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Interrogating the promises and perils of climate cryptogovernance: Blockchain discourses in international climate politics

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ABSTRACT

This article interrogates the assumed promises and perils of climate cryptogovernance or deployment of cryptographic technology (i.e., blockchain) within climate governance. We distill how climate cryptogovernance is being discussed by influential climate policy actors, and the implications for reinforcing or challenging how climate governance currently occurs. Specifically, through discourse analysis, we explore how blockchain technology is presented in the communications of international organisations and multistakeholder initiatives in the climate policy space. We identify a dominant storyline being advanced that views blockchain as an enabler of ambitious climate action, through its potential to enhance the reliability, transparency, accountability, and democratic quality of climate governance. We critically interrogate each of these component elements of the dominant storyline, arguing that, taken as a whole, they tend to privilege a technocratic, market-oriented approach to climate governance. We conclude by reflecting on whether this risks reinforcing a problematic 'post-political' turn in environmental governance in the future.

1. Introduction

With the explosion of blockchain-based cryptocurrencies over the past few years, blockchain technology has increasingly entered the public domain. Applications of blockchain technology are quickly extending beyond the private interests of the financial market and reaching into the realm of inter-governmental policy initiatives. This has been true of areas as diverse as female empowerment and refugee humanitarian aid (UN Blockchain, 2018). Numerous international environmental organizations have also shown an interest in such technology, including the United Nations Environmental Programme (UNEP, 2016), the United Nations Framework Convention on Climate Change Secretariat (UNFCCC, 2018) and the Convention on International Trade in Endangered Species (CITES, 2017).

Blockchain can most simply be described as a database of virtual transactions that occur across a decentralized peer-to-peer network system (Al-saqaf and Seidler, 2017). Blockchain is considered a 'cryptographic technology' because it ensures that ledgering of such transactions happens securely, despite the potential presence of malicious third parties. The key potential benefits of blockchain, as widely asserted in the literature, are assumed to be twofold: first, blockchain may enable the secure transfer of digital assets (or virtual representations of physical offline assets); second, blockchain may allow for the disintermediation of such transfers by ensuring truthful records about asset owners that do not require a trusted intermediary like a registrar, notary or financial institution (Savelyev, 2017).

In the environmental policy domain, French ecologist Guillaume Chapron (2017) was one of the first to propose that "the environment needs cryptogovernance". The core of the argument made by Chapron and other proponents of blockchain is that a key feature, and benefit, of cryptogovernance in the context of the environment is the outsourcing of trust, law and enforcement to computer code (Chapron 2017: 404). The claim is that this outsourcing will ultimately induce cooperation and reduce fraud, and enhance transparency and accountability in environmental governance.

Climate change has become a particularly prominent issue that advocates of blockchain technology have speculated could be cryptogoverned. Prominent international organizations and initiatives have voiced substantial support for the development of blockchain-based climate initiatives. For example, the UNFCCC secretariat (2017), World Bank (2018) and World Economic Forum (2018) have all been vocal proponents of applying blockchain technology to addressing climate change. UNFCCC programme officer Alexandre Gellert Paris in a news article claimed that 'blockchain could contribute to greater

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stakeholder involvement, transparency and engagement and help bring trust and further innovative solutions in the fight against climate change, leading to enhanced climate actions' (UNFCCC, 2017). In one of its first publications on the topic, the UNFCCC secretariat identified four specific ways in which blockchain technology could be used to tackle climate change: to improve carbon emission trading; to facilitate clean energy trading; to enhance climate finance flows; and to improve tracking and reporting of greenhouse gas (GHG) emissions (UNFCCC 2017).

Despite these presumed applications, the actual implementation of blockchain projects in the climate realm is in relatively early stages (WEF & PwC, 2018). Beyond small projects headed by startup companies and early-stage experimental technologies, the incorporation of blockchain into climate policy instruments is largely anticipatory and remains more speculative than real. At the same time, future use of blockchain may have a transformative impact on modes and outcomes of climate governance.

Indeed, given that climate cryptogovernance is relatively underdeveloped, what is said and communicated about blockchain in the context of climate change becomes extremely relevant. In this anticipatory space, the ways in which knowledge claims are crafted by influential actors can have a substantial impact on how the phenomenon comes to be understood, and potentially deployed. Such expert understandings can *de facto* steer an emerging, anticipatory governance landscape in specific directions (Gupta and Möller, 2019).

In a similar vein, Swartz (2017) notes the consequences in the present of speculations about the future, or what she refers to as efforts by some blockchain advocates to "colonize" the future, i.e., to act as if the future has already arrived in the present. As she notes:

> 'As soon as a [blockchain related] proposal is offered – whether as a white paper, a slide deck, or a blog post – it is treated as though it already exists, ready to go. Indeed, blockchain projects exist in a particular temporality and have their own sense of the past and future, of change. It performatively leans into a future, always just around the corner, which might as well be here already.' (Swartz, 2017, p. 89)

Visions and speculations, particularly of influential actors, can thus be performative and exercise steering effects. If so, they become particularly important to interrogate.

In light of this, discourse analytical approaches offer the potential to unpack the plurality of ways in which blockchain is being discussed as a means of climate governance (Hajer, 2002; Feindt and Oels, 2005). In this article, we undertake a discourse analysis of key claims being advanced by influential international actors in the multilateral climate governance space, in order to identify and interrogate emerging discourse(s) around climate cryptogovernance, and what they imply for modes and outcomes of climate governance.

We do so by analyzing publicly available texts authored by or linked directly or indirectly to international organizations, such as, for example, the UNFCCC Secretariat and the World Bank. Intergovernmental organizations play an influential role in climate governance through their role as distributors of knowledge, upholders of norms and facilitators of technological and capacity building assistance (Biermann and Siebenhuner, 2009). For this reason, they are key climate governance actors in their own right, as noted by those who theorize them as 'international climate bureaucracies' (Biermann and Siebenhuner, 2009: p.37). Multistakeholder initiatives consisting of technology developers, investors and other actors also collaborate and interact with these organisations in the climate policy space.

Using discourse analysis as our method and the storyline as an analytical concept (Hajer, 2010), we identify here a dominant discourse on climate cryptogovernance being promulgated by these influential actors. This dominant discourse advances the notion that use of blockchain in climate governance arrangements serves to enhance ambitious climate action, through its assumed potential to enhance the (i) reliability, (ii) transparency, (iii) accountability, and (iv) democratic quality of climate governance.

We first present and then critically interrogate this dominant storyline, through examining the assumptions and limitations underpinning the claims advanced on each of these four component elements. We do this by critically interrogating the *assumed direct links* between blockchain technology, and enhanced reliability, transparency, accountability, and democratization in climate governance; and also by identifying the *type or notion* of reliability, transparency, accountability and democratization being advanced within the dominant storyline.

Taken as a whole, this discourse analytical interrogation allows us to discern a privileging of a technocratic and marketized mode of climate governance in the visions of climate cryptogovernance being articulated by influential international actors. We conclude our analysis by reflecting on whether this privileging of a technocratic mode of blockchain-enabled climate governance reinforces what some have referred to as a 'post-political turn' in the environmental and sustainability domain.

2. Blockchain and the emergence of digitalized sustainability governance

There is a small but growing body of social scientific literature examining blockchain in relation to sustainability governance. Early work in this field stressed the potential of blockchain to promote greater sustainability and repair flaws and shortcomings in existing governance systems. These studies for example emphasize the 'unique affordances' of blockchain to contribute to socially and environmentally beneficial outcomes (Kewell et al., 2017), and have proclaimed blockchain a 'game-changer' for sustainability (Chapron, 2017).

What such early explorations of blockchain in sustainability governance have in common is that they focus on *potential* benefits. Furthermore, claims about such benefits rely on rather deterministic links between assumed 'inherent features' of blockchain technology and societal outcomes. A more recent body of work looks more critically at the promises and perils of blockchain in specific sustainability domains, including marine conservation and fisheries supply chains (Howson, 2020a), agriculture and food (Balzarova and Cohen, 2020; Ge et al., 2017), and the (green) electricity system (Buth et al., 2019; Diestelmeier, 2019; Downes and Reed 2020). The emphasis here is on how blockchain may be able to redress key challenges in sustainability governance, such as lack of transparency and trust in global supply chains. This literature also discusses specific technical and socio-political challenges of implementing blockchain initiatives in particular contexts.

