governments

Entities: Post-issuance

9. Data aggregation
10. Data reconciliation/mapping
11. Data analytics
12. Traders
13. Primary market trading infrastructure: Auction platforms
14. End user
15. Brokers
16. Retail aggregators/traders
17. Secondary market trading infrastructure: Exchange
18. Secondary market trading infrastructure:
Over the counter market
19. Post trade infrastructure: Clearing house
20. Trade repository
21. Carbon credit rating
22. Carbon insurance
23. Disclosure regulation
24. Web3 platform

Mapping Functionalities (Pre-Issuance) to Entities



UNFCCC to play a role where applicable. May not have a role to play in case of certification under VCM



Mapping Functionalities (Post-Issuance) to Entities



	Issuance	Authorization	Labelling	First transfer	Trading	Settlement/clearing/fulfilment	Retirement and cancellation	Reporting	Post-trade infrastructure
Pre-issuance entity	1. Project developer 3. Registry with transaction functionality 6. Carbon crediting program/standard setters	1. Project developer 2. Register/accounting and tracking registry 3. Registry with transaction functionality	6. Carbon crediting program/standard setters	1. Project developer 3. Registry with transaction functionality 6. Carbon crediting program/standard setters	4. Infrastructure providers 6. Carbon crediting program/standard setters	4. Infrastructure providers	2. Register/Accounting and tracking registry 3. Registry with transaction functionality	1. Project developer	4. Infrastructure providers
Post-issuance entity	13. Auction platforms 23. Disclosure regulation	12. Traders 13. Primary market trading infrastructure: Auction platforms 14. End user 15. Brokers 16. Retail aggregators/traders	21. Carbon credit rating 22. Carbon insurance	13. Primary market trading infrastructure: Auction platforms	12. Traders 13. Primary market trading infrastructure: Auction platforms 14. End user 15. Brokers 16. Retail aggregators/traders 17. Exchange 18. Over the Counter market 20. Trade repository 24. Web3 platform	14. End user 19. Post trade infrastructure: Clearing house	14. End user 23. Disclosure regulation	14. End user 23. Disclosure regulation 33. National governments	9. Data aggregation 10. Data reconciliation/mapping 11. Data analytics 21. Carbon credit rating 22. Carbon insurance
Regulatory/governance Entity	27. Supply-side integrity standards 32. UNFCCC 33. National governments	26. Demand-side integrity standards 32. UNFCCC 33. National governments	27. Supply-side integrity standards 32. UNFCCC	32. UNFCCC 33. National governments	24. Standardized contract hosts 25. Demand-side integrity standards 28. Financial regulators 29. Market regulators 32. National governments	24. Standardized contract hosts 28. Financial regulators	26. Demand-side integrity standards 32. UNFCCC 33. National governments	28. Carbon accounting standard setters 29. Financial regulators 30. Market regulators 31. Financial accounting standard setters 32. UNFCCC 33. National governments	29. Financial regulators 30. Market regulators 32. UNFCCC 33. National governments

Role of actors will change as negotiations around 'first transfer' are finalised. The stage at which the first transfer takes place will affect the entities involved

See Legend [here](#) →



State of play

The CMI WG's ecosystem mapping builds on and is informed by prior efforts.

These include the 2021 TSVCM report and the World Economic Forum's 2023 report *Scaling Voluntary Carbon Markets*. TSCVM's map categorized participants into three main groups: supply-side actors, demand-side actors, and market intermediaries.⁵ The World Economic Forum identified key players and their roles within the voluntary carbon market and highlighted the core functionalities across the market, focusing on the interconnectedness of entities and their contributions to scaling the market.⁶ The CMI WG has also drawn on the growing body of work that provides technical definitions of processes and functionalities related to carbon asset creation, thereby clarifying and formalizing the processes that underlie carbon asset creation and trading. These include IOSCO's analyses offering standardized definitions and frameworks for understanding how voluntary and compliance carbon markets operate, which address critical components like market oversight, transparency, and integrity.⁷ As well a recent ICVCM report introduces widely accepted definitions for key market functions, establishing essential criteria for carbon credits.⁸

The ecosystem mapping effort by the CMI WG takes a step further, offering a more granular and comprehensive scope by delving into detailed entities and functionalities with laid-down definitions.

