



THE INTEGRITY COUNCIL
FOR THE VOLUNTARY CARBON MARKET

Continuous Improvement Work Program report: Digital Monitoring, Reporting and Verification

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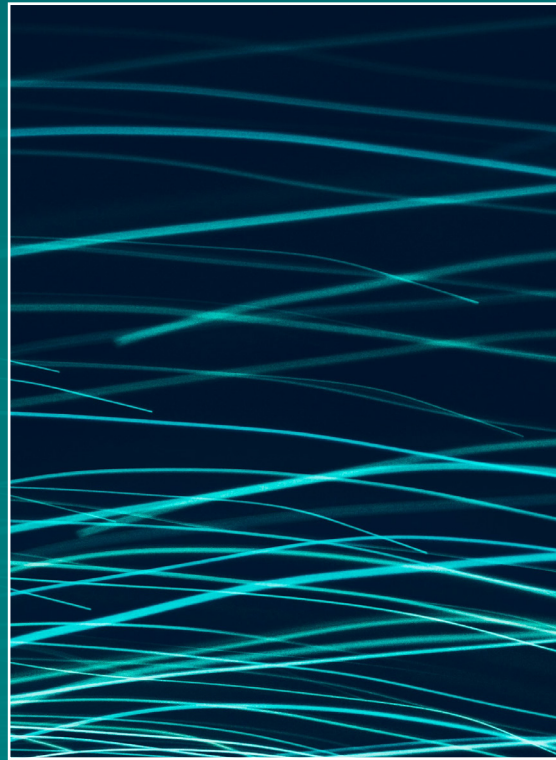
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The ICVCM's Continuous Improvement Work Programs

The ICVCM's CIWPs ensure that carbon markets continue to evolve by bringing together leading experts and key stakeholders in a collaborative effort to address complex challenges, provide thought leadership and develop the next generation of solutions to accelerate high-integrity carbon markets. The CIWPs harness the latest science, emerging technologies and innovative approaches from across the market to inform the next generation of carbon market integrity systems and standards.

The recommendations of these multi-stakeholder expert working groups will inform further refinement and development of the ICVCM rule book, particularly the CCP Assessment Framework. They may also refer to actions that are more appropriately implemented by entities other than the ICVCM but that are nonetheless crucial to the future development and maturation of the market.



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Executive summary

Summary

The use of digital tools for monitoring, reporting and verification (MRV) is transforming how carbon markets generate credits. While digital MRV (DMRV) does not change the fundamental environmental integrity principles applied in carbon markets, including the ICVCM's Core Carbon Principles (CCPs) and Assessment Framework, its potential benefits and risks to environmental integrity need to be explored. Digital technologies are changing how MRV could work and introducing new entities, such as digital tool and/or data providers, thereby raising questions about traditional roles and responsibilities in the MRV cycle.

At the same time, given the rapid evolution of this space, including the number of initiatives piloting new market practices and governance frameworks, this report represents the ICVCM's first exploratory investigation into the topic. As pilots mature and emerging frameworks and guiding principles come online, this work can inform how the ICVCM should best address DMRV.

The ICVCM's CIWP on DMRV, co-facilitated with the World Bank, brought together a multi-stakeholder expert working group to assess these developments and provide recommendations on how the CCP Assessment Framework should respond. The working group met six times during 2026, covering data quality; models, algorithms, artificial intelligence and machine learning; roles and responsibilities; equity and the digital divide; and the implications for validation and verification bodies (VVBs). Its work was informed by a market-wide survey and a review of the literature and emerging market practices.

The recommendations in this report reflect the discussions and findings of the working group. They do not indicate individual endorsement or commitment by the ICVCM, nor were they negotiated through a process of strong consensus. Recommendations directed to the Integrity Council will be considered by the ICVCM, including as inputs to refinements of the Assessment Framework through the CCP Rule Architecture. If taken forward, these changes will be subject to a separate process, with additional opportunities for public consultation and feedback.

The working group found that the existing CCPs and CCP Assessment Framework are robust and largely fit for purpose in a digital context. The fundamental principles of transparency, permanence, conservativeness, relevance and independent validation and verification do not need to change. What is needed is additional guidance to ensure that these principles are consistently applied in a digital context. The group also identified two open questions for the broader carbon market to address. As the MRV process changes and new entities, such as DMRV tool or data providers, are introduced, their responsibilities and the appropriate approaches to certifying these tools need to be clarified.

Key takeaways

The full set of recommendations and supporting information is provided in the main report, while [Annex 1](#) contains the table of recommendations and their constituent elements.

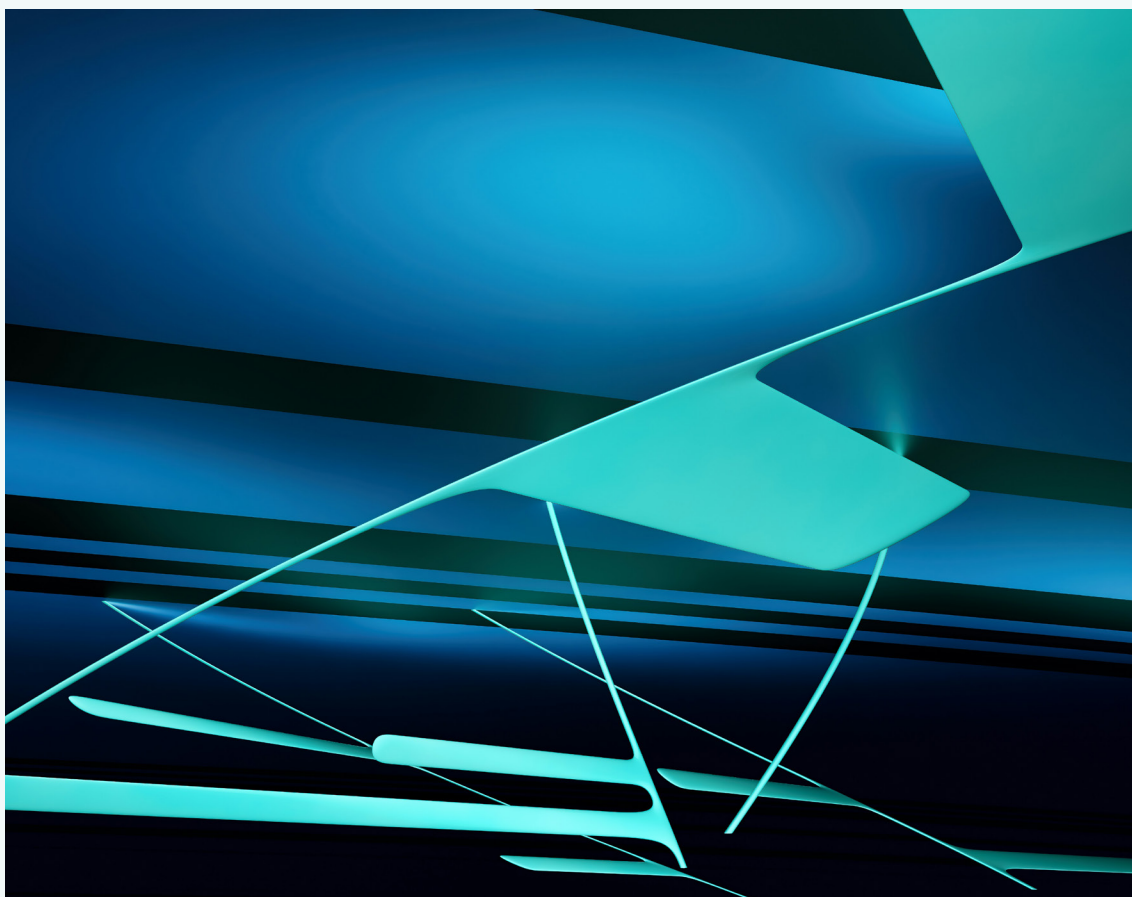
- 1. Carbon-crediting programs need governance frameworks that explicitly address digital data integrity:** The governance frameworks of carbon-crediting programs need to include documented DMRV governance provisions that address cybersecurity, conflicts of interest, the approval and re-approval of digital tools, and error remediation procedures. Establishing these provisions across programs would provide a common foundation for programs to develop a harmonised approach to digital methodologies, tools and requirements.
- 2. Transparency includes digital tools:** The public disclosure requirements of the CCP Assessment Framework include digital tools, including their logic, inputs, training data, assumptions and applicability conditions. Where proprietary constraints arise, alternative assurance mechanisms demonstrating equivalency to full disclosure requirements should be established.
- 3. Independent approval of digital tools prior to deployment:** Carbon-crediting programs should be required to approve digital tools against transparent, predefined criteria. These criteria should address the tool's technical accuracy, applicability conditions and data governance, as well as re-approval triggers and processes.
- 4. VVBs need digital competency when working with digital tools:** Where VVBs work on or with digital tools, their personnel must possess adequate digital competency (e.g. data traceability, algorithmic audits, pipeline-level review and system-level risk assessment).
- 5. Digitalisation can strengthen the integrity and transparency of verification records:** Building on the recommendations of the CIWP on the Oversight of VVBs, programs that use both DMRV and digital registry systems should have controls to ensure that the validation and verification records displayed in the registry match the final versions. The ICVCM should also support efforts to standardise status tracking, report formats and data sharing with accreditation bodies. While not yet resolved, potential impartiality issues arising where VVBs are digitally contracted and engaged by programs could be examined in future work.

6. **Assigning accountability for technology providers:** Digital tools are typically developed and operated by third-party technology providers that currently sit outside the accountability structures applied to project developers, carbon-crediting programs, VVBs and other traditional carbon market actors. Before obligations can be specified, it is necessary to establish which actor is responsible for imposing and enforcing them – carbon-crediting programs through tool approval, project developers through contractual pass-through, accreditation bodies through a provider certification route or some combination of these.
7. **Complete and verifiable data pipeline documentation:** The focus should not be solely on the final data outputs but also on documenting the full digital data pipeline, including how uncertainty is assessed and quantified at each stage. Where this is not possible, conservative deductions or other guardrails need to be in place.
8. **The rights and interests of both Indigenous Peoples and local communities should be recognised and protected:** Governance frameworks should explicitly address the rights implications arising from the deployment of digital tools for both Indigenous Peoples and local communities. Local and Indigenous knowledge, as well as the roles of local and Indigenous communities in the MRV process, should also be respected and acknowledged.