The use of digital technologies is also debated in the climate governance literature, although there are only a small number of studies focusing on blockchain specifically. Scholars have assessed the (theoretical) potential of blockchain to address governance challenges in the context of global climate finance (Schulz and Feist 2020) and the 2015 Paris Agreement more generally (Reinsberg, 2021). Other studies include critical perspectives on the use of blockchain in market-based mechanisms such as the Reducing Emissions from Deforestation and Forest Degradation (REDD+) programme (Howson et al., 2019), but also the imaginaries surrounding innovative blockchain-based climate finance experiments (Campbell-Verduyn, forthcoming), and its potential use in disaster response and humanitarian action (Bettini et al., 2020; Zwitter and Boisse-Despiaux, 2018).

What these studies argue is that blockchain initiatives do not land in a political void but instead are implicated in a governance system with existing power imbalances and specific governance rationales. Examining the wider socio-political context of blockchain projects enables a more careful assessment of claims about the potential emancipatory effects of blockchain for the environment and for (different) social groups. Blockchain proposals and initiatives need to be assessed on a

case-by-case basis in order to understand how, and for whom, benefits are created. These critical perspectives echo arguments made in the global governance literature about the political economy of digital technology in sustainability governance. As Peter Dauvergne (2020) argues, corporate actors propose to use digital technologies, such as artificial intelligence, for enhancing the sustainability of their operations but this may legitimize business as usual, hide ecological costs, and strengthen the power of private governance actors. In a similar vein the use of blockchain technology for carbon offsetting and green investments may enable new forms of extraction and resource appropriation from the Global South (Howson, 2020b). Bernards et al. (2020) point to a paradox in technology-led multi-stakeholder sustainability initiatives, which in their words "tend to reduce rather than expand the set of actors, enhancing instead of reducing challenges to participation and transparency, and reinforcing rather than transforming existing forms of power relations" (2020, p. 523).

While this recent scholarship raises important questions and concerns around the use of blockchain and other digital technologies in sustainability governance, real-world blockchain applications are still scarce, and therefore in-depth empirical analyses of how blockchain projects are operating and the effects they have in specific contexts are yet to be conducted. Nevertheless, as with other emergent technologies, expectations around the potential of blockchain continue to be voiced in press statements, reports, news articles, and at conferences (Borup et al., 2006). As such, a study of the discourses (or the 'hype') around blockchain in climate governance, including its promises, benefits and limitations, is precisely the kind of empirical analysis that is currently most suitable, and also most needed, for such an emergent technology. Importantly, our aim here is not to undertake a general assessment of the (theoretical) potential of blockchain for climate governance. Rather, it is to identify and interrogate how influential actors in the international climate arena *talk about blockchain, and how such talk might be performative*, i.e., what climate governance directions it might privilege.

3. Background and methods

For our discourse analysis, we analysed texts and communications put forward by influential international actors. Discussions among intergovernmental organizations about using blockchain for climate governance have only come to the forefront since approximately 2016, and have rapidly gained traction since.

The UNFCCC, for example, is now a co-chair of the Climate Chain Coalition, a global initiative to support collaboration around blockchain for climate action (UNFCCC, 2018).

Following on from tentative expressions of interest in earlier years, the UNFCCC secretariat issued a press release in 2018 entitled 'UN Supports Blockchain Technology for Climate Action' (UNFCCC, 2018). Massamba Thioye, a leading figure in the UN's work on exploring DLT and blockchain, stated that:

> 'The UN Climate Change secretariat recognizes the potential of blockchain technology to contribute to enhanced climate action and sustainability' (UNFCCC, 2018).

Another influential international bureaucracy in the context of climate cryptogovernance is the World Bank. In 2018, the Bank released an extensive working paper on blockchain and emerging digital technologies for enhancing post-2020 climate markets. It has also collaborated with various blockchain and climate-oriented organizations in exploring the topic (World Bank, 2018). The most notable examples are the Hack4Climate, Innovate4Climate and Tech4Climate initiatives of the broader Connect4Climate (2018a) partnership, where the World Bank Group works with the Italian Ministry of Environment and German Federal Ministry for Economic Cooperation and Development to 'take on climate change by supporting ambitious leadership, promoting transformative solutions and empowering collective action'. The co-organization of conferences are further manifestations of the World Bank's interest in developing climate-orientated blockchain based solutions, including the Innovate4Climate conference and #Hack4Climate 2017 (Connect4Climate, 2018b).

We identify and interrogate the promises and perils of climate cryptogovernance as articulated in these emerging collaborations and communications. We thus focus our discourse analysis on emerging visions discernible within or advanced by these influential international actors, where mainstream understandings are just starting to take shape. As other research on emerging technologies has shown, in such an early 'hype' phase, expectations are formed that often focus on the promise of a technology (Borup et al., 2006). At the same time, given the performative nature of early expert visions on novel technologies (Flegal and Gupta 2018; Gupta and Möller, 2019), this is also a key phase in which empirical tracing and critical interrogation of speculative claims becomes particularly necessary.

As our primary source of data, we examine publicly available grey literature, including press statements, reports, news articles, conference materials as well as published secondary literature. In selecting texts, we chose those that (a) explicitly discussed interactions between blockchain and climate; and (b) were authored by or linked directly or indirectly to international bureaucracies, such as the UNFCCC or the World Bank, as well as multistakeholder partnerships and initiatives operating in the international climate policy space. With this in mind, a body of 50 texts, authored by 33 authors over the three-year period 2016 to 2018 were collected.

To identify the content of these early discourses around using blockchain in climate governance, we used a qualitative method of coding the texts. We then engaged in multiple rounds of identifying component elements of what might add up to a dominant discourse, a process that required refining and creating/removing specific elements as we went along. This iterative analysis eventually allowed us to identify four key (and inter-related) component elements of a dominant storyline: reliability, transparency, accountability and democratization. We turn next to presenting and explaining the dominant storyline and the four component elements below.

Table 1
Dominant storyline of climate cryptogovernance and its four elements.

Dominant storyline of climate cryptogovernance Use of blockchain in climate governance enables more ambitious climate action. It does so through enhancing the reliability, transparency, accountability and democratic quality of climate governance arrangements	
Element	Overview of key claims and assumptions underpinning each
Reliability	By shifting trust away from fallible and unreliable human actors onto predictable and neutral computer code, blockchain enhances the reliability of climate governance arrangements
Transparency	By enabling (ac)counting and measurement to make visible carbon market transactions and the climate actions of key actors, blockchain enhances the transparency of climate governance arrangements
Accountability	By stimulating the generation of reliable and transparent information, blockchain enhances the prospects to hold climate actors to account, thereby enhancing accountability of climate governance arrangements
Democratization	Through its decentralized and disintermediated nature, blockchain enhances the democratic quality (i.e., inclusiveness and participatory potential) of climate governance arrangements

4. Identifying a dominant storyline of climate cryptogovernance

When analyzing texts produced by influential international actors, a simple core argument became discernible: use of blockchain enables more ambitious climate action. We characterize this here as a dominant storyline. Through our discourse analysis, we disaggregated this further into four component elements, each of which supported, expanded or contextualized the overarching claim. The four component elements are blockchain's assumed ability to enhance: (a) reliability; (b) transparency; (c) accountability, and (d) democratization of climate governance. We summarize each of these in Table 1 below, and then explain each one further, supported by illustrations from the analyzed texts.

4.1. Reliability

A key element of the dominant storyline focused on the potential of blockchain technology to enhance *reliability* of climate governance arrangements. Specifically, the key claim is that through enshrining trust away from human actors onto efficient and neutral computer code of blockchain and associated technologies, the management of carbon and subsequent mitigation of climate change can be more effectively achieved.

