NATURE FINANCE

The Rise of Web3: Nature's Potential in the Digital Age

Identifying opportunities and strategies for Web3 technologies within nature markets.

April 2024

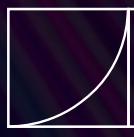
NIC | Initiative of NATURE FINANCE

About NATURE FINANCE

NatureFinance is committed to aligning global finance with nature positive, equitable outcomes.

Our work is shaping the many dimensions, actors and change pathways at the nature-finance nexus to thrive and contribute to development.

How we make change:



Nature Markets: shaping principles-based nature markets by increasing awareness, innovations and better governance of nature-linked markets including nature credits and soft commodity markets.

Nature Liability: extending the liabilities of financial institutions for nature outcomes, including the application of anti-money laundering rules to break the links between investment and nature crimes.

Nature Data & Disclosure: Increasing the quality and quantity of nature data, risk assessment and transparency across financial markets to enable integrated assessments of nature-climate risks and impacts.

Sovereign Debt: Engaging market actors, and governing institutions in efforts to place nature in the world's sovereign debt markets, including scaling the issuance of sustainability performance-linked sovereign bonds.

Nature Investment: Creating new nature focused investment opportunities that address climate, food security, equity and broader sustainable development goals.

NatureFinance is the next phase of impact of the Finance for Biodiversity Initiative (F4B), established with support from the MAVA Foundation. The work also benefits from partnerships with, and support from, the Children's Investment Fund Foundation (CIFF) and the Finance Hub of the Gordon and Betty Moore Foundation.

About NIC

NIC (The Nature Investor Circle) is an initiative of NatureFinance. NIC is a growing community of early-stage investors, thought leaders and scientists shaping the nature markets we need.

Read more about NIC

The research and opinions expressed in this report represent the views of NatureFinance.

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Executive Summary

As we witness a more assertive integration of nature into markets, we face multiple challenges: philosophical, economic, financial, social, political, technological, and environmental. Indeed, we should not integrate nature into existing systems that don't ultimately benefit people and the planet.

This calls for creative and generative solutions. Designing nature markets is not about analysing or optimising existing mechanisms. It is about making new paradigms for nature in our economies, founded on principles of equity and ensuring benefits are shared fairly amongst all stakeholders, including Indigenous Peoples and Local Communities.

As Web3 technologies mature, they offer new approaches. The synergies of Web3 and AI, improvements in environmental performance, and alternative models for data management and monetisation are just some of the recent innovations presenting opportunities for the design of just and equitable nature markets.

Solution providers are already developing and testing applications showing promising design principles. For example:

- In **sovereign debt**, blockchain may improve the issuance and management of sustainability-linked bonds, providing a framework for structuring debt based on nature-related outcomes.
- **Supply chain management** may benefit from decentralised ledgers for tracking sustainable practices and verifying eco-friendly materials from origin to end-user.
- **Biodiversity credits** could be enhanced with the use of tamper-proof ledgers, smart contracts and tokenisation, creating a marketplace where investments are accurately tracked and rewarded.
- **Water trading** could be transformed with smart contracts and decentralised platforms, enabling the efficient and transparent allocation of water resources.
- **Consumer nudging** could use tokenisation to incentivise sustainable consumer behaviours by tapping into the gaming industry.

More possibilities will emerge from future Web3 technological advancements, creating effective applications for nature markets. Building digital representations of nature assets or integrating AI and Web3 technologies are just some examples that can revolutionise the information, knowledge and value distribution needed to restore nature.

Technologies cannot be simply good or bad. They act as mirrors, reflecting the complexities, biases, and intentions of the societies that create and utilise them. Despite drawbacks, Web3 demonstrates promising applications which could provide unique solutions. In essence, consideration must be given to not replicate existing unsustainable nature market dynamics; with the development of product solutions identifying appropriate leverage points for using Web3 technologies. Critical aspects for the emergence of companies that have the ability to shape nature markets with equitable principles will have to encompass transparency standards, data governance and quality, participation of Indigenous Peoples and Local Communities, and help improve policies and regulations.

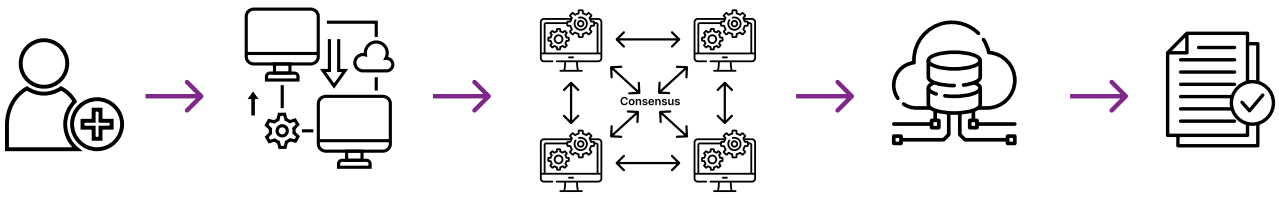
Background Knowledge and Glossary

Web3 is a concept for the next generation of the internet. It is built on decentralised technologies and it was developed to create a more open, transparent, and communally controlled internet.[1] However, Web3 is not infallible; as we have witnessed in the crypto world, implementing such a concept comes with major challenges.

Web3 technologies do not inherently possess openness and transparency and cannot eliminate bad actors altogether. The implementation of Web3 technologies covers the entire spectrum from centralised to decentralised, and it remains the choice of the developer how to construct power relations in a Web3 environment.

The following diagram and glossary present several core components of Web3 technologies potentially residing within private, public or hybrid networks.

EXHIBIT 1 A transaction using Web3 technologies



A user requests a transaction

P2P Network:
The requested transaction is broadcast to a peer-to-peer network consisting of computers, known as nodes.

Validation:
The network of nodes validates the transaction and the user's status using algorithms, and reaches consenus.

Transaction verified & stored:
A verified transaction can involve tokenization, smart contracts, records or other information.

The transaction is complete

Web3 technologies that can be employed in a transaction:

Distributed Ledger
Immutable and transparent system of digital data & records establishing consensus and trust

Smart contracts
Automatic programmatically-executed transaction

DAOs
Governance structures that oversee the allocation of resources.

Payment tokens
Crypto-currencies

Asset tokens
Digital asset representation

Utility tokens
Digital access and participation in decision-making

dMRV
Digital solutions to verify the state of the asset and outcomes

Oracles
Integration of exogenous real-life information

EXHIBIT 2 Basics and Definitions

TERM	DEFINITION
Distributed Ledger Technology (DLT)	A type of digital database meant to safely record and store transactions across several computers (nodes) connected to a peer-to-peer network.[2]
Blockchain	A type of DLT. Transactions are combined with other transactions to create blocks of data. New blocks are added to an existing blockchain in a permanent and immutable way, forming a time-ordered record.[3]
Smart Contract	A computerised protocol that executes the terms of a contract and satisfies common contractual conditions automatically.[4]
Tokenisation	Digital representations of assets or access rights managed by a smart contract in a DLT-supported ecosystem.[5] Tokens serve various purposes in blockchains depending on their characteristics and role in the system.
Payment Tokens	Also commonly known as cryptocurrencies, payment tokens serve as a simple means of payment.[6]
Utility Tokens	Utility tokens allow participation to an application or service in a blockchain ecosystem. A utility token's purpose is to confer digital access rights to an application or service.[7]
Asset Tokens	Digital representations of various types of assets (e.g. forests, a house, fishing grounds, land). Asset tokens represent ownership of an asset, debt or form of equity. The value of the conferred token depends on an underlying represented asset.[8]
Non-fungible Tokens (NFTs)	NFTs are not interchangeable. An NFT's data can be linked to digital assets, they can be used to provide its owner with exclusive access rights, or to be linked to physical assets.[9] Utility and asset tokens are types of NFTs.
Programmable Money	Digital money that can be programmed to be spent when certain conditions are met.[10]
Oracle	Entities that connect blockchains to external systems, thereby enabling smart contracts to execute based upon inputs and outputs from the real world. Different types of oracles exist: input, output, cross-chain and compute-enabled.[11]
Distributed Autonomous Organisation (DAO)	DAOs are groups that form for a common purpose, such as investing in reforestation. They are "governing bodies that oversee the allocation of resources tied to the projects they are associated with".[12]
Regenerative Finance (ReFi)	A movement based on blockchain technology to encourage people to practice low-carbon and curb or reverse climate change through innovation in financial incentives.[13]