What's next

The outputs of this CIWP will inform further refinement of the CCP Assessment Framework, including through the CCP Rule Architecture, and signal broader developments needed to ensure integrity across carbon markets in relation to DMRV. While some recommendations are directed to the ICVCM, others are intended for carbon-crediting programs and wider market actors, reflecting the wide range of actors influencing the application and evolution of DMRV.



Digital Monitoring, Reporting and Verification

Introduction

The introduction of digital tools and the digitisation of parts or all of the measurement, monitoring, reporting and verification (MRV) cycle is transforming how carbon market projects operate, as well as the traditional roles and responsibilities of stakeholders. Digital tools encompass those currently used in carbon market MRV, including algorithms, models, artificial intelligence (AI) and machine learning (ML) systems, remote sensing and satellite data, Internet of Things (IoT) sensors, automated pipelines and geographic information system (GIS)-based tools ([see Table 1](#)).

The growing use of digital MRV (DMRV) does not change the fundamental principles underpinning the assessment of environmental integrity. Transparency, conservativeness, relevance, permanence and independent verification remain fundamental to applicable standards and underpin the ICVCM's Core Carbon Principles (CCPs), as elaborated in the CCP Assessment Framework. The introduction of digital tools does not replace or supersede these principles, but warrants consideration of how they apply in a digital context.

Both DMRV and traditional MRV processes offer models of reality with their own integrity and uncertainty challenges, neither being inherently superior to the other. However, the use of digital tools introduces new instruments and processes into the MRV cycle, raising questions about how environmental integrity is assessed and safeguarded in this new context.

The ICVCM's Continuous Improvement Work Program (CIWP) on DMRV, co-facilitated with the World Bank, brought together experts from a wide range of carbon market actors to consider the use of digital tools in the MRV process. The group considered whether clarification, supplementary or new guidance is needed to uphold the CCP integrity threshold in a digital context. It comprised representatives from carbon-crediting programs, DMRV service providers, multilateral development banks, accreditation bodies, Indigenous Peoples, validation and verification bodies (VVBs) and non-governmental organisations, as well as members of the ICVCM Governing Board and Expert Panel.

This report presents the recommendations of the working group and consolidates the outputs of six meetings held from March to July 2026. The meetings covered data quality; algorithms, models, AI and ML; roles and responsibilities; equity and the digital divide; and a breakout discussion on the implications for VVBs. A discussion on roles and responsibilities also took place as a side event at Innovate4Climate in Singapore in May 2026. Additional input and comments were sought from the [Indigenous Peoples and Local Communities Engagement Forum](#).

These recommendations will inform the further refinement and development of the ICVCM's CCP Assessment Framework and any additional guidance. They may also refer to actions or guidance that may be better developed by other carbon market stakeholders. Where possible, the recommendations are intended to be technology-neutral.

These recommendations also build on the work of the CIWP on Oversight of VVBs, which briefly considered issues relating to DMRV. The working group on VVBs referred several issues concerning digital tools to the DMRV working group for further consideration. These included impartiality and conflicts of interest arising where VVBs are digitally engaged and contracted; how greater digitalisation of project registration and MRV can enhance the integrity and transparency of validation and verification outcomes; greater tracking of project status and VVB activity; and data sharing with accreditation bodies. These topics are reflected in the recommendations of this report, particularly those relating to Criterion 4.1¹ of the Assessment Framework.



¹ Criterion 4.1 of the CCP Assessment Framework sets out requirements relating to robust independent third-party validation and verification.

Background and scope of work

The use of DMRV tools is a new and rapidly evolving field, with a number of initiatives and organisations exploring how DMRV can be used to improve market integrity, scale and interoperability. A key challenge for the working group was to define an appropriate scope of work that focused on issues relevant to the ICVCM's work while leveraging, without duplicating, ongoing and emerging efforts by other actors.

The focus of the working group was on how DMRV affects the assessment and upholding of environmental integrity in carbon-crediting activities. DMRV is defined as the use of tools and technologies that digitise, automate and enhance traditional MRV processes ([see Table 1](#)). A distinction is made between individual digital tools and digital systems. Individual tools include instruments such as drones and IoT sensors, whereas digital systems refer more broadly to automated data pipelines that connect these tools in an end-to-end workflow.

In developing these recommendations, the working group focused on the ICVCM's role in setting high-level integrity standards that are technology- and sector-neutral where possible, with other actors, such as carbon-crediting programs, translating these into methodology- and sector-specific requirements. The scope of the report was also informed by insights from an ICVCM stakeholder survey² conducted between December 2025 and January 2026, which received responses from 137 respondents active in the carbon market.

² [ICVCM, 2026. Digital MRV and Carbon Credit Integrity Survey Summary.](#)

Table 1. DMRV tools and technologies

Tools	Description	Illustrative applications
IoT sensors	Continuous measurement devices that continuously transmit data to a central platform in near real time.	Cookstoves and clean cooking (usage); clean energy (generation data); industrial and methane projects (leakage and flow).
Remote sensing	Satellite and aerial imagery used to generate land-cover, biomass and other environmental data.	Forestry and REDD+ (deforestation, biomass); blue carbon; agriculture and soil carbon.
Drones	Low-altitude aerial devices that capture high-resolution imagery for on-site monitoring and inspections.	Forestry (canopy- and plot-level biomass); restoration and afforestation, reforestation, revegetation (ARR); blue carbon; localised verification.
Automated data platforms	Cloud-based systems that incorporate multiple data streams, generate reports and automated calculations and create audit trails.	Cross-sector applications (aggregation, reporting and audit trails; combining multiple tools for reporting).
Artificial intelligence and machine learning	Systems that use large datasets to learn and detect patterns, generate metrics, detect anomalies and discrepancies and run model simulations.	Forestry (biomass estimation; deforestation risks and/or baselines); agriculture (soil carbon models); anomaly and fraud detection; cross-sector applications (dynamic baselines).
Geographic information system tools	Systems that process and layer spatial imagery and data for project boundary definition and monitoring.	Forestry (boundaries, leakage and buffer mapping); agriculture; blue carbon.
Automated data pipelines	Digital systems that encompass an end-to-end workflow, connecting individual DMRV tools from data measurement and collection through processing and transformation to final use for reporting and verification.	Cross-sector applications (system integration), often used in near-real-time issuance projects.

The DMRV landscape

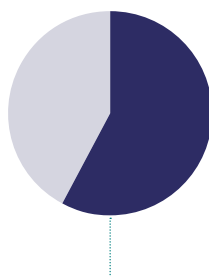
Potential benefits and risks

As reflected in the survey conducted to support this working group, DMRV brings potential benefits and challenges for assessing and upholding environmental integrity. Importantly, DMRV does not change the underlying principles of environmental integrity. However, as it changes traditional MRV processes and the roles and responsibilities of actors in the MRV cycle, the market needs to assess whether existing guidance and processes reflect the reality of how digital tools are used in carbon market projects.

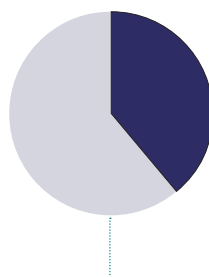
When used properly, DMRV can bring significant integrity benefits to the carbon market, most notably by increasing the transparency and accuracy of MRV. Almost three-quarters of survey respondents cited transparency as a key benefit, while more than half cited increased accuracy ([see Table 2](#)). DMRV may also bring other benefits, such as greater cost efficiency and scalability, but these are not directly related to integrity and are therefore not considered below. Whether these potential benefits materialise will depend on the quality of the underlying data, the robustness of models and algorithms and the strength of governance frameworks.

At the same time, these digital tools raise new integrity risks and questions. Some risks may require further examination to understand their potential consequences and interactions with carbon market practices. Moreover, some risks may be inherent to these technologies and need to be managed, while others can be actively mitigated through additional guidance and adjustments to governance frameworks. While guidance and regulations are beginning to evolve to reflect market practice, many of the issues raised in the survey are still developing and have real operational consequences for credit quality, issuance and liabilities.

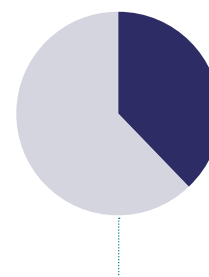
Survey respondents were particularly concerned about:



58%
Data quality
and integrity



39%
Algorithmic
or model bias



38%
The opacity
of digital tools
([See Table 3](#))

Table 2. Potential benefits

Benefits	Details	Relevance to integrity
Transparency and accountability benefits		
Transparency and traceability	Digital trails, data pipelines and automated platforms can create a more complete and accessible record of the MRV process.	This can support verification and public accountability.
Auditability	Structured, timestamped and machine-readable records allow verification steps to be reconstructed and re-examined after the fact.	This can make errors and their origins easier to locate and support post-issuance review where questions arise.
Comparability	Standardised digital data formats allow outputs to be compared across projects, geographies and methodologies.	This can support benchmarking and market-level scrutiny that is difficult with heterogeneous manual records.
Data and measurement benefits		
Precise and near-continuous monitoring	Digital tools such as IoT sensors and satellites can monitor, measure and report data at greater frequency and granularity than manual processes.	This can reduce reliance on periodic sampling and default measures and could make anomalies, reversal risks and other issues more detectable.
Dynamic baselines	Models using real, observed data can generate baselines that reflect current conditions rather than outdated information and/or proxy data.	This can improve accuracy and additionality claims.
Reduced manual errors	Automated data collection, processing and reporting can reduce instances of human error.	This can improve overall data integrity.
Uncertainty quantification	Digital methods can make uncertainty explicit and calculable at each stage of the data pipeline rather than assumed.	This allows conservativeness to be applied proportionately rather than through blanket discounts.
Detection and assurance benefits		
Fraud and anomaly detection	Pattern-recognition systems can flag outliers or inconsistencies that manual reviews may miss or take longer to detect.	This can strengthen data integrity.
Earlier detection of reversals and non-permanence	Continuous data flows can identify underperformance, disturbance or reversal closer to the time it occurs.	This can allow corrective action before credits are issued or claims are made, reducing the remediation burden.

