UNIVERSITY OF CAMBRIDGE

Scientific credibility for high-integrity voluntary carbon markets

Cambridge PACT

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Cambridge Centre for Carbon Credits,
University of Cambridge, UK

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Contents

Contact

Please send comments to:
Tom Swinfield – tws36@cam.ac.uk
Eleanor Toye Scott – eft20@cam.ac.uk

Navigation

Scroll through the document, or click on the relevant section in the table of contents to go directly to that section. To return to the contents list, click the page number at the bottom of the page.

Executive summary

High-integrity carbon credits are vital in our response to the climate crisis but high-profile research in early 2023 called into question the very basis of the voluntary carbon market (VCM)[1,2]. Two years later, although the VCM has shrunk from its peak of $2bn/year to $723m [3], there are signs of recovery. The recent COP29 agreement at Baku has finally operationalised Article 6 of the Paris Agreement, and the Integrity Council for the Voluntary Carbon Market (IC-VCM) has approved three new REDD+ methodologies, including Verra's Jurisdictional & Nested Redd+ Framework (JNR), under their Core Carbon Principles (CCP) framework, indicating a concerted effort from accreditation and standards bodies* to respond constructively to these criticisms of the market and rebuild lost confidence.

Nonetheless, deeper and more comprehensive reforms are required to assure the market's longer-term sustainability. Rebuilding lost confidence demands common standards that enable scalable and sustainable impact. The Cambridge Centre for Carbon Credits (4C) has identified several key areas where progress is urgently needed, including changes to project design, accreditation processes, and governance structures.

The problems we are addressing are complex, and our proposed solutions are not necessarily complete or straightforward to implement. Making these changes will require active and open collaboration between carbon accreditation and standards bodies, which we welcome. 4C and our partners would engage in this process if invited. We believe that, at least in principle, our proposed approach would enable the design and monitoring of high-integrity nature-based carbon projects that could credibly be used to offset hard-to-abate emissions, accelerating the deployment of carbon finance to support the ambition of the Paris Agreement to store carbon in nature.

Specifically, we propose the establishment of common standards for carbon quantification and accounting, that cover additionality, leakage and permanence. These standards must avoid perverse incentives and align the motivations of all stakeholders with high-integrity outcomes.

Current standards have inadequately dealt with these conflicts, which are effectively preventing the transition to high-integrity standards. We further propose that all carbon credits be issued based on trusted primary observations, all data necessary to reproduce carbon calculations be made available in standard file formats and that, as far as possible, the social and biodiversity dimensions of projects be reported separately from carbon calculations.

Finally, we note that current approaches to carbon and biodiversity accounting tend to lay heavy financial and administrative burdens on nature-based projects and the local communities participating in or affected by them. This runs counter to the stated goal of the carbon accreditation bodies, which we share, to support communities and improve financial flows to developing countries. Our approach addresses this problem while also raising the bar for best practice for high-integrity carbon credits. Thus, we believe that our solutions allow greater transparency, fairness, efficiency and accuracy in the voluntary carbon market.

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* *In this document, we refer to standards bodies and accreditation bodies. Standards bodies are those which have a role at either a strategic or an operational level in establishing quality criteria that carbon projects and carbon credits must fulfil. These organisations include governance bodies such as the IC-VCM and the VCMI, as well as Verra and others which issue credits. Accreditation bodies are those which receive project applications, arrange auditing of these projects by Validation and Verification Bodies (VVBs) and issue carbon credits which project developers can sell. Verra, Gold Standard and other credit issuing organisations are therefore accreditation bodies as well as standards bodies.*

Challenges identified and proposed solutions

Challenge identified	Proposed solutions for stakeholders
Inaccurate quantification of carbon benefits, leading to over-issuance of carbon credits from project-based initiatives	**Standards and accreditation bodies**: • Identify key parameters that affect credit issuance • Actively invite and incentivise scientific participation in data and methods • Where there is uncertainty, issue credits at the lower bound • Issue bonus credits to compensate for historic pessimism once scientific methods have reduced uncertainty **4C/scientific community**: Collaborate with accreditation bodies to operationalise good data governance and scalable and efficient scientifically valid methods
Perverse incentives within the VCM lead to ineffective interventions and overstated offsetting claims	**Standards and accreditation bodies**: • Revoke delegation of decisions about carbon benefit claims (i.e. numbers of credits) from market participants with a financial interest in credit sales • Guarantee that credit claims are reviewed retrospectively by third-party assessors independently once better data or evaluation methods are available **4C/scientific community**: Contribute to development of common standards and methodologies; develop standard protocols for independent third-party assessment