An example of this reliability element of the storyline is provided in a news article in which Sven Braden, a member of the Climate Ledger Initiative is quoted. He states:

> 'Right now, in terms of mitigation, everything goes through the UNFCCC and the CDM –it's centralised. One of the major challenges is in synching databases to ensure all ledgers have the same information. With blockchain, you don't have to check the datasets and that they all add up, you just have to check the hash.[1]' (Lovett, 2018)

According to this element of the storyline, blockchain enhances the reliability of climate governance through the *technologized streamlining of existing administrative processes*, particularly relating to measuring, reporting and verification (MRV) procedures and systems under the UNFCCC. It is assumed to have the potential to redress what is seen as a major challenge facing mitigation: the need to reform existing administrative processes. Thus, the key tenet of this element is that existing technologies and administrative procedures are characterized by a certain degree of unreliability and cumbersomeness that can be reduced through deployment of blockchain.

As a result, this element often emphasizes the importance of trust, harking back to the earliest arguments made by Chapron (2017) in his discussion of environmental cryptogovernance. The claim is that blockchain can replace the need for human trust by ensuring reliability and reducing uncertainty through use of computer code. This logic is summarised by an overview of the CIGI Climate Cup Roundtable event:

> 'As the technology eliminates the need for a trusted party to facilitate digital relationships or curate data, it also vastly expands the range of automatable operations about which it is possible to have reliable information.' (Aganaba-Jeanty et al., 2017)

Similarly, an article published on the World Economic Forum website as part of the Sustainable Development Impact Summit diagnoses a fundamental lack of reliability in existing carbon markets that could be reduced through the application of blockchain. The chief executive of Ecosphere+, which is a carbon credit solution business and member of the Climate Chain Coalition, writes:

> 'Differing standards and regulations in different jurisdictions and the potential for double counting have resulted in a lack of confidence from potential market participants. And without a universal ledger it isn't easy to track how much carbon you've used or – if you offset it –what the impact of your reduction has been on a tangible level.' (Walker, 2017)

All in all, the *reliability* element of the dominant storyline proposes that through enshrining trust into computer code, blockchain can facilitate more optimal climate mitigation in the context of presently unreliable and administratively cumbersome governance arrangements.

4.2. Transparency

The *reliability* component of the dominant storyline often interacts with another widely evoked element, relating to *transparency*. In fact, blockchain's claimed potential to enhance transparency underpins, in important ways, the claims around reliability explored above. This notwithstanding, the 'transparency' component of the dominant storyline extends beyond its connections to reliability, and is one of the most consistently present elements within the texts and communications that we analyzed.

This element of the storyline diagnoses the current activities of climate governance as being all too often opaque in nature, and thus suffering from a lack of transparency. As Ecosphere+'s chief executive suggests in a World Economic Forum web article in the context of carbon trading:

> 'Since its inception, carbon trading has suffered from some issues that have suppressed its potential. The market is beset by a lack of visibility, which prevents people from trusting the carbon credit as an asset' (Walker, 2017)

The above quote highlights one common thread within the transparency element: the importance of transparency for integrating stakeholders into marketized climate governance. Blockchain is posited as crucial way forward to realize this aim. As the World Bank headed initiative 'Connect4Climate' notes, this is assumed to be so because blockchain:

> ' … increases transparency and thus stakeholder involvement." (Connect4Climate, 2018b)

Similarly, as the Carbon Ledger Initiative argues in the case of blockchain technology:

> 'Major transparency advances are well within reach, which is vital for successful stakeholder integration and thus to reach a larger scale.'(CLI, 2018a)

A strong normative element is also present in the transparency element, with transparency advanced by advocates as a vital element of good governance. The ClimateCoop for example, a 'blockchain based platform' which won a 2018 'Synergistic Solutions for Sustainable Development' contest co-organised by UN Environment (dCentra, 2018), argues for the value of the transparent and openly accessible features of blockchain in maintaining the common public sector principles of "Transparency, Democracy, Incorruptibility & Auditability" in climate governance (ibid).

The 'transparency' element was often explicitly linked to carbon accounting. Key technical phrases used include: carbon stocktaking, carbon leakage, additionality, double counting (of carbon), and monitoring, verification and reporting (MRV). Indeed, the fundamental promise of blockchain in relation to transparency is to provide what a report by the World Economic Forum (WEF) and PricewaterhouseCoopers (PwC) describes as:

> 'next-gen sustainability monitoring, reporting and verification' (WEF & PwC, 2018)

[1] A hash can be seen as a digital fingerprint of the data stored in the blockchain. Hashing is used to store data in a change-sensitive way. By checking the hash value, a user can thus verify whether the stored data has been changed or not (Drescher 2017).

A particularly notable aspect of the transparency element is in the case of REDD+, where discussion has centered on commodifiable carbon as a key mode of climate governance. Discussing a distributed ledger technology (DLT) solution targeted at REDD + at the Innovate4Climate conference, a news article from the European Institute of Innovation and Technology (EIT) Climate-KIC states the following:

> 'Developed in close cooperation with Cleantech21, REDD-Chain exemplifies how DLT might be used in forest conservation. It posits a global forest ledger where every square meter of land is identified using remote sensing, satellite, and/or drone technology. Then, the forest can be monitored using images taken at different time intervals—to determine whether it's still intact. Recorded on a publicly accessible distributed ledger, this data could be used to stimulate climate finance. For example, countries could be paid to keep their forests intact and plant new trees.' (EIT Climate-KIC, 2018)

With its emphasis on quantifying carbon and other greenhouse gases, the above example demonstrates the typical rhetoric around the transparency element. Forests are understood as carbon sinks which can be rendered amenable to management and control, facilitated by use of blockchain.

A similar sentiment is expressed in some secondary literature in the context of the 2015 Paris Agreement's implementation:

> 'Article 6 of the Paris Agreement urges nations to 'apply robust accounting' methods to ensure transparency in their emissions mitigation efforts. The public, decentralised and immutable nature of DLTs may be the key to ensuring accurate emissions reporting. More accurate and verifiable results can be recorded by enabling climate data to be input and shared on a blockchain; not only by government sources, but also by NGOs, local communities and businesses.' (Truby, 2018)

In general, transparency is often taken for granted as being unequivocally positive and automatically leading to substantive climate impacts. For example, Laura Altinger, a senior climate change adviser to the UN Economic and Social Commission for Asia and the Pacific, is reported as saying:

> 'As long as you agree on the MRV behind it, it kind of gives it the transparency and the credibility and allows you to develop a mechanism based on the Paris Agreement for internationally transferrable mitigation outcomes and carbon trade across borders … ' (Namgyal, 2018)

Regardless of whether it is applied to carbon accounting or carbon trading, the widely used *transparency* element proposes the following: blockchain enhances transparency, and transparency is required both for effective climate governance and enhanced climate action.

4.3. Accountability

Reliability and *transparency* in turn often interact with the *accountability* element of the dominant discourse. Here, authors of analyzed texts identify a lack of accountability in climate governance arrangements that may be redressed by using blockchain to augment generation of transparent and reliable information. For example, a news article from the EIT Climate-KIC claims:

> 'transparent decentralised ledger could indeed be a more trustful way of recording impact and validating delivery on environmental commitments for various stakeholders' (EIT Climate-KIC, 2018)

Specifically, the accountability element often centers around a claim that, due to lack of transparency and reliability of information about measurable greenhouse gas emissions, governance actors are unable to make informed decisions or penalize free-riders. For example, the Climate Ledger Initiative claims the following regarding the Paris Agreement:

> 'Two of the most fundamental challenges facing the Paris Agreement are to ensure that different countries exchange information on their greenhouse gas (GHG) emissions safely and transparently, as well as take responsibility for their promised actions.' (CLI, 2018b)

The claim is that by bringing to light their actions through the transparency enabled by blockchain technology, key actors can be held accountable for opaque activities. For example, Jon Truby in *Nature Middle East* suggests:

> 'Blockchain would facilitate localised reporting of climate data to help hold nations to account on their mitigation results, regardless of political obstacles.' (Truby, 2018)

Similarly, a World Economic Forum (WEF) and PricewaterhouseCoopers (PwC) report highlights the accountability element in a report on blockchain in climate governance, by making the ambitious claim that:

> '[B]lockchain has the potential to transform both sustainability reporting and assurance, helping companies manage, demonstrate and improve their performance, while enabling consumers and investors to make better-informed decisions. This could drive a new wave of accountability and action, as this information filters up to board-level managers and provides them with a more complete picture for managing risk and reward profiles' (WEF & PwC, 2018)

Seldom present in the accountability element are specific redress mechanisms through which such account-holding would occur. Regardless of how the accountability storyline is utilized, the crux is that with the enhanced transparency that accompanies use of blockchain comes enhanced accountability, as the actions of nation states and other powerful actors can be held up to scrutiny.

