OPEN COLLABORATION DIGITAL MRV WORKING GROUP

PUBLIC CONSULTATION DRAFT GUIDANCE DOCUMENT ON DIGITISING METHODOLOGIES FOR CLIMATE MARKETS

PUBLIC CONSULTATION PERIOD

December 13, 2022 to January 20, 2023

SUBMIT STAKEHOLDER FEEDBACK (online form)

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INTRODUCTION

In 2021, the Open Collaboration partners (Gold Standard, ClimateCHECK, IOTA) published a white paper on Next Generation Digital Solutions for MRV. The white paper describes an ambitious vision to leverage emerging technologies to empower MRV that increases the quality and utility of the data inputs and outputs needed by stakeholders to vastly scale up mobilisation of resources to support transformational systems change for high-impact climate actions that catalyse sustainable development. Investing in better MRV systems for climate actions can have a better ROI – financially and for sustainability overall.

In 2022, with the support of Google.org, the Open Collaboration launched three working groups involving over 60 organisations to develop a series of white papers, guidance, and tools for:

- Digital Assets (WG1)
- Digital MRV (WG2)
- Digital Infrastructure and Open APIs (WG3)

The Open Collaboration is guided by a set of core principles including:

- An ecosystem built with open source and public good approaches
- Robust, transparent governance
- An inclusive, participatory global community
- Interoperability for the Digital and Data Economy
- Cost-effective solutions (for example, feeless transactions)
- Technologies that are low energy use and low environmental footprint

Based on stakeholder engagement, research and assessment, the goal of the Open Collaboration is to develop resources that will help advance digitisation for climate markets to achieve tangible benefits for stakeholders, for example:

- achieving higher levels of confidence in GHG claims with higher environmental integrity that could command a price premium
- shortened timelines for MRV that could accelerate market engagement to help scale resources into more climate actions
- streamlined verifications (for example, a rigorous first verification is followed by automated and continuous digital verifications with periodic spot checks)
- in other words, achieve an overall 10x decrease in MRV time and cost and achieve an overall 10x increase in resource mobilisation, high-impact climate actions.

CONTEXT

Carbon Markets are enabled by rigorous MRV, which is a demanding process to provide the necessary assurance for stakeholders that claims about impacts have integrity and are credible. At a high level of assurance, MRV requires substantial costs and time demands. There is always continuous improvement for the standards of practice and resources for auditing and assurance, which is largely transferable to MRV, for example the ongoing transformations in the financial sector towards "digital audit" (e.g., IAASB).

However, many stakeholders continue to be concerned about 'greenwashing', sometimes questioning 'the data' and other times Recognising the relative immaturity of sustainability standards and climate MRV (e.g., proliferation and variability of many standards and programs, uncertainty, difficulty of determining a credible baseline from which additionality is determined, lack of resources). To address such concerns, there is considerable work needed to improve methodologies, and also the 'standardisation system' that develops the methodologies and manages the system of methodologies and the resources necessary to successfully implement methodologies.

Digital tools have been an important component of MRV for many years, for example:

- Spreadsheet calculators
- GHG inventory software and data management systems
- Life cycle inventory databases and life cycle assessment software
- Emission factor databases
- Knowledge hubs
- Remote sensing
- GIS (Geographic Information Systems)
- GPS (Global Positioning System)
- Online reporting and registries
- Video-conferencing tools (e.g., remote audits)

However, there continue to be several challenges and opportunities for improvement in conventional MRV, even with the use of the above digital tools. Examples of specific challenges include:

- Current MRV practices in companies, cities, etc. involve substantial manual processes and analog data capture. This also involves in-person visits to audit sites, which is inefficient and costly. Occasional (e.g., annual) visits mean reporters are limited in their ability to monetise climate assets or participate in climate markets in a timely manner.
- Current MRV practices, and even many new efforts to digitise data from climate actions, lack adequate security and trust, thus reducing utility due to a lack of

confidence. The existing digital equipment at sites is variable and does not always prevent data manipulation.

- Current MRV practices for data analytics and quality assurance/quality control (QA/QC) are limited: for example, basic visual inspection and spreadsheet calculations.
- Investors, sellers, buyers and other stakeholders are limited from participating in climate markets and climate finance without secure, immutable, reliable source data, available in near real-time via Distributed Ledger Technology (DLT) to climate registries (NDC registry, carbon credit registry) and in accordance with linked MRV standards.
- There are many different types of climate actions with different data and MRV standards that are neither comparable nor consistent and do not add up with confidence as "one version of the truth". This leads to a lack of cohesiveness and confidence, thus limiting the ability to scale NDC climate actions towards efficient and effective transformational change (for example, 50% decarbonisation).

To date, stakeholders (e.g., digital MRV solution providers) are independently deciding to use a mix of digital technologies to automate MRV methodology requirements into their MRV systems. There is no consistent process or common framework, therefore there can be considerable variability among 'digital MRV solutions' for a specific project type, and within a specific program – that can cause even more variability in the results from one project to the next. Similarly, there is no consensus on a common approach with guidance for standards programs and methodology developers to include new digital requirements within existing MRV methodologies – that can cause even more variability across the global markets.

More advanced digital technologies that are becoming mainstream could enhance digital GHG methodologies activities, for example:

- Data APIs
- Big Data Analytics
- Artificial Intelligence (AI), Machine Learning (ML), Natural Language Processing (NLP), Deep Learning
- Robotic Process Automation
- Structured data formats, including eXtensible Business Reporting Language (XBRL)
- Internet of Things (IoT) Networks, Digital sensors and Edge Computing

The combination of these digital technologies has the potential to reduce timelines and costs, while increasing transparency and trust in the entire MRV process.

Furthermore, emerging technologies that can overcome some of the above challenges and improve the utility of MRV outputs, are rapidly advancing and are anticipated to be commercial in the foreseeable future, for example:

- Digital twins
- Distributed Ledger Technologies (DLT) and blockchain
- Smart contracts
- Tokenisation (digital assets)

There is growing interest among stakeholders to accelerate progress on the journey from today's conventional MRV, roughly characterised as 90% manual and 10% digital, to transition towards more digital MRV, roughly characterised as 10% manual and 90% digital. Such general vision guides overall efforts; however the extent of potential digital transition varies sector to sector, location to location, over time. Digital MRV will gradually become more and more common over time, however it still has a long way to go before it becomes the dominant form of MRV. As well, some activities (e.g., continuous measurement using a digital sensor of gas flow at a facility) can be more easily digitised than other activities (e.g., raw materials measured and recorded on a piece of paper then delivered by a supplier's truck, i.e., Scope 3). Sometimes the challenges to the ability to digitise MRV are the amount of costs and of benefits (value-added), accessibility, or control, among many other potential reasons.

The transition to 10% manual and 90% digital remains to be thoroughly defined, however based on current understanding and capabilities there is an expectation that the overall time spent by verifiers doing manual verification activities may not change much. Rather verifiers will reallocate their valuable time away from activities that can be more cost-effectively and thoroughly performed using digital technologies so verifiers can focus on more value-add activities as MRV evolves with more interrelated uses and users of MRV results. With 90% digital it is expected to substantially increase quantity and rigour of verification activities for data trails that will provide greater assurance on data confidence and reported information in GHG statements.

