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Article

Smart, Commodified and Encoded: Blockchain Technology for Environmental Sustainability and Nature Conservation

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Abstract

We explore the implications of blockchain technology for conservation and environmental policy. Drawing on an analysis of 27 initiatives, we examine their goals, assumptions, visions and workings. We find that these initiatives do not yet form a coherent approach, there is too much variety in their environmental focus, and the role of blockchain technology in achieving their goals. However, they share a faith in environmental-commodity markets, a penchant for surveillance and upward accountability, and lack a critical analysis of the main causes of environmental problems. Blockchain initiatives are forming a growing community of praxis and deepen ongoing trends in neoliberal environmental governance, characterised by the increased commodification and global accounting, surveillance and marketisation of environmental goods, services and outcomes. We suggest these services and outcomes fail to challenge the actual root causes of environmental degradation. At the same time, they are not all necessarily flawed by these characteristics. They can render information held by communities financially valuable in ways those communities may find useful. Future research should focus on exploring whether blockchain initiatives may at least translate in concrete environmental outcomes and contribute to the well-being of natural resource managers.

Keywords: blockchain technology; distributed ledger; commodification; surveillance; trustlessness; cypherpunk

INTRODUCTION

Imagine you could donate money directly to an indigenous community to protect their forests, without any intermediaries.

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Your funds would be tied to 'smart' contracts, and only released once independently verifiable criteria had been met. You would be able to follow the success of your support, from home, following progress of key local indicators online.

Working with Kayapo people, the NGO GainForest (2020a;b) is trying to realise this vision through the use of blockchain. Blockchain is a technology originally developed for the cryptocurrency Bitcoin, meant to circumvent financial institutions by using cryptographic proof (Nakamoto 2008). Instead of using institutions and their auditors, the verifiable origin of the funds is encoded, unalterably, into the cryptocurrency itself. The possibilities of blockchain intrigue conservationists. Conservation International's CEO

Jennifer Morris considers blockchain "a futuristic solution to conservation's greatest challenges" (Morris 2017). The World Wildlife Fund (WWF) partners with various blockchain projects (WWF n.d.; 2018a,b,c; OpenSC n.d.a.), whilst the Global Environmental Facility (GEF) identifies a myriad benefits including enabling greater transparency and lower transaction costs (GEF 2019).

There are, however, few examinations of the currently existing projects and the conservation that blockchain technology enables. These expectations about the potential benefits of blockchain-driven conservation, however, have not yet been interrogated in the light of early evidence. We survey blockchain-driven environmental sustainability and conservation initiatives to understand the conservation approaches they advocate and the sort of world they might sustain. Specifically, we ask:

1. Which blockchain-based initiatives exist and what environmental services or products do they offer?
2. What do they want to achieve and how? and,
3. What sorts of conservation do they enable, and what social change do they facilitate?

These questions respond to recent calls to investigate the 'political imaginaries' underpinning blockchain projects (Husain et al. 2020: 390). These authors argue that blockchain embodies 'prefigurative politics', which suggests that "their technical and organisational forms, to a large extent, embody the political imaginaries and power structures which they want to enable in society" (ibid.: 380). The concept of 'prefigurative politics' emphasises the political nature of blockchain initiatives and the ecologies they aim to shape, echoing the well-established idea in political ecology that ecologies are power-laden, rather than politically inert (Robbins 2012: 13). Furthermore, we argue that the prefigurative politics embodied in blockchain projects can deepen and extend practices of neoliberal conservation (Sullivan 2005; Igoe and Brockington 2007; Apostolopoulou et al. 2021), and in so doing make evident these projects do not 'save the world', but change, reform and remake it (Brockington et al. 2008).

In the following section, we review the fundamentals of blockchain technology and the debates surrounding its application. In section three, we explain our methods, and present our findings in the fourth. Section five discusses the results, highlighting how these speak to different bodies of knowledge and section six concludes with thoughts on future research on blockchain-driven conservation.

INTRODUCING BLOCKCHAIN

A blockchain is a "distributed and immutable electronic database—a ledger of every transaction that has ever taken place on a network" (Howson et al. 2019: 1). Information about the transactions is stored simultaneously and immutably on different computers in a peer-to-peer network.[1] No central authority (such as a bank's ledger) is needed to store or access information, neither are auditors required to verify it. In a distributed ledger, transactions are stored by multiple entities ('nodes') that participate in the network. Information is collectively validated by each and every node. No intermediary is necessary to verify information (Galen et al. 2019: 8).

Blockchain's roots lie in the cypherpunk movement of the 1980s, which promoted digital freedom and self-determination secured by cryptography (Hütten 2019). Cypherpunk activists see the State as a threat and cryptography and technology as a tool for liberation. This ideology, known as libertarian techno-utopianism or cyberlibertarianism (Soos 2018), maintains that self-governing individuals—with the help of technology—can organise social life without no or little State support. Blockchain technology embraces many ideas from cyberlibertarianism: individualism, a distrust for central authorities, and the pursuit of both individual and collective wealth.