Updated project assessments based on better data or methods risks jeopardising credit value and attending offsetting claims	**Standards and accreditation bodies**: • Badge high-integrity credits as premium products **Investors/buyers**: • High-integrity costs more • Cheaper credits are less likely to offer genuine benefits • Buyers must accept higher risks when purchasing lower priced credits **4C/scientific community**: Contribute to development, communication and credibility of high-integrity standards and methodologies
Lack of accessibility / transparency of data and methods used to assess carbon benefits	**Standards and accreditation bodies**: require that the data needed to reproduce carbon benefit claims are made publicly available (with appropriate safeguards for privacy and to avoid misuse). **Investors/buyers**: incorporate consideration of data and methods into due diligence **4C/scientific community**: develop tools to increase availability and transparency of data to all stakeholders without compromising project outcomes.
Unnecessary transaction costs for both buyers and sellers due to lack of clarity/ certainty on appropriate assessment of carbon benefits	**Standards bodies and accreditation bodies in collaboration with 4C/scientific community**: • Establish consensus regarding best practice assessment methods with respect to additionality, leakage and permanence. • This is likely to reduce administrative burdens downstream on both supply-side and demand-side of carbon transactions.

Background

Since its foundation in 2021, and working with key partners, the Cambridge Centre for Carbon Credits (4C) has been producing high quality scientific research to establish standards and methods to scale up the supply of credible nature-based carbon credits, starting with avoided deforestation in tropical moist forests (REDD+*). 4C supports the need for markets for nature-based credits to help achieve the <1.5º C ambition set out in the Paris Agreement. We welcome two recent significant positive developments for the voluntary carbon market.

In November 2024, at COP29 in Baku, a key achievement was the finalisation of the operational details of Article 6 of the Paris Agreement, a landmark framework for governing international carbon markets. This is expected to bring more structure and transparency to the voluntary carbon market and to clarify how emissions reductions activities are accounted for in relation to country-level targets, removing a source of risk of double-counting.

In the build-up to the Baku agreement, the ICVCM announced that it has approved three methodologies for issuing high-integrity carbon credits for REDD+ under its new Assessment Framework (The Core Carbon Principles | ICVCM). These are:

- (ART) The REDD+ Environmental Excellence Standard (TREES) v2.0, TREES Crediting Level
- (VCS) VM0048 Reducing Emissions from Deforestation and Forest degradation v1.0
- (VCS) Jurisdictional and Nested REDD+ (JNR) Framework v4.1.

These new methodologies are developing in the context of attempts to address criticisms that have been levelled at the VCM and REDD+ over the past two years. The jurisdictional methodologies created by ART TREES and Verra operate at a much larger scale than project-based REDD+, through national or regional level programmes to protect very large areas of forest through policy and regulation. We are supportive of the greater consistency that these jurisdictional methods provide for the way REDD+ projects estimate their carbon storage benefit. Their potential for aligning with the reporting of Nationally Determined Contributions (NDCs) is also an important feature and a significant step forward. And, the involvement of independent data providers should act to reduce issues arising from perverse incentives. Unsurprisingly, there are still some unresolved issues with the current generation of jurisdictional approaches.We will offer here some suggestions for constructive ways to address the remaining problems and improve these methods further (see "Carbon quantification and accounting" below).

Our experience at 4C of developing scientifically validated approaches to carbon quantification in the context of tropical moist forests has given us opportunities to reflect deeply on many of the issues which have led to the credibility crisis in the international voluntary carbon market. As stakeholders look for collaborative ways forward, we offer this response to the recent agreements in a constructive spirit. We recognise that we may be seen as provocative, but hope that other stakeholders will nonetheless engage with us to address issues of mutual concern.