However during the early phase of the digital transformation, costs for digital MRV will be relatively high and most 'first-time, one-off' implementations will not likely be cost effective. As with other IT solutions, cost savings are expected with low-cost replication.

In some cases it might not be appropriate or a worthwhile improvement to transition to digital MRV, whether entirely or partially, for reasons associated with the local situational context, for example:

- Resource availability (e.g., lack of reliable internet connectivity, lack of financial resources for capital expenditures to purchase required devices or services)
- Existence of trusted options at lower cost
- Other barriers (e.g. institutional, training, overhead, local stakeholder digital literacy and trusted relationships)

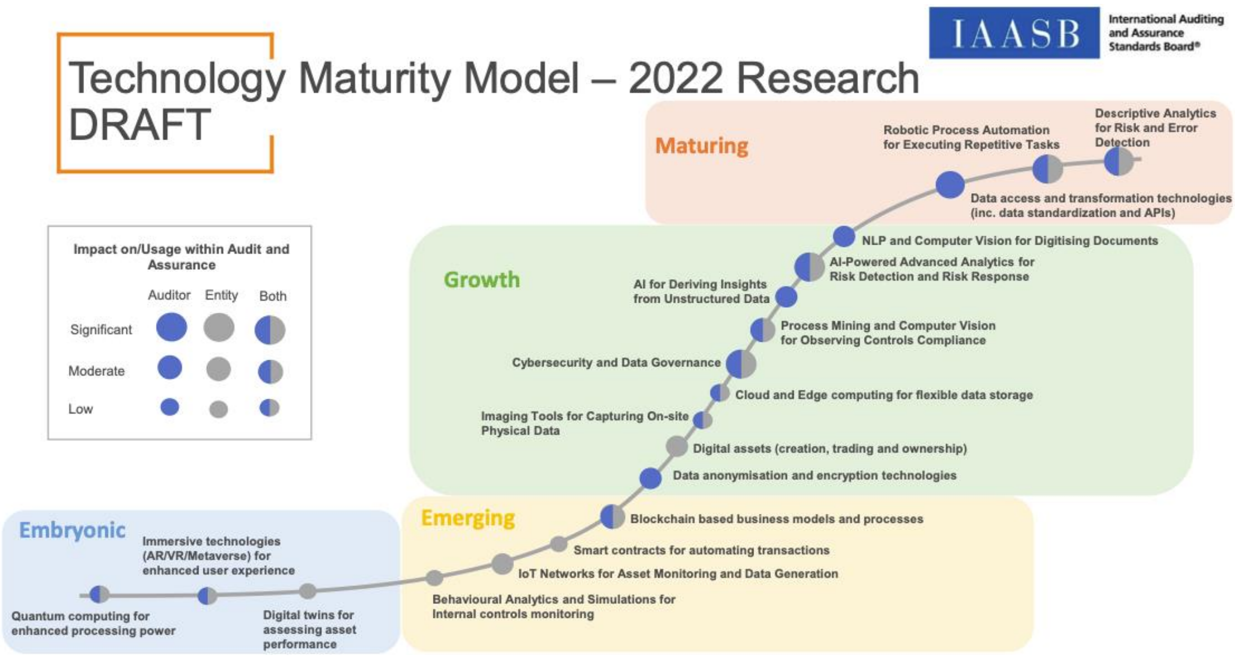
OBJECTIVES AND SCOPE

The objectives for this public consultation draft guidance document are to:

— present context and draft content related to defining key terms, recommending core principles, outlining processes for methodology developers and other interested stakeholders such as project developers and digital MRV solution providers

— use this draft document to invite stakeholder feedback via an online survey to inform the subsequent development of the guidance document.

This guidance document is being developed in recognition of the drivers for next generation digital solutions for climate and sustainability and the rapidly evolving landscape of digital technologies for MRV. The International Auditing and Assurance Standards Board (IAASB) has researched digital technologies (automated tools and techniques) as part of its strategic planning and development of guidance resources. The following figure presents IAASB assessments of the relevance and availability of digital technologies for MRV.



In addition to the above assessment of digital technology maturity, international standards development organisations and initiatives are developing guidance, standards and related resources for emerging digital technologies, for example:

ISO TC 307 Blockchain and Distributed Ledger Technologies

- Strategic Business Plan
- Work Programme

- Reference Architecture
- Taxonomy and Ontology
- Governance

ISO/IEC JTC 1/SC 41 Internet of Things and Digital Twin

- Strategic Business Plan
- Work Programme
- Reference Architecture
- Methodology for trustworthiness of IoT system/service

ISO/IEC JTC 1/SC 42 Artificial Intelligence [and Big Data]

- Work Programme
- Framework for Artificial Intelligence Systems Using Machine Learning
- Artificial Intelligence Reference Architecture
- Big Data Reference Architecture
- Artificial intelligence Trustworthiness

OECD Artificial Intelligence

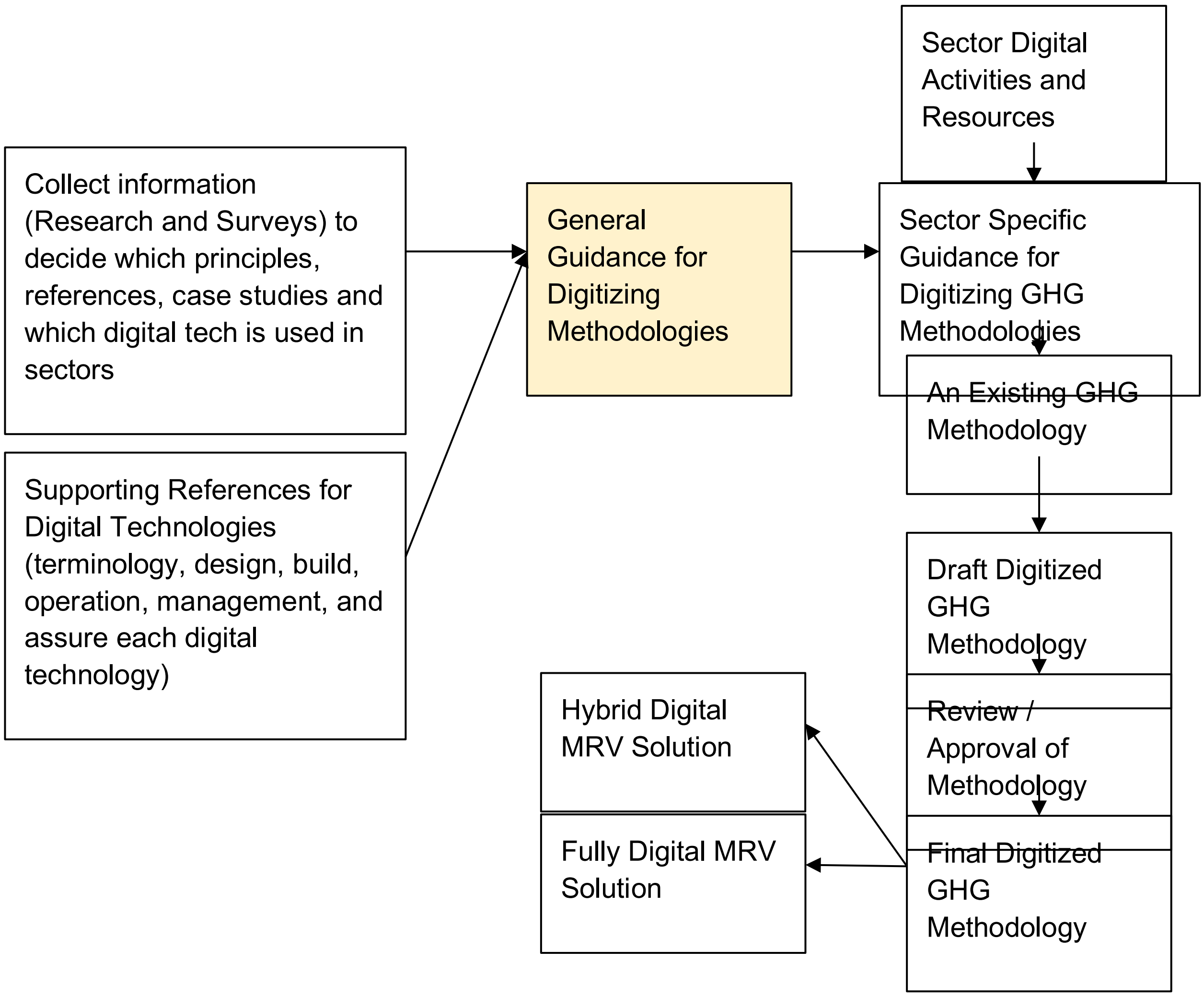
- OECD Framework for the Classification of AI Systems
- Tools for Trustworthy AI

