Strong transparency required for carbon credit mechanisms

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The credibility of carbon offset mechanisms is threatened by many issues related to their true effectiveness. We advocate that these issues cannot be effectively addressed without a dramatic improvement in transparency across the entire value chain of carbon offsetting, a crucial step for achieving a reduction in carbon emissions.

Voluntary carbon credits have emerged as a key financing mechanism to scale up reforestation and forest conservation, climate-friendly agriculture, and the clean energy transition, as well as activities such as waste management and improved cookstoves. Carbon credits can be used by private firms for offsetting their own emissions, for corporate social responsibility purposes, or as pilots for compliance markets. The Voluntary Carbon Market (VCM) has grown enormously in recent years: over 286 million credits were generated in 2023, up from just over 5 million in 2007 (So et al., 2023, see Figure 1). The VCM was valued at roughly $2 billion in 2021 and expected to reach between $10 and $40 billion by 2030 (BCG and Shell, 2023), with forest-based carbon credits expected to represent the lion's share of the market (TSVCM, 2021).

However, concerns about the environmental integrity of credits have been thrust into the spotlight by numerous exposés of overcrediting and lack of impact (Blake, 2023; Greenfield, 2023). Demand for carbon credits fell in the first half of 2023 (Bloomberg, 2023). Market prices dropped at the end of December 2023 on the Xpansiv trading platform (Xpansiv, 2023): at $0,8 per ton for nature-based carbon offsets (compared to $7,5 per ton during the same period in 2022) and at $0,5 per ton for tech industry carbon offsets (compared to $1,1 per ton during the same period in 2022). The prices of these volatile specific products are contrasted with aggregated price data gathered by declarative assessments (Forest Trends' Ecosystem Marketplace, 2023), which recorded a global volume-weighted average price of $7.37 in 2022. Calls have been made for the complete abolition of offsetting (Childs, 2021; Martins, 2023). The fundamental question is whether offset mechanisms can be salvaged through gradual adjustments or radical overhaul - or should they be thrown out altogether?

Those concerns have caught the attention of regulators, who are starting to push for greater transparency in the VCM (Table 1). Here, we provide guidance on the current problems involved

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with carbon offsetting and the extent and type of transparency that regulators and other stakeholders should demand in order to increase the credibility of carbon credits. Transparency is a prerequisite to start addressing the undisputable shortcomings surrounding offset initiatives. Notably, critical information pertaining to transactions and the distribution of value throughout the value chain (including to local communities) remains inaccessible to civil society, even within the regulations, bills and projects that are actually in place. This dearth of data erodes the credibility of offset projects and hampers efforts to rectify some of the core issues in the VCM.

Controversies about carbon offsetting

The VCM is highly controversial. While in theory offsets are an efficient way of meeting climate targets by delivering mitigation at lower costs, the praxis has been challenging (Balmford et al., 2023). Many see offsets as a misguided effort that allows polluting firms to avoid making changes to their business models and technologies (Krishnan et al., 2023); others view the practice as mere greenwashing (Trouwloon et al., 2023). The first and main element of offset projects to take into consideration is additionality, which encompasses two components: incentives, i.e., whether the project would have occurred without revenues from the sale of the carbon credits (as in Michaelowa et al. 2019); and impact, i.e., whether the project actually reduces global warming or not, which is found to be largely overlooked on the VCM (Michaelowa et al. 2023).