While we believe there are serious problems in the voluntary carbon market that are currently not being adequately addressed, we fully appreciate that these problems are very hard to solve, and require a coordinated response from stakeholders with different perspectives and types

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* *REDD+ stands for "reducing deforestation and forest degradation in developing countries, and additional forest-related activities that protect the climate". It is a framework established by the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), adopted in 2013 at COP 19 in Warsaw and included in the Paris Agreement in 2015. 4C's work so far has mainly been focused on REDD+ but is not limited to REDD+.*

of expertise. We have no interest in apportioning blame for the current situation, and recognise that the standards and accreditation bodies and most other stakeholders in the market are well-intentioned. We also wish to avoid giving the impression either that the problems with the voluntary carbon market are insoluble, or that we have fully worked-out and adequate solutions.

Shared ambitions and coordinated action between standards and accreditation bodies are therefore necessary and welcome. However, we believe that progress towards high integrity carbon markets cannot be achieved solely through gradual convergence between standards and new methods. Rather, it will require proactive, strategically led and coordinated collaboration between the standards bodies, the carbon accreditation bodies, and the scientific community to achieve a scientifically robust, transparent and continuously updated set of common standards for high-integrity credits. What we offer here is an analysis of fundamental issues that must be addressed as a necessary condition for the transition towards a high-integrity market that the standards bodies and accreditation bodies have committed themselves to achieving. Where possible, we also make suggestions for immediate actions that specific stakeholders (mostly but not only the accreditation bodies) can take to kickstart this transition, and actions that the scientific community can take to enable and support these actions.

There is, however, an inherent tension preventing a move towards high-integrity credits in the immediate future. Established project proponents, credit agencies and buyers are all exposed to substantial risk if new principles and methods entirely replace old ones. This is because, in almost every case, updated evaluation methods indicate previous issuances have overestimated the climate benefits of projects, with established actors risking claims they have over-sold or under-bought their carbon credits. If such over-issuance is not acknowledged and old methods are retained, the credibility–and hence viability–of the entire sector will continue to be eroded. By contrast, while a transition to a high-integrity market could cause short-term disruption, it is likely ultimately to result in the base price per credit rising, because of their greater credibility and thus desirability to buyers, increasing revenue to projects. In the long run, this should lead to a realignment of incentives and a fundamental change in expectations for all market participants.

The voluntary carbon market peaked in 2021 and 2022 at around $2 bn/year [4], with nature-based solutions providing the majority of these credits according to Sylvera [5], but shrank to around $723m/year in 2023 [3] in the wake of negative press about forest carbon credit schemes in January 2023 [6].

While many buyers and investors have dropped forest carbon credits entirely, or are eschewing REDD+ in favour of reforestation and restoration projects, the supply side of the market has been slow to respond to the demand for higher integrity. There are many reasons for this, but a critical one is that if projects or the accreditation bodies formally acknowledge and adjust for the devaluation of existing credits based on older methodologies, this could have a significant negative impact on individual projects, as well as a further contracting effect on the market as a whole.

While the devaluation of these credits has effectively already happened through a drop in price, their adjustment and revaluation on the supply side needs to be managed sensitively so that it does not undermine the urgently-needed development of the high-integrity voluntary carbon market into the future. It is important that these older credits are not simply abandoned, but are re-evaluated to more realistically reflect their likely climate benefit, relative to genuinely high-integrity credits. Accreditation bodies have a role to play in enabling this transition, and in formally recognising that high-integrity credits are a premium product and can reasonably command a higher price than credits without similarly robust guarantees of quality.

Support for biodiversity is as important as carbon sequestration, and is equally in need of private finance if the ambitions of the Kunming-Montreal and Paris agreements are to be achieved[7]. Biodiversity finance is not the focus of this document but we note here that storing carbon in nature has the potential to create outsized benefits for biodiversity. In addition, it is worth noting that most of the issues addressed here in relation to carbon are also relevant to developing high-integrity standards for biodiversity credits.

Carbon quantification and accounting

The scientific community has a central role to play in understanding how to properly estimate and attribute the benefits deriving from credit generating projects. We suggest that the standards and accreditation bodies will be best equipped to make meaningful progress towards a common set of continuously improving standards if they actively invite and facilitate the integration of contributions from cutting-edge science into impact evaluation. The current growth in the number of standards, methodologies, start-ups and ratings agencies, each claiming to be an arbiter of high–quality credits, will achieve consensus far more slowly than through purposeful and strategic collaboration between all stakeholders.