Introduction

In recent years, there has been an effort towards properly including nature and its critical services in markets to manage the effects of climate change and nature loss. Many emerging financial mechanisms—such as biodiversity credits, nature insurance products and sustainability-linked debt instruments—form nature markets today.[14]

EXHIBIT 3 The Many Forms of Nature Markets - a Taxonomy

TYPE	DESCRIPTION	CATEGORY	TRADED ELEMENT	SEGMENTS
Asset Markets	Markets in which the right to use ecosystem assets with long-lived value are traded	**Real assets**	Rights to use an entire ecosystem asset and resulting services	Agricultural land, timberland, water rights, biodiversity IP, additional ecosystems assets
Intrinsic Markets	Markets in which provisioning, regulating, or cultural ecosystem services are traded	**Products**	Use of provisioning services	Hard and soft commodities, legal and illegal wild species, genetic materials, water rights leases
		Conservation	Conservation of nature for direct economic benefit or altruistic value	Payments for ecosystem services, overseas development aid, philanthropic grants, sustainability-linked debt
		Access	Access to/us of cultural services	Wildlife tourism
Credit Markets	Markets in which credits that reflect efforts to enhance or conserve ecosystem assets or services are traded	**Nature-specific credits**	Credits that reflect the value of ecosystem services	Mitigation banks, water quality credits, voluntary biodiversity credits
		Nature-related carbon credits	Credits that reflect the value or carbon sequestration or storage	Nature-related voluntary carbon credits, AFOLU sector compliance carbon allowances
Derivative Markets	Markets for financial products which directly reflect ecosystem values or ecosystem risks	**Financial products**	Financial products directly tied to ecosystem assets or services	Commodity derivatives, nature-related insurance, wildlife NFTs, biodiversity loss insurance, securitization of ecosystem assets, water futures

Source: Taskforce on Nature Markets and Vivid Economics (2022)

These economic and financial advancements, set to proliferate in the coming years, result from environmental policies and regulations introduced throughout the past decades.

Notable nature policies and guidelines include the Taskforce on Nature-related Disclosures (TNFD), affecting corporates and financial institutions[15]; Article 29 in France, demanding disclosures on dependencies and impacts of financial activities on climate and biodiversity[16]; the Sustainable Finance Disclosure Regulation (SFDR)[17]; and the Global Biodiversity Framework (GBF) which outlines targets for nature protection and conservation by 2030[18], amongst many others.

Responding to these regulatory advancements and developing appropriate operational and financial practices requires technological innovation. Everything, from measuring nature, tracking its presence across supply chains, developing reliable and transparent monitoring, reporting and verification (MRV) processes and setting transaction platforms that can direct funds towards nature and its stewards, needs innovative solutions to achieve global nature targets.

These innovations and the broader nature tech sector are already on the rise.[19]

As we progress into an increasingly digital and technologically sophisticated era, the domain of financial transactions will change. The emergence of Web3 technology and the implementation of smart contracts are making financial transactions savvy by incorporating automated conditions and rules into digital currencies. These innovations are altering our perceptions of currency and financial interactions, presenting novel benefits and possibilities within the digital nature economy.[20]

In order to achieve transparency and traceability, data is needed to verify transactions and the proper allocation of funds. Nature markets need the participation of different stakeholders – from governments and corporates to consumers and local communities – and reducing the use of intermediaries could be beneficial in allowing direct participation while reducing processing time and costs. Designing high-integrity practices and mechanisms for nature markets will be crucial to achieving just and equitable outcomes. Such characteristics are not unfamiliar to Web3 technologies, which could become integral to the solutions.

Some early-stage companies are developing novel products based on this understanding. Some of these innovations include products to trace nature-related data across supply chains, tokens for biodiversity monitoring, biodiversity credit platform exchanges and blockchain-based sustainability-linked bonds. In this context, a helpful question is, which of these Web3 projects really matter for nature markets?

In the following pages, firstly we outline the positives that Web3 technologies could bring to nature markets and why these are important. Secondly, we identify emerging technologies and applications already significantly impacting the future of these markets. Lastly, we look at the landscape of emerging companies poised to capitalise on these opportunities and potential evaluation criteria that can help assess a company's relevance and potential for shaping nature markets.

This paper is for early-stage investors and practitioners in nature markets and technology. It is a resource for those interested in the potential for Web3 solutions and approaches to help align financial markets with nature.

Web3 and the Design of Nature Markets

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Nature plays a pivotal role in addressing climate change. Nature-based solutions enhance biodiversity, improve water quality, and strengthen resilience against climate-induced extreme weather events. These solutions can include reforestation, sustainable agriculture, and the restoration of peatlands, mangroves and seagrasses. Harnessing the power of nature contributes to the fight against climate change, supports ecological balance, and sustains livelihoods. 100% of today's global economy is 100% dependent on nature.[21]

However, nature is often under-priced in the economy or absent altogether. For instance, the annual negative externalities of the global food system are estimated at US$12 trillion per year.[22] "The annual unpriced cost of nature used by the global economy (through greenhouse gas emissions, water use, land use, wild species use, pollution, waste, etc) has been estimated at 13% of global GDP".[23] Aligning the economy with nature doesn't come without its challenges. Long-standing issues regarding transparency and traceability could affect emerging biodiversity credit markets. Enduring practices of misgovernance and exclusion or disproportionate benefit-sharing with Indigenous Peoples and Local Communities is a fundamental challenge to achieving equitable outcomes. Heavy market intermediation brings rising costs and results in barriers to market entry. As a result, the design of innovative operational and financial mechanisms that direct funds towards nature targets needs trusted verifiability for use-of-proceeds.

Taking steps towards progressing these topics is necessary to design just and equitable nature markets. Web3 technologies could hold the key to addressing some of the challenges. Namely, Web3 technologies have the potential to:

- Create traceable, transparent and verifiable data to ensure funds contribute to nature targets
- Allow environmental data ownership and unlock global decentralised exchange platforms for consistent nature data.
- Design mechanisms and practices to include Indigenous Peoples and Local Communities equitably within nature markets.
- Design digitally enabled financing mechanisms and drive price discovery based on differentiation factors.
- Reduce or eliminate the use of intermediaries and, as a result, reduce costs and processing time.
- Create a smarter and more adaptive financing performance for nature markets.

Nature is often under-priced in the economy or absent altogether. For instance, the annual negative externalities of the global food system are estimated at US$12 trillion per year.

Traceability, Transparency and Verifiability

The demand for monitoring, reporting and verification (MRV) is growing, driven by increasing regulatory requirements, policies and guidance such as the TNFD, Article 29 and EU Deforestation Regulation (EUDR).

Organisations must, or are encouraged to, disclose their nature-related risks, dependencies, and opportunities to manage their exposures and ensure actions lead to positive environmental and societal impacts. This level of transparency expected by corporates and their supply chains is also a requirement of restoration and conservation projects, investors and their investment flows.

Within this context, tech-enabled data collection and storage processes – within production sites, supply chains or use-of-proceeds – could use distributed ledger technology to provide and safely store valid data. For example, tech-enabled supply chain traceability can use distributed ledgers to provide valid data on land practices, eDNA, performance indicators, geographic location, deforestation-free certifications, or fair labour standards.[24] Distributed ledgers could become the holding database for proving relationships between the production of a product and its connection to nature and people.

This quality of traceability extends to establishing transparency within nature markets. To maintain trust, any market participant (project developer, investor or corporate buyer) needs a way to audit data in real time.

Distributed ledgers enable the digital documentation and tracking of multiple data relative to an asset. The technology's ability to link a transaction with geographical, environmental, regulatory, and financial data can offer real-time visibility into the impact and effectiveness of use-of-proceeds and induce greater transparency in the market.[25] In addition, recorded data is a permanent, unmodifiable ledger that further heightens transparency and enhances data provenance.

Any asset type can count on transparent rules and verifiable project activities, alterations and reviews from source-generation-level data.[26]

Several companies are utilising distributed ledger technology. For example, BanQu is a blockchain-based, traceability solution providing real-time data and reporting throughout entire value chains.[27] Another example, Veritree is an integrated platform using blockchain technology to verify tree-planting initiatives.[28] The Landbanking Group is tokenising nature assets to track ecosystem services across natural capital accounts.[29]

Data Governance and Ownership

Following the Global Biodiversity Framework (GBF) agreement, governments now require better-quality nature-related data to inform policy and target setting. Businesses and financial institutions will be expected to monitor, manage, and disclose nature-related impacts, dependencies, and risks.