In addition, the References list presents a table of standards, frameworks and guidance related to the design, build, operation and management, as well as the assurance of digital technologies. Overall the above system of resources are key building blocks for a foundation up which to develop roadmaps for the development of sector specific guidance and tools for digital MRV in climate markets.

The following figure illustrates how this guidance document is situated within a system of related resources and processes.

This guidance document is being developed to support:

— Methodology developers to specify digital requirements in methodologies needed to achieve higher levels of confidence and increase consistency in the implementation of the methodologies in digital MRV solutions
— Project developers to determine the optimal MRV solution
— Digital MRV solution providers to achieve increased efficiencies (e.g. save time and money) and to accelerate the scaling of more resources into climate actions.



Examples of guidance, tools and resources that methodology developers should have, or should have access to, to digitise methodologies include:

1. A common approach and process (e.g., high level framework and roadmap) for related methodology developers to
    a. map and prioritise which sector and project type GHG methodologies to digitise first
    b. use so that the resulting series of digital GHG methodologies across and within sectors possesses the desired coherence, interoperability, etc.

2. Access to consolidated up-to-date resources about relevant digital technologies, including necessary ‘bridging documents’ (e.g., technical organisations, standards, terminology,…)

3. A framework and classification system to organise and assess/rate digital MRV systems (e.g. types/maturity of digital technologies used, what MRV processes have been digitised and automated)

4. A readiness assessment process to determine if it is the right time to digitise a methodology for a specific climate action (e.g., emission reduction or removal

enhancement project) in a specific sector or industry segment, and if appropriate for a specific geography.

5. A recommended process, specifying the general criteria and procedures as the starting point common to all sectors (including sub-sectors) and which is augmented with specific requirements for different sectors (and sub-sectors) and project types to determine and specify the digital requirements for 'upgrading' an existing methodology (e.g., assess methodology user capabilities, determine the desired options for the types of digital solutions that users may utilise in accordance with a decision tree to support users). It is possible that a digitised methodology might be:
    a. Adding digital requirements to enrich existing methodology requirements for data monitoring, quantification and QA/QC intended for a 'hybrid digital MRV solutions'; and / or,
    b. Creating an entirely new 'digitally native' methodology intended for fully digital MRV solutions

6. A recommended review process, both internal technical advisory group and external peer-review, and program approval mechanism to validate/certify the quality of the application and results of the above process (e.g., assess feasibility for methodology users to satisfy the digital requirements and to provide evidence for validation/certification of the implementation of digital MRV, consider additional resources to assess the veracity of the specified types of digital solutions to validate performance metrics such as level of accuracy)

7. A compilation of case studies and worked examples for digital MRV solutions and digitised methodologies

TERMS AND DEFINITIONS

This guidance document (when completed and published) will refer to established standards and international initiatives that have developed or are developing relevant terms and definitions, for example:

GHG-related Definitions
(measurement, monitoring, data, quantification, reporting, validation, verification, accreditation)

- IPCC Guidelines
- UNFCCC CDM Standards and CDM Methodologies
- GHG Protocol
- ISO TC207/SC7
- Gold Standard

- Verra
- American Carbon Registry (ACR)

Digital Technology Definitions

- ISO TC307 Blockchain and Distributed Ledger Technologies
- ISO/IEC JTC 1/SC 42 Artificial Intelligence
- ISO/IEC JTC 1/SC 42 Big Data
- ISO/IEC JTC 1/SC 41 Internet of Things and Digital Twin
- ISO/IEC JTC 1/SC 27 Information security, cybersecurity and privacy protection

However, as with other areas of innovation, new terms and definitions will need to be determined, for example, of particular importance are the terms:

- digital MRV
- hybrid digital MRV
- fully digital MRV
- conventional MRV

A definition for "digital MRV", or perhaps more than one definition, will help guide methodology developers to specify digital requirements in GHG methodologies, and will also help other stakeholders including project developers and digital MRV solution providers. Refer to Annex 2 for examples of figures presenting overviews of digital MRV solutions.

Recent reports provide a basis for defining digital MRV, for example:

The EBRD Protocol for Digitised MRV (D-MRV Protocol), December 2020 describes: "an improved automated digitalised MRV system (hereafter referred to as "Digitalised MRV system", or D-MRV) enabling the performance of all MRV functions in an streamlined fashion with maximum degree of digitalisation and no/limited manual data handling, without compromising the environmental integrity of carbon markets." (p.4)

The InterWork Alliance Digital MRV Framework November 2021 describes a Digital MRV solution as: "an implementation of this framework that follows a protocol using a combination of technical devices, services, data sources and applications to automate as much of the claim creation process as possible. The solution is integrated with the Implementation Network by creating ecological claims and submitting checkpoints for the MBP [modular benefit project] implementing it." (p.6)

The World Bank Digital MRV report June 2022 describes Digital MRV as: "A well-functioning D-MRV system integrates these technologies [AI, machine learning, satellite imagery, blockchain, smart sensors, the internet of things (IoT), cloud computing, and drones] into a single, overarching system, using common standards of data exchange and application programming interfaces (APIs) to ensure compatibility and interoperability across the different types of D-MRV systems. This interconnectedness allows for another important benefit of D-MRV systems, which is

the ability to conduct analysis and infer important insights from data covering multiple similar projects in multiple locations." (p.5)