4.4. Democratization

A final element of the dominant storyline is the idea that blockchain enhances *democratization* of climate governance, through facilitating inclusiveness and increased participation of a diverse array of actors, and thereby enhancing the democratic quality of climate governance arrangements. The common thread running through this element is the increased possibility of participation of citizens, consumers and individuals in climate governance, also under the auspices of the 2015 Paris Agreement. This democratization potential is linked to the disintermediated and decentralized character of blockchain.

The disintermediation aspect is visible in claims that blockchain can be applied to situations that otherwise may favor powerful governance actors, to reduce power imbalances. For example, a policy brief published by G20-oriented think tank consortium 'G20 Insights' argues the following about Distributed Ledger Technologies (DLTs), such as blockchain:

> 'By design, they move away from a global economic order centered around powerful but not always trustworthy intermediaries – whether financial institutions, GAFA and BAWT type companies (Google, Amazon, Facebook, Apple and Baidu, Alibaba, Weibo, Tencent, respectively), or in some cases insufficiently accountable government bodies. Blockchain usage tends toward a more decentralized and democratic order which empowers individuals to participate in the global economy directly through systemically embedded transparency, accountability, and inclusiveness mechanisms' (Maupin, 2017)

The claim here is that, where climate governance formerly may have been prejudicially influenced by powerful intermediaries, the neutrality that blockchain endows on climate governance processes can reduce power imbalances. Moreover, the democratization element also heralds

the potential of blockchain to foster participation of, and collaboration between, a variety of actors. A 2018 report by the World Economic Forum (WEF) and PricewaterhouseCoopers (PwC) states that blockchain-based solutions for climate change:

> 'will require deliberate collaboration between diverse stakeholders ranging from technology industries through to environmental policy-makers, underpinned by new platforms that can support these stakeholders to advance not just a technology application, but the systems shift that will enable it to truly take hold.' (WEF & PwC, 2018)

The Greenhouse Gas Management Institute, a non-profit organisation that trains experts on how to credibly account for GHG emissions, including for purposes of UNFCCC reporting, identifies the potential for blockchain to draw stakeholders into climate governance. It suggests that:

> 'Blockchain will be one unexpected force that is capable of stimulating higher levels of participation and ambition and mobilizing large-scale investments into climate actions to achieve the Paris goals.' (Baumann, 2017)

In this component of the storyline, blockchain thus fosters the pooling of resources of multiple actors, which allows for 'coalitions of the ambitious' that encompass diverse actors, including but not limited to blockchain developers, private and public sector organizations, NGOs, academia and citizens. In this view, blockchain ensures effective climate action through bottom-up activities. In line with an increasing turn towards 'polycentric' governance structures that cut across local to national to transnational levels (Au et al., 2011), blockchain is understood as a technology that enables participation across geographical scales. For example, the Blockchain & Climate Institute highlight the potential of blockchain to:

> 'revolutionise currency, government, and corporations - and the climate as well, through facilitating renewable energy grids, accelerating international climate finance, and empowering consumers to make climate-conscious decisions.' (Blockchain & Climate Institute, 2018)

The argument is that blockchain may offer the ability for local actors to gain power through a 'democratization' of climate governance achieved by the decentralized nature of blockchain. A spokesperson for the Climate Investment Funds, which operate in conjunction with multilateral development banks, proposes that blockchain will:

> 'fuel new experiments in secure identity, distributed ownership, and financial transactions. These tools will push us to rethink scale, enabling investment and insurance for more local, less mainstream climate projects' (CIF, 2018)

In the context of decentralization, it is worth paying explicit attention to the purported rescaling of climate governance down to the *individual level* by blockchain. In fact, it is often proposed in the texts we analyzed that climate cryptogovernance will allow for individuals to govern the climate in ways previously unachievable. Blockchain discourses here also intersect with broader discussions on green consumerism, as demonstrated in the following quote from a World Economic Forum published web article:

> 'And crucially, for the first-time consumers will be able to understand the environmental impact of the products they are buying – both positive and negative – at the point of sale, and will be able to mitigate this in an instant, with millions of micro-transactions scaling up to make a huge collective impact.' (Walker, 2017)

According to the democratization element of the dominant discourse, through blockchain's transparency-inducing and participation-enhancing properties, information asymmetries are vanquished for individual consumers and they are empowered in their decision-making. Responsibility is placed in the hands of the people, as the cumulative decisions of individuals and their micro-scale transactions are purported to scale up to culminate in collective impacts. In the same article, it is stated that:

> 'It is not an overstatement to say that we all need to take responsibility for the carbon consequences of every choice we make. What is exciting is that by creating a global, trusted and accessible carbon currency, with the help of new digital technologies available to us, we are on the cusp of being able to do so.' (Walker, 2017)

Such a rescaling of climate governance involves a redistribution of the responsibility for climate change, as individuals are understood to be the ones that contribute to, and must tackle, climate change through their own actions. All in all, the *democratization* component emphasizes that through blockchain, the locus of climate governance can increasingly be rescaled in ways previously unobtainable.

5. Interrogating the dominant storyline of climate cryptogovernance

A key function of storylines, according to Hajer (2010), is that they facilitate the reduction of the complexity of a problem, and allow for problem closure through developing shared understandings. The storyline harnessed by influential climate actors to create collective understandings of climate cryptogovernance is thus also inherently simplifying. Such an understanding of storylines implies, however, that complexity and uncertainty are not vanquished but still loom behind the knowledge claims made by actors. To better understand how discourses around blockchain might eventually impact on climate governance directions, it is thus crucial to illuminate some of the tensions and limits of the claims being advanced.

Below, we first critique the dominant storyline for assuming a direct link between certain properties of the blockchain, and enhanced reliability, transparency, accountability and democratization of climate governance arrangements in practice. We then critically interrogate whether and how the dominant storyline reinforces specific notions of reliability, transparency, accountability, and democratization, and with what implications for governance.

5.1. Interrogating reliability

The *reliability* element proposes that blockchain renders existing governance arrangements more reliable, by shifting power away from unpredictable human actors and into predictable computer code. This reliability is a key stand-alone component of the dominant storyline but also one that underpins the other three.

The claim that blockchain eliminates the necessity for trust in a third party or a central authority is a prominent one, also going beyond the climate domain. Through the use of smart contracts, transactions can be automated and conducted without any human intervention (Wright and De Filippi 2015). Users who transact with each other do not have to trust each other or a third party, because the software code regulates behaviors and interactions of people (De Filippi and Hassan 2018).

Yet, such an understanding of software code as a neutral intermediary ignores the diverse ways in which human decision-making and subjectivity is involved. For example, the coding of a blockchain application is the result of choices and decisions by programmers, for example about the required format and quality of input data, or the setting of the threshold for an algorithm to generate a certain outcome. The idea that blockchain automatically generates and even expands the amount of reliable data about climate disregards the many intermediate steps, value judgements and processes of translation inherent in algorithmic processes (Kloppenburg and Van der Ploeg, 2020). Like any technology, blockchain is not neutral.

Also, while blockchain may enable the automation of data exchange and carbon transactions, much more than that is needed for a reliably functioning carbon market, or a functioning MRV scheme. A blockchain, for example, can never verify whether a tree has actually been planted, or whether REDD + funds reach all members of a community. Even though with the rise of Internet of Things devices, the possibility to make links between physical entities and their digital representation on the blockchain increases, ensuring the accuracy of such information remains a challenge (Reinsberg, 2021). A blockchain records and enables *digital* transactions, thus what happens on the blockchain does not necessarily have links with the real world. In other words, the relations between blockchain and the wider socio-technical infrastructure of the governance arrangement it is assumed to improve needs further scrutiny.

