

STANDALONE REPORT

GLOBAL STANDARDS MAPPING INITIATIVE 4.0

NOVEMBER 2023

SUSTAINABILITY

**GLOBAL BLOCKCHAIN
BUSINESS COUNCIL**

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GSMI 4.0 IN-DEPTH REPORT

SUSTAINABILITY

EXECUTIVE SUMMARY

This report explores the benefits of blockchain technology and digital assets to address the world's most pressing and complex issues that call for prioritizing sustainability. It builds upon prior work focused on the decarbonization of upstream value chain emissions within the digital asset space, and now covers downstream value chain emissions measurement and finance for mitigation. Having addressed the negative impacts of blockchain on the environment with a prior report, now this working group explores positive contributions that blockchain can have to advance sustainability.

Blockchain technology can be deployed with promising outcomes in cases where there are sensors capturing data on climate factors (e.g., emissions, waste and pollution, weather patterns), as a means to measure, monitor, and evaluate the impact of climate mitigation activities. Blockchain technology can also integrate with IoT along digitized supply chains, to measure emissions, record data on responsible business practices, and improve outcomes. To place these solutions into context, this report takes a step back to assess the broader conditions that led to the imminent sustainability concerns the world faces today, and how new models of activity can break harmful cycles, where innovations in blockchain technology can emerge.

Fundamentally, this report discusses the ways our current economic systems have contributed to the situation at hand, and alternative economic models to address these issues including regenerative finance (ReFi), sustainable supply chains, and domestic resource mobilization. Covering real-world examples and use cases of blockchain and digital assets being deployed toward promising solutions, this report also serves as a guide on how these innovations can help companies and organizations meet increasing regulatory requirements for sustainability and make their own transition plans more realistic and effective.

OVERVIEW: IMPORTANCE OF SUSTAINABILITY

Increasing Focus on Sustainability

Sustainability has been an increasing focus area across sectors, impacting the decisions of business leaders, politicians, and all stakeholders concerned with the future of humanity. The UN Sustainable Development Goals (SDGs) call for collective and meaningful action by 2030, mobilizing not billions but trillions in funding from public and private sectors to address the world's most pressing needs. The Paris Agreement, a legally binding international treaty on climate change, also calls for climate change mitigation, adaptation, and financing, to limit the rise of average global temperatures to below 2°C above pre-industrial levels, and to take measures to remain below 1.5°C. Article 6 of the Paris Agreement acknowledges the role of voluntary cooperation across countries, to reach nationally determined emission reduction goals.

Institutions and corporations are realizing that disregarding sustainability has become a material financial risk that can significantly impact bottom lines, while customers are increasingly driving demand for sustainable products and services driven by increasing awareness of the risks for our society and generations to come. As for small and medium enterprises, many are either actively developing sustainability-focused innovations, or being pushed into adopting more sustainable practices through large corporates embedding their sustainability objectives and compliance requirements into their contracts with vendors and suppliers. Ultimately, regulators and standards setters are actively producing requirements for all stakeholders to adhere to.

Urgency of the problem: it's environmental and social

Climate change affects all of us, and it's expected to disproportionately impact marginalized and vulnerable populations with less economic resources, mainly in the Global South. This is why the "E" and "S" in ESG are closely related. With rising temperatures, extreme weather events, and oceans rising due to , an imbalance where snowfall no longer matches ice lost from melting ice caps, the effects on the future of humanity can be major. . These issues can bring major global concerns and aggravate the complex global issues we are already facing today (e.g., migration crisis, hunger crisis, geopolitical conflict, increasing wealth gap perpetuated with rising food and energy prices and inflation).

Researchers have established and quantified nine planetary boundaries, as conditions within which humanity can adequately operate and maintain its well-being. Crossing any of these boundaries is expected to cause irreversible changes, with major consequences for humanity. As of today, six of the nine limits have been breached (climate change, biosphere integrity through biodiversity loss and extinction of species, freshwater change, land system change, biogeochemical flows, and introduction of novel entities), one is close to being breached (ocean acidification), and only two may remain well within the constraints (atmospheric aerosol loading, which has not been quantified, and ozone depletion).