Table 3. Potential risks

Risks	Details	Relevance to integrity
Transparency and accountability risks		
Opacity and explainability	Digital tools, particularly algorithms, models, AI and ML, may operate as a 'black box', where inputs, assumptions and processing (e.g. training data, logic and assumptions) are not accessible or comprehensible to non-experts.	VVBs cannot fully or independently audit a model's outputs if the underlying inputs and architecture are incomprehensible or inaccessible. Opaque tools can also make it difficult to detect biases and other potential limitations in digital outputs.
Verifiability	Independent validation is challenging where ground-truthing is costly, technically demanding or geographically constrained.	This can increase the risk of overcrediting and the introduction of additional biases.
Accountability gaps	With a new actor (DMRV service provider) and new processes in traditional MRV, responsibility for errors may be unclear.	The VVBs' role, and the liability of the DMRV provider compared with the carbon-crediting program or project developer, requires clarification.
Blind faith	Over-reliance on digital outputs without human scepticism, checks or oversight.	Risks blind acceptance of digital tools and their outputs without adequate scrutiny.
Data and model quality risks		
Data quality	The usability and relevance of data – including accuracy, timeliness and reliability – are not governed by common minimum standards.	There is no common approach to minimum expectations for data quality, quantifying uncertainty, assessing calibration or determining geographic applicability.
Bias	A lack of transparency can make biases difficult to detect. Models may have geographic or project-type biases depending on the training data.	Algorithms trained on unrepresentative data can lead to sectoral or geographic biases, particularly in the Global South.
Temporal and spatial applicability	The extent to which a digital tool can be used in different settings (biomes, geographies and sectors) is often unclear. Tools can also degrade as conditions change or introduce errors over time (e.g. model drift).	An algorithm trained on one ecosystem type may be ill-suited to another. Re-approval triggers can help ensure that these tools remain applicable across different temporal and spatial contexts (ecosystems/geographies).

Table 3. Potential risks (Cont.)

Risks	Details	Relevance to integrity
Security and operational risks		
Security	The reliability and security of digital tools and technologies, including whether they have been manipulated, tampered with or subjected to fraud.	There needs to be sufficient confidence that digital data and outputs have not been subject to fraud, manipulation or other forms of tampering.
Pipeline integration risks	Errors introduced at one stage can be amplified through subsequent stages.	A small conversion error can propagate undetected through to the credit issuance stage.
Equity and climate risks		
Displacement of local/ indigenous knowledge	Digitisation and automation risk marginalising community knowledge that may not be easily digitised or quantified.	This raises the risk of overemphasising digital outputs, which may lead to inaccuracies, biases and the loss of community roles.
Data sovereignty, privacy and community roles	Who owns the raw, processed and final data outputs from digital tools, particularly when the data comes from communities or households?	These issues are particularly acute in projects involving continuous community monitoring, such as cookstoves. It is also unclear to what extent free, prior and informed consent (FPIC) covers digital tools and technologies.
Energy and climate costs	Training and operating digital tools, particularly AI and ML, may consume significant amounts of energy.	There is a potential tension between the environmental footprint of the DMRV process and the environmental benefits of the carbon market project.

The DMRV governance landscape

The governance landscape for DMRV in carbon markets is nascent and has yet to evolve to reflect current practice. Carbon-crediting programs, international standard-setting bodies and multi-stakeholder initiatives are all assessing and developing frameworks, pilots and guidance. Given how rapidly these efforts are evolving, this working group and the report do not attempt to fully capture them. The focus of the working group was to ensure that integrity frameworks remain relevant and maintain robust principles and clear integrity requirements against which DMRV practices can be assessed. The recommendations in this report build on existing and emerging work within the carbon markets and DMRV ecosystems.

Alongside new tools and technologies, digitisation also introduces new entities and actors to the carbon market space: digital tool, infrastructure and/or data providers. This introduces new obligations, roles, conflict-of-interest considerations and entitlements for these actors and may require additional guidance, regulation and oversight from other bodies. At the same time, the ICVCM's mandate, CCPs and the Assessment Framework focus on carbon-crediting programs and, as such, this is the main focus of the group's recommendations. Where carbon-crediting programs interact with these providers or provide DMRV services themselves (e.g. through partnerships or contractual relationships), the ICVCM sets the integrity standards that these services and contracts would have to meet, directly or indirectly, under the CCPs.

The multiplicity of providers, tools and programs also makes interoperability a core governance consideration for DMRV, as for any digital infrastructure. Interoperability is distinct from uniformity: it does not require a single tool or platform, but rather that data, models and outputs produced by different systems can be exchanged, understood and verified across programs, registries and market participants. This needs to be designed in at the data architecture layer, through common data models, identifiers, metadata and interfaces, rather than retrofitted once tools are deployed, so that integrity requirements can be applied consistently and no actor is locked into a single provider.

The role of VVBs in DMRV tools and processes is also evolving. As DMRV tools change how MRV is conducted and introduce new actors and tools, greater clarity is needed on the role, skills and responsibilities of VVBs in relation to other actors. This clarity is likely to be needed on a tool-by-tool basis, with VVBs having significant experience and established practices for tools such as continuous monitoring systems, whereas the role of algorithms and the validation of AI systems remain very nascent. Alongside carbon-crediting programs, other actors, such as accreditation bodies and standards bodies, are also examining these issues.

As pilots implement a variety of new tools, they provide valuable lessons and feedback to participants on what is working, which areas need support and where further guidance is needed. This includes areas for future work, such as the role of VVBs in projects with near-real-time credit issuance. As more sophisticated tools are introduced into the MRV process, validation could become more of a multilayered, multistakeholder exercise rather than a single validation conducted by a sole actor. Instead, it may involve a consortium of entities with different areas of expertise to manage sensing technologies, models, algorithms and software, for instance. How the role of VVBs may shift, and who should define this role, remains an open question where guidance is needed, particularly as ISO and other international standards are pending updates.

The CCP Assessment Framework

The existing CCP Assessment Framework and the CCPs themselves are robust and remain largely relevant with the introduction of digital tools and technologies. The rulebook focuses on principles and outcomes rather than being overly prescriptive or technology- or sector-specific. The relevant rules from the rulebook that were considered and discussed during the CIWP, leading to the final recommendations are summarised at the end of this report.

Outcomes and recommendations

The outcomes and recommendations in this report are organised according to their area of impact and type. They can be grouped into seven themes:

1. Governance, definitions and institutional foundations;
2. Cybersecurity, data integrity and conflicts of interest;
3. Transparency and disclosure;
4. Verification and data quality assurance;
5. Equity, rights and community;
6. Flexibility and accountability mechanisms; and
7. Capacity building and convergence.

Recommendations relating to the CCP Assessment Framework are presented in the order of the relevant criteria within the rulebook. The relevant Assessment Framework rules associated with each recommendation are set out at the end of the report.

The order of presentation does not imply relative importance or prioritisation. All recommendations are relevant to supporting the effective and high-integrity use of digital tools within carbon market MRV systems.

Finally, a number of topics were identified for future research by the ICVCM Science and Research Network.

Governance, definitions and institutional foundations

6.1 The ICVCM should define key DMRV terms.

Clear and consistent terminology is foundational to a coherent regulatory framework. Without it, confusion and inconsistencies may arise in how the Assessment Framework is understood and applied.

- **Suggested terms:** At a minimum, the following terms should be incorporated into the ICVCM definitions: blockchain, claims, data, interoperability, digital carbon assets, data life cycle, data quality, uncertainty, DMRV, tokenisation and digital public infrastructure. For DMRV, the ICVCM could also consider defining key tools, including algorithms, models and AI/ML. Finally, a distinction between deterministic and inference-based digital tools should be included, as they raise different integrity challenges and may warrant different guidance.
- These definitions should be developed through a consultative process led by the ICVCM to finalise the definitions, particularly given that these terms will affect how actors interpret and use the report's recommendations. Definitions can also be aligned with emerging international standards, such as upcoming ISO revisions.

6.2 The ICVCM should require that digital tools used in MRV are independently approved by programs prior to deployment, alongside clear re-approval triggers.

Greater clarity is needed on how carbon-crediting programs use DMRV within their standards, including whether they use proprietary tools and systems or allow third-party solutions, and which tools may be used and under what conditions. Applicable validation requirements should be developed alongside minimum technical and performance requirements, including the level of end-to-end validation required.

The approval and certification of digital tools prior to use are not explicitly covered in the CCP Assessment Framework. The group considered that this should be the responsibility of carbon-crediting programs and is distinct from the responsibility of VVBs to verify project claims. Further work is needed to determine which actor(s) should establish the criteria that these digital tools must meet.

- **Minimum criteria:** Carbon-crediting programs should be required to approve digital tools against a set of transparent, predefined criteria that, at a minimum, should include:
 - Technical functions and accuracy;
 - Applicability (relevant geography, sector and project type);
 - Compliance with Criterion 3.1 of the CCP Assessment Framework and the tool's data governance framework(s);
 - Performance limitations (i.e. what the tool can and cannot do);
 - How local and Indigenous knowledge is considered, respected and incorporated, where relevant, into the tool's applicability. This is especially pertinent where tools are used in projects affecting both Indigenous Peoples and local communities, to ensure that local and Indigenous knowledge is respected in its own right, rather than treated solely as a component of the tool's approval;
 - Approvals granted by other systems could also be accepted if equivalence is demonstrated.