From a science perspective, we know that remotely sensed data is available which enables regular ex post monitoring of nature-based carbon projects, including correcting for the inevitable uncertainty in initial forecasts. While ex ante forecasts of additionality are needed to enable developers to raise finance, they are reliant on assumptions about the future which could later turn out to be false. It is therefore essential that both baseline and project deforestation rates are regularly reassessed throughout the credit issuing period. Such monitoring can be done automatically at low cost to projects. It offers a way to enhance buyer confidence in carbon credits by providing ongoing evidence of their climate contribution and protects sellers from ex post research-based scepticism about the additionality of their projects.

Wherever there is uncertainty, we therefore advocate that quantification of climate benefits should be based on the lower bound of the uncertainty, with a facility for bonus credits to be issued, if appropriate, once scientific consensus reduces uncertainty. This would apply to the evaluation of credit additionality (i.e. how much extra carbon is stored as a result of a project, relative to an evidenced and quantified counterfactual), leakage (i.e. the emissions associated with forgone production) and permanence (i.e. the expected duration of the project's carbon storage).

This would inevitably reduce initial estimates of the climate benefit provided by projects with wider uncertainty intervals, whether nature-based or technology-based, which might reduce the prices these credits could command. On the other hand, while their claimed climate benefit would be lower, the certainty associated with those claims would be higher, and as high-integrity credits they should command a premium, especially if higher-integrity claims were differentiated from lower-integrity claims by standards and accreditation bodies. The short-term impacts of this change on prices are therefore somewhat unpredictable. On the one hand they may initially lead some project developers to conclude that their proposed projects are commercially unviable, the promise of possible future bonus credits notwithstanding. At the same time, a significant benefit of our approach for buyers and sellers is that by acknowledging uncertainties upfront, the likelihood of overcrediting is reduced and the value of demonstrably additional vintage credits is retained. While the immediate revenue from sales may be lower, projects can count on keeping it, and may realise more from the same credits in future. We also believe that in the medium- to long-term, greater scientific certainty about climate benefit will both boost and stabilise prices in the VCM. However, in the light of the short-term risks, the shift to our proposed approach would of course need careful consideration and management.

We acknowledge that making these adjustments could have unwelcome immediate consequences. A sudden effective devaluation of existing credits to reflect their more accurately measured carbon storage value could create a short-term shock to investor confidence. Some potential project developers might be dissuaded from entering the VCM if they saw the revenue per credit heavily marked down, reasoning that the costs of setting up the project would now be higher than the expected return on investment. However, this analysis assumes that the price of carbon per tonne would remain constant. A reduction in

the supply of carbon credits from high-integrity accounting would in fact be likely to push up the price per carbon tonne, as would greater certainty about the amount of carbon storage represented by credits. Higher credit prices should compensate suppliers for lower credit issuances and would make an "offsetting first" strategy[1] uneconomic for buyers, which is highly desirable.

We now discuss additionality, leakage and permanence in greater detail.

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[*] *While this document focuses on improving the credibility of carbon credits through better carbon accounting, the appropriate use of credits by buyers is also a source of concern and controversy. We would recommend that, as a condition of purchase imposed by carbon accreditation bodies, all institutional buyers should be required to follow an agreed carbon mitigation hierarchy for corporate climate action, as enshrined, for example, in the Science-Based Targets Initiative's Corporate Net-Zero Standard[8]. In effect, institutions must reduce their emissions before offsetting - but the SBTi also encourages institutions to "invest in mitigation outside their value chains to contribute towards reaching societal net-zero"(p.21), which could be done through purchasing and retiring high-integrity carbon credits.*

Additionality

Additionality may be viewed in purely binary terms – either a project is storing additional carbon, or it is not. However, this perspective does not hold weight in practice. Impact evaluation techniques developed over decades [9,10] enable us to evaluate how much additional carbon is being stored. The 4C approach does this by comparing projects to a population of equivalent land areas ("pixels") that are nearly identical in all respects except that they are not in receipt of carbon finance. We always measure these impacts ex post, i.e. by comparing deforestation rates in both the project area and the comparison areas over the same period (since the project began its carbon financed interventions).