Multiple research teams have investigated the impact of offset projects, i.e., the net emission reductions attributable to the projects (Wunder, 2015): in a systematic review, Probst et al. (2023) find strong evidence that the achieved benefits were much lower than claimed across all important categories of offset projects. Several studies of avoided deforestation or REDD+ (Reducing Emissions from Deforestation and Forest Degradation) projects, a key source of carbon credits, have found little or no evidence of additionality (Delacote et al. 2022, Guizar-Coutiño et al. 2022, West et al. 2020, West et al. 2023, Groom et al. 2022). West et al. (2020) found that 11 out of 12 REDD+ projects in the Brazilian Amazon substantially overestimated their impacts on deforestation, consequently inflating credit issuances. In their analysis of 40 REDD+ projects, Guizar-Coutiño et al. (2022) found a 47% decrease of deforestation in project areas, but the impact was concentrated in a few projects. Delacote et al. (2022) could not find any evidence of additionality in five out of six REDD+ projects they evaluate. Most recently, West et al. (2023) estimated that over 90% of the anticipated carbon offsets from 27 REDD+ projects across the tropics were not associated with actual carbon emission reductions. Improved Forest Management (IFM) projects have similar issues, although lack of data makes them more difficult to assess. Badgley et al. (2022) found that 29.4% of the projects analyzed were over-credited in California's forest carbon offset program due to coarse regional carbon baselines. Similar additionality issues also haunt improved cookstoves projects. Gill-Wiehl et al. (2024) find that improved cookstove crediting methodologies are overcrediting projects to a great extent.

Beyond additionality, the total impact of the projects on emissions also depends on permanence. The permanence of emission reductions associated with offsets has been questioned as well. Not only should offset projects unequivocally demonstrate that emissions have been reduced in the immediate term, but achieved reductions must be permanent once the project has ended, which may not be the case for forest-based projects (Dutschke et al., 2008; Honegger et al., 2022). For example, Simonet et al. (2019) showed that a pilot REDD+ project in the Brazilian Amazon had effectively reduced deforestation while the project was active. However, Carrilho et al. (2022) found in a follow up analysis of the same case study that there was a rebound in forest loss (and a

decrease in declared households well-being) once the project had ended, challenging the project's long-term efficacy.

The difficulties of evaluating and controlling emissions displacement are a third key concern (Delacote et al. 2016, Filewod and McCarney, 2023). Emissions "leakage" resulting from offset projects may be as significant a source of overcrediting as inappropriate baselines, but this phenomenon is complex, challenging to measure, and frequently underappreciated (Haya et al. 2023). Even in the best case, technical limits to market leakage measurement precision (Murray et al. 2004) considerably reduces the accuracy of the true level of impact (hence credits) for key classes of projects (such as those that reduce the supply of economic goods and services, like most REDD+ or IFM projects). Haya et al. (2023) found that 82% of the IFM credits issued by California's Air and Resources board did not represent true emissions reductions due to poorly constructed leakage assumptions. This problem is intertwined with the measurement of impacts: first, leakage has to be considered for a complete evaluation of impacts; second, despite recent advances in the state-of-the-art for assessing project impacts, leakage may cause serious identification uncertainty, as it makes the proper selection of a counterfactual more complicated. Uncertainties in measurements can subsequently lead to complications in environmental bookkeeping and the functionality of buffer pool systems (Delbeke et al. 2023). Measuring leakage credibly, or at least conservatively, and communicating net impacts consistently and transparently, are vital steps toward effective carbon markets.

Other challenges include the management of non-carbon externalities, whether positive or adverse. Co-benefits include for example the enhancement of ecosystem services, biodiversity conservation and livelihoods; they contribute to making carbon "charismatic" (Lou et al. 2022). As noticed by Simonet et al. (2016), taking co-benefits into account has an impact on project implementation and carbon credit transactions. In contrast, recurrent concerns arise regarding the harmful impacts of carbon projects, encompassing issues related to property rights (Asiyanbi, 2016) and resource control (Ehrenstein, 2018). Recent investigations by The Guardian and Follow the Money (Grenfield, 2023), among several other major news outlets, have even shed light on potential violations of human rights in connection with these projects (Greenfield et. al, 2023). The complexity of achieving both environmental conservation and livelihood improvement has been repeatedly emphasized (Delacote et al., 2022, Nantongo et al., 2024).

Nevertheless, offsets have a place within the political action climate change toolbox (alongside more restrictive regulations and taxes) for a reason: in theory, they are an efficient market-based solution to our generation's most pressing sustainability challenge. In practice, market mechanisms have worked for environmental challenges before, including pollution control, fair trade certification, and sustainable production reporting (Schmalensee et al., 2017). However, their effective implementation is not guaranteed. Notably, the effectiveness of any market mechanism is conditional on the quality, accuracy and transparency of information provided to stakeholders. This is true across the VCM value chain: for example, lack of transparency by offset buyers can enable misleading advertising and greenwashing (Bottega et al., 2024).