- **Re-approval triggers:** These should be defined and should, at a minimum, include: (1) material changes to the tool; (2) changes to training data or parameters; (3) applications outside the approved scope; and (4) defined maximum periods for re-validation.
 - **Minimum criteria for approvals and re-approvals:** Supplementary guidance on minimum criteria for approvals and re-approvals should also be developed by the ICVCM.
- **Alternative assurance mechanisms:** Where ground-truthing is not feasible, guidance on alternative assurance mechanisms should be developed, including minimum standards that these alternatives must meet.

6.3 The accountability, obligations and responsibilities of DMRV and/or data providers need to be addressed and clarified.

As digitisation brings new market players into the mix, including DMRV service and/or data providers, clarity is needed on how these actors' responsibilities, obligations and accountability relate to those of other carbon market actors in the MRV process. This should be developed through a broader consultation process involving a broad representation of market actors and building on lessons learned from DMRV pilots and initiatives.

6.4 The ICVCM should require carbon-crediting programs that approve, endorse or reference digital tools to have a publicly accessible DMRV governance framework.

There is currently no requirement for carbon-crediting programs to disclose or document how they govern the digital tools they use or rely on. This framework should cover the various stages of the DMRV process, from the digital tools used for measurement and monitoring, through to the provider, the entity calculating or translating the claim from the raw data, the standard approving the claim and the credit-issuing registry.

- **Minimum components:** A DMRV governance framework should, at a minimum, address:
 - Predefined and transparent tool approval criteria;
 - Predefined re-validation triggers (including, at a minimum, material changes to the tool's architecture, maximum periods between re-validation and impacts on credit issuance);
 - How material errors are identified, assessed and managed;
 - Cross-program notification requirements where a material error is identified in a shared tool.
- **Guidance:** The ICVCM could also consider developing illustrative guidance on what constitutes a material error, as well as more specific guidance on re-validation triggers for specific tools (e.g. model drift for models), if this is not taken up by other actors.

Cybersecurity, data integrity and conflicts of interest

6.5 The ICVCM should require carbon-crediting programs to explicitly address cybersecurity and data integrity within their anti-fraud provisions.

Current anti-fraud provisions do not address issues that arise with digital systems, such as cybersecurity and processes for managing digital data integrity. The requirements of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) likewise only broadly address data integrity and data management risks, leaving programs without a clear reference point for what constitutes adequate digital security.

- **Internationally recognised cybersecurity frameworks:** Carbon-crediting programs should have provisions consistent with internationally recognised cybersecurity frameworks (e.g. ISO/IEC 27001, the NIST Cybersecurity Framework or CIS Controls), including audit logging and tamper-evidence requirements. These requirements should be proportionate to the scale and materiality of the systems concerned. Such provisions can help manage the risk of individual data points being manipulated, as well as fraud and manipulation at a systemic level across the entire pipeline.
- **Managing failures:** Carbon-crediting programs should also set out how cybersecurity or data integrity failures affecting MRV data are to be managed, including definitions of material incidents and timelines for detecting, remedying and disclosing them.
- **Third-party providers:** Requirements should extend to the systems on which carbon-crediting programs rely, not only those they operate directly. Where MRV data is generated, processed or transmitted by project developers or third-party technology providers, programs should specify the cybersecurity expectations that apply across the data pipeline and how compliance is evidenced.
 - Carbon-crediting programs should consider requiring DMRV system providers to submit a declaration confirming that they have complied with relevant cybersecurity and data protection requirements, to support transparency and accountability. However, this should not be a substitute for the independent verification described above.
- **Credits:** Carbon-crediting programs should specify the consequences for credits affected by a material incident, including when issuance should be suspended, when credits should be 'quarantined' pending investigation and how remediation should apply to credits that have already been issued or retired.

6.6 The ICVCM should require that carbon-crediting programs' conflict-of-interest policies explicitly address DMRV conflicts.

Digital tools introduce a new actor (the digital tool and/or data provider) and also raise new questions about the relationships and roles involved in the MRV cycle, particularly where an entity may have a commercial relationship with or financial interest in a DMRV provider whose tool it is approving or using.

- **Addressing and identifying conflicts:** Carbon-crediting programs should be required to disclose how digital conflicts of interest are identified and addressed.

- **VVB involvement:** Policies need to address situations where VVBs are involved in building, licensing or operating a DMRV system or tool that they are validating.
- **Safeguards:** Independence safeguards should also be considered where a VVB has built or is operating a digital tool that it is also assessing.
- **Guidance:** The ICVCM could also consider developing supplemental guidance with illustrative examples.

Transparency and disclosure

6.7 The ICVCM should require carbon-crediting programs to ensure the public disclosure of digital tools used in MRV.

The current requirement mandates “all necessary information” but does not explicitly address what this means when digital tools are involved. As such, this could lead to ambiguity in how programs interpret and apply transparency requirements.

- **Minimum components:** At a minimum, the ICVCM should require programs to disclose the following components in relation to digital tools: the underlying logic, training data characteristics, inputs, assumptions and applicability conditions.
- **Alternative assurance mechanisms:** Where disclosure is limited due to proprietary constraints or applicable national privacy laws, alternative assurance mechanisms should be applied. These should provide an equivalent level of assurance to full disclosure. Such mechanisms should also be documented and subject to independent review.
- **Minimum disclosure template:** To guide programs, the ICVCM should develop a minimum disclosure template in consultation with key carbon market actors. The template should differentiate between cases where more technical, granular disclosure is required (e.g. for VVBs) and where higher-level disclosure is sufficient (e.g. for the wider public). Where feasible, the template should generate structured, machine-readable outputs aligned with existing market schemas, such as the Carbon Data Open Protocol or G20 Carbon Credit Data Model.

Verification and data quality assurance

6.8 The ICVCM should require programs to ensure that VVBs demonstrate sufficient competency to assess digital tools where their work involves these tools.

VVB competency requirements currently do not address the skills needed when engagements involve digital tools or how to exercise professional scepticism in a digital context. Carbon-crediting programs should require VVBs to demonstrate that they have adequate competency to audit the specific digital tools involved.

- **ISO coordination:** The ICVCM should support ISO updates addressing digital tools, including relevant ISO revisions, as well as the work of the International Association of Validation and Verification (IAVVB) and other key actors on digital competencies. ISO TC 207 has issued a call for nominations for a task force focusing on DMRV issues in relation to ISO 14064-3.

Currently, the focus is on progressing the joint ISO/GHG Protocol revision of ISO 14064-1 and ISO 14064-2 before turning to ISO 14064-3. The ICVCM should review these revisions to ensure that relevant ISO standards are reflected in the CCPs. Until these revisions are made, VVBs will need guidance and clarity on how to address digital tools, including the expectations and responsibilities that apply in these contexts.

- **Claims in a digital setting:** The ICVCM should clarify what constitutes a claim when MRV is digitally generated. Conventional verification assumes a discrete assertion made by a responsible party at a defined point in time; continuous or automated data generation does not necessarily produce such a moment, leaving it unclear when a claim crystallises and what precisely is being verified. Related to this, it should be clarified where responsibility attaches when outputs are produced by a digital system, including the roles of those who configure, approve and operate it. This can help VVBs better understand their roles and responsibilities when digital tools are involved. This also ties to DMRV Recommendation 6.3.
- **Final report controls:** Building on Criterion 3.1 on information in the Assessment Framework and the full data pipeline requirements, programs using digital registration and MRV systems should apply controls to ensure that the validation or verification report displayed on a registry matches the finalised version, regardless of whether it is uploaded by the project proponent or the VVB.

6.9 If any digital tool is used for quantification, the ICVCM should require a review of that tool as part of the methodology approval process.

Criterion 5.1 on the methodology approval process does not explicitly require a review of digital tools used as part of a methodology. To ensure that these tools are appropriately scrutinised, the ICVCM should require that they be included in the carbon-crediting program's methodology approval process.

- **Minimum components:** This should include:
 - Uncertainty and bias treatment;
 - Tool applicability;
 - Training data and known performance limitations (i.e. what the tool can and cannot do);
 - Evidence that ground-truthing has been carried out (where possible), rather than relying solely on internal vendor testing;
 - Assurance that tools are operating within applicable parameters;
 - In methodologies that will be used in projects affecting Indigenous Peoples as well as local communities, an assessment of how local and Indigenous knowledge was considered in the tool's applicability conditions;
 - Where tools are used to detect reversals: the methodology, including the granularity, frequency and threshold for investigations; timelines for reporting and disclosure, as well as any evidence standards; how material data gaps are defined, detected, reported and addressed, including any conservative assumptions, effects on credit issuance and buffer pools; and how extended tool failure is detected, reported and addressed.

- **Relationship to Recommendation 6.2:** To avoid duplication and streamline processes, the ICVCM should clarify the relationship between program tool approval prior to deployment and methodology tool approval.
- **Independent benchmarking:** Future iterations of the CCP Assessment Framework could consider whether independent benchmarking should form part of the methodology approval process.

6.10 The ICVCM should require carbon-crediting programs to fully document the digital data pipeline where digital tools are used in quantification, including how uncertainty is assessed at each stage.

To ensure that quantification and documentation cover the full data pipeline, programs should be required to document how data is transformed and used at each stage. This should also include how uncertainty is assessed and quantified at each stage. Without explicitly considering the full data pipeline, there is a risk that the focus will be limited to the final outputs. A documented and auditable trail of the intermediate stages can help identify small errors in the pipeline that could otherwise go undetected until the final credit issuance stage.

- **Guidance:** The ICVCM should provide illustrative guidance on what such documentation should include.

6.11 The ICVCM should require the use of conservative deductions, relative to the degree of uncertainty, where the uncertainty of digital tools cannot be quantified.

The current Assessment Framework does not explicitly address situations where the uncertainty of digital tools cannot be quantified, beyond higher-level guidance in Criterion 5.2. Programs should be required to use conservative deductions and document the logic and basis for determining the appropriate level of conservativeness.