Other widely used approaches for assessing additionality suffer from significant inadequacies. For example, prior to the introduction of the new JNR framework, Verra's Voluntary Carbon Standard (VCS) stipulated that projects predicted baseline deforestation in the project area as a continuation of the historic deforestation trend in a reference area whose land characteristics were not matched to the project. This suffered from two problems: the lack of careful application of matching permitted the use of reference areas that were not similar to projects; and historic deforestation rates, used to predict the future, were not the same as like-for-like comparisons at the same time. Consequently, it was not possible to determine whether ex post differences in deforestation rates between projects and their baselines (i.e. additionality) were due to the actions of projects or to systematic differences between projects and their reference areas.

Jurisdictional approaches to carbon crediting have been introduced as an alternative to project-based methods, aiming to address the criticisms levelled at the voluntary carbon market. These methods calculate deforestation rates over a historic reference period, prior to the start of forest protection interventions and use these to forecast expected future rates, in the absence of REDD+, to use as baselines. While promising in several respects, these approaches are not without their challenges.

One of the key benefits of jurisdictional approaches is their alignment with Nationally Determined Contributions (NDCs) under the Paris agreement, which ensures that carbon credits contribute to national climate goals and creates a more cohesive system for tracking progress.

The use of past deforestation rates to establish baselines also means that subsequent baseline setting will reflect gains already achieved, setting the bar higher for jurisdictions to continue reducing deforestation in order to earn

credits. This mechanism inherently incentivises sustained and incremental improvements over time. Jurisdictional approaches also require independent data providers to calculate baseline rates. This limits the role of financially conflicted stakeholders with perverse incentives to artificially inflate baseline deforestation rates. Delegating this responsibility to independent parties should therefore enhance the credibility and integrity of the system.

Furthermore, the nested nature of jurisdictional approaches offers a way to distribute credits more equitably among stakeholders. Since threats to forests and climate gains are often unevenly distributed within a jurisdiction, these methods enable the allocation of credits to those actors who achieve the greatest reductions in deforestation, ensuring that local efforts are recognised and rewarded and promoting a fairer and more effective system.

However, jurisdictional approaches also have their shortcomings. Foremost among these is the reliance on ex ante methods to predict deforestation and establish baselines. Predictions made today are inherently uncertain, as the drivers of land-use change are dynamic and influenced by shifting economic, social and political factors. Inaccuracies in jurisdictional baselines could result in over- or under-estimation of credits, so it is critical that they are unbiased and accurately reflect future deforestation threats.

Current nested approaches, in which the deforestation reduction achieved by individual projects is calculated in relation to deforestation across the jurisdiction, face additional challenges: they rely on ex ante spatial risk mapping to identify areas most at risk of deforestation, but like ex ante baseline predictions, these risk maps are highly uncertain, as local deforestation threats can change over time in unpredictable ways. This means credits could be issued that do not correspond to real climate gains or there could be a failure to reward genuine results in areas where risks have shifted unexpectedly.

To address these challenges, we propose several key steps. First, ex ante baselines should be made conservative by using the lower bound of predictions. This would ensure that credits issued are less likely to be overestimated, maintaining the integrity of the market [11].

Second, it is crucial to acknowledge the importance of ex post methods for evaluating the impacts of jurisdictional REDD+ efforts. As a financial mechanism, the credibility of REDD+ credits depends on continuous improvement in monitoring and evaluation. We encourage the proactive development of robust ex post approaches in collaboration with the scientific community and their integration into credit issuing mechanisms. While the IC-VCM's CCPs currently do not mandate the incorporation of ex post methods, we believe this should become a requirement. This would strengthen the reliability of credits and provide a pathway to continuous improvement.

Finally, to enhance the accuracy of the spatial risk mapping used in nested approaches, contemporary information on deforestation threats should be incorporated into decision-making. Dynamic updates to spatial risk models, informed by the latest data on economic and policy drivers, would reduce the risk of outdated predictions and improve the precision of credit allocations.

Although these suggestions are particularly relevant to jurisdictional REDD+, they have broader implications for all types of carbon credits. The integration of conservative baseline, dynamic threat mapping and robust ex post evaluation methods could enhance the integrity of carbon markets overall, creating a system that is more credible, equitable and aligned with global climate goals.

We would therefore like to see the next update of these and other CCP-compliant methodologies include measures to address the issues that we have raised, subject to discussion and agreement among all stakeholders.