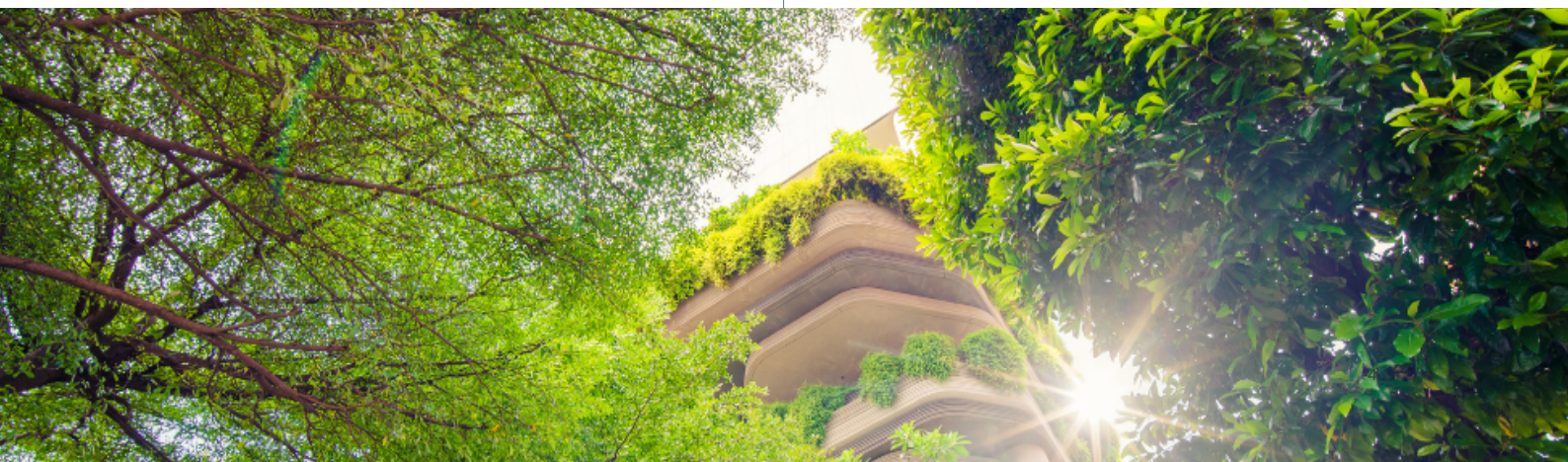
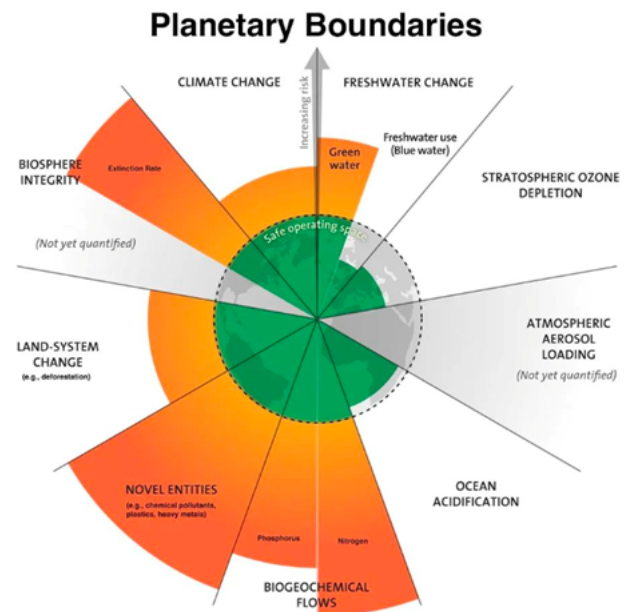