A recent publication by the Taskforce on Nature-related Disclosures (TNFD) has put forward the creation of "A distributed access public data facility: A global entry point to a decentralised data exchange that connects to nature-related data products and services provided by contributing organisations, both public and private, whose data sets meet certain methodological and quality standards".[30] By using Web3 technologies and creating a flexible framework for different stakeholders to share nature-related data, the access to nature data is accelerated and potentially addresses issues with gaps and inconsistencies.

Public and private sector organisations, Indigenous Peoples and Local Communities all play a crucial role in accelerating the collection, connection and disclosure of credible in situ nature-related data while preserving and maintaining ownership of that data and knowledge. However, data gaps, data access, and benefit sharing are key issues to address.[31] Within this paradigm, the architecture of data and its ownership need to be carefully designed.

Given the diverse stakeholders that will collect and utilise nature datasets, how do we ensure a focal point for trusted data access, while simultaneously reducing processing time and costs? How do we ensure that participants, especially Indigenous Peoples and Local Communities, own their data?

Web3 technologies empower users to control their data instead of relying on centralised entities. Protocols automate data collection and verification processes, eliminating the need for centralised authorities to govern and verify data. This solution could enable farmers, local communities and project developers to collect and own their data. They could also share it with relevant stakeholders when necessary, under verified protocols. This could eliminate the fragmentation of digital infrastructure that currently limits progress in nature monitoring.

In addition, "the current data monetisation model often involves intermediaries, raising concerns about data ownership and privacy, which is where distributed autonomous organisations (DAOs) come into play. They represent a new way of managing and monetising data in a decentralised manner. This solution empowers communities to collaboratively curate, monetise, and govern valuable datasets".[32]

Blockchains and digital ledgers could potentially help achieve global biodiversity goals by accelerating information exchange. They could do this by keeping data ownership and responsibility in the hands of the original owners.[33] In addition, the construction of novel revenue models for nature stewards, Indigenous Peoples, and Local Communities based on this shift of data ownership could, for example, create revenue through ground-source data streams.

There are several new companies in this space. For instance, SimplexDNA is an environmental-DNA-based biodiversity monitoring system using blockchain to connect local communities, large corporations, and governments to generate a biodiversity baseline layer. They aim to create "a collaborative global biodiversity monitoring system that rewards all stakeholders" using Web3 technologies.[34]

Indigenous Peoples and Local Communities

Indigenous Peoples and Local Communities are not a homogeneous group. Globally, these communities have very different socio-economic, educational, and cultural backgrounds. When it comes to technology adoption, acceptance levels vary greatly. Tech can assist many, but it may not be for all.

Participation in nature markets has been a constant struggle for Indigenous Peoples and Local Communities. Recognition of land ownership, delivery of community benefits, governance, and decision-making inclusivity are complex and far-reaching topics. These concerns impact the equitable participation of Indigenous Peoples and Local Communities.

One concern is disputed land rights. Today, land rights are often unclear or unsettled, leading to land grabbing, illegal resource use, and, in some cases, violent conflict involving disputes between forest communities and parties trying to appropriate land. Although Web3 technologies cannot grant rights, they can establish transparency in land ownership and exclusive land-use rights while protecting historical records. For example, "using remote-sensing technology such as drones, camera traps, and GPS to map and protect territory".[35]

Although Web3 technologies cannot grant rights, they can establish transparency in land ownership and exclusive land-use rights while protecting historical records.

A second concern is benefit-sharing. Revenues generated from the sale of environmental services and resources have to be shared fairly with local populations. Blockchain technology can facilitate this by documenting the full financial flow from investors to local people, monitoring the distribution of financial resources to local and Indigenous groups with their approval[36] and verifying they receive the appropriate benefit level.

A third concern is the current disregard of Indigenous knowledge when it comes to nature or the ecosystem services they govern. Indigenous Peoples could develop indicators for ecosystem management or performance, creating methodologies for verifying transactions and outcomes within financial instruments. Digital exchange platforms based on Web3 technologies could host financial instruments with methodologies based on Indigenous knowledge and backed by data provided by Indigenous Peoples and Local Communities for proof of performance, creating a direct link in the market.

A fourth concern is ensuring a sound governance system underpins nature projects. Grassroots entities and local groups must be integral to governance, contributing to decision-making and profit sharing. Facilitating meaningful participation with digital platforms considers their perspectives and areas of expertise during decision-making, for example, by validating mandatory steps for profit sharing and investment on the ground.

Several companies are working with Indigenous Peoples and Local Communities to develop solutions. JESAC monitors carbon storage, biodiversity, and rural livelihoods and triggers traceable and transparent payments for the restoration of sites in Burkina Faso and Niger.[37] It is implemented by the joined forces of Oxfam, Lobelia Earth, and Caelum Labs and communities in Niger and Burkina Faso.

Savimbo teaches farmers how to track their offsets using trusted methodologies that work off-grid. They utilise drone photography, satellite monitoring, machine learning, GPS, and blockchain to track offsets from creation, certification, and sale.[38]

Financing Mechanisms and Price Discovery

Emerging financial mechanisms for nature, like biodiversity credits and sustainability-linked sovereign debt, are poised to capitalise on Web3's capacity for data integrity. This feature paves the way for transparent operations, ensuring all market activities can withstand scrutiny regarding the origin, measurement, reporting, and verification of assets. Such granular transparency significantly influences the valuation and exchange of these assets. This ensures investors and stakeholders can make informed decisions based on comprehensive asset histories.

Web3 can facilitate an auditable trail connecting financial transactions to their tangible counterparts in the real world. This trail enhances trust in data accuracy and clarifies the economic value attached to each dataset, thus streamlining financial workflows.[39]

Acknowledging the unique characteristics of biodiversity and nature assets through semi-fungible or non-fungible tokens makes recognising and monetising their distinct contributions possible. Machine learning algorithms help to differentiate and value these unique aspects, providing liquidity and compensation for custodians of nature. This approach does not dismiss the value of traditional metrics, like the metric tonne in carbon markets, but integrates them with unique asset attributes to bolster nature investments.

Furthermore, the ability to extensively search and analyse asset data makes assets valued for their unique characteristics rather than just their commonalities. The depth of data accessible for these assets empowers a more nuanced market approach. With the capability to perform in-depth analyses of asset characteristics, stakeholders can recognise and reward the true worth of each asset based on its unique ecological impact rather than generalised features.

For instance, Indigenous Peoples and Local Communities could create branded biodiversity credits following their culture-based methodology and price based upon the community's differentiation characteristics, or based on the benefits provided to the community. This approach fosters a marketplace that not only acknowledges but also compensates for the vital roles played by custodians of nature and the services provided by ecosystems.[40]

Examples of companies that create marketplaces for nature are Water Ledger which deploys a blockchain framework to manage water resources with integrity and accountability. It is a definitive source for tracking water allocation and usage, critical for sustainable management.[41] Open Forest Protocol, on the other hand, incentivises accurate monitoring of ecological assets, then monetises verified climate projects through a transparent marketplace.[42]

Reduced Costs

Adopting Web3 technology within the nature market's value chain can significantly cut costs, democratise access, and expand the reach of environmental financing. This aspect is particularly significant for smaller projects. With disclosure requirements imposed on smaller businesses due to regulatory requirements in Europe and elsewhere, Web3 technologies stand to streamline several key cost areas by lowering the threshold for participation in nature markets.

The first area is the measurement, reporting, and verification (MRV) process. Nature markets and the verification of biodiversity outcomes for financing mechanisms will become infeasible for most of the world's small-scale farms due to prohibitive costs. Small scale farms represent over 84% of all farms.[43] Blockchain can revolutionise this by enabling cost-effective MRV solutions at any scale, thanks to automation that reduces the financial burden, thus welcoming participation from smallholder farmers.

Secondly, blockchain makes cost reductions possible through smart contracts, which automate financing and transactional flows upon fulfilling predefined conditions. Smart contracts eliminate numerous intermediaries and the necessity for third-party verification.

CreditNature, which utilises distributed ledger technology offering nature tokens, is an example. By employing "computational smart contracts, the standards and the data are minted into the asset". Due to the blockchain's transparency, the issuance and transfer of these digital tokens are securely recorded, minimising the need for manual data management and simplifying regulatory reporting and auditing.[44]

The third aspect where Web3 drives cost efficiencies is by enabling the creation of microcosms, such as bespoke methodologies or community currencies, thus bypassing the traditional value chain. Initiatives like Kolektivo[45] are exploring such opportunities by piloting local currencies linked to regenerative agriculture practices and distributing micro-grants.