Further, this effort goes beyond the core stages of the carbon asset creation process, encompassing sub-stages of both pre- and post-issuance phases, establishing a foundational analytical framework. It also includes an assessment of potential bottlenecks (Table 2) in the carbon market infrastructure ecosystem, providing a basis for assessing potential overlaps, gaps, and conflicts of interest. This will enable stakeholders to better understand and address inefficiencies within the current carbon markets infrastructure.

The ecosystem mapping effort by the CMI WG takes a step further, offering a more granular and comprehensive scope by delving into detailed entities and functionalities with laid-down definitions.

TABLE 2

Identified bottlenecks in ecosystem governance within carbon markets infrastructure

Inconsistent terminologies and technical definitions	<p>A lack of consistent terminologies and definitions is creating confusion. For instance, a carbon crediting registry might be referred to as the “register,” “issuance registry,” or “transaction registry,” leading to ambiguity about its specific functions. Similarly, the term “monitoring, reporting, and verification (MRV) system” is applied to systems encompassing various standards and processes across both national and project levels. There is a need for more standardized and precise terminology to reduce confusion and enhance clarity.</p>
Overlapping roles and responsibilities	<p>Roles and responsibilities within carbon market infrastructure often overlap significantly among entities, leading to potential inefficiencies. For instance, registries may be managed at the national level by individual countries, centralized under the UNFCCC, or operated by independent standard bodies, exchanges, and other infrastructure providers. Additionally, multiple actors frequently perform similar functions—such as issuance, tracking, verification, certification, and retirement of credits—resulting in redundancy and blurred lines of accountability.</p>
Potential conflicts of interest and weak incentive structures	<p>Conflicts of interest and weak incentive structures pose significant challenges to the carbon market’s integrity and credibility. Without the right safeguards, financial motivations and misaligned responsibilities could undermine the rigor of project validation, risking environmental outcomes. For instance, if project developers select and pay VVBs, these bodies may feel pressured to deliver favorable assessments to secure repeat business. Similarly, fee structures based on credit volume could incentivize quantity over quality, potentially allowing projects to pass with insufficient scrutiny if robust safeguards are lacking. Limited accreditation and enforcement for VVBs could also lead to inconsistent validations if weak oversight allows underperforming VVBs to operate without consequence, eroding trust and threatening the market’s long-term sustainability. While some standards bodies and market actors have implemented mitigation measures, universal adoption across all standards operating in the market is necessary to ensure consistency and integrity.</p>

Roles and responsibilities within carbon market infrastructure often overlap significantly among entities, leading to potential inefficiencies and blurred lines of accountability



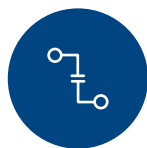
Way forward

The next stage of the CMI WG's work in this priority area is to develop a detailed guidance note to enhance clarity and foster a common understanding of ecosystem governance within the carbon market infrastructure. This guidance note will build upon initial ecosystem mapping efforts, offering a comprehensive assessment and laid-down technical definitions for entities and functionalities across the lifecycle from pre-issuance to post-issuance. The guidance note will be based primarily on three efforts:

- **Diagnostic assessment of governance structures:** Building on the framework established in the preliminary ecosystem mapping (Figure 4), the guidance note will present a diagnostic assessment of roles and responsibilities, identifying potential overlaps, gaps, conflicts of interest, and issues within accountability and liability chains. Based on these findings, it will provide actionable recommendations to address identified challenges.
- **Incorporation of technical deep dives and stakeholder consultations:** The guidance note will be shaped by comprehensive technical deep dives and consultations with CMI WG members, subject-matter experts, and practitioners, ensuring a well-rounded and evidence-based approach.
- **Integrating findings into capacity-building and technical assistance for countries:** Findings from this workstream will inform the development of capacity-building and technical assistance activities, tailored to address the diverse capacities and requirements across different markets. This targeted support will contribute to a cohesive and resilient carbon market infrastructure.