Lack of transparency

The lack of transparency around voluntary carbon credit transactions is consequently a cross-cutting and urgent concern. Although information on offset projects (documentation, provenance, transfer, retirement) is made increasingly publicly available by carbon offset programs, it is far from

exhaustive (Table 2). For example, while geospatial site boundaries are, in theory, publicly available from many offset programs, many projects do not provide this information, while others provide either corrupted files or boundaries that do not match the actual project areas; as noticed by West et al. (2020, 2023) and Guizar-Coutiño et al. (2022), some projects had to be discarded from their analysis due to these quality issues. Equally important is the lack of geographical information concerning reference areas, from which baseline emission levels were derived. Such shortcomings make assessing climate impacts difficult or impossible. Meanwhile, impacts on co-benefits are even harder to measure; such as the number of individuals affected by projects, the nature and amount of compensation they received, or the non-CO2 ecological impacts (biodiversity, water management).

Data on transactions are especially scarce. As an over-the-counter mechanism and with no legal requirements to report sensitive information, data on prices or the identity of buyers and sellers are almost nonexistent. Collection efforts depend on personal networks and voluntary declarations: the long-established reports by Ecosystem Marketplace, for example, rely on a network of market respondents and make public only aggregated annual syntheses (Forest Trends' Ecosystem Marketplace, 2023). Moreover, given the complex web of intermediaries between the projects developers who generate credits and the firms who buy them on the VCM, many—if not most—offset sales cannot be traced to specific and verifiable projects (Carbon Market Watch, 2023). Furthermore, the distribution of revenues across these value chains is completely opaque. Many firms cite concerns over proprietary business models to explain their reluctance to share data on their carbon offsetting practices (IOSCO Board, 2022), particularly for price data. As things stand, firms lack incentives to disclose: the high-profile investigation into overstated offset impacts by The Guardian, Die Zeit and SourceMaterial (Greenfield, 2023), for example, has not been followed by data releases from private companies and carbon offset programs. These issues are even more critical in light of recent calls for nature-based carbon credits to be differentiated on the basis of their contributions to biodiversity (Tedersoo et al., 2023) and local livelihoods (Larson et al., 2022).

Transparency for effective mechanisms

We argue that improved transparency on carbon credit markets, in particular on transactions, is necessary to establish the proper functioning and credibility of this important financial mechanism. Transparency on disclosures has many benefits for diverse stakeholders. Although it will not solve all the controversies related to carbon offsetting, it is a prerequisite without which the other issues cannot be solved.

In terms of impacts and additionality, first, disclosures would help avoid fraud and protect both investors and consumers, as in established commodity markets. As for any market, verification and accountability are required. Additionality testing is the core of ensuring the integrity of market-based mechanisms (Michaelowa et al., 2019) and recent developments have clearly shown that additionality claims cannot be taken on trust. Such testing cannot be done credibly without complete information disclosure and full transparency. Firms with the most robust climate strategies should see their own interest: they will be able to prove (1) the amount they invest in carbon offsetting, (2) how those investments coincide with their own mitigation strategies, and (3) what real-life impacts they are having. The weight of evidence suggests that voluntary certification alone is not enough to ensure that offsets are real. Only through transparency can truly impactful initiatives dispel accusations of greenwashing. In contrast, keeping carbon credit transactions opaque will jeopardize their mere existence, as suspicions of greenwashing will continue to grow

and transform the VCM into a 'market for lemons' in which low quality offsets (risky, impermanent, non-additional) purge the market of high quality ones (Akerlof, 1970).