Blockchain stores data in cryptographically secured 'blocks'. These blocks are chronologically "strung together in a chain" (Howson et al. 2019: 1). Traditionally (that is, with a so-called Proof of Work consensus mechanism), blocks are created by 'mining' them[2]. A 'miner' (a very fast-calculating computer) applies a complex mathematical formula, turning the information about a transaction into a 'hash'. This is a unique string of letters and numbers that represents the data in the block. Every block contains its own hash as well as the hash of the previous block. If the data in a block are altered, the hash is altered because it no longer represents the data that were originally entered. The block that comes after it then no longer contains the correct previous hash. If someone tampers with the information contained in any block, this will be visible across the network. This makes it difficult to tamper with the data contained in a blockchain network[3] (see Figure 1; Galen et al. 2019: 8-9; Howson 2020a).

The information contained in the hashes can include all sorts of interactions. Participating in a blockchain network enables a participant to retrieve information about, for example, the origins and processing of a product without checking with a certifier. Ideally, these data are added using complementary technology. For example, the WWF's tuna project document the geolocation of fish with a Radio Frequency Identification tag (ConsenSys 2018). When the tuna enters a processing facility, it and its detached parts receive a quick response (QR) code that enables tracking from ocean to a supermarket shelf (WWF 2018c). Other complementary technology could be satellite imagery, artificial intelligence, and drones. For example, the Land Life Company is using these technologies to monitor forest management in their 'smart reforestation' projects (Land Life Company n.d.a;b). Another central aspect of many blockchain applications is the deployment of 'smart contracts'. These are programmed protocols that execute automatically when predetermined conditions are met, again without intermediaries providing verification (Sève et al. 2018: 5). As Larry Lohmann puts it, smart contracts enable a world "of order without law. Of finance without banks. Of regulation without regulators. Of trust without governments...a world in which you could safely own and trade private property without having to involve other human beings at all." (Lohmann 2020:

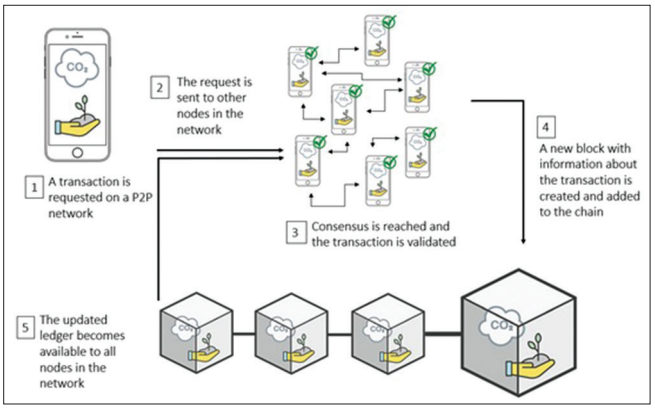

Figure 1
Basic workings of a blockchain network (Howson 2020a)

5). GainForest entails a smart contract between the donor and the community (provided by GainForest) that uses machine learning and satellite imagery to trigger periodic payments if given levels of forest cover are maintained.

The above mentioned technologies in combination with blockchain can help establish automated interactions and preserve information through its hashes. This makes it possible to remove intermediaries who would otherwise verify, analyse, access or store data. Blockchain, tamper free, and verification-independent, is also often referred to as 'trustless' (Forbes 2019). Trust in other people is made obsolete, it is 'outsourced' to computer code (Chapron 2017). The 'trust-based' alternative to GainForest's initiative would require an intermediary to validate that the community is keeping its forest. Blockchain makes intermediation superfluous (Galen et al. 2019: 8).

Blockchain intrigues environmentalists because it may result in new funding streams. Its capacity for automatisation means it can be used rapidly to pay for diverse environmental benefits. Cryptogovernance could improve environmental monitoring and reporting, reduce human error and corruption, and enable supply chain transparency for consumer goods (Chapron 2017; Saberi et al. 2018; Sève et al. 2018; WWF 2018c; GEF 2019).

But critics argue that blockchain is not a 'trustless' technology, rather it puts trust in those who can write algorithms, or smart contracts, or who compile the data informing them (Lawrence 2017; Dodgson et al. 2018: 8; Seyedsayamdost and Vanderwal 2020). Transparency requires people to understand blockchain technology sufficiently to interrogate it. Arts et al. (2015) have encouraged nature conservation scholars to ask questions about "who controls, pays for, benefits from, is negatively affected by, or administrates digital technology" (Ibid.: 669). In this regard, a study about humanitarian aid and blockchain shows that blockchain tends to replace traditional intermediaries with new ones that have expertise in code and blockchain (Seyedsayamdost and Vanderwal 2020). It is beyond the purview of many local communities and indigenous peoples to use the technology sufficiently well to render it transparent (Oberhauser 2019). Such circumstances would thus undo the supposed empowering and decentralising character of blockchain. Coppi and Fast (2019: 1) warn that blockchain in humanitarianism may facilitate a surveillance-type system, increasing power imbalances between humanitarian aid organisations and vulnerable populations (cf. Rugeviciute and Mehrpouya 2019).

Howson (2020c) argues that financial help through crypto-philanthropy reflects the interests of donors rather than recipients and that they may reproduce the limited incentive-based policies to protect nature and support local livelihoods (Howson 2019). Environmental blockchain applications can oversimplify socio-environmental problems and pay insufficient attention to social justice issues, which is characteristic of previous market-based environmental protection schemes (Calvet-Mir et al. 2015; Börner et al. 2017). Issues regarding privacy and ethics also arise. Blockchain is immutable and so its information cannot be deleted, which is at odds with the 'right to be forgotten' (Dodgson et al. 2018: 7). Blockchain applications are not at all simply following consensus rules "neutrally"—they will serve the interests of some more than others.