Building on the framework established in the preliminary ecosystem mapping, the guidance note will present a diagnostic assessment, identifying potential overlaps, gaps, and conflicts of interest.





Priority area II

Information security and transaction integrity

Scope

Priority area II of the CMI WG consists of strengthening information security and transaction integrity in carbon markets. As with any nascent market, carbon markets depend on robust information security and transaction integrity to build trust, ensure reliability, and establish credibility.

Ensuring information security in carbon markets involves safeguarding data associated with carbon credits and transactions from unauthorized access, manipulation, or breaches. This entails implementing comprehensive cybersecurity measures, governed by well-defined policies and standards, to protect sensitive information and uphold market integrity. Additionally, it requires a commitment to continually advancing the maturity of security controls, adapting to evolving threats, and ensuring resilience across the market infrastructure.

TABLE 3

Key concepts within information security

Data protection	Safeguarding information from unauthorized access, disclosure, alteration, or destruction.
Encryption	Protecting the confidentiality of data both in storage and during transmission.
Access control	Conducting authentication (verifying identity) and authorization (granting/restricting permissions based on roles or needs).
Data retention	Policies and procedures for secure storage, archiving, and/or deleting data in compliance with legal, regulatory, or business requirements.
Monitoring systems security	Continuous oversight and improvement regarding security related to activities/systems deployed to detect, prevent, and respond to security incidents to identify potential threats or breaches.
Maintaining audit trails	Recording and preserving logs of all significant actions or events within an information system which can be used for compliance, forensic investigations, and ensuring accountability.



Transaction integrity in carbon markets refers to ensuring that transactions between buyers, sellers, and intermediaries occur within a trusted, secure, and compliant carbon markets infrastructure environment. This involves strict adherence to regulatory standards such as KYC, AML, and ABC programs, which help verify the legitimacy of market participants and prevent illegal activities. Transaction integrity requires clearly defined roles and responsibilities for all parties involved, establishing accountability across the transaction process. It also entails ensuring the authenticity of carbon credits and the validity of each transaction, preventing issues like fraud or double counting, which could undermine the credibility of the market.

As with any nascent market, carbon markets depend on robust information security and transaction integrity to build trust, ensure reliability, and establish credibility.

TABLE 4

Key elements of transaction integrity

Know your customer	KYC processes are designed to 1) verify the identities of their clients and individuals with significant control (e.g., beneficial owners and directors) and 2) assess the risk associated with clients. These processes help prevent fraud and financial crimes, ensuring that only legitimate participants engage in carbon market transactions.
Anti-money laundering	AML procedures and regulations are designed to prevent criminals from disguising illegally obtained money as legitimate. This requires financial institutions to monitor and report suspicious activities.
Anti-bribery and corruption	ABC policies and practices prevent bribery, corruption, and fraud within organizations. They ensure that business dealings are conducted ethically and in compliance with anti-corruption laws.

Given that countries are at different stages in developing their carbon market infrastructure, information security and transaction integrity measures must be tailored to specific needs, capacities, and regulatory environments.



State of play

As carbon markets face increasing scrutiny from regulators and stakeholders, both information security and transaction integrity have become crucial components for ensuring compliance, mitigating risks, and maintaining trust in the market.

Currently, there is limited information and documentation on existing standards and market practices for information security within carbon markets. In this context, information security means protecting sensitive data related to carbon credits and transactions from unauthorized access, tampering, or misuse. This includes ensuring that information about who owns carbon credits, how they are traded, and the details of each transaction are kept secure and private. Robust information security helps prevent fraud and builds trust among participants, making the carbon market a safer and more reliable place for buying and selling carbon credits.