The Climate Ledger Initiative report December 2020 explains: "The concept of digital MRV can be summarised as the enhancement and automation of MRV to improve trust, efficiency and value, and implies disruption by different technological solutions to the predominantly manual processes of data collection, emission calculations, reporting and verification." (p.31)

Considering the recent reports noted above, potential attributes for a definition of "digital MRV" might include:

- real time data collection and processing, corresponding to the intended user and use requirements for the specific project type, and with appropriate redundancy and backup systems
- end-to-end digitisation along the data trail from data collection to quantification to reporting to verification
- uses common standards of data exchange and application programming interfaces (APIs) to be compatible and interoperable across different digital MRV systems
- does not compromise environmental integrity

Additional potential attributes for a definition of "digital MRV" might include:

- digital technologies have been audited for security and assurance to established standards (e.g., regarding risk of hardware, software and data tampering associated with MRV automation)
- includes a minimum level or combination of digital technologies that are more advanced (e.g., AI, DLT) than commonplace digital tools often used in conventional MRV such as personal computers, spreadsheets, databases, GHG quantification software, password protection, digital photos from smartphones, etc.

Additional considerations for developing a definition for "digital MRV" should recognise different sectors that use different digital technologies, for example, remote sensing and AI are relatively more common in land use, forestry and agriculture, whereas digital sensors and IoT are more common in energy and industry.

Furthermore, a definition of "digital MRV" might also consider:

- how much of the total GHG emissions should be using the digital MRV solution. Is that defined in absolute terms (e.g., tonnes of CO2e) or in relative terms (e.g., percentage) for a specific climate action (e.g., project site)?
- whether or not all material GHG sources and emissions should be using the digital MRV solution. Is that defined in absolute terms (e.g., tonnes of CO2e) or in relative terms (e.g., percentage)?

For example, would it be acceptable to consider it a "digital MRV" if one GHG source representing 60% of total GHG emissions is using the digital MRV solution, while everything else is using conventional MRV? What is currently "conventional MRV" might be commonly understood to mean the absence of digitisation (e.g., raw data is collected from analog metres and manually recorded on paper), and/or the use of commonplace digital tools (refer to Context). Therefore, the definition(s) for "digital MRV" might change over time as digital technologies mature and new technologies are invented. For example, what is considered "digital MRV" today (i.e., beyond today's conventional MRV, which uses commonplace digital tools), could become more common tomorrow and therefore be considered the new conventional MRV.

It might not be reasonable or not possible to have a singular exact definition of "digital MRV" for all stakeholders, and therefore the meaning of the term "digital MRV" might be based on an agreed set of attributes while also permitting flexibility on a range of specific issues. Unlike "management system standards" (e.g., ISO 14001, ISO 50001, ISO 9001) that specify a standardised approach for an endless variety of use cases that have very different results, a digital MRV solution goes beyond the paradigm of conformity assessment with a standard in order to assure the environmental integrity of GHG claims about GHG emissions and GHG emission reductions, as well as carbon removals and carbon removal enhancements and carbon sequestration (e.g., carbon credits). Therefore, development of a standardised rating framework might be an appropriate approach to establish a reasonable number of options to identify and differentiate digital MRV with consistency.

With respect to Principles for digital MRV, it is essential to recognise there are many different types of stakeholders and different situational contexts for methodology developers to consider, for example:

- Big organisation (multinational or major city) vs smallholder microprojects
- Country / local conditions
- Sector specific activities
- voluntary carbon markets and compliance (regulated) carbon markets

Both across and within sectors there is variability in the ability to use digital technologies with conventional GHG methodologies. For example, within a specific GHG methodology, some monitoring requirements can use digital technologies such as an onsite wireless gas flow digital sensor whereas other activities such as supplier truck deliveries of feedstock to the site might not be possible to digitise cost effectively or at all. Project developers and stakeholders are usually more knowledgeable of their situational context to decide what is the right digital MRV solution for the right use, and at the right time. In other words, although a certain "top tier" digital MRV solution might produce the highest level of assurance, it might not be the right digital MRV solution if the costs outweigh the benefits.

PRINCIPLES

MRV and digitisation involves an extensive array of use case applications that are rapidly emerging, therefore the following guidance principles are intended to assist methodology developers and other interested users in the application of this guidance document and to achieve increased consistency. Methodology developers should adhere to the following principles when using this guidance document to specify digital requirements to include in a digitised GHG methodology:

Quality

Methodology developers should specify digital requirements that create measurable and tangible improvements in the evidence supporting the accuracy and integrity of GHG claims, including digital assurance and security

Credibility

Methodology developers should specify digital requirements that demonstrate how it contributes to improving the confidence in reported impacts and also transparency and auditability of the performance of the digital MRV solution to assess confidence

Equity

While quality and credibility are the essence of standardisation, whenever possible GHG methodologies should include options that accommodate the needs and interests of, and not exclude or disadvantage access for stakeholders with limited resources. Methodology developers should specify more than one option for using digital requirements, including “low-tech” options. Methodology developers should also maintain neutrality among vendors.

Accessibility

Methodology developers should consider options that encompass simplicity as appropriate, as well as open source and reasonable “low tech” digital (e.g., 2G) corresponding to local conditions

Affordability

Methodology developers should include options in the digital requirements that are low cost to design, build, operate, manage, repair, upgrade, etc.

Sustainability

Methodology developers should prioritise digital requirements that are demonstrably more sustainable, with low energy use and low GHG emissions. Methodology developers should require digital MRV solutions to be net zero.

Interoperability

Methodology developers should specify digital requirements that enable and are aligned with interoperability with other digital MRV systems.

ASSESSING READINESS FOR DIGITISING A GHG METHODOLOGY

Methodology developers should establish a readiness assessment process when determining if it is the right time to digitise a GHG methodology. Methodology developers, including internal experts and external experts, should have appropriate expertise and resources to perform such readiness assessment.