Finally, blockchain projects are created and implemented for purposes that are often far from neutral. The implementation of blockchain technology embodies and reinforces political values in and of itself and may privilege particular modes of governance. This is what Husain et al. (2020b, p.1) refer to as 'prefigurative' politics, whereby in their design, blockchain projects 'embody the politics and power structures that they want to enable in society'. Critical authors have thus also analyzed blockchain's use in governance as a development towards 'technical regulation' (De Filippi and Hassan, 2018). Because blockchain relies on input that can be read and executed by a machine, it requires the (further) formalization of bureaucratic, expert-dominated, or administrative procedures. This has material consequences in terms of new power relationships and sources of authority emerging but also risks feeding into and reinforcing technocratic modes of climate governance.

5.2. Interrogating transparency

The transparency element of the dominant storyline places great emphasis on the importance of rendering visible what countries and other powerful actors are doing, including via a growing emphasis on monitoring, reporting and verification systems. Blockchain technology is seen here to facilitate an ongoing push to make visible and quantify greenhouse gas emissions (also through the ledgering of numerical transactions that blockchain facilitates). As elaborated in section 4.2, a clear motivation for such quantified climate transparency is to facilitate the functioning of carbon markets.

Critics of such quantification question, however, the merits of rendering climate actions transparent through such practices. Blockchain, as an auxiliary technology that builds on decades of technocratic approaches to climate governance (Bäckstrand and Lövbrand, 2006), is hardly pathbreaking in its emphasis on measurement as a way to facilitate effective climate actions (Gupta et al., 2021; Weikmans and Gupta 2021). It nonetheless amplifies the risk of crowding out alternative ways that look beneath the legible veneer of numbers (Scott, 1998).

As various observers have noted, the quantification that blockchain facilitates may result in a narrow and simplified interpretation of reality, legitimated by an understanding of numbers as disinterested and trustworthy (Rose, 1993). In critiquing such a view, Scott (1998) shows that measurement is an inherently political task, given the need to make critical choices about what to measure and how to render an object measurable. While measurability may be framed by blockchain advocates as an objective collection of data to augment transparency, it may in fact have the effect of further stimulating certain forms of centralized control, coordination and exchange that crowd out alternative understandings of the world that resist quantification (Scott, 1998; Agrawal, 2005).

This claim is important in order to critically interrogate what blockchain helps to render visible and how that relates to specific modes of climate governance.

Turnhout et al. (2014), for example, invoke Latour (2004) to show that the use of seemingly neutral quantitative knowledge is anything but neutral, as ecological phenomena are made legible in line with specific political and economic logics. The quantification that blockchain secures pushes towards an environment that is numerically measured and can be broken down into discrete GHG units that are commensurable and exchangeable in carbon markets. Turnhout et al. (2014, 583) term this 'measurementality', which they understand as, "an 'art of neoliberal governance' that emerges from privileging scientific techniques for assessing and measuring the environment as a set of standardized units which are further expressed, reified, and sedimented in policy and discourse and which, in turn, render the environment fungible". Such measurementality is tied up with the new modes of transparency emerging under paradigms of new public management and neoliberalism, and particularly reflected in the unprecedented surge in audit and MRV systems in sustainability governance.

This brings under a critical radar that claim that transparency is an unequivocally positive governance goal that will lead to substantive enhancement of climate ambition. Gupta and Mason (2016), for example, list hurdles hampering the effectiveness of information disclosure in climate governance, including inadequate design of disclosure, the attributes of information disclosed (whether standardized, accurate and comprehensible), the quantity of disclosed information (complete or partial), and the influence of intermediaries, such as auditors and certifiers. With respect to the latter category, while the presence of some intermediaries is likely to decrease in the context of climate cryptogovernance, these may still exist as powerful actors in decentralized modes of system design and oversight (Campbell-Verduyn, forthcoming).

A key question that arises then is: what aims are furthered via blockchain-enabled climate transparency? Disclosure through blockchain-based solutions may not necessarily be in the interests of all stakeholders, despite the claim of advocates that transparency directly enhances trust, stakeholder engagement and (ultimately) more ambitious actions. This is because the ends to be secured via greater climate transparency are diverse and are connected to the ever more heterogeneous and fragmented nature of climate governance itself, which encompasses multiple state and non-state actors across scales (Gupta and Mason 2016). Such arrangements may render the rationales of 'governing through transparency' divergent and potentially contrary to one another, as a growing body of work in 'critical transparency studies' now shows (Ciplet et al., 2018; Gupta and Mason, 2016; Weikmans et al., 2020).

Gupta and Mason (2016) identify, for example, four possible rationales for the uptake of transparency that embody quite different logics of climate governance: a democratization, marketisation, privatization, or technocratization rationale.

As case studies of the Carbon Disclosure Project data and REDD+ reveal, a democratization imperative underpinning public and private transparency can become blunted by rationalist managerial norms of technocratization that drive uptake of transparency (ibid). Transparency may improve domestic decision-making and facilitate peer-to-peer learning, but may also augment private authority, if disclosed information remains behind expensive paywalls. Thus, the professionalization and specialization of climate transparency may result in information that was intended as 'public' becoming restricted or rendered opaque to relevant publics. These different rationales to embrace transparency signal a warning for blockchain: information disclosure may be one important step, but it is never sufficient to ensure inclusive cryptogovernance. Without intentional creation of accessible channels for information to be transmitted, there is no way to ensure that data made transparent by blockchain technology will be publicly accessible or will facilitate comparability or improved environmental performance of powerful actors.

5.3. Interrogating accountability

Related to the above, another key component of the dominant storyline pertains to the ability of blockchain to ensure that powerful actors are held accountable for their climate-related actions. Here a

strong link is posited between *transparency* and *accountability* as central to furthering ambitious climate governance. The illuminating power of transparent information is assumed to be able to render visible formerly opaque actions of diverse actors, thereby enabling the holding of such actors to account.

Yet, critical literature shows the limits to this assumed link between transparency and accountability, while highlighting the challenges of holding states to account in a context of hybrid, multi-actor climate governance (Gupta et al., 2021). As the few scholarly analyses explicitly interrogating the link between transparency and accountability have argued, this assumed link is far from straight-forward. Fox (2007) differentiates between soft and hard accountability; wherein soft accountability refers to states being answerable for their actions and hard accountability includes the possibility of sanctions for lack of performance. While transparency may further soft accountability through facilitating institutional 'answerability' (where actors justify their decisions), there is nothing to suggest that transparency leads to hard accountability. The sanctions, compensation or remediation that would be needed to push the transformative changes imagined of climate cryptogovernance are not a direct outcome of increased transparency.

This disconnect between transparency and accountability holds for multilateral climate governance as well, wherein there are limited mechanisms through which actors can formally be held to account. Mason (2008) outlines how the very nature of transnational issues, such as climate change, are not amenable to conventional pathways of accountability. Diplomatic efforts to hold actors to account through treaty negotiations clash with the geopolitical interests of states and the principle of state sovereignty (ibid.). The exclusive political authority of states over their own populations as a basis for public international law is a barrier to redress, and rules of voluntary consent to international regulation and non-interference by other states in domestic affairs weaken the effectiveness of intergovernmental attempts to hold offenders to account (Mason, 2008). Any claims about the ability of blockchain to hold actors accountable must therefore be considered in this light, with some of these considerations reflected in the already contentious nature of UNFCCC MRV systems, where the international verification of domestic actions has been seen as a potential impingement upon national sovereignty (Gupta and Mason, 2016).

A seemingly simple relationship between transparency and accountability becomes further complicated by systems of transparency becoming sites of political conflict and negotiation over who bears responsibility for taking what action, and who should thus be held accountable to whom for what (Gupta and van Asselt, 2019). Furthermore, looking beyond the nation state, there are additional challenges in operationalizing accountability, as responsibility for taking action is increasingly diffuse and operates at multiple scales. As responsibility moves beyond the state, traditional redress mechanisms, such as those enshrined in international environmental law or institutions, become even less feasible. Indeed, despite the potential for mobilizing international civil society to hold key actors to account for unambitious climate actions made more visible by blockchain, if there is no explicit redress mechanism, accountability is unlikely to be furthered.

Finally, in discussing accountability for climate damage, we open a Pandora's box of discussions about cause-effect relationships between the actions of actors and substantive impacts that manifest in the interdependent and uncertain climate system. If so, despite promising claims put forward by some actors advocating for climate cryptogovernance, the impacts of blockchain in achieving effective outcomes through the union of transparency and accountability are likely to fall short, due to complex pathways linking transparency to accountability, and due to challenges of holding states and other powerful actors to account.