Blockchain technology hinges on simplifying complex social and ecological realities (Howson et al. 2019: 7). It requires quantifiable measurable change in order for the smart contracts to function. These simplifications, as we show below, advance capitalist forms of governance and neoliberal ideology and take us into familiar territory for critics of conservation innovation, because they facilitate commodification (McAfee 1999). Commodification is "the reach of markets into aspects of life traditionally governed by nonmarket values and norms" (Gómez-Baggethun 2015: 94). In environmental policy, commodification isolates individual aspects of complex systems so that they can be economically valued for the purpose of exchange between buyer and seller (Corbera 2012: 613). In so doing, commodification dissolves social relations into monetary exchange, diminishing the role of other (cultural, social, environmental) values in environmental governance (Gómez-Baggethun 2015).

Sullivan (2018) argues that the financing of environmental projects with cryptocurrencies is more aligned with speculative tendencies of financialised neoliberalism than with sound practice. Howson et al. (2019) similarly argues that blockchain-based 'crypto-carbon' applications advance capitalist forms of governance rather than socio-ecological just outcomes. Improved efficiency and consumer confidence interventions "are not geared towards reducing upstream material throughput or tackling over-consumption of resources, but rather to enable new markets and capital accumulation" (Howson 2021: 4). He also warns against 'crypto-colonialism' (Howson 2020b), foreseeing problems of green grabbing, data colonialism, surveillance capitalism and a deepening of global North-South trade and investment inequalities. In the same vein Lohmann (2020) argues that blockchain can be understood as capital's latest upgrade in enlisting new forms of automation. 'Environmentalist' blockchain applications are grounded in "capital's customary insistence that environmental crisis stems

not from capitalist value relations, but from the fact that there are not yet enough of them." (Ibid.: 36).

As the Earth Bank of Codes (2018) puts it, blockchain makes nature 'visible and valuable', but to capital's interests specifically. It helps to "convert both *pachamama* (*pachamama*=Mother Earth) and nature conservation more thoroughly into something that a wide range of actors can buy and sell in the form of exchangeable tokens" (Lohmann 2020: 13).

Blockchain then is a contrary beast. It attempts to bring disparate people and causes closer together, with fewer intermediaries and more direct interaction and accountability. And yet in the process it may facilitate further alienation and extend the capitalist relations which drive much environmental destruction. But all this is merely potential. We need a clearer grasp of how its advocates imagine it will work, and how it might be used and operationalised.

METHODS

To identify suitable blockchain initiatives, we used Google searches with the terms: "Blockchain and conservation;" "Wildlife conservation blockchain;" "Blockchain conservation reforestation;" and "Blockchain for environment". In addition, we browsed blockchain websites such as blockchainforsocialimpact.com, alice.si, climatechaincoaliton.org, and climateledger.org. We included initiatives that have been sufficiently developed either conceptually or in practice to provide web-based content as of September 2020. This means that not all of these initiatives have raised any funds. But they still exist in a form that allow us to see the world that they would like to create. We also used a broad definition of 'environmental/conservation focus' but excluded cases where environmental concerns were not the main driver(s) of the project or where the project's focus was renewable energy production rather than conservation. Readers should note that our search terms in Google may have missed existing initiatives and that there may be projects using blockchain which have not been made public, or which may use another terminology to refer to blockchain technology, such as 'pioneering' or 'smart' technologies. Table 1 lists the 27 initiatives included in our analysis.

For each studied initiative, we collected the texts and documents available on the initiative's website. We read these to identify what service or product they offer, and what they aim to achieve. From these we explored their assumptions and analysed what world these help construct. We also contacted by email all project developers for an interview. Seven agreed, one declined and 15 never responded. Four initiatives were not approached because the lead author was affiliated to one of these and we could not obtain contact information for the rest. The seven interviews with leading architects and creators of the new blockchain initiatives were conducted online from November 2020 until January 2021 by the lead author, they were recorded with consent and lasted between 40 and 60 minutes each. The interviews addressed issues such as the appeal of blockchain, what success looks like, disintermediation and 'trustlessness,' the perceived future and challenges of blockchain, and blockchain applications in relation to whole-ecosystem approaches. We transcribed the main passages for detailed qualitative analysis and used these transcripts, fully anonymised, in this paper. Interviewees were informed that these recordings and transcripts would be used solely for our research purposes and would not be shared with anyone except for the authors of this article. The texts and documents we analysed were all publicly available online. For this reason, the latter data have not been anonymised. The section below combines the interview data and information from the initiatives' websites.

BLOCKCHAIN IN ENVIRONMENTAL SUSTAINABILITY AND CONSERVATION

Varieties of initiatives

We have sorted the initiatives according to the form of environmental issue they focus on, the service or product they offer and their core business (Appendix 1). In total, 10 focus on forest conservation or management, six on climate change mitigation or adaptation, three focus broadly on the environment, four on wildlife conservation, three on marine sustainability and one on watershed management. We tried to distinguish between for-profit or non-profit initiatives. However, this was difficult. In most cases it is unclear whether the initiative is for profit, a 'social enterprise' or a non-profit.