Shifting to nature regenerative practices will be costly and infeasible for many under current circumstances. Web3 technology paves the way for reducing the use of intermediaries at multiple levels and in various forms, offering each system the flexibility to determine the most efficient path forward and opening possibilities for smaller businesses to persevere in a shifting regulatory environment.

Adaptive Financing Performance

Web3 technologies and the areas described in the previous sections could result in more adaptive financing performance.

The financial services sector has already embraced some applications of Web3 technologies, presenting significant enhancements over established financial methods. For example, the introduction of automated and programmable smart contracts is beginning to provide alternatives to conventional financial intermediaries like banks, brokerage firms, and insurance companies.

These innovative solutions, when designed appropriately, can address persistent issues in traditional finance, such as excessive transaction fees, delayed settlements, disproportionate value captured by intermediaries, lack of transparency, and poor system integration.[46]

Due to advancements in Web3 technology, the need for middlemen in data management, functional operations, and even some of the traditional financial players and value transfer could become obsolete. This shift would empower users and developers to take control, driving innovation and growth through open-source platforms instead of closed, proprietary systems. Even though appropriate governance structures, regulations, and safeguards will be necessary to protect participants, this transition could foster creativity and hold potential advantages for nature markets.

Increased transparency could lead to a shift in capital flows to corporates able to showcase trusted data which proves their actions towards nature-positive and equitable operations and practices.

As a result, potential financing costs will be reduced for those same companies as regulatory and consumer/ investor pressure increases.

Due to reduced intermediaries and increased traceability, benefits and financial flows may also reach nature stewards directly.

Pricing will also become more entwined with the specification of information technology and data availability. The data attached to assets and transactions will become near real-time. Transactions can also become contingent on the variability rather than the uniformity of products. All in all, this would be a re-organisation and reorientation of data, financial and benefit flows.

Furthermore, we could think of further adaptations by training algorithms on the systems of trusted data to understand nature projection targets, future performance and even fraudulent behaviours over time.

This shift would empower users and developers to take control, driving innovation and growth through open-source platforms instead of closed, proprietary systems.

Applications and Emerging Technologies

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Applications and Emerging Technologies

The rise of nature markets holds the potential to fundamentally shift our current economy towards alignment with sustainability. However, this hinges on their creation being deeply anchored in a commitment to equity and fairness. A key strategy is accounting for nature and integrating it into global economic and financial flows. Doing so could encourage market actions that prioritise conservation, channel substantial financial investments into safeguarding and restoring natural environments, and equitably compensate guardians of these resources.

Web3 technologies are already under development within the space of nature markets:

- Supply chain management could benefit from decentralised ledgers, which track sustainable practices and verify eco-friendly materials from origin to end-user, enhancing consumer trust.
- Biodiversity credits and biodata could be digitised using Web3, creating a marketplace where investments in ecosystem services are accurately tracked and rewarded.
- In sovereign debt, blockchain may improve the issuance and management of sustainability-linked bonds, ensuring that funds are used for their intended purposes and providing transparent tracking of environmental impacts.
- Water trading could be transformed with smart contracts and decentralised platforms, leading to a more efficient and transparent allocation and management of water resources.
- Consumer nudging through Web3 platforms could leverage tokenisation to incentivise sustainable consumer behaviour, rewarding eco-friendly choices with digital tokens that can be used in various marketplaces.

The following sections present developed applications which could scale in the coming years.

Supply Chain Management (Soft Commodities and Nature Crimes)

The largest segment within nature markets is the soft commodities trade, representing a vast portion of the global food trade and ranking as one of the least transparent markets worldwide. The World Bank estimates that our roughly US$8 trillion a year global food system generates US$12 trillion annually in negative externalities, notably through destroying nature and contributing to global warming. “The annual unpriced cost of nature used by the global economy (through greenhouse gas emissions, water use, land use, wild species use, pollution, waste, etc) has been estimated at 13% of global GDP”.[47] Dominated by six major companies, these entities operate with such opacity and power that no one nation has dared to impose regulations upon them.[48]

At the same time, environmental crime, which includes illicit activities like wildlife trafficking and illegal logging, has burgeoned into one of the world’s most lucrative criminal enterprises, with estimated illegal profits nearing $300 billion annually. These crimes inflict profound environmental and societal harm, often infringing upon local communities’ human rights and imposing broader costs on governments and societies. Not only are these offences perpetrated by organised crime groups, but they are also intertwined with, and often facilitated by, legal sectors, particularly agribusiness, highlighting the need for environmental crime-free financial mechanisms.[49]

Web3 technologies offer the potential to substantially improve supply chain traceability by harnessing the power of blockchain to create decentralised, immutable records and smart contracts to automate and verify transactions upon fulfilment of coded conditions. Blockchain can provide a method for all stakeholders across the supply chain to accurately share trusted information about a product, such as a crop. A distributed ledger solution will help create an unalterable record of every crop detail, from seedlings to the farmer’s practices. Blockchain can capture this data throughout the supply chain, from the nurseries to cultivation information or even storing conditions. Biodiversity damage is also mitigated by improving tracking and reducing mislabelling.[50]

A collaboration between the Norwegian Seafood Trust, IBM’s blockchain solutions, and Atea is a prime example of effective tracking service deployment. An IBM study reinforces this development, highlighting approximately 70% of consumers place a high value on product traceability and are inclined to spend more on products providing clear transparency. This shift towards greater accountability and traceability represents a promising advancement in promoting sustainable practices within global soft commodity markets and, more broadly, nature markets.[51]

Biodiversity Credits

The bio-credit market, which aims to restore and preserve nature, is still relatively immature and faces challenges such as opaque transactions, high fees, data integrity concerns, and limited access for smaller players. These obstacles hinder its key objectives: mobilising finance, valuing nature in corporate behaviour, and emphasising the role of Indigenous Peoples and Local Communities. Web3 technology, characterised by decentralised ledgers, smart contracts, and tokenisation, offers solutions to these issues.

In today’s nascent and fragmented market, the lack of transparency and high transaction costs hinder the efficiency and accessibility of bio-credits. Doubts about the integrity and quality of the environmental benefits claimed by these credits raise concerns. Additionally, the market’s structure often excludes small buyers and sellers due to financial and administrative barriers directly impacting liquidity.

Web3 technology could have potential solutions to these challenges. Decentralised, tamper-proof ledgers ensure the transparent and immutable recording of a credit’s attributes, enhancing trust.

Smart contracts can streamline processes and reduce overheads, making the market more accessible to more participants. The tokenisation of credits enables fractional ownership and micropayments, opening opportunities for smaller buyers and sellers. Overall, Web3 technology could promote higher liquidity due to broader participation, reducing transactional barriers and enhancing market access for suppliers and buyers.

Companies like Pachama[52], Moss Earth[53], and Regen Network, are innovating the application of Web3 technologies to transform carbon markets. Their transparency and accessibility gains have the potential for extension, addressing similar gaps impeding the emerging bio-credit market.

Regen Network's transparent platform economically integrates ecological restoration, trading ecological credits, including carbon and biodiversity. Meanwhile, CreditNature[54] utilises a digital platform to offer Nature Impact Tokens, enabling transparent and credible investments in ecosystem recovery and biodiversity enhancement.

By enhancing integrity and lowering barriers, Web3 infrastructure shows promise in supporting high integrity bio-credit markets. Mainstream adoption is crucial for biodiversity credits given their inherently local characteristics, contrasting the fungibility of carbon credits across regions. The unique, localised nature of biodiversity necessitates systems capable of engaging vast arrays of small-scale stakeholders.[55] This requirement could match Web3's capabilities of integrating distributed technologies like remote sensing, IoT sensors and AI to build inclusive market infrastructure.

Labelled/ KPI-linked Bonds

There are multiple use cases for Web3 and blockchain applications in green, social, and sustainability (GSS) bonds and sustainability-linked bonds (SLBs), both at the corporate and sovereign/sub-sovereign levels.

The first three are financial instruments that earmark the use-of-proceeds (UoP) of bond financing for specific nature-based solutions or investments. SLBs, by contrast, embed key performance indicators (KPIs) measuring progress against predefined sustainability targets, including around nature and biodiversity, and contain financial incentives to pursue those targets in the form of "step-ups/ downs" in coupon interest rates for failing/ achieving them.

These instruments have recently gained prominence in fixed-income markets, rising from less than US$100 billion in 2013 to nearly US$6 trillion in 2023, according to the Institute of International Finance (IIF).[56] They are expected to continue gaining market share on the back of growing investor appetite for nature-linked financing.