There are two primary frameworks that organizations have begun to adopt to navigate regulatory demands and build trust in the rapidly evolving carbon market. These frameworks are the CIS Controls (formerly the SANS Top 20 Critical Security Controls) and the US National Institute of Standards and Technology (NIST) Cybersecurity Framework.⁹ Both provide a structured approach to assessing cybersecurity maturity and identifying critical gaps, aligning with industry best practices and effectively mitigating cybersecurity risks. These frameworks are often incorporated into broader audits, such as Service and Organization Controls 2 (SOC 2) audits, which emphasize information security, confidentiality, and privacy.

In connection with **Priority Area I – Ecosystem governance**, as the carbon market scales and stakeholder roles and responsibilities become more defined, establishing clear lines of accountability for information security and transaction integrity will be essential. Clearly identifying those responsible for safeguarding data and ensuring secure transactions is crucial to upholding market integrity and fostering participant confidence.

As carbon markets face increasing scrutiny from regulators and stakeholders, both information security and transaction integrity have become crucial components for ensuring compliance, mitigating risks, and maintaining trust in the market.



TABLE 5

Identified bottlenecks in information security and transaction integrity

<p>Knowledge gaps in current standards and practices related to information security and transaction integrity</p>	<p>Poor documentation on current security and regulatory standards and market practices in carbon markets hampers efforts to prevent fraud, ensure transparency, and build trust. Adopting frameworks such as the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 27001 for information security, complying with the EU’s General Data Protection Regulation (GDPR), and following IOSCO and CFTC guidelines can address these gaps by improving data security, risk management, and overall confidence in the carbon market’s infrastructure.</p>
<p>Asymmetry of information and knowledge between actors</p>	<p>Governments, business actors, and infrastructure providers often lack equal access to information regarding robust standards and best practices for implementing information security and transaction integrity measures effectively. This uneven distribution of knowledge can lead to inconsistencies in security practices, increased vulnerability to cyber threats, and challenges in establishing trust across the carbon market ecosystem. As a result, misaligned expectations and gaps in compliance may arise, complicating efforts to achieve cohesive, secure, and transparent market operations.</p>
<p>Lack of robust safeguards for transaction integrity</p>	<p>The lack of transaction integrity safeguards in carbon markets poses a serious challenge, enabling fraudulent activities—such as issuing fake credits or double counting—to go unchecked. For instance, without identity verification (e.g., KYC), unauthorized or fraudulent actors can participate in the market, while insufficient AML measures allow illicit funds to flow through carbon credit transactions. Additionally, weak anti-corruption controls (e.g., ABC) can lead to compromised project validations, where validators might be incentivized to issue credits for projects with questionable environmental impact.</p>
<p>Risks of inadequate information security measures</p>	<p>Inadequate information security in carbon markets exposes specific vulnerabilities in key activities, such as credit issuance, transaction tracking, and verification processes. For example, if security measures are weak, unauthorized parties could manipulate or falsify data in carbon credit registries, potentially resulting in fraudulent credits entering the market. Additionally, during transactions, cyberattacks targeting trading platforms could lead to data breaches or financial theft, undermining confidence in the market’s reliability. In verification stages, insecure handling of project data might allow tampering with emissions data or validation reports, compromising the integrity of carbon credits. Such security lapses not only pose financial and reputational risks but also erode the environmental impact and credibility of carbon markets.</p>



Way forward

The next stage of the CMI WG's work in this priority area is to develop a detailed guidance note aimed at enhancing the understanding of robust standards and best practices related to information security and transaction integrity within carbon markets infrastructure. It will document current standards and market practices—specific areas such as information security and data protection as well as MFA, KYC, AML, and ABC standards will be addressed. It will be based primarily on three efforts:

- **Actionable recommendations for implementing robust information security and transaction integrity measures:** The guidance note will deliver comprehensive recommendations to establish robust safeguards for information security and transaction integrity.
- **Incorporation of technical deep dives and stakeholder consultations:** The guidance note will be shaped by comprehensive technical deep dives and consultations with CMI WG members, subject-matter experts, and practitioners, ensuring a well-rounded and evidence-based approach.
- **Integrating findings into capacity-building and technical assistance for countries:** Findings from this workstream will inform the development of capacity-building and technical assistance activities, tailored to address the diverse capacities and requirements across different markets. This targeted support will contribute to a cohesive and resilient carbon market infrastructure.

The CMI WG's guidance note will deliver guidance on implementing robust safeguards for information security and transaction integrity.





Priority area III Interoperability of data and systems

Scope

Priority area III of the CMI WG is based on the recognition that data and systems interoperability in carbon markets is critical to building cohesive and efficient market infrastructure. As highlighted by [IOSCO](#) and [ICVCM](#),¹⁰ interoperability within carbon markets requires unified data protocols and compatible systems across registries to support transparent transactions and seamless data flow across platforms and jurisdictions. Effective interoperability is essential for transparent and efficient data sharing among registries, tracking and reporting platforms, and verification bodies, ensuring accurate information is accessible across the market.

Carbon markets currently face significant data fragmentation, with inconsistencies across data sources, registries, and reporting standards. This fragmentation—resulting from diverse methodologies, incompatible systems, and varying levels of technology adoption—often isolates essential data, such as verification of mitigation outcomes, ownership, and emissions reductions. This siloed information complicates efforts to ensure transparency and accuracy in tracking carbon credits.

In the **pre-issuance phase**, data fragmentation and interoperability issues arise due to inconsistent standards for primary data provision across project registries. Diverse validation and verification protocols, along with varying data collection methods (e.g., satellite imagery vs. ground-based measurements), hinder data alignment and make it challenging to aggregate information across projects. This lack of standardization limits stakeholders' ability to assess project quality uniformly and complicates scaling across regions. In the **post-issuance phase**, fragmentation impacts the tracking and transfer of carbon credits across multiple registries. Incompatible registry systems, where credits issued in one registry cannot be seamlessly tracked in another, create transparency and traceability issues. This makes it difficult to link voluntary and compliance markets, among other issues. Further, limited real-time data integration affects market participants, as delays between registries and trading platforms impact data on credit availability, ownership, and use, reducing market liquidity. Disparate reporting standards also complicate oversight, as varying timelines across registries impede consistent performance assessment.

ICVCM, IOSCO, [TSVCM](#),³ the World Bank, and other key entities have issued recommendations to enhance interoperability across both pre- and post-issuance stages. Recommendations for the pre-issuance phase emphasize the need for standardized data collection and verification through digital monitoring, reporting, and verification tools and unified metadata standards to ensure accuracy from the start. For the post-issuance phase, recommendations focus on creating a metadata layer to integrate registry data and prevent double counting, alongside establishing universal tracking infrastructure supported by open application programming interface (APIs) and industry-wide data standards to enable seamless data exchange. Enhanced cybersecurity measures are also recommended to maintain data integrity across platforms.



State of play

In recent years, several multi-stakeholder initiatives have emerged to address different aspects of interoperability, focusing on common taxonomies, infrastructure linkages, and preventing potential risk of double counting. Several examples include:

- **Climate Action Data Trust** is a not-for-profit initiative that operates a decentralized metadata platform that links, aggregates, and harmonizes carbon credit registry data to enhance transparent accounting in alignment with Article 6 of the Paris Agreement. Founded in 2022 by the World Bank, the International Emissions Trading Association, and the government of Singapore, [CAD Trust](#) builds on the World Bank's Climate Warehouse program. Its data model and work program are governed through a collaborative structure involving both governments and the private sector.¹¹
- **A data model for carbon markets** has been submitted to ISO/Technical Committee (TC) 322/ad-hoc group (AHG) 3 on Sustainable Finance using the CAD Trust data model as a foundation.¹² This proposed ISO standard seeks to harmonize data fields, formats, and models across different registries. If approved, the project will be developed in close collaboration with ISO TC 68 (Financial Services)¹³ and the Financial Information Exchange (FIX) Trading Protocol to facilitate accurate financial transaction data transfer within the global financial markets' ecosystem,¹⁴ including links to data interchange standards like ISO 20022, which provides a unified framework for financial transactions, and the draft ISO working draft (WD) 14060 Net Zero Draft Standard.
- **Carbon Data Open Protocol** was launched in September 2024 by Sylvera. This initiative aims to develop an open-source data protocol for carbon credits. It will be overseen by an independent industry committee featuring principles and policy as well as technical working groups, and it is intended to promote greater transparency and accessibility within the carbon market.
- **Integrity Council for the Voluntary Carbon Market** is a not-for-profit, independent governance body dedicated to establishing and upholding global standards for high integrity in the voluntary carbon market. Beginning in late 2024, the ICVCM launched its Continuous Improvement Work Program to drive advancements in market transparency, standardization, and scalability, strengthening the voluntary carbon market's credibility and accessibility.¹⁵
- Emerging guidance on the **Centralized Accounting and Reporting Platform and Agreed Electronic Format** for reporting Article 6 transactions, and the development of an International Registry under the UNFCCC are shaping a global framework for transparency. These advancements establish standardized processes for data exchange, with significant impacts on infrastructure operators worldwide.
- **Science Based Targets Initiative** and the **Voluntary Carbon Markets Integrity Initiative** are independent initiatives designed to promote best practices for carbon credit use and support the harmonization of carbon credit data.



TABLE 6

Identified bottlenecks in data and systems interoperability

Lack of common data frameworks	Absence of universally accepted data frameworks, leading to fragmented data exchange and reduced transparency.
Incompatible data formats and inconsistent standards	Diverse data formats and standards across platforms make integration and data comparison difficult, causing inefficiencies.
Fragmentation due to disparate registry and MRV systems	Independent registry and MRV systems create data fragmentation, complicating data alignment and leading to information gaps.
Lack of data standardization and fungibility	Lack of standardized data management reduces fungibility across systems, complicating the transfer and integration of credits.
Double counting risks	Without unified tracking mechanisms, there's a high risk of credits being double counted, impacting market credibility.
Inconsistent pre-issuance standards	Diverse validation and verification protocols and data collection methods pre-issuance hinder data alignment across projects.
Incompatible post-issuance tracking systems	Credits issued in one registry may not track seamlessly in another, causing transparency and traceability challenges.
Limited real-time data integration	Delays in data synchronization between registries and trading platforms limit real-time access to credit availability and ownership.
Disparate reporting standards	Varying reporting timelines and standards across registries impede consistent oversight and accurate performance assessment.

Carbon markets currently face significant data fragmentation, with inconsistencies across data sources, registries, and reporting standards.