Leakage

There is also a need for common standards of accounting for emissions caused by projects inadvertently displacing forgone production or creating new demand [12]. These emissions, which reduce realised climate benefits, are often ignored in projects' carbon calculations, but may be equal in size to additionality [13]. This is especially likely where:

- carbon projects intervene to reduce or forestall productive land uses, thereby displacing food and fibre production, potentially leading to habitat loss or emissions-intensive increases in production elsewhere;

- direct carbon capture and storage increase total demand for energy and consume renewable energy which would otherwise be used to decarbonise existing energy demand.

Approaches that focus solely on measuring and correcting for local leakage within a discrete leakage area will always be problematic because of the high and growing likelihood of "market" leakage outside these areas as trade grows[13]. Substantial, broader-scale market leakage is very likely, especially for widely-traded commodities when there are alternative areas of natural habitat available for the expansion of agriculture or forestry.

Current approaches to measuring leakage from jurisdictional REDD+ assume that emissions occurring outside the jurisdiction as a result of REDD+ activities are not deductible from credit issuances. However, this ignores the ability of finance for activities causing deforestation to move across international borders. In other words, credits given for halting deforestation in one jurisdiction actively ignore the fact that the responsibility for dealing with it has now been displaced elsewhere.

There is therefore considerable work to be done to estimate, for different regions and products, what fraction of forgone production leads to leakage. This involves understanding where production is likely to get displaced to, and what proportion of that production is then met by bringing new land into production relative to intensifying production on existing land. In the first instance, this would mean more research aimed at understanding leakage as a phenomenon and its impact on carbon emissions, as well as different possible approaches to accounting for it and managing it. We are also mindful that if carbon accreditation bodies were, for instance, to adopt an approach which required project developers to conduct field studies to gather data on crop yields, this would place another significant burden on projects.

Project developers face an unfortunate paradox: if they take the trouble to provide evidence to enable a realistic evaluation of leakage, rather than assuming leakage from their project doesn't occur, the scientific integrity of their credits will go up but the estimated climate benefit will go down, within an unknown effect on the price they can expect from buyers.

At present, then, our minimal expectation is that carbon accreditation bodies should clearly acknowledge the existence of leakage, and should start considering how it can be estimated fairly for all projects, informed by ongoing scientific work, without placing greater burdens on project developers. We believe, based on evidence to date[12], that assuming at least 40% market leakage for REDD+ projects is better than current practice. That said, we recognise that this is a very rough approximation and an interim solution; for any given project, market leakage may be higher or lower than 40%, so even with this level of leakage correction at the outset, there could be a need for further future corrections in response to emerging evidence.

Corporate carbon credit buyers therefore also have a responsibility, in the face of scientific uncertainty about leakage, not to demand that projects provide evidence about leakage without recognising that this information has a cost. This cost should be reflected in a higher price for credits from projects with a credible leakage evaluation because of their enhanced integrity, even if the resulting estimate of their climate benefit is reduced.

In the meantime, we believe there is considerable scope for improving projects so they actively reduce the quantity of leakage, which may prove more satisfying than estimating exactly how much foregone production occurs and its attendant climate consequences. One option is to establish projects in areas where current land uses are relatively unproductive and could make way for large amounts of carbon storage[14,15]. Another option is to invest in the intensification of current agricultural production within the project area or beyond it. As a concrete example, if cattle farming can be localised to a smaller area of a large ranch, enabling regrowth of trees in other areas, then forgone production and hence deductions to account for leakage should be correspondingly lower. The success of these approaches will also be greatest within the context of enforced policies to protect natural habitats (e.g. zero-deforestation policies).

Accreditation bodies and standards bodies, in consultation with the scientific community, therefore need to agree on:

- guidelines for where to establish projects so that leakage is minimised, such as areas where food and fibre yields are low;
- common methods for remotely measuring and evaluating a land area's historical productivity;
- methods for quantifying forgone production and increased demand for energy arising from carbon projects, and their emissions consequences, so that these can be subtracted from the additionality claimed for carbon projects.