We also categorised the initiatives according to the product or service that they offer (Table 1): fund raising initiatives; investment businesses; digital market environments or platforms; carbon offsetting services; transparent information sharing, and 'other'. Some of initiatives would fit under more than one category. For example, Forestcoin[.com] aims to attract investors, but in practice resembles more a fund-raising

Table 1
Categories of initiatives core business

Fundraising	Investment businesses	Digital market environment or platform	Carbon offsetting services	Transparent information sharing	Other
GainForest; Global Mangrove Trust; Wildcards; Wildchain	Ekofolio; Fauna Chain Project; TreeCoin	Adaptation Ledger; DAO IPCI; Earth Ledger; Regen Network	Carbonfuture; Land Life Company; Nori; Poseidon; Reforestum; TreeWallet; Veridium	Cecil Alliance; Fishcoin; OpenSC; WWF BC Tuna Project; WWF Canada	ForestCoin[.com]; ForestCoin[.earth]; ForestCoin[.space]; Plastic Bank

Note: Adaptation Ledger is many things but its website mentions it is an 'integrated platform' and so it has been categorized as a digital platform. The Fauna Chain Project has been categorized as investment business because it seems to revolve around trading derivatives

initiative than an investment company. These categories therefore must be understood as heuristic devices. They provide ways of seeing difference and patterns, but they do not provide the rigorously different categories of activity that could constitute a typology.

'Fundraising initiatives' aim to attract donors for conservation work. These initiatives have in common the fact that they use blockchain to strengthen transparency of where funds flow. For both Gainforest and the Global Mangrove Trust, disintermediation plays an important role too. Wildcards and Wildchain use blockchain to raise funds by creating 'non-fungible-tokens' that represent wildlife.

Investment businesses focus on nature as a tradeable asset with financial returns. These initiatives aim to protect the environment by making it financially profitable to do so. They use blockchain to tokenise their assets, such as larger areas of forest, dividing them into smaller lots which are easily traded. Digital market platforms bring together and incentivise different actors. For example, Earth Ledger invites users to bring forth (environmental) issues, investments, products and services, and solutions. These initiatives use blockchain to create trust, accountability and transparency.

Carbon offsetting services use blockchain to sell carbon credits. They connect reforestation or forest preservation projects to businesses or individuals that want to offset their carbon footprint. Contrary to forest-oriented investment businesses, they do not aim to make planting trees or forests an investment opportunity. These initiatives have similar reasons for using blockchain as the digital market platforms but put a greater emphasis on avoidance of double counting.

Finally, there is a broad category of initiatives that have been developed specifically for transparent data sharing. The initiative of WWF Canada, for example, aims to create a transparent database for watershed data, whilst WWF New-Zealand, OpenSC, and FishCoin use blockchain to track supply chain data. The Cecil Alliance wants to track, transact, and store data to create digital identities for animals.

In some instances, the initiatives' objective, role or 'type' of environmental action are ambiguous. 'Platforms' can mean different things. GainForest, and Earthledger both refer to themselves as a platform, but the latter is a networking platform, and the former enables transactions from donors to forest conservationists.

Four initiatives were more difficult to categorise, three of which, somewhat confusingly, are all called 'ForestCoin'. The one which is not called Forest Coin is 'Plastic Bank' which uses blockchain for its smart contracts to secure transactions surrounding plastic collection and to make them transparent. Forestcoin[.space] is a forest conservation project developed by former Thai government officials. It uses blockchain to offer a voucher-like scheme whereby donors gain access to services within a tourism project. Similarly ForestCoin[.earth] offers digital coins for planting trees. Forestcoin[.com] is a cryptocurrency selling, among other things, the protection of forty acres of land (for USD100,000) and 'Forever Young' cannabidiol cream (for USD40). Its use of blockchain is related to its strong distrust of governments and presents a worldview not seen in other initiatives:

> "We have been chemically infiltrated through chlorine and fluoride. It has separated us from God, and through that, separated us from nature. Every country that has applied it, has emptied out their churches, mosques, and synagogues. In modern day autopsies we find that most humans today in America have saturated pineal glands by age 12. [The] gland… binds us to nature itself. By getting rid of it, it make[s] us easier to control" (From 'About us' section, written by CEO Forestcoin[.com], 2020).

This narrative is interesting because it expresses a strong distrust in government which characterises the zeitgeist of blockchain's origins. This was expressed by another interviewee thus:

> "...[W]e live in a rigged society…. You know they, especially now with COVID and all the stuff that's happening…. The numbers don't make sense, the data doesn't make sense...[With our initiative] COVID would be gone. It would be like 'no, that's not real, next'. It would just move on. ...the people know what's best […] the government only knows what's best for themselves" (Interview 3, project architect, 2020).