A readiness assessment process to determine if to digitise a methodology should include, for example:

1. There is sufficient evidence that a critical mass (i.e., sufficient market demand) of project developers and other stakeholders have indicated their willingness and readiness to implement digital MRV solutions (e.g., sufficient resources of data, capital, trained personnel);

2. There is sufficient evidence the sector, industry segment and/or project type is at a high enough technology readiness level (TRL) in order for a digital MRV solution to be designed and implemented for a sufficient amount of the market. Preferably, methodology developers have information of the level of 'digital transformation' occurring and projected to occur for the next 2-5 years. The more of the following digital transformations that exist, the more probable digital MRV solutions can be implemented successfully. For example according to a sequence of:
   a. First, ability to collect data digitally, e.g., with good internet connectivity or mobile digital device such as a smartphone
   b. Second, digital technologies are used for operational and business management
   c. Third, additional new technologies enable more advanced "smart" activities (e.g., higher efficiency, better service) such as smart buildings, smart agriculture, smart mobility, smart cities, smart industry, smart grids, etc.

   d. Fourth, used in combination with better sustainability and climate practices to be “climate smart” (e.g., less energy with transit route optimisation and traffic management, less fertiliser use optimised for conditions)
   e. Fifth, used in combination with synergistic solutions such as digital finance

3. There is sufficient evidence that potential digital MRV solutions can demonstrate:
   a. scope of digital technologies used and level of maturity
   b. technical performance (e.g., security, scalability, reliability, speed…)
   c. scope of MRV activities digitised (e.g., M, M + R, M + R + V)
   d. MRV performance (e.g., as good as or better in terms of accuracy and completeness, or is more conservative, than conventional MRV at determining the desired ‘level of assurance’ regarding environmental integrity)
   e. sustainability performance (e.g., energy use, GHG emissions, e-waste)
   f. transparency and auditability for certification (i.e., it is not a ‘black box’)
   g. supporting resources and ecosystem to support ongoing successful operation of the digital MRV solution
   h. accessibility (e.g., users and stakeholders can understand and use it with limited dependences)

ASSESSING DIGITAL MRV SOLUTIONS

As part of the process for methodology developers to collect the information needed to decide if it is the right time to digitise a GHG methodology, methodology developers should gather the following types of information about digital MRV solutions:

- Scope of use case applications
- Scope of MRV activities
- Scope of digital technologies used
- Transparency
- Environmental footprint
- Solution ecosystem
- Professional services and resources
- Vision and values

Scope of Use Case Applications

Methodology developers should determine:

- What types of use case applications does the digital MRV solution serve? For example, carbon credit projects, low carbon supply chains, entity inventories, products, technologies, … and what are the system boundaries and value chain included in those applications?
- Which sectors does the digital MRV solution serve?

Scope of MRV Activities

Methodology developers should determine:

- What MRV activities have been digitised and incorporated into the solution? For example, data collection and ingestion using digital technologies from more sources and with bigger volumes of data. Data analytics and calculations are automated to assess data and compute results. Data and information are incorporated into standardised reporting templates.
- What data QA/QC activities and verification/assurance activities are performed by the digital MRV solution? Furthermore, to what extent have MRV activities been digitised, and what MRV activities are still performed manually with human involvement?
- What MRV standards, protocols, guidelines, etc. does the digital MRV solution enable?

Scope of Digital Technologies

Methodology developers should determine:

- How have MRV activities been digitised and automated? For example, does the digital MRV solution apply to all GHG sources, or to all material GHG sources, or a sub-set?
- What digital technologies are part of the digital MRV solution, whether directly part of the solution or integrated with the solution? For example, digital sensors, IoT devices, digital twins, remote sensing, real-time data, DLT (Blockchain), smart contracts, AI, ML, data analytics… and at what level of maturity / sophistication?

Transparency

Methodology developers should determine:

- To what degree is the solution a “black box” (overall and for each component)?
- How does the digital MRV solution enable auditors and programs to certify the solution meets or exceeds required MRV performance, as well as IT / cybersecurity?

Environmental Footprint

Methodology developers should determine:

- How “green” is the IT, especially the DLT and the AI, in the digital MRV solution?
- Does the digital MRV solution provide evidence for the energy it saves relative to conventional MRV (e.g., avoided travel emissions) and also relative to other MRV solutions?
- If the digital MRV solution has a worse environmental footprint, how is that compensated to ensure the integrity of the net environmental benefit?
- Refer to next section for more details

Solution Ecosystem

Methodology developers should determine:

- Who are the partners and stakeholders involved in the design and implementation of the digital MRV solution? For example, has the solution been developed mainly by “tech experts” with a limited track record on climate change?
- Is it relatively easy to connect the digital MRV solution with other digital systems regarding compatibility and interoperability, as well as to enable both end-to-end and broad participation throughout the value chain?

Professional Services and Resources

Methodology developers should determine:

- Does the digital MRV solution provider also offer professional services to deliver a complete package of deliverables and results? For example, perform initial digital MRV readiness assessments, methodological development (e.g., transform conventional standards into “smart standards”), project design as well as conventional MRV activities?
- What resources, such as expertise (technical, climate and sustainability), IP, financial, infrastructure, does the digital MRV solution provider have to expand and mature applications in cooperation with customers and stakeholders?

Vision and Values

Methodology developers should determine:

- How well do the digital MRV solution provider’s vision and values align with market and stakeholder needs and expectations?
- How does the digital MRV solution provider’s vision, and action plan, of the climate and SDG space differ from others? For example, considering both technical (e.g., hardware, software, content, open data, open source) and non-technical issues

(e.g., governance, markets, equity, empowerment) are digital innovations aligned with governance innovations, social innovations, financial innovations, etc.?

Recognising the potential variability among different types of digital MRV solutions, should this guidance document include an assessment and rating system to support stakeholders (e.g., investors, certification bodies, governments, NGOs) to better understand and differentiate between digital MRV solutions and the results?

ASSESSING THE ENVIRONMENTAL FOOTPRINT OF DIGITAL MRV SOLUTIONS

Recent studies (WEF) estimate digital technologies can help achieve 15% of the goals of the Paris Agreement via applications that reduce energy and material use in smart buildings, smart agriculture, smart mobility, smart grid, smart cities, etc. The benefits of digitisation are also attractive to the service sector, for example accounting, auditing, finance, etc.

However, there also remains substantial environmental impact related to digital technologies such as e-waste (electronic waste) and increasing energy use. The internet economy and digital technologies are directly responsible for approximately 2% of global GHG emissions (IEA).

"Green IT" is an ongoing initiative to reduce the environmental footprint of digital technologies. More initiatives are developing the tools, guidance and standards to quantify the environmental footprint (energy consumption, GHG emissions) of digital technologies, as well as solutions to reduce the footprint.

Therefore, with respect to the principle of environmental integrity of GHG claims from climate actions, when such claims involve the use of digital technologies it is reasonable to 19ecognize stakeholder interest to know and to reduce the environmental footprint of digital technologies and to account for those GHG emissions and to deduct those GHG emissions from GHG claims. Standards Development Organisations (SDOs) and international initiatives are developing guidance and standards to help define and quantify the environmental footprint (e.g., energy consumption and GHG emissions) of using digital technologies.

The International Telecommunications Union (ITU) Focus Group on Environmental Efficiency for Artificial Intelligence and other Emerging Technologies (FG-AI4EE) has 3 working groups:

- Working Group 1: Requirements of AI and other Emerging Technologies to Ensure Environmental Efficiency

- Working Group 2: Assessment and Measurement of the Environmental Efficiency of AI and Emerging Technologies
- Working Group 3: Implementation Guidelines of AI and Emerging Technologies for Environmental Efficiency

The Organisation for Economic Co-operation and Development (OECD) established the OECD AI Policy Observatory including also the document OECD Measuring the environmental impacts of artificial intelligence compute and applications.

There are many more initiatives and resources posted in the References list about the issues and methods for assessing the environmental footprint of digital technologies – if you know of additional resources, please include your feedback in the online survey.