Disclosure is equally crucial for research, innovation and policy recommendations: scholars and stakeholders require access to transaction information to assess the impacts of offset projects and advance methodologies for estimating emission reductions, risk and equivalence, as well as elucidating contemporary questions of public interest. Transaction disclosures will allow cost-benefit analyses that will deliver policy-relevant information, complementing and extending the impact analysis that have been performed so far. Furthermore, transaction disclosures will allow researchers to assess whether the characteristics of credits that are valued by the market are aligned with permanence, leakage and other socially important characteristics that determine their social value (Groom and Venmans, 2023). This will bring important insights for policy formulation and market design.

In terms of co-benefits, accurate information on value chains would help redress power asymmetries, especially in internationally traded offsets, allowing impacted communities to negotiate a more equitable share of profits. Indeed, many offsetting projects explicitly aspire to impact both carbon emissions and local livelihoods. It has been shown that the combination of those two objectives influences project implementation (Delacote et al. 2022). However, the current lack of information about how value is distributed to affected communities utterly prevents independent assessment of such outcomes (Sills et al. 2017).

Open and reliable information on project locations, actions and volumes produced (currently imperfectly provided by offset registries) are a vital minimum requirement; given the current crisis of confidence faced by the voluntary carbon market, the prices paid by carbon credit buyers and the amounts received by project beneficiaries (including communities living on the lands where projects occur) should also be disclosed.

Improving VCM transparency

One solution would be to strengthen transparency requirements within the existing governance framework of third-party certification. Project proponents selling carbon credits and firms buying them could commit to sharing reliable information on transactions, potentially with a short time-lag to protect business interests. Since the voluntary carbon market is not (yet) regulated by an international administrative body, efforts to develop frameworks and registries are central to building legitimacy and credibility, and have blossomed in the past few years. Table 3 sheds light on the multifaceted approaches of transparency within these initiatives and throughout the entire project life cycle. On the supply-side, it often involves the establishment of a centralized registry facilitating the clear identification of carbon credits and including varying degrees of precision in project documentation. A system of this nature, taking into account the interactions between compliance and voluntary as well as domestic and international markets, is essential to prevent double counting in the context of the Article 6 of the Paris Agreement (Schneider et al. 2019). Price disclosure is another facet of transparency: for some, it entails the development of digital platforms where carbon credits are converted into financial instruments built on blockchain technology (a secondary voluntary carbon market) (Marchant, 2022). On the demand side, initiatives for greater transparency focus mainly on the use of carbon credits in net-zero claims (Kreibich and Hermwille, 2021). Ironically, the VCM also remains highly opaque due to this polysemy of transparency.

We doubt that the necessary increases in transparency can be delivered by industry-led voluntary certification schemes alone. First, certification standards face stringency and participation problems: standards designed to include most market participants can implement low-requirement rules, while standards with the most stringent rules may fail to attract participation. Second, the proliferation of standards can also have a dilution effect, leaving credit buyers unable to differentiate quality; this is a general problem of many standards (e.g. energy efficiency, green finance). The growth of rating agencies which use their own frameworks to determine the quality of VCM credits, such as BeZero, Calyx Global, Renoster, and Sylvera, represent a push for higher transparency in the market. Yet, inconsistencies among rating methodologies, which usually are not fully transparent, can lead to different outcomes in project-specific analysis and potentially legitimize low quality credits (Wawrzynowicz et al. 2023). Third, it is not clear whether carbon credit buyers actually care about the quality of the credits. For instance, Bakhtary et al. (2023) show that even if buyers are willing to pay more for credits with co-benefits, they care more about the number of attributes (Sustainable Development Goals) than measured climate impacts.

Given our skepticism of the potential to adequately strengthen transparency requirements within the existing governance framework of third-party verification, we see regulation as the key tool to increase transparency. The VCM is Voluntary, but as it grows in importance so does the case for public intervention. The European Parliament has already moved to limit carbon-neutral claims based on offsetting - commercial practices will be deemed "misleading" if they fail to distinguish the role of offsets in environmental claims (European Parliament, 2023), and the United States Commodity Futures Trading Commission has indicated interest in engaging to limit environmental fraud. In California, Assembly Bill 1305 has made information disclosure mandatory for entities operating in the state. To the best of our knowledge, this recent tendency toward better transparency does not encompass information about transactions.