Faith in markets, businesses and capitalism

A market-based approach was common in most of the initiatives. Their conception of success is related to how environmental markets may function and how much money these may be able to mobilise. For example, Veridium (2020) believes that "the best way to combat carbon emissions and environmental degradation is by bringing the power of markets to bear on the problem" and that "addressing tough issues... can not only be the right thing to do but also the profitable thing to do." (Ibid.). OpenSC (n.d.b.) targets businesses to make supply chains more transparent and "...believe[s] that what is good for the planet and humanity, should be good for business." In a blog post, the Cecil Alliance defines success as when "clients are willing to pay for our [animal-welfare enhancing] solutions." (Cecil Alliance Foundation 2019) and Earth Ledger, in turn, seeks to "[resolve] the 17 SDG's [Sustainable Development Goals of the United Nations] whilst making them profitable…. [A]nd help grow the new green economy" (Earth Ledger 2020). Nori (2020a) believes that "[i] f people [could] make money being carbon removers, ...much of the conflict between economic growth vs. the environment would vanis h." Forestcoin[.space] aims to make conservation profitable by creating a tourist-driven 'self-reliant economy'. Finally, TreeCoin supports large-scale eucalyptus plantations covering thousands of hectares in Paraguay, with success being measured in terms of investment returns.[4]

Specific words and metaphors accompany the market-drive: nature is 'tradeable', 'liquid', or made of 'natural assets'. For instance, Ekofolio aims to make 'global forest assets to be investable and liquid' by making sustainable timber profitable and in doing so 'help save the planet' (Ekofolio 2020), and

the Fauna Chain Project sees success when they can 'tokenise' individual animals into 'derivative trading commodities' (Fauna Chain Project 2019).

The market-based approach is also apparent in the initiatives' focus on economic 'incentivisation' for pro-environmental or pro-conservation behaviour. For example, Forestcoin[.earth] rewards the planting of trees by offering tokens (the 'Forest Coin'). These are intended to become a cryptocurrency that recognises the value of the planted trees the coins signify. Plastic Bank is incentivising people to collect plastic in return for diverse benefits (e.g., school tuition for children, vouchers for basic needs). Fishcoin offers rewards for supply chain stakeholders for sharing data, whilst TreeCoin offers financial returns for those who invest in their reforestation activities.

The faith in markets is accompanied by the development of 'new' commodities. Veridium's core business consists of isolating and quantifying carbon. Nori (2020b) works with farmers who store carbon in their soils and uses blockchain to store 'quantified and verified carbon' data. The Fauna Chain Project intends to commodify wildlife in the form of futures, options and warrants (Fauna Chain Project 2019). Ekofolio (n.d.) commodifies forests by "facilita[ting] the growth of…. [forests] towards a trillion-dollar, dynamic, transparent and liquid global market for natural capital assets."

Two initiatives mention more explicitly how biodiversity conservation and ecosystem restoration feature in their market-driven approach. The Land Life Company plants biodiverse tree-species in its reforestation projects and assesses the ecological situation of the land 'extensively' (Land Life Company n.d.). The Regen Network offers their carbon sequestration scheme only to farmers who adopt no-tillage agricultural practices, cover cropping, crop rotation, agroforestry, rotational grazing and other sustainable farming practices.

The pursuit of commodified, commercialised nature conservation through blockchain is not just the application of a new technology. It is underpinned by a powerful ideology: capitalism provides choice, and blockchain gives more people the power to choose (to pay for) environmental management and conservation. In the words of an interviewee:

> "The simple reason is: we have reached a state of capitalism where people can vote with their money…. There are things like mangroves, a friend of mine is working on tokenizing mangroves, which has no economic value in themselves but are systematically very important for preventing receding shorelines, and they hold about five times more carbon then trees…. When you put them on a blockchain, they behave differently financially…. It allows people with different persuasions to hold with their money what they want to support…. Capitalism gives people choice...I think the process of putting different assets, of different types and different behaviours on the blockchain, that allows you to put your money where your mouth is" (Interview 4, project architect, 2020).

For some visionaries, this market-driven and technology-enabled power will remove the need for government altogether:

> "Anyone can vote. If you're walking down your street and there's a pile of trash sitting there, you can go 'in my neighbourhood there's a pile of trash that needs cleaning up', and everyone in the neighbourhood can vote on it, and then [name initiative] awards the resources to get that done. So you're automating the clean-up of the planet, without bureaucracy" (Interview 3, project architect, 2020).

While the faith in markets is strong, it is not universal. The GainForest and the Global Mangrove Trust initiatives, as well as WWF Canada with their watershed blockchain project do not (over-)emphasise the role of environmental commodity markets in determining success.

Intermediaries, surveillance and upward accountability

Blockchain initiatives cast themselves as 'intermediary-free', while they set up new supply chains and create new intermediaries for funding conservation initiatives. GainForest, for example, writes that: "we replace the need for third-parties by introducing a self-enforcing smart contract that parks donation funds from individual donors" (Dao 2020: 8). But the much-vaunted 'trustlessness' of blockchain technology still requires a fair degree of trust in human verification and data provision. The Cecil Alliance requires vets and other middle-people to obtain data about animals and put it in the blockchain. Forestcoin[.earth] verifies tree planting activities through other network participants' pictures. Nori uses independent accredited third-party verifiers to check the quantum of carbon credits and researchers and volunteers put information about watersheds in the blockchain database of WWF Canada's initiative.

Some initiatives try to ensure data quality through automation. For example, OpenSC automate verification in supply chains "for individual products in real time by using data science and machine learning to analyse digital information such as satellite imagery, live video monitoring and worker biometric data" (OpenSC n.d.c.). The flip side is that their verification entails considerable monitoring. In order to ensure that supply chains are slavery free, workers need to register themselves by providing information for biometric digital ID's to their employers as well as accepting live video monitoring. These tendencies towards micro-level intervention and control of funding enhance upwards accountability (Howson 2021), allowing donors to investigate the affairs of the organisations they support. This surveillance is touted as an advantage by its advocates:

> "[T]he advantage [is] that it's very transparent, so everyone could see when the transfer was made….to a microlevel... this money went here and from there it went there and there and you could see it all under transparent ledger, right" (Interview 6, project architect, 2020).