- **Conservativeness levels:** The ICVCM should develop guidance on how programs can set appropriate conservativeness levels.

6.12 The ICVCM should make it clear that monitoring requirements extend to the full DMRV data pipeline and not just the final outputs.

Current requirements risk focusing only on the final monitoring outputs rather than the full pipeline. The ICVCM should clarify that integrity requirements for carbon-crediting programs apply to each stage of the MRV data pipeline. As this responsibility for monitoring extends beyond carbon-crediting programs, efforts should also be made to encourage similar actions by other carbon market actors, such as project developers.

Equity, rights and community impacts

While finalising the recommendations in this section, the working group received feedback that DMRV should not be presumed to be the default system against which Indigenous and local knowledge is reconciled. Rather, such knowledge must be respected in its own right. The ICVCM recognises Indigenous Peoples and Local Communities as different and distinct peoples with discrete rights and interests, as expressed in international and national instruments and traditional laws.

6.13 The ICVCM should require carbon-crediting programs to address how digital tools are used and their effects on community rights and participation within their stakeholder engagement and grievance frameworks.

Current requirements do not explicitly address the ways in which digitisation could affect the rights and roles of Indigenous Peoples and/or local communities.

- **Minimum components:** At a minimum, programs should address:
 - Data ownership, privacy and access rights where digital tools collect Indigenous and/or community data or data from their territories;
 - How the MRV roles of Indigenous Peoples as well as communities are affected by digital tools;
 - Accessible pathways for communities to raise issues and seek remedies related to these digital tools. These pathways should reference and align with the Indigenous Peoples and Local Communities Engagement Forum’s grievance mechanism workstream rather than being developed separately.
- **Free, Prior and Informed Consent (FPIC) assessments:** Programs should be required to assess and document whether FPIC obligations are triggered by the use of digital tools on or affecting Indigenous Peoples or local communities (and their territories). This is a distinct issue from FPIC obligations relating to project design and does not replace existing FPIC requirements. The assessment criteria should be co-designed with Indigenous Peoples’ organisations and community representatives. The ICVCM could also develop illustrative guidance on this, for instance, where automation or digitisation replaces community MRV roles that previously generated income, participation and/or ownership rights. Guidance could consider options for maintaining a hybrid community role, such as acting as verifiers of record, or providing equivalent compensation or ownership stakes before DMRV rollout.
- **Community roles:** Where DMRV tools displace a community role, further guidance on recommended actions and remedies by the carbon-crediting program will be needed. This should be developed in collaboration with Indigenous Peoples and local community representatives. This also relates to Criterion 7.6, specifically the requirements around FPIC. The ICVCM should clarify whether FPIC should also be explicitly extended to cover digital tools, including whether, consistent with FPIC principles, consent should be treated as revocable in the DMRV context.

6.14 The ICVCM should require explicit consideration of the rights and risks that arise from digital tool deployment in projects involving Indigenous Peoples or local communities.

Risk assessments may not adequately cover situations where digital tools are used in projects involving Indigenous Peoples or local communities, including projects on their territories.

- **Risk components:** At a minimum, these assessments should include: (1) data sovereignty and data rights; (2) the impact of digitisation on community roles and economic participation in the MRV process; (3) any benefits arising from the commercial use of data from their territories; and (4) the accessibility of these digital outputs to communities whose rights are affected by them.
- **Co-assessment:** The ICVCM should require that the risk assessment is conducted by carbon-crediting programs in collaboration with affected Indigenous Peoples or local communities.
- **Appropriate solutions to mitigate identified risks:** Where assessments reveal risks, for instance to data sovereignty, appropriate actions and remedies will need to be implemented, such as pausing deployment until appropriate solutions have been put in place. Additional work and discussions with key market actors may be needed to determine what these actions, remedies and solutions should be.
- **Interaction with Sustainable Development Benefits and Safeguards:** The ICVCM should clarify how the benefit component interacts with the recommendations of the CIWP on Sustainable Development Benefits and Safeguards report to ensure consistent interpretation and appropriate sequencing of these recommendations.

6.15 The ICVCM should require carbon-crediting programs to assess the impact of digital tools on the rights of both Indigenous Peoples and local communities and ensure that these impacts are adequately addressed across the appropriate frameworks.

It is difficult to classify the implications of digital tools for both Indigenous Peoples and local communities under a single criterion and/or MRV component. As such, the ICVCM should require carbon-crediting programs to document and assess how these communities are affected across the MRV cycle and, based on this assessment, address the associated risks and rights coherently across the appropriate frameworks, such as digital governance and grievance mechanisms.

- **Appropriate solutions to address risks:** Similar to the preceding recommendation (6.14), the ICVCM could develop guidance on appropriate actions, solutions and remedies to address any risks and infringements of rights identified through the assessments in Recommendation 6.15.
- **Sequencing:** The ICVCM should also consider and clarify whether the deployment of digital tools should be contingent on first conducting these risk assessments and implementing appropriate solutions to any risks identified.
- **Avenues for community MRV roles and participation:** Future work by the ICVCM should consider whether other avenues (e.g. community-led MRV roles and participation) should be considered beyond grievance mechanisms following deployment, to ensure that the rights and roles of both Indigenous Peoples and local communities are respected and protected.

Capacity building and convergence

6.16 The ICVCM should support convergence and work by other carbon market actors on the following issues where other actors are better placed to lead.

Topics include:

- **Digital capacity building for lower-resourced participants:** The ICVCM should support and work with carbon market actors by providing guidance on its Assessment Framework requirements in a manner that does not further entrench the digital divide and support capacity-building efforts by other actors.
 - The ICVCM could also consider using plain-language guidance, templates and worked examples to help these actors. Where others are already active and/or better placed to deliver capacity building, such as multilateral development banks, NGOs, bilateral programmes and other actors, the ICVCM should support these efforts.
 - Where DMRV is used on or near Indigenous Peoples' or local communities' territories, capacity-building support should focus on genuine knowledge and technology transfer, as well as improving local capacity. This way, digitisation can support community autonomy and participation rather than creating new forms of dependency. Support should recognise Indigenous Peoples' and community-led entities and organisations as a distinct stakeholder and constituency for capacity building.
- **Open reference datasets and benchmarks:** The ICVCM could also support efforts to develop public goods, such as open-reference datasets and benchmarks.
- **Liability allocation:** Where data providers disclaim liability under standard terms, mechanisms are needed to ensure that liability does not fall through the gaps across the DMRV chain.
- **VVB liability:** Clarity is needed on where VVB liability begins and ends, and whether it can be understood as extending from the receipt of information until report submission, with project developer liability for fraud and responsibility for ensuring that measurement systems are certified. Clarity is also needed on what the addition of a DMRV tool or data provider changes, if anything, in this understanding.
- **Conditions under which the provisional use of digital tools is allowed:** The ICVCM can work with or support the work of other actors to encourage innovation and DMRV pilots under specific conditions. A clear distinction should be maintained between tools that are not robust or relevant, where there is a high integrity risk, and those that are suspended or denied approval, on the one hand, and genuine cases where provisional use may be appropriate, on the other.
 - Three potential situations that could be considered include: (1) first-mover situations (novel use of a tool where there is no comparable reference point, with the onus on the developer to demonstrate novelty); (2) an approved tool in a novel context (subject to ongoing applicability validation); and (3) capacity-constrained projects (lacking the financial, infrastructure or technical capacity to reach full integrity standards). In all three situations, the integrity risks must be identified and must be low to medium risks that are adequately addressed under the provisional conditions.
 - Where provisional use affects Indigenous Peoples or local community territories, carbon-crediting programs should notify and consult with those communities prior to DMRV deployment.

- **Common benchmarks:** Shared approaches to assess the accuracy and applicability of DMRV tools, including consideration of which actor(s) are best placed to develop and maintain such benchmarks.
- **Role of governments:** As national frameworks develop to reflect digital practices and tools, governments have roles to play in areas such as data ownership and oversight, as well as cross-jurisdictional comparability.
- **Independent, robust and accessible datasets:** As with traditional MRV, the quality of DMRV outputs depends on robust reference datasets, particularly those that are accessible or open access. Investments in this type of public infrastructure by other market actors should be supported.
- **Accuracy metrics:** The ICVCM should support efforts to standardise accuracy metrics for uncertainty disclosures relating to digital tools.
- **Digitalisation and project tracking:** The ICVCM should support efforts by carbon-crediting programs to digitise project registration and the MRV cycle where this results in greater integrity and transparency of validation and verification records. In particular, the ICVCM should encourage more systematic tracking of project status, as well as VVB activity data, across the validation and verification pipeline.
 - This includes, at a minimum, engagement status, standardised reporting formats and data sharing with accreditation bodies. Where possible, these should be in a harmonised, machine-readable format and align with existing market data schemas.

Future research: Science and Research Network

A number of topics were flagged by the working group for future research, including through the ICVCM Science and Research Network.

The following topics were identified as technical gaps that could be taken up by the ICVCM Science and Research Network or the carbon market research community:

- **Data sufficiency and confidence thresholds:** Particularly in data-sparse geographies, what would data sufficiency and confidence thresholds look like for different DMRV tools, sectors and biomes?
- **Market concentration and systemic risk:** An analysis of market concentration risk could be conducted to examine the systemic integrity risks arising where a small number of digital tool developers or data providers account for a significant share of credits within a given market segment, sector or geography and to assess whether concentration risk warrants additional refinements to the Assessment Framework or supplementary guidance.
- **Cost-benefit analysis:** The costs and benefits of DMRV compared to traditional MRV could be explored, particularly the implications of a significant share of climate finance being diverted to technology providers and consultancies rather than sustainable development activities, particularly in smaller or community-led projects.
- **Use of digital tools by VVBs:** Building on the work of the CIWP on Oversight of VVBs, future work by the ICVCM should explore how digital tools are used by VVBs and whether additional guidance or guardrails are needed.