The following process outlines steps methodology developers should consider to determine the environmental footprint of digital MRV solutions:

1. Determine the types and details of the digital technologies, e.g., blockchain(s) / DLTs, artificial intelligence, remote sensing, digital twins, IoT, used in the digital MRV solution

2. Determine the methodologies and resources, e.g., ITU, IEEE, ISO – see Reference list, used to quantify the energy consumed by the digital MRV solution.

3. Determine the estimated energy consumption of the digital MRV solution for a 12 month period (e.g., calendar year) and also on an appropriate per unit basis (e.g., per site, per data transfer, per annual report). Include evidence and explanation for the estimation.

4. Determine the methodologies and resources, e.g., ITU, GHG Protocol, IPCC, ISO – see Reference list, used to quantify GHG emissions and other environmental footprint impacts (e.g., e-waste) caused by the digital MRV solution.

5. Determine the estimated GHG emissions and other environmental footprint impacts (e.g., kg e-waste) caused by the digital MRV solution for a 12 month period (e.g., calendar year) and also on an appropriate per unit basis (e.g., per site, per data transfer, per annual report). Include evidence and explanation for the estimation.

6. Determine what actions are planned or are happening, including the appropriateness of such actions, to mitigate energy consumption, GHG emissions and other environmental footprint impacts caused by the digital MRV solution, for example

    a. Energy Efficiency
    b. Developing or contracting renewable energy projects
    c. Purchasing renewable energy certificates
    d. Developing carbon offset projects
    e. Purchasing carbon offsets
    f. Recycling
    g. Ecodesign
    h. Other (explain)

DETERMINING DIGITAL REQUIREMENTS IN GHG METHODOLOGIES

As illustrated by the figure in the Objectives and Scope section, this general guidance document outlines a high-level framework with general criteria and processes as a starting point common to all sectors for methodology developers to develop digital requirements for GHG methodologies. Previous sections highlight some of the variability of digital technologies corresponding to different sectors, locations, markets, etc., as well as across the data trail. Therefore, using this general guidance document methodology developers should develop guidance that is sector specific for specific project types to determine and specify the digital requirements for 'upgrading' an existing methodology (e.g., assess methodology user capabilities, determine the desired options for the types of digital solutions that users may utilise in accordance with a decision tree to support users).

Based on the sector specific guidance, methodology developers specifying digital requirements to upgrade a GHG methodology might elect to develop a hybrid digital GHG methodology or might create an entirely new "digitally native" GHG methodology for fully digital MRV solutions.

Methodologies developers should determine digital requirements for

- Project design/information, including GHG program issues such as baseline determination, additionality, leakage, stakeholder engagement…
- Data measurement and monitoring
- QA/QC

— Quantification
— Reporting

Furthermore, for “end-to-end” digitisation methodology developers should consider each of the steps and activities along the data trails corresponding to operations for every GHG source/sink relevant to the specific methodology requirements, for example:

Steps and Activities along the Data Trail	**Conventional**	**Digital**	**Standards & Guidance**	**Resources & Stakeholders**
Project design (Site construction and operational blueprints and records, PFDs, PandIDs, regulatory permits and approvals, program eligibility of activities and emissions, business and ownership structure, organisational management systems, …)				
Data production (observation, manual records; sensors/metres, frequency, planned and unplanned shutdown…)				
Assessment of the means of data production (qualified installation, independently calibrated metres, frequency of diagnostics and maintenance, COI (is it the buyer’s sensor or the seller’s sensor, or another party’s sensor such as the government), staff are trained and uncompromised such as not overloaded with work, or distracted surfing the web, or…)				
Assessment of the produced data (data anomaly detection… record count, missing data, limits/range of				

Steps and Activities along the Data Trail	Conventional	Digital	Standards & Guidance	Resources & Stakeholders
data, valid alphanumeric character check, statistical, historical, technical/operational trends and correlation checks…)				
Missing data procedures (interpolation, historical, peer operations…)				
Data management and compilation, data storage, e.g., manually entered data into spreadsheets and data files				
Data transmission and transfer security				
Data recording, logging and storage (physical access control to computers, IT rooms, login security and protection, backup servers, cloud based data redundancy and processing.…)				
Data preliminary processing, data structuring and standardisation, data annotation and metadata				
Data access control and checks to preclude data manipulation (password protection, data encryption, read-only data…)				
Managed and audited local data/IT system (also for remote and cloud systems)				

Steps and Activities along the Data Trail	Conventional	Digital	Standards & Guidance	Resources & Stakeholders
Data processing using formulae for calculating and reporting as outputs the emissions and emission reductions (removals and removal enhancements) according to the GHG methodology				
QA/QC on calculations (approved methods, emission factors, coefficients…)				
Uncertainty assessment covering the data trail (measurement uncertainty, formulae uncertainty, data uncertainty)				
QA/QC on calculated and reported output data (historical, technical/operational trends, correlation checks, profile analysis, industry analysis, confirm conformance with standards and reporting requirements…)				
First party internal pre-verification process activities and results				

Methodology developers should identify the types of digital tools used corresponding to both each of the general activities and each of steps and activities along the data trails, for example:

- Stationary and mobile IoT and Digital Sensors
- Operational Management System (SCADA, edge servers, …)
- Digital Twins (3D graphical representations with high fidelity of actual physical object or site, equipment, metres, …)
- Big Data Analytics
- Artificial Intelligence, Natural Language Processing, Machine Learning
- Smart Contracts and other algorithm coding

— Tokenisation
— Blockchains and DLTs
— APIs
— Remote sensing
— Not a static list, it is constantly growing with other digital tools, some proven and widely adopted, while new emerging technologies to be added

Methodology developers should determine the status for each of the digital tools used for digitising the methodology:

— Digital technology ratings and certifications
— Digital technology design standards (also important to know if the standards are private/proprietary, industry standards, multi-stakeholder consensus standards, open standards, *de facto* vs *de juris*, current or out of date because technology changes much faster than carbon market standards…)
— Digital technology assurance and certification standards and programs exist (for both hardware and software, e.g., smart contract auditing)
— Supporting resources (certified experts, related standards and tools, for example, Data Confidence Fabric and Alvarium SDK…)

REVIEWING DIGITAL REQUIREMENTS IN GHG METHODOLOGIES

In general, methodology developers have well-established review and approval processes for the development of GHG methodologies. Such review and approval processes should be augmented to provide confidence on the digital requirements to be included in upgraded or new GHG methodologies (hybrid digital and fully digital GHG methodologies).