But the power relations resulting are also acknowledged: "[W]e're going to have something called a donation score and the people will be able to allocate it to different projects. So, yeah, at the end it's about what the user wants." (Interview 6, 2020).

Another dimension of surveillance is its tendency to enhance quantifiable measures of life and change. As one interviewee put it:

> "We want to quantify the impact. So that means we are asking the charities for something tangible. For example, we ask them how much does an insurance costs for a wildlife ranger? And then they say, 20 dollars per month…. So we need something concrete" (Interview 6, project architect, 2020).

Quantification can be a fraught process, entailing radical simplification and brave assumptions. But the blockchain approach can be bullish in the face of these difficulties, as is plainly visible in the rhetorical question one blockchain developer asked the second author when debating how blockchain works: 'Is there anything which cannot be quantified?' (pers. comm. June 2019).

The ultimate case of intermediary-free, quantifiable, upward accountability in conservation affairs of which we are aware is fictional. Brett Matulis' satirical video imagines a world where wildlife themselves can earn the revenues needed for their conservation.[5] Chips implanted in animals are linked to tourists' cameras to record their preferences for photographing specific animals. Particularly popular and photogenic beasts thus earn the rent required to live in a protected area. Less charming animals are eaten.

But it may not be fictional for much longer. The Cecil Alliance, founded in response to the death of Cecil the lion in Tanzania, is based on the premise that if only Cecil's caretakers would have given him his own blockchain ID, with his own data, then he could have raised funds for himself in the form of tokens. His caretakers could have used these to fund extra security measurements (DeStift n.d.). If initiatives like this emerge and succeed, popular animals will be able to pay for their own protection by virtue of their appeal to the tourists' gaze.

A WORLD THAT NEEDS BLOCKCHAIN

A striking aspect of blockchain initiatives is that their technical savvy, financial wizardry, and ingenious entrepreneurship are not always matched by a sophisticated understanding of the issues they support. This lack of understanding produces framings which then require blockchain-based interventions. Consider, for example, the reported 'discovery' of well-known facts that reduces conservation challenges to a lack of money:

> "A friend and I became very curious like, why are so many species dying out? ...we kind of discovered that usually, nowadays, there's a couple of reasons why animals die out. One of them is climate change, the global warming caused by climate change. Too much hunting. Too much fishing. Too much agriculture. Usually animals die out because their habitat gets destroyed…. So we said we need to do something about that. So we analysed the problem more and more and more and we just saw the biggest problem is lack of funding" (Interview 6, project architect, 2020).

Improbable claims made about conservation problems justify the heightened surveillance blockchain solutions require:

> "My personal view is that the assets in conservation ...are most at risk because they are at some far corner of the world where there's no eyeballs on it. Most of the assets in the Amazon that are burning is because nobody knows it's happening or know what to do about it" (Interview 4, project architect, 2020).

Other perspectives are peculiarly apolitical, passing over their social, economic and political contexts. In the words of an interviewee, "there are natural forests in Borneo and Kalimantan that…. belong to the planet" (Interview 4, project architect, 2020). These views set aside the politics of Indonesian forestry, and instead invoke a global responsibility of care that provides a useful justification of blockchain solutions (Zeng et al. 2020).

Environmental issues can also be presented as politically inert—it is solely a question of putting the right technologies to work in order to solve them. To quote Earth Ledger's (2020) website, "we believe that all of the solutions to our world's challenges are here today. The technology is available to us now, we need only to apply it." In some instances, blockchain advocates' blindness to conservation politics, or indeed any politics, is marked:

> "Right now at this time most people want to do the right thing. If you ask any question about destroying the planet or cleaning it up, I guarantee it you get a good answer. That's why you have the trust the self-organising nature of the planet. Stop controlling it, stop getting in the way…. You ask the planet what do we do next? What's the most important thing to do next? And it always will know, because we're all connected. We're one. There's no separation between anything. You think birds, and bees, and you think fish are going around having meetings about how to organize and writing rules down? [It] just organises. That is the self-organising principle, that is something that is inherent to the planet. So what we're doing is... biomimicry, with the technology platform of copying nature" (Interview 3, project architect, 2020).

This strange thinking may not be the outlier it at first seems. There is a deeper hankering among advocates of neoliberal conservation strategies both to allow an unfettered nature to flourish, and to allow markets to govern this liberalised utopia. Market-governed nature provides the natural order of things (cf Büscher 2013).

DISCUSSION

We began this research seeking to understand what sort of world blockchain-driven conservation enables. But we may have been premature. Despite the enthusiasm of its advocates and dreams of visionaries there is not yet a discrete collective of blockchain conservation projects. The initiatives we put together—after a fair bit of searching—are best characterised by their eclecticism. From businessmen to conspiracy theorists, from climate adaptation or aquaculture professionals to Thai ex-government officials—they share a belief in the possibilities

of blockchain but have little else in common. The blockchain revolution is still gathering momentum. Its drive comes from blockchain entrepreneurs' ingenuity rather than from conservation imperatives. Their most noticeable products are new chains of blocks, not environmental successes. As such, blockchain technology has yet to be properly habituated by environmental sustainability and conservation interests.