Web3 can enhance the value proposition of use-of-proceed bonds and SLBs and support their continued uptake by investors and issuers in at least two ways. First, Web3 solutions such as blockchain can ensure the transparency, traceability, and integrity of the data feeding the KPIs, whether for specific projects (GSS+) or general use of proceeds (SLBs). Investors need complete visibility into each step of the data processing pipeline, from the collection of source data to the transformation into the specified indicators to the final delivery at the reporting date.

The unique, localised nature of biodiversity necessitates systems capable of engaging vast arrays of small-scale stakeholders. This requirement could match Web3's capabilities of integrating distributed technologies"

The blockchain can store the raw data and indicators on an immutable ledger, creating a single source of truth that each user can inspect at their will. Investors also need total confidence there is no alteration of the data to obtain a better reading for the issuer. The blockchain consensus algorithms can ensure each new data point is vetted and validated by the appropriate stakeholders, including second-opinion providers, before the KPI ledger is updated and results released to investors. By creating stronger oversight via collective decision-making, the blockchain can provide an added layer of quality assurance to guard against greenwashing.

The blockchain for the bond KPIs space is still nascent, and the number of providers is steadily growing, including start-ups and established players building new lines of business. Evercity[57], a Berlin-based green debt origination platform, employs the Hedera protocol to enable sustainability reporting on the blockchain, while Singapore-based STACS[58] is collaborating with Deutsche Bank and the Monetary Authority of Singapore (MAS) to develop a "bond-in-a-box"[59] that tracks and reports bond proceeds on the blockchain.

Secondly, the blockchain can serve as a digital platform to issue, trade, and settle bonds—be they GSS, SLBs, or conventional vanilla bonds. By combining and automating many roles performed by agents, exchanges, clearinghouses, underwriters, and central security depositaries (CSDs), digital bond platforms can lower transaction costs, boost liquidity via fractionalisation (splitting bonds into smaller portions) and speed up settlement. Smart contracts embedded within sustainability-linked digital bonds can even "self-execute" payouts when KPIs reach or miss their targets (i.e., they payout automatically against certain predefined conditions).

A growing number of private and public sector institutions have piloted digital bonds on the blockchain in recent years. The World Bank pioneered this space when it issued an AUD110 million, 2-year digital bond on a private Ethereum blockchain in 2018.[60]

This action was followed in short order by pilots from commercial banks (e.g., Santander in 2019)[61], central banks (e.g., Bank of Thailand in 2020)[62], corporates (e.g., Siemens in 2023)[63], and cities (e.g., Lugano in 2023)[64]. The European Investment Bank (EIB) was the first to issue a bond settled in central bank digital currency (CBDC)[65] provided by the Banque de France, which enabled payment processing on chain.

Together, these pilots have provided ample proof of concept, potentially setting the stage for mainstreaming "bonds in a box" in the foreseeable future. The scale potential is enormous given the global bond market is around US$130 trillion in notional outstanding,[66] against US$3.9 billion of digital bonds issued so far,[67] according to Moody's.

However, there are several barriers to scaling up these instruments, including technology risks such as cyberattacks or errors in smart contracts, which cannot be corrected due to the immutability of the ledger. The challenge of "cashing in and out" of digital bonds (i.e., converting fiat currency into digital assets via a stablecoin such as a CBDC) creates a major obstacle for countries without advanced digital market infrastructure. For KPI blockchains, quality control does not extend to data at the point of entry into the ledger, nor does it guarantee the transformations of the source data are correct. Still, the efficiency savings from blockchain-based KPI reporting and bond issuance suggest the outlook for these use cases is promising.

Water trading

Water scarcity is a pressing global issue affecting billions of people, threatening health, economies, and ecosystems. It arises from the imbalance between the availability of freshwater resources and the demand from populations and industries.

Driven by factors such as climate change, population growth, and increased consumption

patterns, water scarcity is not only about experiencing physical shortages but also the lack of infrastructure or capacity to access water of good quality. Trading water as a commodity on the stock market is considered an effective approach to distributing water resources. This method is advocated for because it not only enhances the efficiency of the market but also mitigates the challenges of water scarcity and insecurity, especially in the context of more prevalent droughts linked to climate change.[68]

In the early 20th century, Australia set a precedent in water rights trading, emerging as an international frontrunner in the distribution of water resources between its valleys, particularly within the expansive Murray-Darling Basin. Yet, an investigation into the basin's water market conducted by the Australian Consumer and Competition Commission along with the Department of Climate Change, Energy, the Environment, and Water unearthed several systemic issues.

These issues ranged from outdated paper-based methods combined with inadequate digital systems to sluggish transaction processes, resulting in the erosion of trust among market participants. The repercussions of these systemic flaws have been seen in various forms, notably the deterioration of water quality and the decrease in environmental water flow, with the dire situation highlighted by the stark imagery of mass fish deaths in Australian media.

As water scarcity looms as an ever-greater threat against the backdrop of evolving climate conditions, achieving long-term sustainability becomes more pressing. Although there is no single solution to the complexities of water markets, the adoption of blockchain technology offers a way forward by enhancing trust and transparency and providing a more reliable means of authenticating the activities of market participants.[69]

A blockchain-based water rights trading platform can streamline the process of water rights transfers, making it more efficient and cost-effective. This system is designed to be highly scalable and offers dynamic management capabilities that are both efficient and easily controllable. It is also characterised by its safety, reliability, low operational costs, and convenient management operation and maintenance.[70]

ARUP and IBM have collaborated on a discussion paper[71] exploring blockchain technology's potential to enhance accountability and transparency in the management of Australia's Murray-Darling Basin. This paper lays the groundwork for engaging with essential stakeholders in the basin to co-develop projects leveraging blockchain's capabilities. Water Ledger is an application leveraging blockchain's immutable and decentralised nature to track the exchange of water rights, validate transactions, and ensure compliance with regulatory requirements. It aims to simplify the process of trading water rights, reduce associated costs, and provide a reliable record that is accessible to all stakeholders in the water market.

Consumer Nudging (Gaming)

People are and always will be inextricably linked to nature. For the sake of those with whom we share this planet – human and otherwise – we all must make different choices about how we interact with other species and natural resources.[72] Considering environmental issues are mainly rooted in human behaviour, facilitating behaviour change amongst people towards pro-environmental behaviour is necessary to protect the environment.[73]

Nudging and gamification can be influential in implementing behavioural change towards more nature-friendly behaviour and consumption patterns. Globally, one in three people play video games. That is a compelling audience for environmental campaigners to communicate with regarding the climate crisis and other planetary threats. To reach gamers, UNEP launched the Playing for the Planet Alliance in 2019, a partnership with the gaming industry. So far, 50 gaming companies, reaching more than 130 million gamers, have joined, embedding environmental themes in their games.[74]

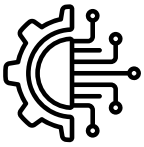
The emergence and scaling of blockchain solutions opens this space to Web3 games based on the distributed ledger. After the controversies of the initial play-to-earn model (see, for example, Javier Barnes's blog on the Deconstruction of Fun)[75], blockchain game developers today are targeting higher-quality games focused on better user experience.

The aim is to make blockchain technology complement the game rather than being a defining characteristic. Increasingly, AI tools enhance the look and feel, bringing a new level of realism and an immersive experience to games. As blockchain technology matures, traditional gaming companies are exploring ways to integrate Web3 features into their ecosystems. These steps in bridging Web3 and traditional gaming bring a much broader potential audience.[76]

The impetus enjoyed by Web3 games is due to players enjoying true digital ownership—a step that changes the business model for developers and the value proposition for players. Ownership of virtual assets affects how players engage with a game as users increasingly appreciate the opportunity to buy or sell in-game assets in the form of NFTs on decentralised platforms.[77]

Web3 games could become an important tool for nudging a wide audience towards nature positive outcomes if some of the early challenges, such as association with crypto projects, user (un)friendliness (e.g. need to open a wallet for in-game transactions), and regulative issues are solved. Integrating nature outcome payments (e.g., biodiversity credits) into Web3 game ecosystems could simultaneously nudge users towards engagement with real life conservation projects and generate financial flows to protect nature.

One example of a company in this space is Untamed Planet[78], which creates products for gaming, entertainment, content, film, and more with a mission to direct 50% of its profits back to nature. The company developed a "play-to-protect" model, which "was successfully tested in Untamed Planet's first game, built on the Roblox platform, which has generated 30 million plays since launch in early 2021. The game has already funded the adoption of a Black Rhino calf in Kenya and supported rangers protecting the Eastern Lowland Gorillas of Virunga National Park in Congo using the proceeds from in-game transactions.