Figure 1: The nine planetary boundaries and their status

1. CLIMATE CHANGE
2. CHANGE IN BIOSPHERE INTEGRITY (BIODIVERSITY LOSS AND SPECIES EXTINCTION)
3. STRATOSPHERIC OZONE DEPLETION
4. OCEAN ACIDIFICATION
5. BIOGEOCHEMICAL FLOWS (PHOSPHORUS AND NITROGEN CYCLES)
6. LAND-SYSTEM CHANGE (FOR EXAMPLE DEFORESTATION)
7. FRESHWATER USE
8. ATMOSPHERIC AEROSOL LOADING (MICROSCOPIC PARTICLES IN THE ATMOSPHERE THAT AFFECT CLIMATE AND LIVING ORGANISMS)
9. INTRODUCTION OF NOVEL ENTITIES



The expected melting of the **110 tons** of ice from the Greenland ice cap alone can cause oceans to rise by **10.6 inches** (27 cm), affecting **600 million** people living in coastal areas and costing trillions of dollars. With other factors at play, the ocean could rise up to **30.7 inches** (78cm), and with further ice caps melting (Himalayas, Alps, Antarctic) and continued global emissions, the rise in oceans can be multi-meter and affect billions of people with floods.

Financing for sustainability

Urgent and effective climate action can have a dramatic impact in reducing potential future damage. Limiting rising temperatures by **1.5 degrees C**, as set out by the Paris Agreement, can bring down the total global cost of climate change by hundreds of trillions of dollars, cutting expected losses by more than half. Leading institutions have developed frameworks for sustainable investments, such as the UN supported Principles for Responsible Investment (PRI), which have gained significant traction since being introduced in 2005, having been adopted by many of the world's largest institutional investors such as BlackRock (signatory since 2008).

Over the last decade, there has been an explosion of funding going into sustainability-related investments, largely with a focus on climate finance. In 2023 alone, global sustainable funds attracted **\$23.6 billion** and **\$13.7 billion** in Q2 and Q3 respectively.¹ By now, the World Bank has issued USD \$18 billion worth of green bonds since the first issuance in 2008, as a form of debt financing for sustainability initiatives to provide positive impact to societies.² According to the Reserve Bank of Australia, **\$13 billion** in green bonds were issued in the first half of 2023 which is a record amount to date in the Australian green bond market.³ Yet there is a wide spectrum of approaches, and the specific objectives have yet to be standardized, starting with a commonly agreed upon perception of the issues and the standardization of the data to measure, monitor, and evaluate impact.

The United Nations Framework Convention on Climate Change (UNFCCC) refers to climate finance as "finance that aims at reducing emissions, and enhancing sinks of [greenhouse gases](#) and aims at reducing vulnerability of, and maintaining and increasing the resilience of, human and [ecological systems](#) to negative climate change impacts,⁴" and the Climate Policy Initiative has produced a database of climate finance that provides guiding parameters and definitions for the private sector.⁵

While there is no concrete definition of climate finance as of yet, there is still a need for harmonized and actionable guidance on climate action. Common standards for project financing, reporting, and monitoring impact can greatly mitigate concerns of ineffective climate action, misaligned initiatives, and greenwashing. For instance, developed nations have reported financing projects to the UN and other international organizations as contributing toward national climate finance goals, when the true impacts toward sustainability have been minimal or even detrimental.⁶

Innovations in blockchain technology can advance sustainability:

The transparency and trust offered by blockchain technology can improve accountability, while the community-driven action that peer-to-peer relationships enable can propose new governance models (the “G” of ESG) to drive environmental and social impact. These models can facilitate a harmonized approach to climate action at scale, while democratized ownership can enable collective action starting from individuals and small entities. Digital transformation is fundamental to coordinate urgent global action addressing pressing issues like biodiversity loss, disaster displacement, energy grid deficiencies, and social and geopolitical strife. Blockchain and digital assets can greatly improve mitigation and adaptation efforts through greater integrity of data, real-time visibility on carbon emissions and sequestration, and cost-effective transactions.

These innovations can ultimately support a more sustainable and inclusive system of capital flows through built on a transparent accounting system, and are even forming the backbone of a regenerative economy that not only reduces emissions but deploys resources toward conservation and restoration of ecosystems, for a better future for humanity and the planet. The movement to mitigate climate change could create more opportunities that may increase chances for achieving higher rates of equality, especially for the most vulnerable populations. Restoration of environmental, social, and financial stability can bring a holistic series of benefits alongside monetary gains. Therefore, the movement to mitigate climate change is integrated with improving equality.