5.4. Interrogating democratization

A final component of the dominant storyline is about *who* actually partakes in climate cryptogovernance. This *democratization* component emphasizes the inclusive and multi-stakeholder nature of climate cryptogovernance, with the potential for involvement of a diverse range of actors across scales. Yet, the link between blockchain and democracy as well as the boost this democratization may give to climate actions are not self-evident.

The democratization element stresses that blockchain enables greater and more equal participation in climate governance. However, the question is who will actually partake in the design and implementation of blockchain-based applications, and where the power to do so lies. In considering who ultimately shapes climate cryptogovernance, it is important to analyze entitlement and status in the form of admission to (climate cryptogovernance) multi-stakeholder partnerships. Swyngedouw (2005) explores how the assignment of such status is not neutral, and conferred upon participants who already exercise a certain power.

This has implications for would-be blockchain solution developers and users, who reject mainstream political action or adhere to alternative political views, such as deep ecologist, anti-globalist and anti-capitalist actors (Swyngedouw, 2005). The new choreographies of non-state governance and hybrid climate governance wherein blockchain features thus may give rise to the prominence of particular social actors, but exclude or diminish other social actors (ibid.). Or they may continue to exclude actors who have never had a seat at the table in the first place. Considering the largely reformist nature of the blockchain-based initiatives that have sparked the most interest, it is possible that actors ideologically aligned with market-based approaches and those from the Global North will remain at the center of decision-making, while social democratic and anti-privatization groups seeking to represent those in the developed world remaining on the margins (Campbell-Verduyn, forthcoming).

A useful distinction here is thus between incorporative/incremental and radical blockchain-based climate governance approaches (Swartz, 2017). Incorporative projects slot into existing (financial) institutions, they do not necessarily seek to transform underlying structures, but rather to make existing systems or processes more efficient or transparent. Radical projects, on the other hand, challenge existing social and political structures and aim to create new techno-economic orders (ibid.) This distinction between incorporative and radical projects highlights that there is nothing inherently democratizing about blockchain technologies. Instead, for each individual use, we need to critically examine the political imaginary behind the project (Husain, Franklin & Roep 2020a), the actors involved, and how their visions and design choices challenge or entrench power relations and decision-making.

With blockchain offering to rescale climate governance down to the individual level via platform and app-based solutions, there are also broader critical questions about the extent to which individualizing climate governance enables meaningful participation. It is worth reconsidering the claim made by some actors advancing the *democratization* component that a limiting factor to mitigating greenhouse gas emissions is that consumers have imperfect information about the climate impacts of their actions or purchased products. A growing body of critical theorists have argued against such a diagnosis, showing that green consumerism overemphasizes the agency of individual consumers, when the ability to enact substantial change in consumption patterns lies with large producers (Scales, 2014). Soneryd and Uggla (2015) highlight the paradox between 'simple solutions', which in this case include buying products with blockchain-enhanced transparent supply chains or offsetting emissions with blockchain-based credits, versus acknowledging the global, transboundary and complex character of environmental problems. In other words, whereas blockchain solutions may enable consumers to engage in various climate actions—participation in carbon markets, tracking and offsetting emissions—this does not necessarily challenge underlying unsustainable patterns of consumption

and their political, economic and cultural causes.

Moreover, in order to assess the 'collective impact' of these micro-transactions, we need to examine who can access, use and benefit from market-based approaches to climate governance. As such, the collective impact of individual actions may not be as large as proponents suggest. Even if blockchain *technically* makes visible individuals' carbon footprint and enables 'instant' mitigation at the individual level, it is still the individual who has to act on that information, and make the active choice to offset emissions.

In sum, interrogating the democratization claim embedded in the dominant discourse of climate cryptogovernance highlights both the power dynamics within which such a claim has to be assessed, and throws into relief the power and promise of individual agency versus the structural dimensions of securing effective and ambitious climate action from all.

6. Conclusion

This article has considered claims advanced by influential international actors regarding the promise of using blockchain technology in climate governance ('climate cryptogovernance'). In scrutinizing these claims through a discourse analytical lens, we identified a dominant storyline underpinning climate cryptogovernance, with four component elements. The dominant storyline sees blockchain as a potentially powerful handmaiden in realizing more ambitious future climate action, through its propensity to engender more reliable, transparent, accountable and democratic climate governance. In interrogating this dominant storyline, we showed that, far from transforming current modes of governance, it risks privileging further the currently dominant technocratic, market-friendly and procedural approach to multilateral climate governance. As such, our analysis highlights that, despite claims about its transformative potential, climate cryptogovernace is often imagined by influential actors in an incorporative and incremental rather than radical manner.

Our interrogation of influential claims relating to climate cryptogovernance suggest that the most widely anticipated applications of blockchain relate to augmenting the efficiency of market-based approaches to climate governance. This is unsurprising, if we consider that blockchain has increasingly taken on the identity of fintech, with its incorporation into mainstream financial markets and with a move away from the bottom-up, transformative and disruptive cryptocurrency solutions imagined in its earliest iterations. This latter is characterized by Husain et al. (2020b) as cryptoanarchism, in contrast with the mainstream, reformist cryptoinstitutionalism that undergirds the dominant discourse that we identify here.

The reinforcing of mainstream market-based modes of climate governance implicated in the dominant storyline highlights, as we suggested at the outset, the performative power that speculative future claims about blockchain-enabled climate governance can exercise in the present. Our analysis shows not only how the dominant storyline advanced by influential international actors can exercise *de facto* steering effects in the present, but also the directions in which such steering might go (Gupta and Möller 2019).

In sum, our distilling of a dominant discourse and the critical interrogation thereof suggests two things: on one hand are the bold claims made by advocates of climate cryptogovernance regarding the transformative impacts of blockchain in fostering more reliable, transparent, accountable and democratic climate governance. On the other hand, the dominant discourse privileges, in practice, the light-touch, voluntary, technocratic approach to climate governance that currently dominates, with one key aim to facilitate carbon markets.

Yet such approaches have thus far failed to realize the scale of ambitious action needed to prevent dangerous climate change. In concluding, therefore, we note that this constellation of elements is akin to what has been referred to a 'post-political' (Wilson and Swyngedouw 2014) turn in climate and sustainability governance (see also Clark and Flannery, 2020). As Wilson and Swyngedouw suggest (2014, p. 6), in post-politics, 'political contradictions are reduced to policy problems to be managed by experts and legitimated through participatory processes in which the scope of possible outcomes is narrowly defined in advance'. In exploring this concept further within marine spatial planning, Clark and Flannery note that the 'post-political' consists of 'highly-interconnected modalities of depoliticization, including: neoliberalism, choreographed participation, path dependency, technocratic-managerialism and the illusion of progressive change' (2020, p. 170).

The dominant storyline of climate cryptogovernance that we identify here manifests many of these elements of the 'post-political'. In ascertaining these, our analysis also draws attention to the often-unspoken contradiction between the accountability and democratization strands of the dominant climate cryptogovernance storyline versus a reinforcing of business-as-usual, technocratic and de-politicized modes of climate governance in practice.

To quote a developer interviewed in Swartz (2017), blockchain is 'not magic beans, it's just software". Yet our argument here, drawing on our analysis, is that the design of the software and its evocation by influential climate policy actors requires critical scrutiny. The need of the hour, we argue, is to interrogate and re-politicize visions relating to blockchain 'software' and its transformative potential. This could be done by interrogating and reconsidering the design of blockchain-based projects, by paying attention to who has access rights to information on the blockchain; or by enabling participation of NGOs, for example, in the approval of digital transactions (Reinsberg, 2021).

That said, another key challenge is the need to counter the privileging of measurement, the prioritization of market efficiencies, and the technocratic mode of climate governance that the dominant storyline advances. This technocratic approach risks generating what Andrew Barry has described as 'anti-political' effects, wherein 'governments become less concerned with questions of distribution and public ownership, and more concerned with fostering a culture of … monitoring, measurement, auditing, testing and compliance. And [with] all such activities …. delegated to experts' (Barry 2002, 279–280). Aligned with this, the dominant mode of technocratic climate cryptogovernance can crowd out alternative and necessary approaches, including mandatory state-driven regulation that targets the structural causes of climate change and the most powerful actors implicated herein (see also Gupta 2019).