Policymakers worldwide can and should make transparency requirements mandatory to access the VCM and create rules for carbon offsets within existing regulatory structures. Growing transparency requirements on food products in the European Union provide a model to follow. For example, in France, a label designed to provide information on the conditions under which producers are paid is currently being tested (CGAAER, 2022). Extra-financial regulation is another policy pathway to transparency, with firms increasingly obliged to report and make transparent their use of carbon credits - for example, under the newly approved rules of the European Sustainability Reporting Standard and in particular the Corporate Sustainability Reporting Directive. As the use of carbon credits grows around the globe, we must ensure that such initiatives are replicated and harmonized.

Transparency as a required preliminary step

We recognize that carbon offsets and the VCM face many well-known issues that jeopardize their credibility - and, indeed, their very existence. Furthermore they cannot be the only tool used to reach net zero. As suggested by Jones and Lewis (2023) for the forest conservation case, demand-side policies are also necessary to effectively conserve tropical forests and halt deforestation. Yet, they are now playing an important role, and their growth is driven by strong policy and market inertia. We argue that without a dramatic increase in transparency, including full disclosure on transactions and value sharing, the issues plaguing carbon offsetting cannot be fixed. Improving the transparency of carbon offsetting mechanisms now, through decisive actions that mandate

information disclosure, is essential if their promise of economically efficient mitigation is to be realized in time.

Achieving transparency is the first necessary step for restoring the credibility of VCM, but is not sufficient. Consensus about robust impact evaluation of offsets, as well as clear statements by companies on their offset-based climate strategies, are also necessary if the offset market is to become a serious contributor towards net zero.

Figures and tables

Figure 1: Number of credits generated over time by the voluntary carbon market categorized by type: reduced emissions, impermanent removals, and mixed. Source: (1)
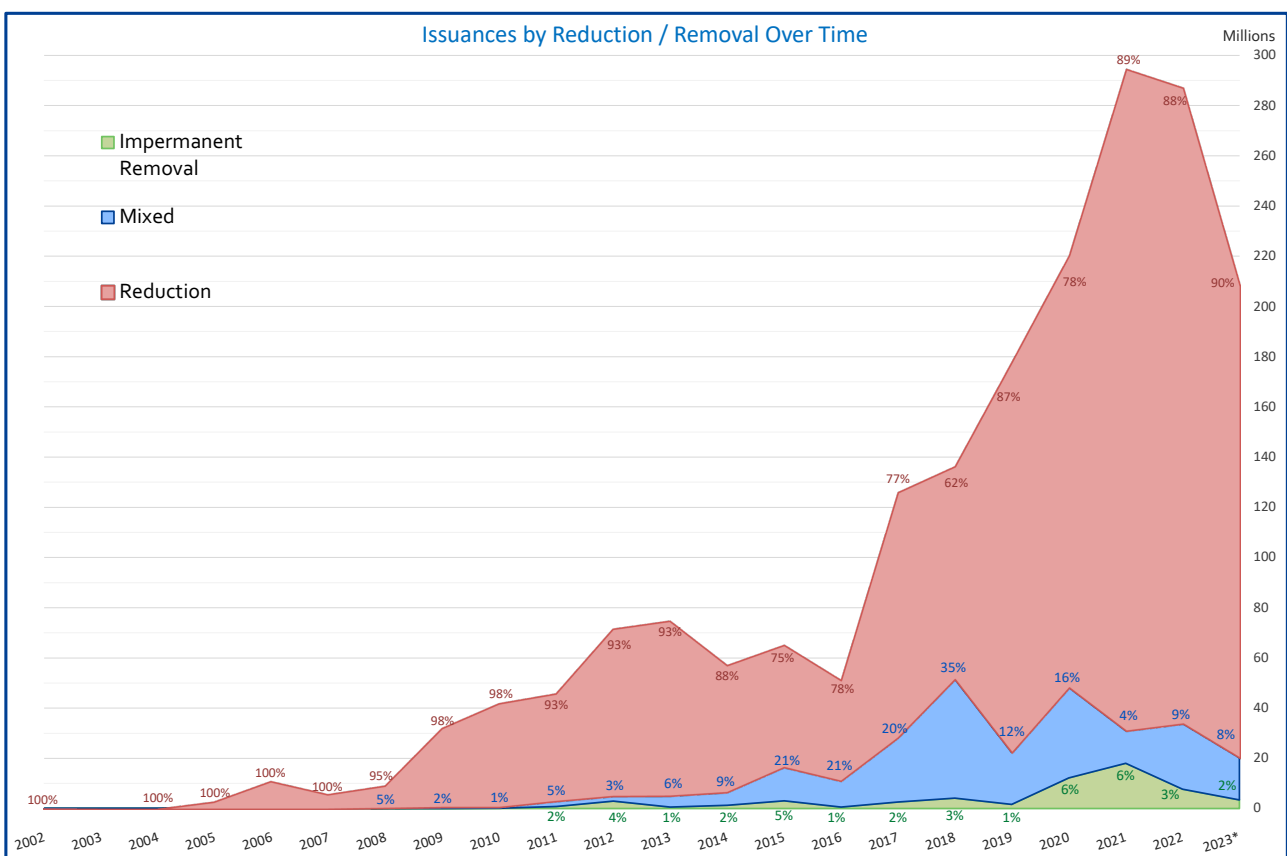
Table 1 : Examples of regulatory impulses for transparency on the VCM