STATUS QUO & PROBLEMS

Existing business models, which traditionally have not been built with sustainability as a priority, are not being effective enough to address the sustainability concerns the world is facing today, many of which originate from numerous externalities of those business models themselves.

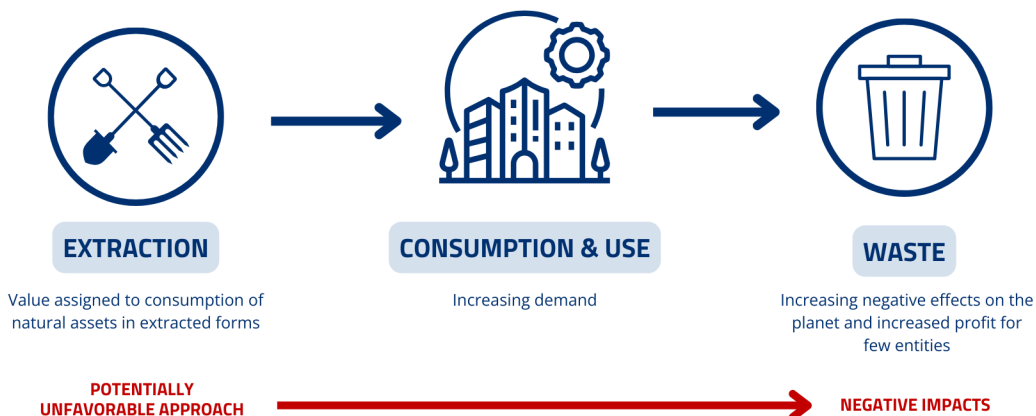
Currently, many sustainability-linked risks that affect businesses' bottom lines are not envisioned in their central market strategies or main profit and cost items, such that they become increasingly substantial yet still non-market costs. Many major global corporations suffered major losses and reputational damage when customers, activists, and interested stakeholders brought light to unsustainable practices that came from a narrow focus on their pure market strategy to maximize short term profits (e.g., Nike for hiring labor from sweatshops, Nestle for purchasing palm oil from plantations that depleted natural ecosystems, oil companies for not responding adequately to oil spills). Sustainability strategies within those very business models, without innovations that seriously rethink current processes, may only get us so far.

Extractive approach to commerce

Currently, the global economy has valued and paid for products in their extracted format, at the end of the supply chain, fostering a system of perpetual extraction of natural resources, largely in the Global South, production, consumption, and waste. With this economic model, most of the economic benefits favor large corporates in the Global North, while the impacts and risks sit in the Global South where capital chases low-cost labor and less expensive resources.

This extractive cycle, where the conservation of natural resources is not recognized as a central part of this (until we feel the effects as today), also shapes the commercial dynamics between the Global North, where the largest markets lie, and the Global South, where most of the resources are based to meet the commercial demands of the former. This view can be narrowly focused on short term profits, with several blind spots with respect to the importance of sustainability, not only to remain competitive, but to even allow the possibility of business practices to continue.