Emerging Technologies and Future Potential

Web3 technologies are still in a state of rapid development and innovation. As developers, entrepreneurs and technologists continue to explore this uncharted territory, the evolution of Web3 technologies remains a dynamic and unfolding story. As the technical capacities of Web3 technologies advance, so will new opportunities for applications in nature markets.

So, how revolutionary could emerging Web3 technologies become beyond the above existing applications?

The concept of Self-Sovereign Nature Assets is a pioneering movement at the intersection of environmental conservation and Web3 technology. It involves assigning legal rights to natural ecosystems, such as forests and rivers, akin to those held by persons or corporations, allowing them to own property, earn income, and even sue for damages.

These ecosystems can be endowed with self-sovereign identities, leveraging Web3's capabilities, which are decentralised, autonomous, and not controlled by any single entity.

This paradigm shift redefines our legal and ethical relationship with nature. It paves the way for innovative conservation strategies, potentially transforming ecosystems into active stakeholders in the global economy and guardians of their own sustainability.

Smart contracts and blockchain technology enable these ecosystems to engage in self-transactions, manage resources, and potentially channel funds for their preservation and improvement.

This paradigm shift redefines our legal and ethical relationship with nature. It paves the way for innovative conservation strategies, potentially transforming ecosystems into active stakeholders in the global economy and guardians of their own sustainability.[79]

Furthermore, recent efforts to integrate AI with Web3 technologies could unlock new computational potentials for nature markets. Distributed AI computing is an innovative approach bringing the power of artificial intelligence to the edge of the network, closer to the generation of data.[80]

In the context of environmental monitoring and conservation efforts, this could revolutionise the way we collect, process, and act on data from sources like farms or natural conservation sites. By leveraging a distributed network of AI-enabled nodes, data can be processed on-site, leading to real-time insights and immediate actions.

This distributed architecture reduces the latency typically associated with sending data to centralised cloud servers and enhances trust and security, as the data does not need to traverse through vulnerable channels. In practical terms, this could mean faster and more reliable verification of environmental conditions and outcomes, better data privacy, and empowerment of smaller organisations or communities to participate in the market.

In addition, innovations relating to integrating distributed machine learning (ML) with blockchain introduce two transformative elements: native payment rails and AI agent wallet ownership. Distributed ML Rails is a framework or infrastructure enabling machine learning agents to operate within decentralised marketplaces. These ML agents, powered by distributed artificial intelligence, can execute transactions, manage assets, and optimise networks without traditional intermediaries.[81]

In the context of nature markets, where ecosystem services and natural capital are bought, sold, or traded, AI agents can help streamline these assets' valuation, exchange, and monitoring. By incorporating AI into these markets, stakeholders can benefit from more efficient pricing mechanisms, real-time data analysis (including faster detection of outcome changes) for better decision-making, and enhanced liquidity for nature-based assets.

Furthermore, distributed machine learning rails could lead to a reduction in the use of intermediaries by reducing reliance on traditional financial and regulatory institutions. This could lower transaction costs and barriers to entry for smaller participants, empowering local participation, and potentially creating a more democratic and accessible marketplace for natural capital.

Beyond the above, there could still be more possibilities. These areas are nascent, and their application and commercialisation are yet to be tested. According to Roni Bulent Ozel, Co-founder of Lucidminds and expert in EthicalAI and DLT4Good, "The combination of AI and Web3 could lead to significant economic, societal, and personal benefits. Web3 allows for safe, decentralized data exchange, making it easier for AI models to work together across different organizations. However, we must address challenges such as data privacy, ethical use, and biases in algorithms. It's crucial to work together—policymakers, industry leaders, and the public—to create strong guidelines that safeguard personal rights, build trust in new systems, and prevent societal gaps by ensuring fair access to these technologies".

Still, beyond the AI and Web3 hype, application examples have not been fully developed yet. Ultimately, as nature markets rise and mature, the usefulness of the underlying technologies of Web3 will start becoming more apparent, finding appropriate applications when other technologies and institutional infrastructures fail.

Web3 Evaluation Criteria

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Web3 Evaluation criteria

Landscape of Companies and Market Opportunities

Technologies are mechanisms that reposition agents, environments, protocols, materials and infrastructures with the power to compose and organise communities. They become catalysts for change, the consequences of which are determined by the dynamic interplay of human choices and societal structures.

In the coming period, we will witness the advancement of Web3 technologies within nature markets; the union of the two could potentially generate influential opportunities. The two fields have a significant alignment of conceptual approaches and technical deliveries. In these developments careful consideration must be given to not replicate existing unsustainable nature market dynamics; with the development of product solutions identifying appropriate leverage points for using Web3 technologies.

We will probably observe hybrid solutions and products operating in Web2 but integrating Web3 technologies. We will see architectures placing certain things on the chain but not others. For example, modelling and source data collection can happen in Web2, but verification and transaction executions may happen in Web3 for greater transparency and accessibility. This hybrid approach would also allow for a wider adoption of these solutions today.

However, what operates in Web3 and how is an important choice and an essential factor for designing just and equitable nature markets. We have already witnessed fraudulent behaviours in cryptocurrencies, multiple hacks, scams, and market implosions. Therefore, careful consideration must be given to the core challenges faced by nature markets (addressed in section 4) within the development of product solutions. An integral part of the design and implementation process, not to be disregarded, is the institutional and regulatory oversight needed within nature markets.

Several applications and early-stage companies are developing products based on Web3 technologies to address current challenges in nature markets. The technology is in its early stages of development, but there have been several proofs-of-concept and working products. As the code and infrastructure further develop, there are real opportunities for wider adoption.

Below, we list some of the emerging companies within the landscape of nature markets and Web3. We invite others to suggest additional companies as they emerge in order to build a knowledge hub around this early-stage investment area.

Contact nic@naturefinance.net to suggest new companies to our team.

EXHIBIT 4

Web3 companies in nature markets

SECTOR	Biodiversity Credits	Supply chain management	dMRV for biodiversity	Infrastructure
COMPANIES	REGEN NETWORK TERRASOS SYLVA Centigrade biota SINGLE.EARTH BioDivToken PLANET creditnature bluebell index	Wholechain CARNES VALIDADAS SAP BanQu PROVENANCE TraceX TECHNOLOGIES origintrail Peer Ledger The Responsible Supply Chain Company Makersite	veritree SimplexDNA® OPEN FOREST PROTOCOL dClimate THE LANDBANKING GROUP	r3. Hedera CELO Chainlink

SECTOR	Gaming & consumer nudging	Water trading	Sustainability-linked sovereign bond	Other
COMPANIES	UNTAMED PLANET QuestaGame My Lovely PLANET HEALV3RSE	Water Ledger IBM ARUP H2O SECURITIES BOTANICAL WATER TECHNOLOGIES	evercity #STACS NEXUS OF ESG	kolektivo JESAC

However, while Web3 heralds a new era of internet technology with its promise of decentralisation, transparency, and enhanced user sovereignty, it has its challenges and potential downsides. The Nature Investor Circle is developing evaluation criteria through which Web3 opportunities for nature markets can be understood and potentially assessed, with a reminder that these technologies should not exacerbate unsustainable nature market dynamics. The content below looks at some preliminary lenses through which to view Web3 product strategies.

Technological adoption: As mentioned earlier, the shift to Web3 could inadvertently create new forms of digital divide, leaving behind those without the technical capabilities or resources to participate in this emerging landscape.

Technological readiness: Blockchains, having been around for just over ten years, still fall into the category of emergent technologies. The development cost can be steep, and given the swift pace of tech advancements, some blockchain solutions may become outdated rapidly. Additionally, user interfaces are not always user-friendly, and securing expertise can be challenging and costly.[82]

Reliability of oracle systems and data quality: MRV data inputted into the blockchain to enhance transparency is currently substandard and fails to achieve its expected outcomes. There is a pressing need to conduct a thorough analysis to identify the core issues within the MRV's scientific underpinnings and its ability to be traced effectively before incorporating more MRV data into the blockchain system.[83] In scenarios where establishing a dependable oracle system proves challenging, the digitisation of external real-world data becomes unlikely, casting doubt on the advantages of using blockchain technology to administrate environmental services.[84]

Commodity oligarchs: Web3, amid claims of democratisation and mass wealth creation, faces scrutiny as a speculative bubble that disproportionately enriches the wealthy; a mere 0.01% of Bitcoin holders command 27% of the currency. Practices like wash trading and market manipulation are prevalent, inflating values and facilitating profit from deceptive trades. Critics like Edward Ongweso Jr. and Jacob Silverman describe it as a mechanism for wealth transfer to the top.