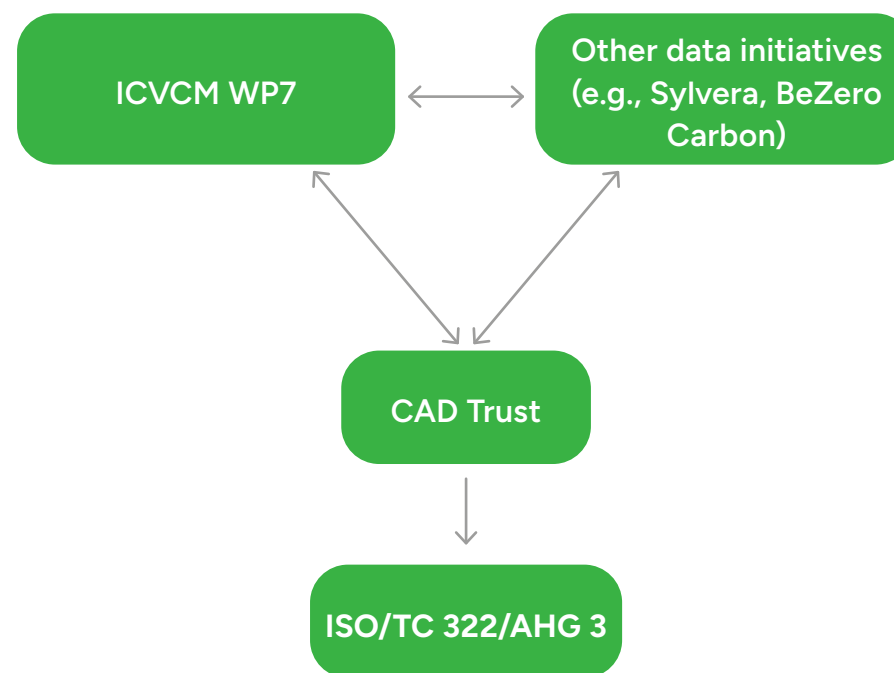
Way forward

The next stage of the CMI WG's work in this priority area is to develop a detailed guidance note aimed at strengthening the interoperability of data and systems within carbon markets. The guidance note will deliver actionable recommendations to encourage the adoption of standardized data taxonomies and frameworks. This guidance will provide strategies for aligning data and systems interoperability efforts with global policies, including Article 6 of the Paris Agreement, to ensure that reporting processes meet international standards. It will be based primarily on two efforts:

- **Stocktaking and coordination of existing initiatives:** To avoid duplication and fragmentation, the guidance note will stocktake and consolidate current initiatives addressing data and systems interoperability. This will ensure that all efforts are strategically coordinated, supporting a unified approach to interoperability across carbon markets (Figure 5).
- **Technical deep dives and stakeholder consultations:** The CMI WG will conduct technical deep dives and consultations with members, subject-matter experts, and practitioners to understand and address challenges in data use and accounting. Insights from these discussions will inform the guidance note, ensuring it reflects a balanced and expert-informed perspective on interoperability.

FIGURE 5

Connecting key data initiatives in carbon markets



Conclusion

This roadmap and the forthcoming guidance notes aim to provide practical, actionable guidance to stakeholders navigating the complex challenges and opportunities currently facing carbon market infrastructure. Their objective is to accelerate progress in developing a reliable, high-impact carbon market infrastructure that delivers meaningful climate outcomes.

Long term, the objective of these workstreams is to enhance carbon markets infrastructure, ensuring its scalability and effectiveness through achieving the following goals:

- **Accelerating standardization, efficiency, and unification of digitally enabled market infrastructure:** This effort aims to establish minimum service standards and common frameworks that improve interoperability and support seamless transactions, ultimately strengthening trust and participation across the carbon market ecosystem.
- **Increasing access to secure, robust, and harmonized market infrastructure solutions:** By providing streamlined, reliable solutions, this approach will enable better management of carbon assets and facilitate broader engagement in carbon markets, mobilizing essential financial resources.

- **Enhancing capacity building and technical assistance:** Strengthening stakeholders' skills and knowledge will equip them to develop and deploy systems aligned with international standards, promoting smooth operations and greater transparency within carbon markets.
- **Elevating investor confidence and mobilizing the private sector:** Through standardized processes, data accuracy, and secure, interoperable systems, these efforts will reduce market risks, build trust, and foster a stable environment, encouraging active private sector participation.

The objective is to accelerate progress in developing a reliable, high-impact carbon markets infrastructure that delivers meaningful climate outcomes.