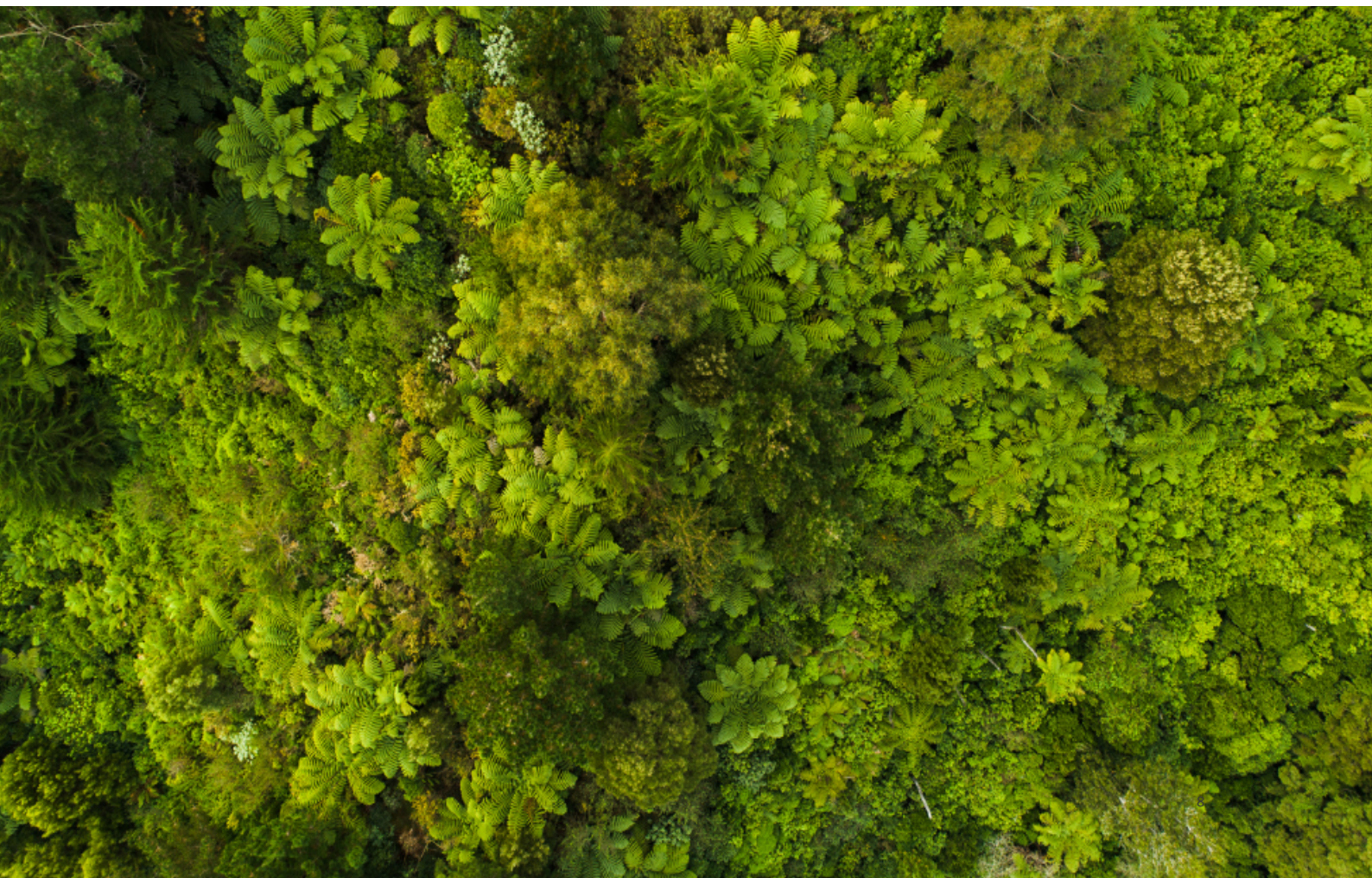
Figure 2: Extractive economic systems



Climate stress models, for instance, repeatedly underestimate the economic impacts of climate change, and there has been widespread criticism of climate stress tests (e.g., costs of carbon emissions can be estimated to be much higher than the US federally accepted estimate of **\$51** per ton – affecting climate policy and outcomes).⁷ Carbon Tracker research, for instance, recognizes that scenario modeling is important for financial institutions to assess the impact of climate change scenarios. However, many climate scenario models for financial services significantly underestimate the risk of climate change. As a result, budgets to deal with carbon impacts may be smaller than anticipated and necessary, while the risks may unfold more quickly than expected, leading to uncertainty and lack of predictability.⁸ With this underappreciation of climate risks, underestimating the effects to the Global North in particular gives false confidence of the ability to ‘raise the drawbridge’ when the preceding issues hit with full impact.

Not enough funding for the Global South

There are currently a number of blockages to funding in the Global South, which especially impacts climate mitigation funding. While traditional finance has benefitted the extractive commercial approach, it has underinvested in the Global South where investments are most needed. In some cases, traditional capital flows absorbed and intermediated the resources needed to be mobilized domestically in the Global South, though both illicit fund flows and legal fund flows that avoided weak local institutions (e.g., sovereign funds, concealed flows). Often funds from the Global North to invest or pay for resources in the Global South go through financial centers in the Global North that take a cut (e.g., transaction costs, intermediaries), such that a portion of the funds directed toward the Global South get absorbed back to the Global North, and domestic markets in the Global South remain under-resourced.