Permanence

Measures taken to quantify and extend credit durability are needed, as are guarantees that any reversals are reflected in estimates of project performance. However, the widely-used buffer pool approach is an inadequate insurance mechanism, since it requires that buffer credits are of equal or higher quality than those they compensate for, and currently there are no controls to ensure this. Further, it provides no incentive, once credits have been issued, for project developers to safeguard already-credited carbon[16]. Current moves by Verra and the ICVCM requiring guarantees of permanence for a minimum period (100 and 40 years respectively) offer some certainty to buyers, but they may not provide the flexibility and nuance needed by sellers. Contractual obligations of 40 years are considered very long in rapidly evolving landscapes, such as tropical deforestation frontiers, which may slow the much-needed adoption of REDD+. On the other hand, projects will likely still want to differentiate themselves via offers of greater permanence, which may or may not be easily substantiated within a binary assessment of permanence.

Broadly, we advocate for approaches that take a pessimistic and evidence-based view of the likely durability of carbon benefits and adjust credit worth accordingly. For example, in the context of carbon credits representing carbon storage in tropical moist forests, 4C has developed the PACT method (based on the Permanent Additional Carbon Tonne metric) which embeds this approach[16].

For any type of nature-based carbon credit project, monitoring (e.g. remote sensing) of projects and control/reference area stocks must continue for the minimum period over which durability is claimed. For example, 4C's PACT approach uses ongoing monitoring to quantify reversals, and allows project developers to claim new credits where estimates of reversals prove to have been overly pessimistic - thereby incentivising long-run safeguarding of previously-credited carbon.

Perverse Incentives

For a variety of reasons, perverse incentives have emerged throughout carbon markets which, intentionally or otherwise, are effectively inhibiting the transition to high-integrity standards.

In the case of sellers, carbon credits represent a new revenue stream that may be used to finance activities that would have occurred even in their absence. For instance, carbon credits could be used to pay for forest conservation where there was no threat of deforestation, or to pay for forest restoration on land where agriculture would naturally transition to forest. There is currently considerable methodological freedom for project developers when selecting key parameters (e.g. business-as-usual deforestation / restoration rates), which have outsized effects on credit generation.

In the case of buyers, there are opportunities to offset their emissions using low-integrity (and low-cost) credits, which delays the more difficult and costly actions needed to reduce emissions. Further, a shift towards high-integrity standards could risk exposing previous offsetting efforts as inadequate. This carries reputational implications, particularly where investments or products have been sold using claims based on offsetting[7].

The common principles for carbon quantification and accounting suggested in the previous section, if adopted by the standards and accreditation bodies, would go a long way towards tackling perverse incentives for both buyers and sellers; and indeed for the carbon accreditation bodies themselves, which currently have limited incentive to refuse to issue credits to low-quality or poorly evidenced projects.

This proposal would entail that all monitoring, reporting and verification (MRV) of credit-generating projects would be done by third parties. This would avoid the conflict of interest inherent in a project "marking its own homework", and would relieve projects of the practical and administrative burden of MRV work. The proposal does raise questions, both about the current capacity of independent MRV companies to meet this potentially increased demand, and about the ability of projects to pay for independent MRV services. However, our parallel proposal to standardise data formats and democratise access to it, alongside promoting much greater use of remote sensing data, should help to address these concerns by reducing the MRV workload and its associated costs.

Data quality and transparency

The data and methods used to issue carbon credits are currently not transparent even to expert analysts. Accreditation bodies require projects to produce project design documents (PDDs) and monitoring reports which can be hundreds of pages long, and reference data or annexes, essential to auditing the project, that are not in the public domain. This makes it very difficult for potential buyers of credits to assess and compare the quality of different credit offerings, which is a barrier to establishing a market for high-integrity voluntary credits. It is also a principal reason for the widespread involvement of consultancies and rating agencies, creating additional costs for buyers and sellers and limiting credit availability, but without resolving the transparency problem.

With respect to the carbon benefits of credits, we propose that:

1. All carbon credits should be issued based on trusted primary observations, typically from remote sensing. Nature-based credits have the specific advantage that their carbon benefits can be increasingly evaluated almost entirely from remotely-sensed observations, backed up by appropriate in situ validation. Where remotely-sensed observations are not possible, audited in-person observations, collected by appropriately trained local people, are an effective - although, we suggest, typically much costlier - substitute.

2. All data necessary to reproduce carbon calculations should be made available, within the public domain, in standard file formats, especially:

- spatial polygons of project sites and reference areas;
- carbon plot data;
- ground validation points;
- remote-sensing products.