Despite the diversity it is still possible to identify some patterns in blockchain's engagements with environmental initiatives and discern some elements of the prefigurative politics that may characterise future engagements with conservation goals. We believe that these elements make clear blockchain's role in a new round of neoliberal conservation initiatives (Sullivan 2005; Igoe and Brockington 2007).

A recent comprehensive review of neoliberal conservation identifies a crucial element of neoliberal conservation, that we found to be at the root of many blockchain projects, namely, an increasing use of market-based instruments and practices:

> "[which] directly relates to the broader shift towards the economic valuation of nature, primarily in the form of ecosystem services and natural capital accounting... [N] eoliberal conservation...manifests an attempt to transform nature into a marketable commodity in order to create new sites of capital accumulation and new profits" (Apostolopoulou et al. 2021: 9).

Blockchain did not feature in Apostolopoulou and colleagues' otherwise comprehensive review of neoliberal conservation literature, but it is plain that it could. The most obvious element of blockchain's neoliberal politics is its desire to 'make nature pay for its conservation'. That sentiment underpins many of the initiatives we have reviewed. They seek to commodify one of nature's aspects to solve a conservation issue. They recall Robertson's (2006: 367) words "capital wants nature it can see." Blockchain is particularly suited for such an approach to saving nature because it allows for transparent reporting and accounting of quantitative data while saving costs. It fits capital's desire to capture and value the world in marketable, quantitative, 'visible' terms (Lohmann 2020). With the help of blockchain and complementary technology, the owners of capital can now "see" its 'natural assets' from behind their personal computers—and in real time. It helps to establish an extreme form of 'payments by results' and thereby extends neoliberal forms of market governance (Robertson 2006). Through disintermediation and automatised verification, it helps to commodify nature, i.e., to turn nature into a marketable commodity.

The commodification of nature introduces a host of issues. The problems associated with it are an old complaint of conservation social scientists. Vatn (2000) observes that commodification "ignores important technical interdependencies within the environment and the relational character of environmental goods" (Vatn 2000: 493), and it "twists the perception of the environment from systems preservation to items use or transformation" (Ibid.). Ecosystems are complex and cannot be reduced to the parts of its total sum. Similarly McAfee (1999) warns that such a simplification can create outcomes that do more harm than good in relation to biodiversity and sustainability. These specific dangers of commodification of nature are visible in the schemes we have examined above. Eucalyptus plantations become important natural assets if we focus on their carbon and timber alone. Lions can earn tokens, but insects, and other less charismatic creatures, upon which ecosystems depend, will find token-earning much harder.

While blockchain is often about creating new valuable commodities, it is, however, too early to talk about blockchain facilitating a new round of 'accumulation through conservation' (Büscher and Fletcher 2015). As Dempsey and Suarez (2016) found with respect to conservation finance, the funds are yet to flow, as it has been the case for some varieties of biodiversity offsetting in specific countries (Corbera et al. 2021). In this respect it is useful to recall Astolopoulou et al.'s (2021: 16) call for a better understanding of how neoliberal conservation commodities create (or reconstitute) value. As they put it, we need to understand better, "what constitutes a commodity and a market, how exactly nature is commodified, whether, when and how conservation supports capital accumulation, and whether the instruments that bring about the economic valuation of non-human natures are vehicles for the production of value or for rent extraction."

We initially started this research by asking ourselves "what worlds does blockchain create?" Yet as much as it co-constructs and changes the world around it, so it also sustains a world that already exists. Blockchain initiatives are situated in a world with particular modes of knowing, being and doing that are aligned with the rationalities of capitalism (Kallis et al. 2020). It is, therefore, not surprising that the architects of blockchain-driven conservation seek solutions accordingly. Despite their disruptive ambitions, the reviewed projects do not necessarily challenge drivers of environmental degradation because they do not challenge the economic systems causing them. Blockchain maintains a separation between environmental problems and broader political-economic issues. Such a separation "promotes a bias toward technological solutions and away from social-structural change" (McAfee 1999: 135). Many initiatives attempt to solve issues of environmental degradation with technological ingenuity, whereas these in fact require deeper, social-structural change. Take transparent supply chains. These could help avoid unsustainable and unethical practices. This is a big win for local people, NGO's and others concerned with violations of human rights and nature. But transparent supply chains do not prevent the problem of global overconsumption by wealthy people and nations. Neither do they address the social-economic drivers of, for example, illegal fishing or logging.

We must, however, avoid the trap of assuming that all innovations in neoliberal environmental management and conservation are problematic. They are rarely the solutions that their advocates claim them to be, but they can introduce changes that local people turn to their advantage (Gardner 2012; Wright 2017; Shapiro-Garza et al. 2019). As

Howson (2021) has shown blockchain might even be used to facilitate degrowth, and less capitalism, under certain conditions. It is not necessarily a tool of extended capitalist relations and market-driven surveillance. Accordingly, while commodification may simplify nature, blockchain can also make commodities more complex. An example is Fishcoin which makes fishery practices more legible and might introduce a welcome change for fishing communities. It could add commercial value to existing practices. Another way of putting this is that blockchain and associated technology has an extraordinary capacity to make the finer details of local environments legible to distant interests. It can capture and scrutinise the provenance of fish catches and changes in tree cover—as they happen in real time. It may well be that this power is used to increase levels of surveillance and control. It may result in remote rural areas becoming more accountable to donors and funders interests in richer locations. But that is not necessarily all it will do. Rural people may be able to turn these new arrangements to their advantage. It will be hard for them to do so but they will undoubtedly be trying to.