At the same time, investor Rex Woodbury in The Atlantic labels it as the problematic financialisation of everything. Molly White's "Web3 Is Going Just Great" highlights the sector's numerous scams and collapses, depicting a tumultuous, unregulated frontier.[85]

Regulatory barriers: Financial entities are navigating a regulatory void regarding cryptocurrency transactions and smart contracts. Without established and clear regulations, these institutions will find it challenging to adopt blockchain technology for their operations.[86]

Data protection: The current system's approach to data privacy is considered insufficient by many. Initially, wallets maintain anonymity, but advancements in technology are increasingly enabling the association of wallets with their owners through analysis of transaction histories. When this anonymity is compromised, the details of all transactions become potentially accessible globally. Although the transparency of this system has its advantages, for the technology to attract widespread interest, it's crucial that users have the option to obtain privacy as needed.[87]

Environmental impact: Web3's environmental toll is significant, primarily from high energy consumption and electronic waste linked to cryptocurrency mining. Intensive computational tasks required for blockchain operations consume vast amounts of electricity. At the same time, the rapid turnover of mining equipment contributes to a substantial e-waste problem, with Bitcoin alone generating waste comparable to the annual output of a country like the Netherlands. However, several innovations are minimising environmental impact today.[88]

Interoperability: "In the ever-evolving landscape of blockchain technology, achieving interoperability across different networks remains a paramount challenge. While the benefits of cross-chain compatibility are evident, several hurdles must be surmounted to ensure users' seamless and secure experience", which also hampers mainstream adoption.[89] The plethora of Web3 platforms and protocols is a challenge as it potentially reduces interoperability and harmonisation of a common language in the market.

Volatility: Prices of digital assets exhibit extreme fluctuations, with the worth of these assets and Web3 enterprises capable of soaring or plummeting abruptly. Should their value decrease, there is no assurance of recovery. Consequently, this presents a considerable degree of risk.[90]

Web3 could become catalytic to nature markets. However, this depends on how its technologies evolve and whether it upholds its promises of decentralisation, openness and transparency. But if we assume Web3 remains faithful to decentralisation and transparency, some of its most catalytic characteristics would be decentralised banking and payment functionalities. This is of particular importance for locations in which intermediaries are corrupt or there are no proper transaction infrastructures.

Digital ownership, data ownership and self-sovereign identities could also catalyse nature stewards and the adoption of new data business models that empower local people. Interoperability between applications, so that information and value are transferrable between blockchain platforms, can prevent any siloed monopolies or centralisation of one actor in the market.

The governance aspect of nature markets in a Web3 environment will be an important factor and would ideally encompass a combination of technical standards, governance approaches and ethical guidelines. For example, one could argue on-chain governance and DAOs should prevent centralisation by design. Interoperability and open standards are also critical in preventing centralisation.

Concerning data and digital ownership in nature markets, another essential aspect is developing data privacy protections and consent mechanisms. In tandem with the above, security standards are another big topic. Ethical guidelines could also be developed specifically for Web3 applications for nature markets.

Currently, work within this space is under-developed (i.e. the regulation for nature markets on Web3), but there is little happening with the regulation of Web3 in general.[91] In this context, it is important to pay close attention to the backbone infrastructures of Web3 and the uptake of different blockchain-as-as-service ventures that will be used by companies to build products for nature markets.

The integration of nature into market economies presents multifaceted challenges. This reorientation necessitates innovative, equitable solutions that fairly distribute benefits across all stakeholders, including Indigenous People and Local Communities. Web3 technologies are at the forefront of this transformation, offering novel approaches. These technologies can potentially incentivise sustainable behaviour and reimagine nature markets' governance and transactional structures.

However, their application should be carefully considered and only used when it is absolutely necessary for creating democratic, auditable and transparent processes. These technologies can be relevant if there is a lack of other appropriate institutions to govern nature markets. As Web3 continues to evolve, so too does the potential for nature markets to promote environmental sovereignty and a just realignment of our economic systems with the natural world.

Endnotes

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Annex I: Identified Landscape of Companies

The Rise of Web3: Nature's Potential in the Digital Age

Identifying opportunities and strategies for Web3 technologies within nature markets.

NATURE FINANCE

Identified Landscape of Companies

SUB-SECTOR	NAME	DESCRIPTION	WEBSITE
Biodiversity credits	Regen Network	Platform that supports origination and investment in ecological credits, which include but are not limited to carbon.	https://app.regen.network/
Biodiversity credits	Single.Earth	Uses methods based on big data and AI to evaluate and quantify forest attributes and give input for developing a new green currency called MERIT. MERIT has many use cases. It can be used as a Proof of MERIT to enable transparent nature-positive contributions, a green crypto token for investing, and a potential future eco-currency which places nature in the heart of the economy.	https://www.single.earth/
Biodiversity credits	Biota Nexus	Global open market for biodiversity credits enabling conservation in Costa Rica	https://biota.land/
Biodiversity credits	Terrasos	A proposal that combines the concept of biodiversity credit with digital tokens to provide greater traceability and transparency to transactions by implementing distributed ledger technologies (DTL), which store information in multiple locations at any given time.	https://www.iadb.org/en/news/idb-lab-announces-results-its-digital-tokens-biodiversity-challenge
Biodiversity credits	CreditNature	Platform provides dashboard access to easily understandable metrics (scored 0 – 100), linked to Nature Credits, enabling direct investment in land assets with commitments to adopt ecological land management that will deliver benefits to land managers and measured uplifts in biodiversity and ecosystems.	https://creditnature.com/
Biodiversity credits	Savimbo	Built by, and for, Indigenous groups and smallfarmers in tropical forests to disintermediate climate markets. The solution includes Biodiversity, Tree, Water and Carbon credits.	https://www.savimbo.com/
Biodiversity credits	Sylva	Self-serve technology and project development resources simplify and shorten the development process. Land-owning communities and small-scale landowners can evaluate and develop nature assets on their own, using geospatial AI and dMRV.	https://sylva.earth/
Biodiversity credits	Centigrade	Open marketplace for carbon and nature credits.	https://www.centigrade.earth/
Biodiversity credits	BioDivToken	The Biodiversity Conservation Tokens (BCT) initiative is a revolutionary project aimed at leveraging blockchain technology to fund and support global biodiversity conservation efforts.	https://biodivtoken.com/
Biodiversity credits	Bluebell Index	A climate fintech that values, certifies and monetizes environmental assets. Bluebell's blockchain-based tokens are generated using science-based international methodologies and proprietary algorithms.	https://bluebellindex.com/

SUB-SECTOR	NAME	DESCRIPTION	WEBSITE
Biodiversity credits	rePlanet	rePLANET projects produce premium quality carbon and biodiversity credits with substantial benefits to local stakeholders, and the costs of these credits are deliberately kept competitive so that they attract large scale-funding to restore or protect substantial areas.	https://www.replanet.org.uk/
dMRV for biodiversity	SimplexDNA	Environmental-DNA-based biodiversity monitoring system that uses blockchain to connect local communities, large corporations, and governments to generate a biodiversity baseline layer	https://www.simplexdna.com/
dMRV for biodiversity	Open Forest Protocol	Protocol that incentivises accurate monitoring of ecological assets, then monetizes verified climate projects through a transparent marketplace.	https://www.openforestprotocol.org/
dMRV for biodiversity	Veritree	Integrated platform using blockchain technology to verify tree-planting initiatives. By combining geolocation technology with blockchain verification, Veritree is aiming to “revolutionize” the restoration space by making projects verifiable and transparent.	https://www.veritree.com/
dMRV for biodiversity	dClimate	dClimate is a decentralized climate data infrastructure network transforming the way climate tech applications are brought to life to power a resilient future.	https://www.dclimate.net/
dMRV for biodiversity	GainForest	Developed by leadingPutting together the best of research from leading universities such as ETH Zurich, MIT, and Stanford, and infused with a dash of unwavering passion for climate, our technology allowshelps donors to monitordonors monitor and track the environmental impact of their contributions through a fully transparent model.	https://gainforest.earth/
dMRV for biodiversity	dMeter	dMeter is unique in the dMRV space, in that we're not designing a product, hardware or software stack, but facilitating the development of a robust, diverse, distributed decentralized MRV ecosystem that offers options to land users, project developers & community/citizen scientists.	https://explorer.gitcoin.co/#/round/10/0xb6be0ecafdb66dd848b0480db40056ff94a9465d/0xb6be0ecafdb66dd848b0480db40056ff94a9465d-119
dMRV for biodiversity	The Landbanking Group	The Landbanking Group is tokenizing nature assets to track their ecosystem services across natural capital accounts	https://www.thelandbankinggroup.com/
Gaming & Consumer nudging	Untamed Planet	Creates products across gaming, entertainment, content, film and more with a mission to direct 50% of its profits back to nature.	https://www.untamedplanet.earth/
Gaming & Consumer nudging	QuestaGame	QuestaGame is a global social enterprise that believes in working (and playing) together to protect life on our planet for a sustainable future. With Earth’s biodiversity under serious threat, we embrace the power of mobile technology - from gaming apps to machine learning - to take new audiences outdoors where they grow to become environmental scientists.	https://questagame.com/
Gaming & Consumer nudging	My lovely planet	Financing concretely and efficiently. We have created an amazing fun game on smartphone to unite 100 million players around the world on the first and biggest "Play to Save".	https://www.mylovelyplanet.org/#ourGame