In concluding, we should note that our focus here has been on visions and discourses around blockchain-based governance as articulated by a set of actors operating in the international climate policy space. Outside these spaces, other discourses may be emerging. Furthermore, the dominant discourse we have identified is being put forward at an early stage of technology development, and is thus likely to be speculative and optimistic at the same time. Future research is needed to examine how this dominant discourse changes and evolves over time, what tensions and contradictions appear and whether different coalitions with complementary or competing discourses emerge.

Furthermore, even as a current dominant climate cryptogovernance discourse appears to interface with international climate policy in an incorporative rather than a radical manner, this does not foreclose the possibility that blockchain can be envisioned in more radical terms. Blockchain makes possible, for example, the creation of so-called 'tokens'—digital representations of a physical good or unit of value—which theoretically allow for alternative valuations of things or practices.

It is important thus to also focus, in future research, on emerging projects, events, and collaborative spaces wherein actors may promote and initiate blockchain projects with the explicit aim to enhance the agency of marginalized actors or address inequities in the current system. Such alternative discourses and real-world experiments relating to climate cryptogovernance may emerge in very different settings. Our analysis here suggests that it will be important to ask whether and in

what ways such alternative discourses and future experiments will enter the spaces of international climate policy, with what effects, and how scalable they may be. While any claim about the transformative potential of blockchain needs to be critically interrogated, the performativity of emancipatory visions of blockchain and their potential to (re-) politicize climate governance also warrant our attention.

CRediT authors contribution statement

Jed Hull: undertook the first literature review, developed an initial article draft and undertook the empirical analysis. **Aarti Gupta** and **Sanneke Kloppenburg:** contributed to conceptual development and the writing of the article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Aganaba-Jeanty, T., Anissimov, S., Fitzgerald, O., 2017. Blockchain Climatecup Round Table [Online]. Centre For International Governance Innovation, Toronto, Canada. https://www.Cigionline.org/Sites/Default/Files/Documents/2017_toronto_climatecupweb-final1.Pdf. (Accessed 28 October 2018).

Agrawal, A., 2005. Environmentality. Curr. Anthropol. 46 (2), 161–190.

Al-saqaf, W., Seidler, N., 2017. Blockchain technology for social impact: opportunities and challenges ahead. Journal Of Cyber Policy 2 (3), 338–354.

Au, B., Conrad, B., Deng, L., Hale, T., Liepprand, T., Lieber, A., Wang, J., 2011. Beyond a global deal. A UN+ Approach to climate governance (Berlin: Global Public Policy Institute).

Bäckstrand, K., Lövbrand, E., 2006. Planting trees to mitigate climate change: contested discourses of ecological modernization, green governmentality and civic environmentalism. Global Environ. Polit. 6 (1), 50–75.

Balzarova, M.A., Cohen, D.A., 2020. The blockchain technology conundrum: quis custodiet ipsos custodes? Current Opinion in Environmental Sustainability 45, 42–48.

Baumann, T., 2017. What is blockchain GHG management? - GHG and carbon accounting, auditing, management & training | greenhouse gas management Institute [online] GHG and Carbon Accounting, Auditing, Management & Training Greenhouse Gas Management Institute. At. http://ghginstitute.org/2017/10/18/what-is-blockchain-ghg-management/. (Accessed 16 January 2019).

Bernards, N., Campbell-Verduyn, M., Rodima-Taylor, D., Duberry, J., DuPont, Q., Dimmelmeier, A., Reinsberg, B., 2020. Interrogating technology-led experiments in sustainability governance. Global Policy 11 (4), 523–531.

Bettini, G., Gioli, G., Felli, R., 2020. Clouded skies: how digital technologies could reshape "Loss and Damage" from climate change. Wiley Interdisciplinary Reviews: Climate Change 11 (4), e650.

Biermann, F., Siebenhüner, B., 2009. Managers of Global Change, first ed. MIT Press.

Blockchain & Climate Institute, 2018. New book reveals blockchain solutions to fight climate change [online] blockchainclimate.org. Available at. https://ipci.io/blockchain-is-a-powerful-solution-to-climate-change- problem-the-new-book-claims. (Accessed 29 September 2021).

Borup, M., Brown, N., Konrad, K., Van Lente, H., 2006. The sociology of expectations in science and technology. Technol. Anal. Strat. Manag. 18 (3–4), 285–298.

Buth, M.A., Wieczorek, A.A., Verbong, G.G., 2019. The promise of peer-to-peer trading? The potential impact of blockchain on the actor configuration in the Dutch electricity system. Energy Research & Social Science 53, 194–205.

Campbell-Verduyn, M. (forthcoming) Conjuring a Cooler World? Imaginaries of climate governance evolving in blockchain space. On file with authors.

Chapron, G., 2017. The environment needs cryptogovernance. Nature 545 (7655), 403–405.

Ciplet, D., Adams, Kevin M., Weikmans, Romain, Timmons Roberts, J., 2018. The transformative capability of transparency in global environmental governance. Global Environ. Polit. 18 (3), 130–150.

CITES, 2017. Sixty-ninth meeting of the standing committee - information documents. Cités. Retrieved From. https://cites.org/Eng/Com/Sc/69/Inf/Index.Php.

Clark, J., Flannery, W., 2020. The post-political nature of marine spatial planning and modalities for its re-politicisation. J. Environ. Pol. Plann. 22 (2), 170–183.

CLI, 2018b. Overview of blockchain applications for climate action. online Climateledger.org. Available at. https://www.climateledger.org/en/Focus/Resources.36.html. (Accessed 28 October 2018).

CLI, 2018a. CLI focus - DLT. Climateledger.org. https://climateledger.org/en/Focus/DLT-Blockchain.16.html. (Accessed 28 October 2018).

Climate Investment Funds, 2018. A new Story to Spark the Future of climate action. [online] Climate Investment Funds (CIF) and the Institute for the Future (IFTF). Available at. https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/cif_iftf_future_of_climate_action.pdf. (Accessed 16 January 2019).

EIT Climate-KIC, 2018. EIT Climate-KIC shines the spotlight on distributed ledger technology at Innovate4Climate. online] Available at. https://www.climate-kic.org/news/innovate4climate-distributed-ledger-technology-for-climate-action/. (Accessed 15 October 2018).

Connect4Climate, 2018a. Connect4climate. [Online]. Available At. https://www.Connect4climate.org/. (Accessed 27 August 2018).

Connect4Climate, 2018b. *#Hack4Climate - why Climate needs blockchain | Connect4Climate*. [online] Connect4Climate. Available at. https://www.connect4climate.org/initiative/hack4climate-why-climate-needs-blockchain-cop23. (Accessed 28 October 2018).

Dauvergne, P., 2020. AI in the Wild: Sustainability in the Age of Artificial Intelligence. MIT Press.

dCentra, 2018. ClimateCoop Flyer. https://www.dcentra.io/climatecoop/. (Accessed 29 September 2021).

De Filippi, P., Hassan, S., 2018. Blockchain technology as a regulatory technology: from code is law to law is code arXiv preprint arXiv:1801.02507.

Diestelmeier, L., 2019. Changing power: shifting the role of electricity consumers with blockchain technology–Policy implications for EU electricity law. Energy Pol. 128, 189–196.

Downes, L., Reed, C., 2020. Distributed ledger technology for governance of sustainability transparency in the global energy value chain. Global Energy Law and Sustainability 1 (1), 55–100.

Drescher, Daniel, 2017. Blockchain Basics. A Non-technical Introduction in 25 Steps. Apress (New York).

Feindt, P., Oels, A., 2005. Does discourse matter? Discourse analysis in environmental policy making. J. Environ. Pol. Plann. 7 (3), 161–173.

Flegal, J., Gupta, A., 2018. Evoking equity as a rationale for solar geoengineering research? Scrutinizing emerging expert visions of equity. Int. Environ. Agreements Polit. Law Econ. 18 (1), 45–61.

Fox, J., 2007. The uncertain relationship between transparency and accountability. Dev. Pract. 17 (4–5), 663–671.