CONCLUSION

We have reviewed 27 environmental and conservation blockchain-based initiatives to understand which services or products they offer, what they wanted to achieve, how, and what sorts of conservation and social change they pursued. From tree plantations, to animal tokens, or transparent supply chains we have found that these initiatives are highly varied. They do not lend themselves to a ready typology. This is a field which is still new and young. However, it is also plain that the measures that are being advocated by each of the reviewed initiatives will require new forms of commodification and surveillance that will extend practices of neoliberal environmental management and conservation. In this respect it is not just the practices that are significant, but the way these practices are advocated which matters. To blockchain entrepreneurs, new markets and new commodities are perceived to be the obvious, incontestable way forward. It is through these means they envision environmental management and conservation to proceed.

Much of this will be unwelcome to critics of neoliberal conservation. But we want also to sound a note of caution for these critics. It would be best to see these initiatives from below, from the point of view of the people and places which they hope to transform. The transformations critics deplore may be more ambiguous to those who experience them. They may provide resources with which to tackle other inequities. It is still too early to tell. Future research should build upon this explorative study by examining, on the ground, the outcomes of blockchain environmental and conservation initiatives – we need to better understand them from within. This includes studying projects during their implementation phase as well as established projects. What do their conservation 'successes' look like in practice, and in the long term? For whom are they a success? Doing so will allow to understand how they affect different peoples and natures for which these solutions are meant. Future research could also explore how blockchain applications for conservation could be designed so that they cater to the needs of end-users by including them in the design process (cf. Pschetz et al. 2020).

Lastly, we need to better understand blockchain project's creators' mentalities and personal journeys that led them to see blockchain as a solution to environmental sustainability challenges. We have briefly interviewed a small number of blockchain creators and architects, but a more in-depth analysis is needed of how they perceive their solutions and the problems they mean to solve. The relationships, histories and financial backings underlying blockchain initiatives, and more rigorous typologies of their efforts will help us to understand this unfolding phenomenon.

Author Contributions Statement

All authors conceived and designed the study, which was originally submitted as an MSc dissertation of ICTA-UAB MSc in Economic, Social and Environmental Sustainability, November 2020. A.S. collected secondary data and conducted the interviews, analysed the data, and led the drafting of the manuscript. All authors contributed critical, intellectual content to the drafts and gave final approval of the version to be published.

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Declaration of competing/conflicting interests

A.S. declares that she has acted as an advisor in the Treewallet initative.

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Research Ethics Approval

This research was conducted under the auspices of the Universitat Autònoma de Barcelona and is categorized as not requiring prior approval from the university's Ethics Commission. Most of the data analysed are publicly available in the organizations' websites and the information collected via interviews did not contain any reference to personal data or sensitive information from the interviewee and her/his organization. However, as detailed in the methods section, we followed good practice in the collection and analysis of qualitative data in the social sciences, such as the anonymization of interviewees' names and their position within

organizations, and obtaining prior informed consent to using and analysing data.

Data Availability

All the reviewed secondary data, alongside the article pre-print version would be made available through the Universitat Autònoma de Barcelona open repository platform in case the article was to be accepted. Interview recordings and transcripts will not be uploaded to the repository to respect our interviewees' confidentiality. All data, notwithstanding, could be made available to reviewers upon reasonable request.

Preprint Archiving

A pre-print version of the article will be uploaded to the UAB Open Repository if the paper was accepted for publication (link provided in due course).

NOTES

1. In principle, this could be anyone, but it depends on whether it is a public ('permissionless') blockchain network, like Bitcoin, or a private ('permissioned') blockchain network (Wüst and Gervais 2018).
2. Proof of Work (PoW) is the most common blockchain consensus mechanism. Bitcoin, due to its use of PoW, has been criticized for its large energy consumption, comparable to that of a country like Belgium (De Vries 2020; Martin and Nauman 2021; Cambridge Centre for Alternative Finance n.d.). The energy requirements of blockchain are clearly an important aspect of their environmental credential and we encourage readers to explore that aspect in the publications just cited. Note also that other, less-energy intensive, consensus mechanisms exist as well (Platt et al. 2021; for a review on other consensus mechanisms see Aggarwal and Kumar 2021). The most notable example here is Proof of Stake (PoS), that currently is being implemented by Ethereum, one of the larger blockchain players.
3. Blockchain might be a transparent, hard to tamper, immutable database, but that does not automatically make the data that is uploaded trustworthy (Howson 2020a: 4). For other challenges to the authority of information contained in blockchain, see also Lyons (2018: 15-21), van Rijmenam's (2019) and Zheng et al. (2018).
4. We doubt the environmental benefits of eucalyptus plantations in Paraguay, but include it here because they are claimed to offer such benefits.
5. Uploaded in 2016 by the 'Umoja Project': Making Nature Pay. https://www.youtube.com/watch?v=esByOP8L92U&feature=youtu.be.

Appendix 1: https://bit.ly/3oYESwX

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