Recommended actions for methodology developers that are in addition to their existing methodology development and review processes for digital requirements should include the following:

— add internal expertise
— engage external expertise
— maintain appropriate resources
— check alignment with relevant resources
— road test
— maintenance

Internal Expertise

Add digital expert(s) to existing internal advisory and review processes, e.g. technical advisory group (TAG). Different digital experts might be necessary for:

- different sectors, for example remote sensing and AI are relatively more common in land use, forestry and agriculture, whereas digital sensors and IoT are more common in energy and industry)
- different areas of digital technologies, for example assurance on trustworthiness of the design, build, operation and management of digital tools (e.g., IoT) to automate data collection for a specific GHG methodology, as well as assurance on IT and cybersecurity (e.g., hardware is tamperproof)

External Expertise

Identify and engage (e.g., formal liaison relationships) with relevant external initiatives, for example

- standardisation group(s) for digital technologies, for example ISO, IEEE, ITU
- related initiatives on digital for climate, for example IETA Digital Taskforce, Verra DMRV, Climate Chain Coalition, World Bank, UNFCCC, UNEP, GBBC IWA, WEF Crypto Sustainability Coalition, Ethereum Climate Platform

Also, establish a consultation group with digital MRV solution providers (certified and new vendors).

Appropriate Resources

Recognising digital technologies change rapidly (relative to the climate and sustainability), maintain frequent, or if possible continuous, connections with the above groups to ensure relevant information is up to date, and to be sure it is accurate and complete (refer to Assessing Digital MRV Solutions and Assessing the Environmental Footprint of Digital MRV Solutions)

Alignment with Relevant Resources

The internal review process should check the digital requirements are aligned with the Principles, as well as relevant standards, guidance and other resources (see References) to ensure interoperability.

Road Test

For digital requirements involving relatively new digital technologies that are considered emerging, especially in certain applications (e.g., with limited market

share), the review and approval process should perform appropriately designed road tests (e.g., minimum amount of time, minimum number of sites and conditions…) of the proposed new digital GHG methodology, and subsequently make appropriate revisions and communications with relevant stakeholders.

Maintenance

Of relatively high importance during the first 24 months of experience using the digital GHG methodologies, methodology developers (GHG programs) should proactively track the use of digital GHG methodologies in digital MRV solutions to receive feedback from users, understand performance and identify opportunities for improvement to maintain the quality of the digital GHG methodology as the digital MRV marketplace continues to evolve.

NEXT STEPS AND ROADMAP

As illustrated in the figure in the Objectives and Scope, this general guidance document outlines a high-level framework and processes as a common foundation to develop sector specific guidance documents for digitising GHG methodologies that support comparability and interoperability.

The following table presents an overview of proposed next steps for sector specific guidance, which can be elaborated with priorities, timelines, resources and key stakeholders. This table should be developed in conjunction with the tables in the document "Digitising Verification".

Next Steps	Sector Specific Guidance for digitising Methodologies			
	Energy	Industry	Waste	AFOLU
Add internal expertise, establish external expert consultation groups, engage relevant initiatives (e.g. SDOs, digital technology associations)				
Research digital technologies, develop a framework and classification system for digital MRV solutions				
Assess digital MRV solutions, including market demand, technology readiness, environmental footprint, etc.				
Compile planning and develop sector specific guidance for digitising methodologies				
Plan and prioritise development of digital GHG methodologies (hybrid digital and fully digital) specific project types				
Road test and finalise digital GHG methodologies				

Next Steps	Sector Specific Guidance for digitising Methodologies			
	Energy	Industry	Waste	AFOLU
Track use / performance and maintain digital GHG methodologies				

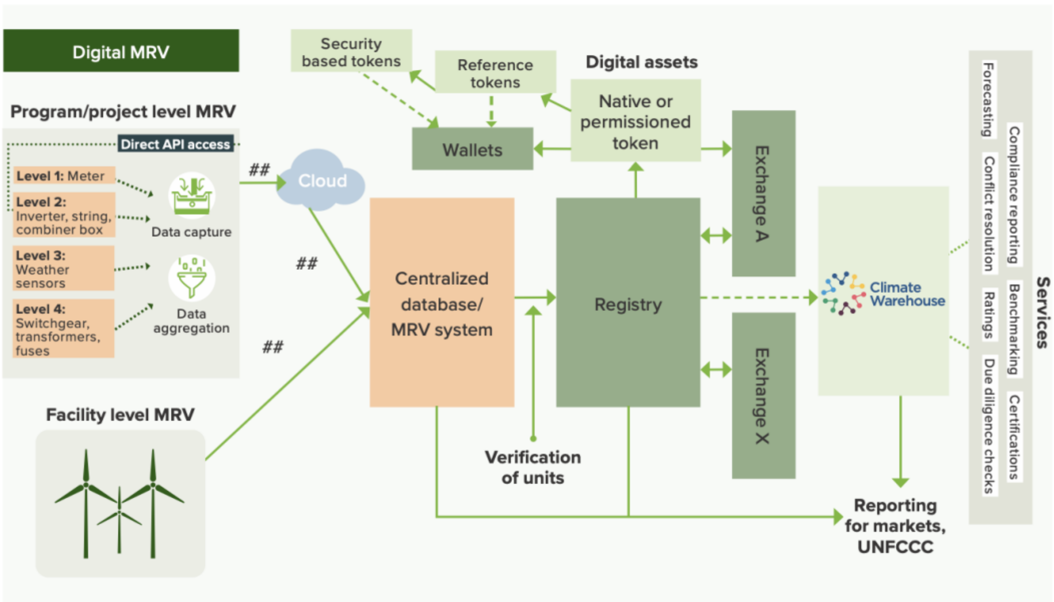
ANNEX 1: REFERENCES

Reference list (10 pages, separate file)

ANNEX 2: FIGURES OF DIGITAL MRV

The following figures have been identified from the Reference list illustrating various concepts of and for digital MRV to inform methodology developers determining what digital requirements to upgrade GHG methodologies.

FIGURE 1: END-TO-END DIGITALIZATION OF CARBON MARKET INFRASTRUCTURE[1]