Documents	Region	Regulation level	Contents related to transparency
Presidência do Conselho de Ministros, Ambiente e Ação Climática. (2024). Decreto-Lei n.º4/2024, de 5 de janeiro. Diário da República, Série I, n.º 4/2024	Portugal	Direct	Establishment of an electronic national platform for registering carbon projects, market agents and transactions
Skidmore, C. (2022) *Mission Zero: Independent Review of Net Zero* (commissioned by the UK government).	UK	Direct	Recommends the establishment of a carbon credit and offset regulator by 2024 (Pillar 6.5)
Climate Change Committee. (2022, October). Voluntary Carbon Markets and Offsetting.	UK	Direct	Necessity of governmental intervention to reinforce guidance and regulate the VCM
European Commission. (2022). Proposal COM(2022) 672 final for a regulation establishing a Union certification framework for carbon removals.	EU	Direct	Minimum quality standards for carbon removals
International Organization of Securities Commissions (IOSCO). (2022, November). Voluntary Carbon Markets: Discussion Paper.	Inter-national	Trading	"Publicly available data to promote transparency", "Price discovery" (Key considerations for a better-functioning VCM)
ISDA - International Swaps and Derivatives Association. (2022, December). Verified Carbon Credit (VCC) Transactions Definitions.	Inter-national	Trading	Standardized documentation to increase legal certainty and consistency to VCC trading
Commodity Futures Trading Commission (CFTC). (2023, June). Press Release N ° 8736-23: CFTC Division of Enforcement Creates Two New Task Forces; Press Release N ° 8723-23: CFTC Whistleblower Office issues alert seeking tips relating to carbon markets misconduct.	USA	Trading	Address fraud and other misconducts. Report information related to manipulative trading, fraudulent practices and potential manipulation in tokenized markets
U.S SEC - Securities and Exchange Commission. (2022, March). The Enhancement and Standardization of Climate-Related Disclosures for Investors, Rel. No. 33-11042; 34-94478 (proposal).	USA	Carbon credit use	Proposes mandatory disclosure of the quantity of carbon reduction achieved through offsets to fulfill companies' climate objectives
European Parliament. (2022). Corporate Sustainability Reporting Directive (CSRD) - 2022/2464/EU.	EU	Carbon credit use	Transparency regarding the utilization and quality of carbon credits in sustainability reporting standards for corporations
California Assembly. (2023, October). Bill No. 1305: Voluntary carbon market disclosures.	USA/ California	Carbon credit use	Mandatory disclosures not only from carbon credit buyers but also from the purchasers and entities asserting the achievements
Federal Trade Commission (FTC). (2012, October). Green Guide on environmentally friendly products.	USA	Sustainability claims	Guideline to employ reliable methods, prevent double-selling, disclose future emission timelines, adhere to legal requirements
Advertising Standards Authority (ASA). (2023, June). Advertising guidance: misleading environmental claims and social responsibility.	UK	Sustainability claims	Guidance to disclose the portion of carbon-neutral and net-zero claims based on offsetting, adherence to standards and schemes