- **Near-real-time credits:** The ICVCM could look into the results and operation of near-real-time credit issuance projects to assess how verification frequency and credit issuance cycles should adapt to near-continuous monitoring and near-real-time credit issuance. This should be done in collaboration with ISO, in particular by considering whether adjustments to ISO 14064-3 and the verification process itself are needed in response to near-real-time credit issuance.
- **DMRV, Indigenous Peoples, as well as local communities:** Other issues that arise from DMRV and communities, such as benefit-sharing arrangements for digital data from their territories or ownership of data generated across jurisdictions, are open questions that should be addressed in future by the ICVCM or other carbon market actors.
- **Digitised methodologies:** Where methodologies are systems rather than guidance documents, additional work is needed on how methodology approval, documentation, updates (and version control) and audits should be conducted to provide insights into how these components would work.
- **Common independent benchmarking as a public good:** A shared, cost-effective independent benchmarking function for key DMRV parameters could be established and maintained as a public good for the market. Further detail is needed on which parameters warrant shared benchmarks, whether benchmarks need to be developed or already exist and viable cost-sharing strategies.
- **Model drift:** How can model drift be detected and corrected over time? How frequently should re-validation and/or re-approval be undertaken for different tools?
- **Digitalised engagement and contracting of VVBs:** Where programs engage or assign VVBs through a shared platform, this may have implications for VVB impartiality (or perceptions of impartiality). This should be assessed, including options for managing risks to actual and perceived impartiality, as well as ensuring that digital engagement processes are designed to be accessible and do not unintentionally discriminate against lower-resourced VVBs.
- **Energy and climate cost of AI and ML:** How should the energy and climate costs of digital tools, particularly AI and ML, used in carbon-crediting MRV processes be measured and addressed? What disclosure methodology would be appropriate? Where these costs are significant, further work should consider how projects can ensure a net climate benefit from the carbon-crediting project despite the energy and climate costs of AI and ML MRV tools.
- **Alternative validation approaches:** What minimum standards should alternative validation approaches meet and how can they provide sufficient assurance when ground-truthing is not possible?
- **Digital carbon assets and tokenisation:** Where DMRV outputs feed directly into the issuance of tokenised carbon assets, further work is needed on registry–ledger reconciliation, custody and control of the underlying unit, retirement and immobilisation logic and safeguards against double counting or double representation.

Participants

The CIWP on DMRV comprised experts from:

- World Bank Group (co-facilitator)
- Sylvera
- ANSI National Accreditation Board (ANAB)
- Carbon Collective
- Bezos Earth Fund
- Carbon Farm
- COMESA
- International Association of Validation and Verification (IAVVB)
- Permian Global
- Smithsonian Institute
- CarbonClear
- Forest Monitoring and Information, Government of Bhutan
- Climate Action Reserve (CAR)
- Arkadiah Technology
- Continuum Research
- University of Wisconsin–Madison
- SustainCERT
- CTrees
- Global Carbon Council
- Equitable Earth Standard
- Indian Institute of Tropical Meteorology, Pune, India

In addition, the following organisations were invited to selected sessions:

- Verra
- Gold Standard
- Climate Action Data
- EcoRegistry
- UNMAI
- Carbon AI
- Singapore's Economic Development Board
- Conservation International
- Senegalese Rural Electrification Agency

The ICVCM also organised a side event at Innovate4Climate in Singapore in May 2026, which was moderated by the World Bank and featured speakers from the ICVCM, the Government of Bhutan, Arkadiah and Global Carbon Council.

The work program was co-facilitated by Gemma Torras Vives (World Bank) and Ismaila Wiafe (ICVCM Expert Panel). Marissa Santikarn provided support as the substantive lead of the work program.

Annexes

Annexes

Annex 1: Table of recommendations

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
Recommendations for CCP Assessment Framework refinement	Definitions	6.1	The ICVCM should define key DMRV terms.	• Suggested terms: At a minimum, the following terms should be incorporated into the ICVCM definitions: blockchain, claims, data, interoperability, digital carbon assets, data life cycle, data quality, uncertainty, DMRV, tokenisation and digital public infrastructure. For DMRV, the ICVCM could also consider defining key tools, including algorithms, models and AI/ML. Finally, a distinction between deterministic and inference-based digital tools should be included, as they raise different integrity challenges and may warrant different guidance. • These definitions should be developed through a consultative process led by the ICVCM to finalise the definitions, particularly given that these terms will affect how actors interpret and use the report's recommendations. Definitions can also be aligned with emerging international standards, such as upcoming ISO revisions.
Recommendation for new criteria for Assessment Framework	n/a	6.2	The ICVCM should require that digital tools used in MRV are independently approved by programs prior to deployment, alongside clear re-approval triggers.	• Minimum criteria: Carbon-crediting programs should be required to approve digital tools against a set of transparent, predefined criteria that, at a minimum, should include: – Technical functions and accuracy; – Applicability (relevant geography, sector and project type); – Compliance with Criterion 3.1 of the CCP Assessment Framework and the tool's data governance framework(s); – Performance limitations (i.e. what the tool can and cannot do); – How local and Indigenous knowledge is considered, respected and incorporated, where relevant, into the tool's applicability. This is especially pertinent where tools are used in projects affecting both Indigenous Peoples and local communities, to ensure that local and Indigenous knowledge is respected in its own right, rather than treated solely as a component of the tool's approval; – Approvals granted by other systems could also be accepted if equivalence is demonstrated. • Re-approval triggers: These should be defined and should, at a minimum, include: (1) material changes to the tool; (2) changes to training data or parameters; (3) applications outside the approved scope; and (4) defined maximum periods for re-validation. – Minimum criteria for approvals and re-approvals: Supplementary guidance on minimum criteria for approvals and re-approvals should also be developed by the ICVCM. • Alternative assurance mechanisms: Where ground-truthing is not feasible, guidance on alternative assurance mechanisms should be developed, including minimum standards that these alternatives must meet.

Annex 1 Table of recommendations (Cont.)

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
Further recommendations	n/a	6.3	The accountability, obligations and responsibilities of DMRV and/or data providers need to be addressed and clarified. This should be developed through a broader consultation process involving a broad representation of market actors and building on lessons learned from DMRV pilots and initiatives.	
Recommendation for CCP Assessment Framework Refinement	n/a	6.4	The ICVCM should require carbon-crediting programs that approve, endorse or reference digital tools to have a publicly accessible DMRV governance framework. This framework should cover the various stages of the DMRV process, from the digital tools used for measurement and monitoring, through to the provider, the entity calculating or translating the claim from the raw data, the standard approving the claim and the credit-issuing registry.	• Minimum components: A DMRV governance framework should, at a minimum, address: – Predefined and transparent tool approval criteria; – Predefined re-validation triggers (including, at a minimum, material changes to the tool's architecture, maximum periods between re-validation and impacts on credit issuance); – How material errors are identified, assessed and managed; – Cross-program notification requirements where a material error is identified in a shared tool. • Guidance: The ICVCM could also consider developing illustrative guidance on what constitutes a material error, as well as more specific guidance on re-validation triggers for specific tools (e.g. model drift for models), if this is not taken up by other actors.
Recommendation for CCP Assessment Framework Refinement	1.1	6.5	The ICVCM should require carbon-crediting programs to explicitly address cybersecurity and data integrity within their anti-fraud provisions.	• Internationally recognised cybersecurity frameworks: Carbon-crediting programs should have provisions consistent with internationally recognised cybersecurity frameworks (e.g. ISO/IEC 27001, the NIST Cybersecurity Framework or CIS Controls), including audit logging and tamper-evidence requirements. These requirements should be proportionate to the scale and materiality of the systems concerned. • Managing failures: Carbon-crediting programs should also set out how cybersecurity or data integrity failures affecting MRV data are to be managed, including definitions of material incidents and timelines for detecting, remedying and disclosing them. • Third-party providers: Requirements should extend to the systems on which carbon-crediting programs rely, not only those they operate directly. Where MRV data is generated, processed or transmitted by project developers or third-party technology providers, programs should specify the cybersecurity expectations that apply across the data pipeline and how compliance is evidenced. – Carbon-crediting programs should consider requiring DMRV system providers to submit a declaration confirming that they have complied with relevant cybersecurity and data protection requirements, to support transparency and accountability. However, this should not be a substitute for the independent verification described above.

Annex 1 Table of recommendations (Cont.)

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
				[cont.] • Credits: Carbon-crediting programs should specify the consequences for credits affected by a material incident, including when issuance should be suspended, when credits should be 'quarantined' pending investigation and how remediation should apply to credits that have already been issued or retired.
Recommendation for CCP Assessment Framework Refinement	1.1	6.6	The ICVCM should require that carbon-crediting programs' conflict-of-interest policies explicitly address DMRV conflicts.	• Addressing and identifying conflicts: Carbon-crediting programs should be required to disclose how digital conflicts of interest are identified and addressed. • VVB involvement: Policies need to address situations where VVBs are involved in building, licensing or operating a DMRV system or tool that they are validating. • Safeguards: Independence safeguards should also be considered where a VVB has built or is operating a digital tool that it is also assessing. • Guidance: The ICVCM could also consider developing supplemental guidance with illustrative examples.
Recommendation for CCP Assessment Framework Refinement	3.1	6.7	The ICVCM should require carbon-crediting programs to ensure the public disclosure of digital tools used in MRV.	• Minimum components: At a minimum, the ICVCM should require programs to disclose the following components in relation to digital tools: the underlying logic, training data characteristics, inputs, assumptions and applicability conditions. • Alternative assurance mechanisms: Where disclosure is limited due to proprietary constraints or applicable national privacy laws, alternative assurance mechanisms should be applied. These should provide an equivalent level of assurance to full disclosure. Such mechanisms should also be documented and subject to independent review. • Minimum disclosure template: To guide programs, the ICVCM should develop a minimum disclosure template in consultation with key carbon market actors. The template should differentiate between cases where more technical, granular disclosure is required (e.g. for VVBs) and where higher-level disclosure is sufficient (e.g. for the wider public). Where feasible, the template should generate structured, machine-readable outputs aligned with existing market schemas, such as the Carbon Data Open Protocol or G20 Carbon Credit Data Model.
Recommendation for CCP Assessment Framework Refinement	4.1	6.8	The ICVCM should require programs to ensure that VVBs demonstrate sufficient competency to assess digital tools where their work involves these tools.	• ISO coordination: The ICVCM should support ISO updates addressing digital tools, including relevant ISO revisions, as well as the work of the International Association of Validation and Verification (IAVVB) and other key actors on digital competencies. The ICVCM should review these revisions to ensure that relevant ISO standards are reflected in the CCPs. Until these revisions are made, VVBs will need guidance and clarity on how to address digital tools, including the expectations and responsibilities that apply in these contexts. • Claims in a digital setting: The ICVCM should clarify what constitutes a claim when MRV is digitally generated. Related to this, it should be clarified where responsibility attaches when outputs are produced by a digital system, including the roles of those who configure, approve and operate it.