SUB-SECTOR	NAME	DESCRIPTION	WEBSITE
Infrastructure	Celo	Celo is building the regenerative path towards prosperity, supporting solutions with their rich ReFi ecosystem using assets and primitives native to Celo.	https://celo.org/
Infrastructure	Chainlink	Chainlink supports a wide variety of use cases across digital measurement, reporting and verification (MRV); registries; exchanges; and other market participants to enable a highly efficient climate ecosystem.	https://chain.link/
Infrastructure	Hedera Guardian	The Hedera Guardian is an open-source platform that leverages the Hedera public distributed ledger network to enable methodologies to be created and dMRV (Digital Measurement, Reporting, and Verification) to become a reality. By acting as the guard rails for the rulesets in carbon markets, emissions, accounting, and biodiversity the Hedera Guardian provides auditable, traceable, and reproducible records that document the process and lifecycle of environmental assets, which reduces fraud in sustainability markets.	https://hedera.com/guardian?utm_term=hedera%20guardian&utm_campaign=Guardian+-+Search&utm_source=adwords&utm_medium=ppc&hsa_acc=1782665900&hsa_cam=20122535662&hsa_grp=149034776316&hsa_ad=658205373724&hsa_src=g&hsa_tgt=kwd-2058297434541&hsa_kw=hedera%20guardian&hsa_mt=b&hsa_net=adwords&hsa_ver=3&gad_source=1&gclid=CjwKCAjw17qvBhBrEiwA1rU9w9NjJwfUSM8HB4sw5VSUMMWJv4vK0K0MCgl2uTOdDelMwfj2AVQfKBoCUagQAvD_BwE
Infrastructure	R3 Corda (debt issuance)	Leading blockchain platform powering the tokenization of traditional financial assets and currencies. The next generation of Corda delivers on R3's promise of enabling a connected 'network of regulated networks'.	https://r3.com/products/corda/
Other	JESAC	JESAC monitors carbon storage, biodiversity, and rural livelihoods and triggers traceable and transparent payments for the restoration	https://jesac.vercel.app/
Other	Kolektivo	Piloting community currencies; environmental credits tied to regenerative agriculture and issuing micro-grants	https://www.kolektivo.network/
Supply chain management	BanQu	BanQu is a blockchain-based, traceability SaaS solution that gets you real-time data and reporting throughout your entire value chain - all in one place.	https://www.banqu.co/
Supply chain management	Makersite	Makersite provides the tools for companies to understand how their products are made and bring information and transparency of deep tiers in the supply chain.	https://makersite.io/
Supply chain management	The Amazon Bank of Codes (ABC)	An open, digital platform that puts genetic codes of Amazonian biodiversity on a blockchain and codifies rights and obligations related to their use. Companies that want access to the data will have to buy it using a cryptocurrency where a portion of the revenue will be paid to the communities taking care of the rainforest. The ABC is a pilot for a larger Earth Bank of Codes (EBC) – the global version of the same idea.	https://www.earthbankofcodes.org/
Supply chain management	SAP Green Token	Unilever's partnership with SAP, a German software company that has developed GreenToken, a blockchain technology. This partnership will allow the consumer goods giant to trace its global palm oil resources. The company has already conducted a successful proof of concept in Indonesia where it applied GreenToken to source more than 188,000 tons of oil palm fruit for deforestation-free palm oil.	https://www.sap.com/products/scm/green-token.html

SUB-SECTOR	NAME	DESCRIPTION	WEBSITE
Supply chain management	Carne Validades	Argentinian supply chain traceability company, recently helped to tokenize and validate its first Argentine beef export to Dubai.	https://www.carnesvalidadas.com/index_en.php
Supply chain management	Wholechain	A blockchain based traceability solution built to enable trust, coordination, and transparency in fragmented supply chains. Using blockchain technology, soybeans can be sourced and traced at the jurisdictional level in Brazil. The company is now expanding its focus from seafood to include beef and poultry.	https://wholechain.com/
Supply chain management	Provenance	Uses blockchain technology to enable secure traceability of certifications and other salient information in supply chains. Provenance enables every physical product to come with a digital 'passport' that proves authenticity (Is this product what it claims to be?) and origin (Where does this product come from?), creating an auditable record of the journey behind all physical products.	https://www.provenance.org/
Supply chain management	TraceX	Harnessing the power of blockchain to drive transparency, accountability and scalability for accelerating net-zero goals with nature-based solutions in supply chains.	https://tracextech.com/
Supply chain management	OriginTrail	OriginTrail Decentralized Knowledge Graph combines knowledge graph and blockchain technologies to enable a universe of AI-ready Knowledge Assets, allowing anyone to take part in trusted knowledge sharing.	https://origintrail.io/
Supply chain management	Peer Ledger	Patented MIMOSI Connect multi-enterprise Digital Product Passport platform helps retailers, manufacturers, and their suppliers in any industry vertical drive positive climate, human, and governance impact on one platform. MIMOSI Connect makes sustainability and compliance reporting believable, and enables new data services within supply chain ecosystems.	https://www.peerledger.com/
Sustainability-linked sovereign bond	Evercity	Evercity platform automates management, issuance and monitoring of sustainable finance. We make it easier, cheaper and more transparent for banks, funds, corporates and SMEs.	https://evercity.io/
Sustainability-linked sovereign bond	STACS	Collaborating with Deutsche Bank and the Monetary Authority of Singapore (MAS) to develop a "bond-in-a-box" that tracks and reports bond proceeds on the blockchain	https://stacs.io/next-generation-green-finance-digital-assets-and-sustainability-linked-bonds/
Water trading	Water Ledger	A secure, end-to-end blockchain enabled solution delivering accountability and transparency for available, utilised, and shared water, ensuring a single source of truth.	https://waterledger.com/
Water trading	IBM & ARUP	ARUP and IBM have collaborated on a discussion paper that explores the potential of blockchain technology to enhance accountability and transparency in the management of Australia's Murray-Darling Basin. This paper lays the groundwork for engaging with essential stakeholders in the basin to co-develop projects that leverage blockchain's capabilities.	https://www.ibm.com/blog/how-blockchain-enables-trust-in-water-trading/

SUB-SECTOR	NAME	DESCRIPTION	WEBSITE
Water trading	H2O Securitites	The H2O Water Network and H2ON Token strategy is designed to address the problems that prevent rapid scalability and deployment of water infrastructure by broadening the participation of global partners. The H2O Water Network is a closed loop ecosystem where a tokenized currency (H2ON Token) is used as a mechanism to reward participation in the network. It lowers the barriers to deploy more water infrastructure, quicker, globally, and to unlock new sources and approaches to water production.	https://www.h2o-securities.com/h2on
Water trading	Botanical Water Exchange	Water Impact Credits support sustainable water projects and technology by utilising Sustainable Water Certificates to both value and account for every unit of sustainable water. Just like Renewable Energy Credits (RECs), water certificates have two components; one that represents the physical unit of water and another that is a water credit.	https://www.wegrowwater.com/our-ecosystem
Gaming & Consumer nudging	HEALV3RSE	What sets HEALV3RSE apart is the unique integration of player avatars actually performing healing actions within the game, such as planting trees, conducting ocean cleanups, or installing solar panels. This interactive feature, which the creators call 'Play to Heal', brings a sense of empowerment to the gameplay experience.	https://www.sandbox.game/en/experiences/healv3rse/06cb9234-2e8a-44e6-8b23-ef804cbede2d/page/