European Parliament. (2023). Empowering consumers for the green transition. P9_TA(2023)0201.	EU	Sustainability claims	Requires clear differentiation of carbon offsets' role in environmental assertions

Table 2 : Transparency requirements of carbon offset programs

	Unique registry listing projects, issuances and retirements	Number of carbon credits issued by project	Credits traceable by serial number	Project validity period and explicit renewal rules	Publication of project description, validation, verification and follow-up documents, with detailed calculations	Follow-up of credit retirements in the registry	Follow-up of credit transfers in the registry	Double-counting verification	Carbon credit prices and distribution of value	Detailed transactions
American Carbon Registry		✓	✓	✓		✓		✓		
Cercarbono		✓		✓						
Climate Action Reserve	✓	✓	✓	✓	✓	✓		✓		
Climate Austria (national standard)										
Fairtrade Climate International	✓	✓	✓		✓			✓		
Forest Carbon Partnership Facility (FCPF)					✓					
Global Carbon Council		✓	✓		✓			✓		
Gold Standard	✓	✓	✓		✓			✓		
Label bas carbone	✓	✓	✓	✓	✓	✓	✓			
Clean Development Mechanism	✓	✓	✓		✓	✓		✓		
Joint Implementation Mechanism	✓	✓	✓							
Peatland Code		✓	✓		✓					
Plan Vivo		✓			✓	✓		✓		
BioCarbon		✓		✓				✓		
Program Architecture for REDD+ Transactions	✓	✓			✓	✓	✓			
Program REDD+	✓	✓				✓				
Puro.earth		✓						✓		
Registro de huella de carbono	✓	✓								
Soil Capital								✓		
Verified Carbon Standard (VCS) / Verra (including CCB projects)	✓	✓	✓	✓	✓	✓	✓	✓		
Woodland Carbon Code		✓	✓		✓			✓		

Table 3: Examples of private initiatives for higher transparency on the VCM

Initiative		Year	Treatment of transparency	Requested information					
				Registry to identify and track credits	Detailed project documentation	Transactions and price discovery	Value distribution	Stakeholders and governance	Use of carbon credits
Core Carbon Principles (CCPs), by the ICVCM		2023	Core	✓	✓				
Carbon Credit Quality Initiative (CCQI) tool		2022	Core	✓	✓			✓	
Tropical Forest Credit Integrity (TFCI) Guide		2022	Peripheric				✓	✓	✓
Iniciativa Brasileira Para O Mercado Voluntário De Carbono (BRVCM)		2022	Peripheric	✓	✓	✓			
Africa Carbon Markets Initiative (ACMI)		2022	Core		✓		✓		
Nordic Dialogue on Voluntary Compensation		2022	Core		✓				✓
ICROA Code of Best Practice		2023	Peripheric	✓	✓				
Ratings by private agencies	BeZero	2022	Peripheric		✓			✓	
	Calyx Global	2023	Peripheric	✓	✓			✓	
	Sylvera	2022	Peripheric						
	Renoster	2022	Peripheric						
Climate Action Data (CAD) Trust		2023	Core	✓					
IHS Markit Carbon Meta-Registry		2021	Core	✓					
State of the Voluntary Carbon Market, by Ecosystem Marketplace		2007	Core			✓			
Info compensation carbone (INFCC)		2022	Core			✓			
Claims Code of Practice, VCMI		2023	Core						✓
High-Level Expert Group on the Net-Zero Emissions Commitments of Non-State Entities		2022	Core						✓
Corporate Net-Zero Standard, Science-Based Targets initiative		2023	Core						✓

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Table 2

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Competing interests

The authors declare no competing interests.