Annex 1 Table of recommendations (Cont.)

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
				[cont.] • Final report controls: Building on Criterion 3.1 on information in the Assessment Framework and the full data pipeline requirements, programs using digital registration and MRV systems should apply controls to ensure that the validation and verification report displayed on a registry matches the finalised version, regardless of whether it is uploaded by the project proponent or the VVB.
Recommendation for CCP Assessment Framework Refinement	5.1	6.9	If any digital tool is used for quantification, the ICVCM should require a review of that tool as part of the methodology approval process. To ensure that these tools are appropriately scrutinised, the ICVCM should require that they be included in the carbon-crediting program's methodology approval process.	• Minimum components: This should include: – Uncertainty and bias treatment; – Tool applicability; – Training data and known performance limitations (i.e. what the tool can and cannot do); – Evidence that ground-truthing has been carried out (where possible), rather than relying solely on internal vendor testing; – Assurance that tools are operating within applicable parameters; – In methodologies that will be used in projects affecting Indigenous Peoples as well as local communities, an assessment of how local and Indigenous knowledge was considered in the tool's applicability conditions; – Where tools are used to detect reversals: the methodology, including the granularity, frequency and threshold for investigations; timelines for reporting and disclosure, as well as any evidence standards; how material data gaps are defined, detected, reported and addressed, including any conservative assumptions, effects on credit issuances and buffer pools; and how extended tool failure is detected, reported and addressed. • Relationship to Recommendation 6.2: To avoid duplication and streamline processes, the ICVCM should clarify the relationship between program tool approval prior to deployment and methodology tool approval. • Independent benchmarking: Future iterations of the CCP Assessment Framework could consider whether independent benchmarking should form part of the methodology approval process.
Recommendation for CCP Assessment Framework Refinement	5.2	6.10	The ICVCM should require carbon-crediting programs to fully document the digital data pipeline where digital tools are used in quantification, including how uncertainty is assessed at each stage. To ensure that quantification and documentation cover the full data pipeline, programs should be required to document how data is transformed and used at each stage. This should also include how uncertainty is assessed and quantified at each stage.	• Guidance: The ICVCM should provide illustrative guidance on what such documentation should include.

Annex 1 Table of recommendations (Cont.)

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
Recommendation for CCP Assessment Framework Refinement	5.2	6.11	The ICVCM should require the use of conservative deductions, relative to the degree of uncertainty, where the uncertainty of digital tools cannot be quantified. Programs should be required to use conservative deductions and document the logic and basis for determining the appropriate level of conservativeness.	• Conservativeness levels: The ICVCM should develop guidance on how programs can set appropriate conservativeness levels.
Recommendation for CCP Assessment Framework Refinement	10.8	6.12	The ICVCM should make it clear that monitoring requirements extend to the full DMRV data pipeline and not just the final outputs. As this responsibility for monitoring extends beyond carbon-crediting programs, efforts should also be made to encourage similar actions by other carbon market actors, such as project developers.	
Recommendation for CCP Assessment Framework Refinement	1.2	6.13	The ICVCM should require carbon-crediting programs to address how digital tools are used and their effects on community rights and participation within their stakeholder engagement and grievance frameworks.	• Minimum components: At a minimum, programs should address: – Data ownership, privacy and access rights where digital tools collect Indigenous and/or community data or data from their territories; – How the MRV roles of Indigenous Peoples as well as communities are affected by digital tools; – Accessible pathways for communities to raise issues and seek remedies related to these digital tools. These pathways should reference and align with the Indigenous Peoples and Local Communities Engagement Forum's grievance mechanism workstream rather than being developed separately. • Free, Prior and Informed Consent (FPIC) assessments: Programs should be required to assess and document whether FPIC obligations are triggered by the use of digital tools on or affecting Indigenous Peoples or local communities (and their territories). The assessment criteria should be co-designed with Indigenous Peoples' organisations and community representatives. The ICVCM could also develop illustrative guidance on this, for instance, where automation or digitisation replaces community MRV roles that previously generated income, participation and/or ownership rights. Guidance could consider options for maintaining a hybrid community role, such as acting as verifiers of record, or providing equivalent compensation or ownership stakes before DMRV rollout.

Annex 1 Table of recommendations (Cont.)

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
				[cont.] • Community roles: Where DMRV tools displace a community role, further guidance on recommended actions and remedies by the carbon-crediting program will be needed. This should be developed in collaboration with Indigenous Peoples and local community representatives. This also relates to Criterion 7.6, specifically the requirements around FPIC. The ICVCM should clarify whether FPIC should also be explicitly extended to cover digital tools, including whether, consistent with FPIC principles, consent should be treated as revocable in the DMRV context.
Recommendation for CCP Assessment Framework Refinement	7.1	6.14	The ICVCM should require explicit consideration of the rights and risks that arise from digital tool deployment in projects involving Indigenous Peoples or local communities.	• Risk components: At a minimum, these assessments should include: (1) data sovereignty and data rights; (2) the impact of digitisation on community roles and economic participation in the MRV process; (3) any benefits arising from the commercial use of data from their territories; and (4) the accessibility of these digital outputs to communities whose rights are affected by them. • Co-assessment: The ICVCM should require that the risk assessment is conducted by carbon-crediting programs in collaboration with affected Indigenous Peoples or local communities. • Appropriate solutions to mitigate identified risks: Where assessments reveal risks, for instance to data sovereignty, appropriate actions and remedies will need to be implemented, such as pausing deployment until appropriate solutions have been put in place. Additional work and discussions with key market actors may be needed to determine what these actions, remedies and solutions should be. • Interaction with Sustainable Development Benefits and Safeguards: The ICVCM should clarify how the benefit component interacts with the recommendations of the CIWP on Sustainable Development Benefits and Safeguards report to ensure consistent interpretation and appropriate sequencing of these recommendations.
Recommendation for CCP Assessment Framework Refinement	7.1	6.15	The ICVCM should require carbon-crediting programs to assess the impact of digital tools on the rights of both Indigenous Peoples and local communities and ensure that these impacts are adequately addressed across the appropriate frameworks.	• Appropriate solutions to address risks: Similar to the preceding recommendation (6.14), the ICVCM could develop guidance on the appropriate actions, solutions and remedies to address any risks and infringements of rights identified through the assessments in Recommendation 6.15. • Sequencing: The ICVCM should also consider and clarify whether the deployment of digital tools should be contingent on first conducting these risk assessments and implementing appropriate solutions to any risks identified. • Avenues for community MRV roles and participation: Future work by the ICVCM should consider whether other avenues (e.g. community-led MRV roles and participation) should be considered beyond grievance mechanisms following deployment, to ensure that the rights and roles of both Indigenous Peoples and local communities are respected and protected.

Annex 1 Table of recommendations (Cont.)

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
Further recommendations	n/a	6.16	The ICVCM should support convergence and work by other carbon market actors on the following issues where other actors are better placed to lead.	• Digital capacity building for lower-resourced participants: The ICVCM should support and work with carbon market actors by providing guidance on its Assessment Framework requirements in a manner that does not further entrench the digital divide and support capacity-building efforts by other actors. The ICVCM could also consider using plain-language guidance, templates and worked examples to help these actors. Where others are already active and/or better placed to deliver capacity building, such as multilateral development banks, NGOs, bilateral programmes and other actors, the ICVCM should support these efforts. Where DMRV is used on or near Indigenous Peoples' or local communities' territories, capacity-building support should focus on genuine knowledge and technology transfer, as well as improving local capacity. Support should recognise Indigenous Peoples' and community-led entities and organisations as a distinct stakeholder and constituency for capacity building. • Open reference datasets and benchmarks: The ICVCM could also support efforts to develop public goods, such as open-reference datasets and benchmarks. • Liability allocation: Where data providers disclaim liability under standard terms, mechanisms are needed to ensure that liability does not fall through the gaps across the DMRV chain. • VVB liability: Clarity is needed on where VVB liability begins and ends, and whether it can be understood as extending from the receipt of information until report submission, with project developer liability for fraud and responsibility for ensuring that measurement systems are certified. Clarity is also needed on what the addition of a DMRV tool or data provider changes, if anything, in this understanding. • Conditions under which the provisional use of digital tools is allowed: The ICVCM can work with or support the work of other actors to encourage innovation and DMRV pilots under specific conditions. A clear distinction should be maintained between tools that are not robust or relevant, where there is a high integrity risk, and those that are suspended or denied approval, on the one hand, and genuine cases where provisional use may be appropriate, on the other. Three potential solutions that could be considered include: (1) first-mover situations (novel use of a tool where there is no comparable reference point, with the onus on the developer to demonstrate novelty); (2) an approved tool in a novel context (subject to ongoing applicability validation); and (3) capacity-constrained projects (lacking the financial, infrastructure or technical capacity to reach full integrity standards). In all three situations, the integrity risks must be identified and must be low to medium risks that are adequately addressed under the provisional conditions. Where provisional use affects Indigenous Peoples or local community territories, carbon-crediting programs should notify and consult with those communities prior to DMRV deployment.

Annex 1 Table of recommendations (Cont.)