Source: World Bank Digital MRV report June 2022

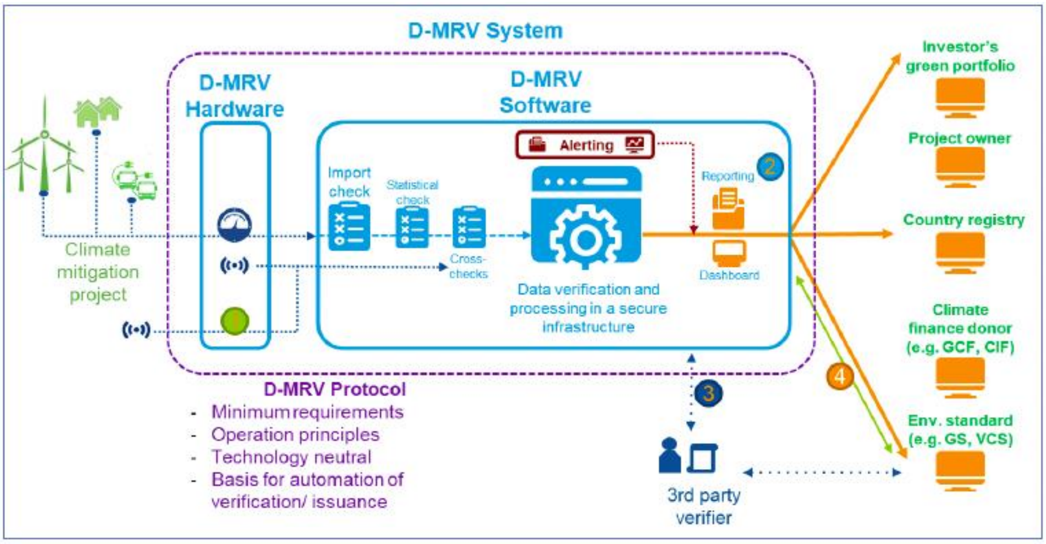
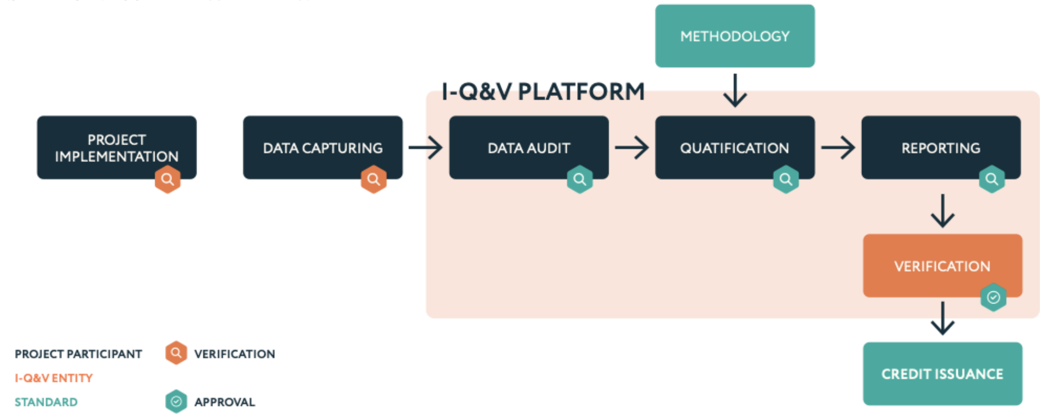


Figure 1: D-MRV process chain from Monitoring (1), Reporting & processing (2) to Verification (3) and issuance (4)

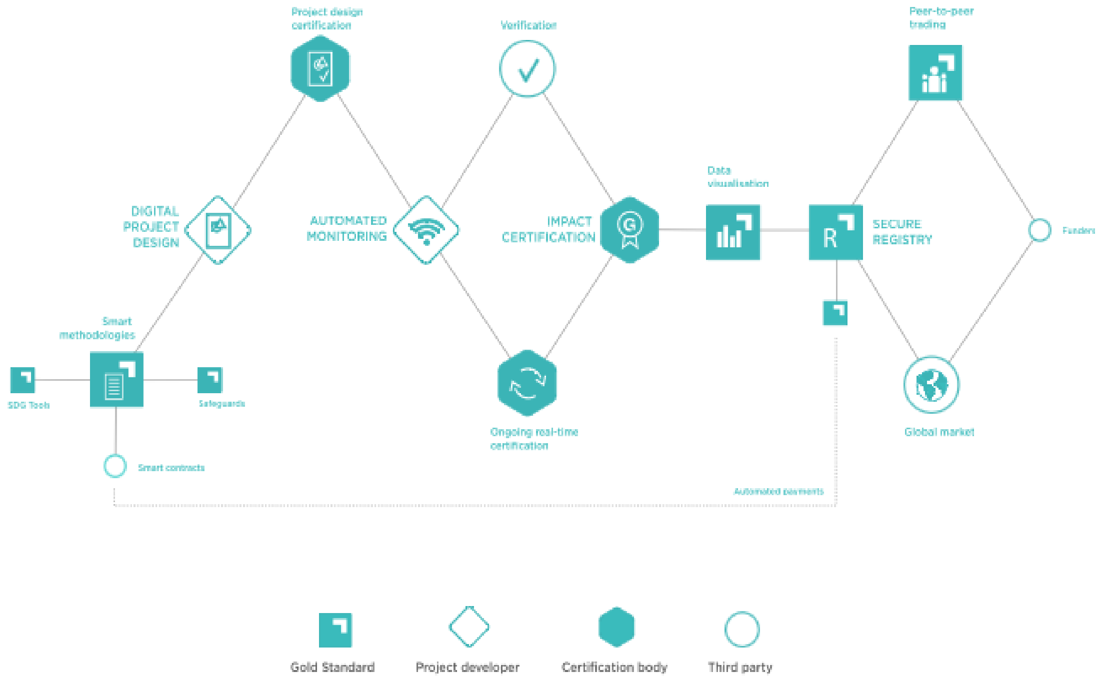
Source: [EBRD Protocol for Digitised MRV (D-MRV Protocol), December 2020]

FIGURE 6 I
VERIFICATION UNDER THE DIGITALIZED I-Q&V BLUEPRINT

The I-Q&V blueprint represents a paradigm shift. The project participant (blue) merely captures data. All other tasks are shifted to an independent integrated quantification and verification (I-Q&V) entity (orange) that maintains a digital platform providing both quantification and verification services. Standards (green) still need to make spot checks of reported and claimed emission reductions (green magnifying glass and approval stamp).



Source: [Climate Ledger Initiative SustainCERT Principles for Best-Practice Digital Verification]



Source: [Gold Standard Digitising MRV]

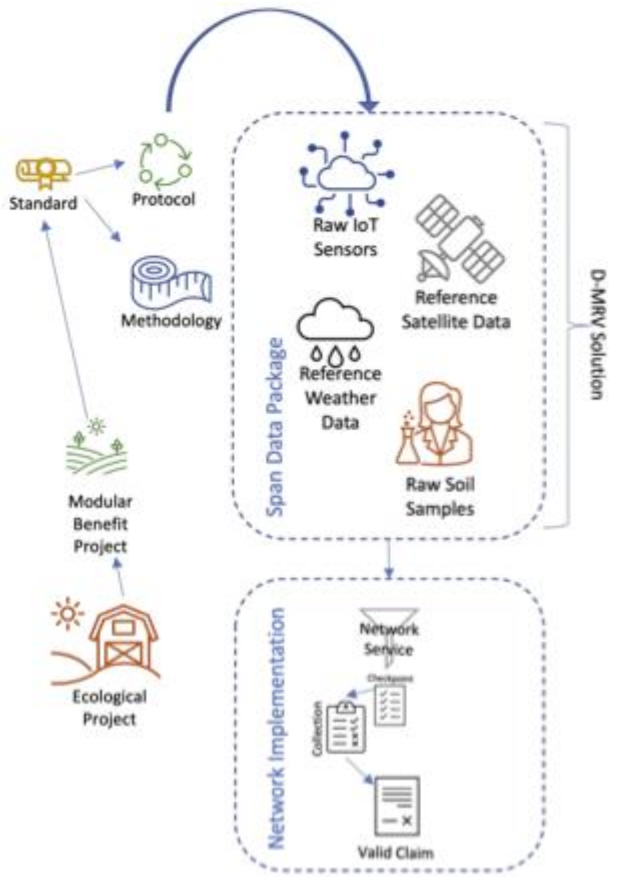


Figure 6 - Framework Process

Source: [InterWork Digital MRV Framework]