Endnotes

- 1 World Bank, *High Integrity, High Impact: The World Bank Engagement Roadmap for Carbon Markets*, 2024. License: [CC BY-NC 3.0 IGO](https://creativecommons.org/licenses/by-nc/3.0/). <http://hdl.handle.net/10986/42016>.
- 2 Institute of International Finance, *Taskforce on Scaling Voluntary Carbon Markets*, 2021. https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf.
- 3 The Board of the International Organization of Securities Commissions, *Voluntary Carbon Markets Consultation Report*, IOSCO, 2023 <https://www.iosco.org/library/pubdocs/pdf/IOSCOPD749.pdf>.
- 4 Commodity Futures Trading Commission, *Guidance Regarding the Listing of Voluntary Carbon Credit Derivative Contracts*, RIN 3038-AF40, 2023.
- 5 Institute of International Finance, *Taskforce on Scaling Voluntary Carbon Markets (TSVCM): Terms of Reference (ToR) for the New Governance Body*, 2021. https://www.iif.com/Portals/1/Files/TSVCM_TOR.pdf.
- 6 World Economic Forum in collaboration with Bain & Company, *Scaling Voluntary Carbon Markets: A Playbook for Corporate Action*, 2023. https://www3.weforum.org/docs/WEF_Scaling_Voluntary_Carbon_Markets_2023.pdf.
- 7 The Board of the International Organization of Securities Commissions, *Voluntary Carbon Markets Consultation Report*, IOSCO, 2023. <https://www.iosco.org/library/pubdocs/pdf/IOSCOPD749.pdf>. The Board of the International Organization of Securities Commissions, *Compliance Carbon Markets*, 2023. <https://www.iosco.org/library/pubdocs/pdf/IOSCOPD740.pdf>.
- 8 The Integrity Council for the Voluntary Carbon Markets, "The Core Carbon Principles," n.d. <https://icvcm.org/core-carbon-principles>.
- 9 Center for Internet Security, "The 18 CIS Critical Security Controls," n.d. <https://www.cisecurity.org/controls/cis-controls-list>. National Institute of Standards and Technology, "Cybersecurity Framework 2.0," 2024. <https://www.nist.gov/cyberframework>.
- 10 The Integrity Council for the Voluntary Carbon Market, *Core Carbon Principles, Assessment Framework and Assessment Procedure*, 2024. <https://icvcm.org/wp-content/uploads/2024/02/CCP-Book-V2-FINAL-6Feb24-compressed.pdf>. The Board of the International Organization of Securities Commissions, *Voluntary Carbon Markets Consultation Report*, IOSCO, 2023. <https://www.iosco.org/library/pubdocs/pdf/IOSCOPD749.pdf>.
- 11 Climate Action Data Trust, "CAD Trust Data Dashboard," n.d. <https://climateactiondata.org/data-dashboard>.
- 12 ISO/TC 322 is the technical committee responsible for the development of ISO standards relating to sustainable finance. Sustainable finance is considered by ISO/TC 322 to mean financing, as well as related institutional and market arrangements, that support progress to achieving the United Nations Sustainable Development Goals and addressing climate change. International Organization for Standardization, "ISO/TC 322," n.d. <https://committee.iso.org/home/tc322>.
- 13 Technical Committee 68 (ISO/TC 68) is responsible for creating global standards for the financial services industry. TC 68 is responsible for standards that cover core banking, capital markets including asset management, payments, credit card processing, and information security aspects specific to financial services. The committee is organized into three subcommittees: SC2 (Information Security), SC8 (Reference Data), and SC9 (Information Exchange). International Organization for Standardization, "ISO/TC 322," n.d. <https://committee.iso.org/home/tc322>.
- 14 FIX Trading Community, "Financial Information Exchange (FIX®) Protocol," 2024. <https://www.fixtrading.org/what-is-fix>.
- 15 Integrity Council for the Voluntary Carbon Market, "Our Continuous Improvement Work Programs," n.d. <https://icvcm.org/continuous-improvement-work-programs>.