Recommendation type	Relevant Assessment Framework criteria	No.	Recommendation	Elements
				[cont.] • Common benchmarks: Shared approaches to assess the accuracy and applicability of DMRV tools, including consideration of which actor(s) are best placed to develop and maintain such benchmarks. • Role of governments: As national frameworks develop to reflect digital practices and tools, governments have roles to play in areas such as data ownership and oversight, as well as cross-jurisdictional comparability. • Independent, robust and accessible datasets: As with traditional MRV, the quality of DMRV outputs depends on robust reference datasets, particularly those that are accessible or open access. Investments in this type of public infrastructure by other market actors should be supported. • Accuracy metrics: The ICVCM should support efforts to standardise accuracy metrics for uncertainty disclosures relating to digital tools. • Digitalisation and project tracking: The ICVCM should support efforts by carbon-crediting programs to digitise project registration and the MRV cycle where this results in greater integrity and transparency of validation and verification records. In particular, the ICVCM should encourage more systematic tracking of project status, as well as VVB activity data, across the validation and verification pipeline. This includes, at a minimum, engagement status, standardised reporting formats and data sharing with accreditation bodies. Where possible, these should be in a harmonised, machine-readable format and align with existing market data schemas.

Annex 2: CCP Assessment Framework criteria relevant to DMRV

Criterion	Text
1.1	Effective governance a) In addition to CORSIA requirements related to governance framework, the carbon-crediting program shall: 1) have a board comprised of independent board members who assume fiduciary responsibility for the organisation and operate according to robust bylaws; 2) publish an annual report that contains the organisation's revenues, expenses, and net assets over the past year and provides an overview of the organisation's mission, major programs and activities, and governance; 3) have processes in place to ensure corporate social and environmental responsibility; 4) have robust anti-money laundering processes in place; 5) follow practices consistent with robust anti-bribery and anti-corruption guidance and regulation.
1.2	Public engagement, consultation & grievances a) In addition to CORSIA requirements related to public engagement, consultation and grievances, the carbon-crediting program shall have a process for: 1) robust and transparent local and global stakeholder consultation, which provide for public comment and issue resolution; 2) addressing grievances, for which the process shall be clear and transparent, ensure impartiality and where appropriate, confidentiality, in the filing and resolution of grievances and for which any applicable fees shall not impede legitimate access to the grievance process by civil society organisations or of Indigenous Peoples and Local Communities (IPs & LCs).
3.1	Transparency: Information a) In addition to CORSIA requirements, the carbon-crediting program shall ensure that in relation to each mitigation activity that requests registration or that is registered, all relevant documentation relating to the mitigation activity is made publicly available (subject to confidentiality and proprietary, privacy and data protection restrictions) including: 1) all necessary information, such as spreadsheets used for calculations, to enable third parties to assess the social and environmental impacts of the mitigation activity and to replicate the GHG emission reduction or removal calculations (including baseline quantification), and assessment of additionality; 2) a mitigation activity design document that includes: i. a non-technical summary; ii. detailed information on the mitigation activity, including its location and proponents; iii. a description of the technologies or practices applied; iv. the environmental and social impacts; v. the methodology used; vi. information on how the methodology is and has been applied for the purpose of determining the baseline, demonstrating additionality and quantifying GHG emission reductions or removals; 3) For Categories listed in 9.1 b) 1, information relating to the monitoring and compensation period. b) The carbon-crediting program shall ensure all relevant program documents are publicly available and have processes to ensure that where requests are made in relation to information that is missing from its website and/or registry, that information is provided (subject to confidentiality and proprietary, privacy and data protection restrictions) and made public alongside other relevant public information.
4.1	Robust, independent third-party validation and verification a) In addition to CORSIA requirements, in relation to validation of mitigation activities and verification of GHG emission reductions and removals, the carbon-crediting program shall: 1) require validation and verification bodies (VVBs) to be accredited by a recognised international accreditation standard (e.g., according to the current edition of ISO 14065 and ISO 14066, or per rules relating to the UNFCCC Kyoto Protocol Clean Development Mechanism or Paris Agreement Article 6, paragraph 4 Supervisory Body); 2) have a process for managing VVB performance, including systematic review of validation and verification activities, reports and remedial measures to address performance issues including measures to ensure that poor VVB performance is reported to the relevant accreditation body, and provisions to suspend or revoke the participation of a VVB in the carbon-crediting program.

Annex 2: CCP Assessment Framework criteria relevant to DMRV (Cont.)

Criterion	Text
5.1	Methodology approval process a) In addition to CORSIA requirements related to Clear Methodologies and Protocols and their Development Process, the carbon-crediting program shall have a process for developing and adopting updates to existing quantification methodologies. b) Approved methodologies or general carbon-crediting program provisions shall address the following essential components: 1) applicability or eligibility criteria; 2) determination of the accounting boundary; 3) determination of additionality (to the extent this is not covered in other general carboncrediting program provisions); 4) establishing the baseline scenario; 5) quantification of GHG emission reductions or removals; 6) monitoring practices. c) The carbon-crediting program shall require that, prior to approval, new methodologies and major revisions of existing methodologies undergo review by a group of independent experts and a public stakeholder consultation. d) The carbon-crediting program shall have procedures to review, suspend and/or withdraw the use of methodologies where the carbon-crediting program has determined, based on evidence, that GHG emission reductions or removals are being overestimated or that additionality might not be ensured.
5.2	Quantifying GHG emissions reductions or removals a) In addition to CORSIA requirements, the carbon-crediting program shall: 1) clearly define a carbon credit as one metric tonne of CO₂ equivalent of GHG emission reductions or removals; 2) disclose the Global Warming Potential (GWP) values used to calculate the CO₂ equivalence; 3) define the length of crediting periods, including the total length of combined crediting periods; 4) provide guidance on steps and requirements for renewal of the crediting periods and any renewal of the crediting period shall include a reassessment of the baseline scenario, including whether the conditions and barriers at the start of the mitigation activity still prevail, and an update of relevant parameters used to calculate emissions reductions and removals; 5) assess the overall uncertainty of emission reductions or removals associated with an activity type and/or require that the mitigation activity proponent assess the overall uncertainty in accordance with an approved methodology. In estimating overall uncertainty all causes of uncertainty shall be considered, including assumptions (e.g., baseline scenario), estimation equations or models, parameters (e.g., representativeness of default values); and measurements (e.g., the accuracy of measurement methods). The overall uncertainty shall be assessed as the combined uncertainty from individual causes; 6) have a systematic approach to ensuring the conservativeness of quantification methodologies it approves for use; 7) require in its program documents that existing government policies and legal requirements that lower GHG emissions (e.g., feed-in tariffs for renewable energy, minimum product efficiency standards, air quality requirements or carbon taxes) be included when determining the baseline emissions. The carbon-crediting program may have provisions to consider the level of enforcement of such policies and legal requirements as well as any associated grace periods.
7.1	Assessment and management of environmental and social risks a) In addition to CORSIA requirements relating to Safeguards System and Sustainable Development Criteria, the carbon-crediting program shall require mitigation activity proponents to: 1) abide by national and local laws, objectives, programs and regulations and, where relevant, international conventions and agreements; 2) assess associated risks of negative environmental and social impacts with regard to the safeguards contained in criteria 7.2 to 7.8 (inclusive), taking into account the scope and scale of the mitigation activity; 3) ensure free, prior and informed Consent (FPIC) processes for IPs & LCs, where applicable, and conduct stakeholder consultations, including local stakeholders, as part of project design and implementation in a manner that is inclusive, culturally appropriate, and respectful of local knowledge, take these consultations into account and respond to local stakeholders' views. b) Where, pursuant to criterion 7.1 a) 2) above, the mitigation activity proponents have assessed that the mitigation activity poses risks of negative environmental and/or social impacts with regard to any of criteria 7.2 to 7.8 (inclusive) the carbon-crediting program shall require the mitigation activity proponents to: 1) include measures, commensurate with the identified risks, to minimise and address such negative environmental and/or social impacts, in validated design documents prior to registration; 2) include information on the measures implemented pursuant to criterion 7.1 b) 1) above, commensurate with the identified risks in the monitoring report.

Annex 2: CCP Assessment Framework criteria relevant to DMRV (Cont.)

Criterion	Text
10.8	Monitoring approaches a) The following approaches are considered to enable conservativeness and robust quantification: 1) the quantification methodology or applicable program documents ensure robust monitoring by: i. requiring the establishment of an operational and management plan for monitoring that addresses the assignment of responsibilities of various parties and the operational process of monitoring; ii. specifying the monitoring approach(es) for all parameters needed for the quantification of emission reductions or removals; iii. ensuring that the approaches related to use of measurements, sampling, data from third parties (e.g., studies, statistics, satellite data) or default values are robust, statistically representative or conservative; iv. ensuring that the choice of the approaches, data, measurement methods or default values appropriately addresses uncertainty and leads to a conservative estimate of emission reductions or removals; v. requiring appropriate quality assurance and quality control measures, such as cross-checking the monitoring results with other sources of data; and vi. requiring a plan or procedure for conservative treatment and deduction of emission reductions or removals in case of unexpected interruption or errors in monitoring equipment or procedures; 2) the quantification methodology or applicable program documents may provide for alternative monitoring approaches to be used when the mitigation activity becomes inaccessible for temporary periods (e.g., is in a conflict zone, or where human movement restrictions are in place, e.g., due to pandemic).



THE INTEGRITY COUNCIL
FOR THE VOLUNTARY CARBON MARKET

The Integrity Council for the Voluntary Carbon Market (ICVCM) is an independent, non-profit governance body for the voluntary carbon market, which aims to ensure the voluntary carbon market accelerates a just transition to 1.5°C. The ICVCM aims to set and maintain a voluntary global threshold standard for quality in the voluntary carbon market. The threshold standard is based on the ICVCM's Core Carbon Principles (CCPs) and is implemented through an Assessment Framework that sets out what high quality means by reference to those principles.



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