If adopted by all carbon accreditation bodies under common standards, these requirements alone would represent a step change in transparency and reproducibility. Currently, some private developers may have valid objections to making all their data public. We recognise that, for example, there may be privacy concerns about sharing location-specific data, and that there are valid questions about how to protect open source data from being exploited to find ways of hiding illegal deforestation activities. Overall, we see this as an incentives issue; we would like to see the regulatory and accreditation landscape change in a way that better aligns private developer interests with common interests in climate benefit, and we are open to discussions with all stakeholders on how to achieve this effectively.

Further progress could be made using a single methodology which prohibits project-specific deviation, but includes optional modules for specific circumstances. The highest level of transparency could be achieved by digitising all methodologies so that input data, algorithmic transformations, and intermediate variables for resulting credits can be intuitively explored[17,18]. In due course, we would like to see a similar approach developed and adopted commonly for the evaluation of biodiversity benefits for credits which claim to provide them.

With respect to project governance, the auditing of projects' ethical standards, community engagement, free prior and informed consent, existence and adequacy of grievance procedures, and impacts on biodiversity, are equal in importance to the assessment of projects' carbon benefits. Further development of transparent governance mechanisms and global standards for ethics, human rights, community involvement, livelihoods and welfare in relation to carbon credit projects is essential (see below).

At the same time, we are concerned that current reporting methods frequently fail to separate these issues adequately from carbon calculations, which can obscure and complicate the interpretation of these important but distinct issues. We therefore propose that, as far as possible, the social and biodiversity dimensions of projects should be reported separately from carbon calculations.

Project governance and downstream effects on financial flows to developing countries

In common with the accreditation bodies, we recognise the need for robust, transparent and pragmatic indicators for benefit-sharing and safeguards for communities participating in nature-based carbon credit projects. For instance, we believe that adopting an appropriate and equitable legal framework is critical for the design of good forest carbon credit projects, whether in the context of national legislation or for specific contracts between investors/buyers and sellers[19]. Further, we advocate for projects that are run with and ideally by local communities[20, 21] and that support local livelihoods[22].

In addressing these aspects of project design and implementation, we recognise a tension between the need to adequately quantify and account for the carbon and biodiversity contributions of a project in exchange for carbon finance and the need to minimise the financial and administrative burdens on projects and local communities. While this tension cannot be completely resolved, we note that the status quo for carbon accreditation tends to exacerbate the burden on projects and communities through expensive, administratively complex, opaque and prolonged assessment and approval procedures prior to credit issuance[23, 24].

This currently militates against the good intentions of the carbon accreditation bodies to support communities and improve financial flows to developing countries. We share with the carbon accreditation bodies a desire to enable the expansion of financial flows to developing countries to support them in achieving their climate mitigation and sustainable development priorities. We believe that the framework we have proposed above would add clarity and certainty to the operation of the voluntary carbon market, and in so doing, potentially contribute to enhanced financial flows to developing countries and to improved local livelihoods.

There is of course a risk that introducing any new framework into an already complex market could lead to the burdens of further time-consuming and expensive requirements being dumped on projects. We are mindful that changes must be introduced in a way that takes account of realities on the ground for project developers. The project design and monitoring process for nature-based projects has seemingly become increasingly complex while conferring relatively minor gains in integrity. The approaches we suggest could offer hope for significant progress towards a high-integrity market with lower complexity and costs.

Conclusion

There is an immediate risk that not acknowledging or addressing the issues we have identified could threaten hopes for the continued growth and scaling-up of the voluntary carbon market. At the same time we recognise there are risks to incumbent actors from taking the necessary actions. Nevertheless, if the immediate interests of incumbent actors are prioritised over the long-term interests of the market-as-a-whole, the shared ambition for voluntary carbon markets to meaningfully contribute to addressing the challenges of the climate crisis are unlikely to be achieved.

The PACT approach established by 4C offers one template for how to develop practical methods using the best available science, which are straightforward to update, free from counterproductive incentives, transparent, replicable, and could significantly reduce the transaction costs associated with bringing credits to market. We recognise the size of the challenge and we do not claim to have all the answers. However, we believe that the only way to facilitate the transition to high-integrity standards in the voluntary carbon market is through the development of common standards, enabled by the active participation of the scientific community.

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