Ge, L., Brewster, C., Spek, J., Smeenk, A., Top, J., van Diepen, F., de Wildt, M.D.R., 2017. Blockchain for agriculture and food: findings from the pilot study. Wageningen Economic Research. No. 2017-112.

Gupta, A., 2019. 'Is climate change the most important challenge of our times? No: because we cannot address climate change without addressing inequality.'. In: Hulme, M. (Ed.), Contemporary Climate Change Debates: A Student Primer. Routledge.

Gupta, A., Mason, M., 2016. Disclosing or obscuring? The politics of transparency in global climate governance. Current Opinion In Environmental Sustainability 18, 82–90.

Gupta, A., Möller, I., 2019. De facto governance: how authoritative assessments construct climate engineering as an object of governance. Environ. Polit. 28 (3), 480–501.

Gupta, A., van Asselt, H., 2019. Transparency in multilateral climate politics: furthering (or distracting from) accountability? Regulation & Governance 13 (1), 18–34.

Gupta, A., Karlsson-Vinkhuyzen, S., Kamil, N., Ching, A., Bernaz, N., 2021. Performing accountability: face-to-face account-giving in multilateral climate politics. Clim. Pol. https://www.tandfonline.com/doi/full/10.1080/14693062.2020.1855098.

Hajer, M., 2002. Discourse analysis and the study of policy making. Eur. Polit. Sci. 2 (1), 61–65.

Hajer, M., 2010. The Politics of Environmental Discourse. Clarendon, Oxford.

Howson, P., 2020a. Building trust and equity in marine conservation and fisheries supply chain management with blockchain. Mar. Pol., 103873

Howson, P., 2020b. Climate crises and crypto-colonialism: conjuring value on the blockchain frontiers of the Global South. Frontiers in Blockchain 3.

Howson, P., Oakes, S., Baynham-Herd, Z., Swords, J., 2019. Cryptocarbon: the promises and pitfalls of forest protection on a blockchain. Geoforum 100, 1–9.

Husain, S.O., Franklin, A., Roep, D., 2020a. The political imaginaries of blockchain projects: discerning the expressions of an emerging ecosystem. Sustainability Science 1–16.

Husain, S.O., Roep, D., Franklin, A., 2020b. Prefigurative Post-Politics as Strategy: the case of government-led blockchain projects. The JBBA [The Journal of the British Blockchain Association] 3, 1.

Kewell, B., Adams, R., Parry, G., 2017. Blockchain for good? Strat. Change 26 (5), 429–437. Kewell et al 2017.

Kloppenburg, S., Van der Ploeg, I., 2020. Securing identities: biometric technologies and the enactment of human bodily differences. Sci. Cult. 29 (1), 57–76.

Latour, B., 2004. Politics of Nature. Harvard University Press, Cambridge.

Lovett, G., 2018. COP23 explores the role of blockchain in climate action [online] Climate-KIC. Available at. https://dailyplanet.climate-kic.org/attention-role-blockchain-implementing -paris-agreement. (Accessed 15 October 2018).

Mason, M., 2008. The governance of transnational environmental harm: addressing new modes of accountability/responsibility. Global Environ. Polit. 8 (3), 8–24.

Maupin, J., 2017. *The G20 countries should Engage with blockchain Technologies to Build an inclusive, transparent, and accountable digital Economy for all*. Policy area: the digital economy [online] G20 Insights. Available at. http://www.economics-ejournal.org/economics/discussionpapers/2017-48. (Accessed 28 October 2018).

Namgyal, T., 2018. UN looks to blockchain, 'climate coin' to rouse sleepy carbon markets. MLex Market Insight [online] Mlexmarketinsight.com. Available at. https://mlexmarketinsight.com/insights-center/editors-picks/energy-and-climate-change/cross-jurisdiction/un-looks-to-blockchain,-climate-coin-to-rouse-sleepy-carbon-markets. (Accessed 16 January 2019).

Reinsberg, B., 2021. Fully-automated liberalism? Blockchain technology and international cooperation in an anarchic world. International Theory 13 (2), 287–313.

Rose, N., 1993. Government, authority and expertise in. Advanced Liberalism. Economy And Society 22 (3), 283–299.
Savelyev, A., 2017. Contract law 2.0: 'smart' contracts as the beginning of the end of classic contract law. Inf. Commun. Technol. Law 26 (2), 116–134.
Scales, I., 2014. Green consumption, ecolabelling and capitalism's environmental limits. Geography Compass 8 (7), 477–489.
Schulz, K., Feist, M., 2020. Leveraging blockchain technology for innovative climate finance under the Green Climate Fund. Earth System Governance, 100084.
Scott, J., 1998. Seeing like A State. Yale University Press.
Soneryd, L., Uggla, Y., 2015. Green governmentality and responsibilization: new forms of governance and responses to 'consumer responsibility'. Environ. Polit. 24 (6), 913–931.
Swartz, Lana, 2017. Blockchain dreams: imagining techno-economic alternatives after bitcoin. In: Castells, Manuel (Ed.), Another economy is possible: culture and economy in a time of crisis. Polity Press, pp. 82–105.
Swyngedouw, E., 2005. Governance innovation and the citizen: the janus face of governance-beyond-the-state. Urban Stud. 42 (11), 1991–2006.
Truby, J., 2018. Using Bitcoin technology to combat climate change. Nature Middle East.
Turnhout, E., Neves, K., De Lijster, E., 2014. 'Measurementality' in biodiversity governance: knowledge, transparency, and the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES). Environ. Plann. 46 (3), 581–597.
UN Blockchain, 2018. UN blockchain. [Online] UN blockchain. Available At. https://Un-blockchain.org/. (Accessed 10 September 2018).
UNEP, 2016. Fintech and sustainable development – assessing the implications. Inquiry Report [Online] UNEP. Available At. http://UNEPinquiry.org/Publication/Fintech-and-sustainable-development-assessing-the-implications/. (Accessed 28 October 2018).
UNFCCC, 2017. How blockchain technology could boost climate action. UNFCCC. Retrieved From. https://UNFCCC.Int/News/How-blockchain-technology-could-boost-climate-action.
UNFCCC, 2018. Un supports blockchain technology for climate action. UNFCCC. Retrieved From. https://UNFCCC.Int/News/Un-supports-blockchain-technology-for-climate-action.
Walker, L., 2017. How blockchain will help save the environment [online] World Economic Forum. Available at. https://www.weforum.org/agenda/2017/09/carbon-currency-blockchain-poseidon-ecosphere/. (Accessed 16 January 2019).
WEF & PwC, 2018. Building Block(Chain)S for A Better Planet [Online]. In: Fourth Industrial Revolution for the Earth. WEF, Geneva, Switzerland. Available At. http://www3.Weforum.org/Docs/Wef_building-blockchains.Pdf. (Accessed 29 October 2018).
Weikmans, R., Gupta, A., 2021. Assessing state compliance with multilateral climate transparency requirements: 'Transparency Adherence Indices' and their research and policy implications. Clim. Pol. https://www.tandfonline.com/doi/full/10.1080/14693062.2021.1895705.
Weikmans, R., van Asselt, Harro, Timmons Roberts, J., 2020. Transparency requirements under the Paris Agreement and their (un)likely impact on strengthening the ambition of nationally determined contributions (NDCs). Clim. Pol. 20 (4), 511–526. https://doi.org/10.1080/14693062.2019.1695571.
Wilson, J., Swyngedouw, E., 2014. The Post-Political and its Discontents: Spaces of Depoliticisation, Spectures of Radical Politics. Edinburgh University Press, Edinburgh.
World Bank, 2018 (English). [Online]. In: Blockchain and emerging digital technologies for enhancing post-2020 climate markets. World Bank Group, Washington D.C.. At. http://Documents.Worldbank.org/Curated/En/942981521464296927/Blockchain-and-emerging-digital-technologies-for-enhancing-post-2020-climate-markets. (Accessed 27 August 2018)
Wright, A., De Filippi, P., 2015. Decentralized blockchain technology and the rise of lex cryptographia. Available at SSRN, 2580664.
Zwitter, A., Boisse-Despiaux, M., 2018. Blockchain for humanitarian action and development aid. Journal of International Humanitarian Action 3 (1), 1–7.