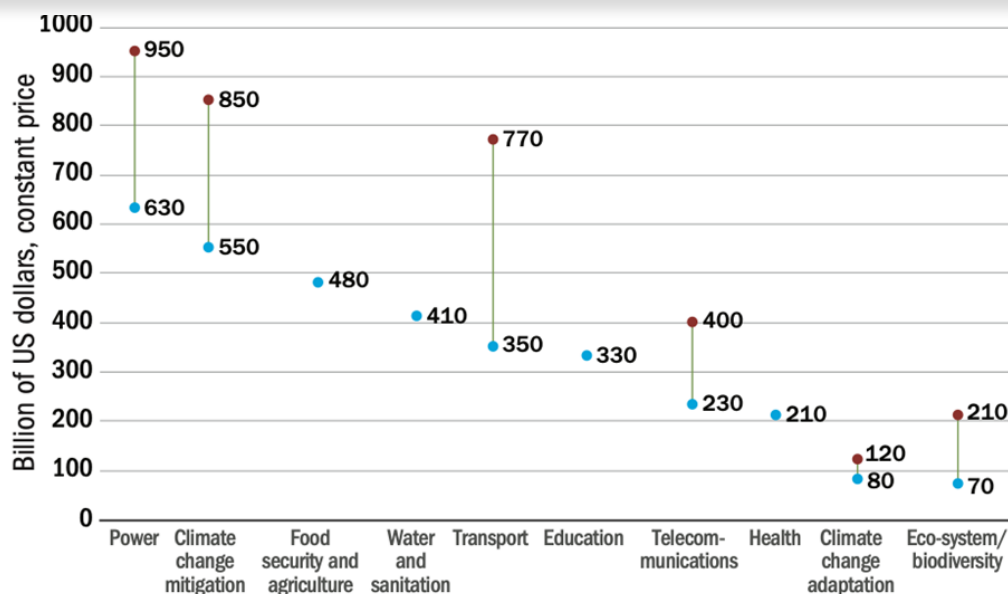




As wealth created from extractive activities in the Global South often flows into financial centers in developed markets, even if a portion of resources are reinvested back into the Global South, they are often done so in hard currencies (e.g., dollars, pounds, euros), with high interest rates because of the high risk perception from hard currency lending to resource-dependent countries. Funding is also deemed to be in insufficient amounts because of perceived high risks and low credit ratings, which are at risk of being accentuated by the physical impacts of climate change in the Global South.

The United Nations Conference on Trade and Development (UNCTAD), which focuses on trade and development, estimates that in order to meet the SDGs by the designated time in 2030, SDG-relevant sectors in developing countries need total annual investments between \$3.3 trillion and \$4.5 trillion. There is an estimated financing gap of around \$2.5 trillion per year, which represents the difference between existing funding and funding needed to be invested in the Global South.⁹ Specifically climate finance needs of emerging & developing countries (ex-China) have been estimated at over **\$2 trillion** per year through 2030, **90%** of which would have to be provided by private sources.¹⁰ This is half or more of the **\$4-5 trillion per year needed globally**.

Figure 3: Investment gap for developing countries in key SDG Sectors (Source: International Finance Corporation using UNCTAD estimates)





Challenges with risk mitigation

This perspective also factors into the approach in terms of mandating specific requirements that may not be feasible at a local level, or may push potential investors away from collaborative solutions that rethink the current systems, perpetuating portfolio biases toward the Global North. Traditional approaches to risk management in the financial sector have also created insufficient financial flows to address this issue. Investors already under-allocate toward the Global South, perpetuating the status quo (e.g., credit ratings, asset allocation model driven investments oriented around emerging market definitions or market cap weighting) and leading to persistent underinvestment. Moreover, the impact of the current debt crisis in many Global South countries post-Covid shows the likelihood of the underinvestment to continue or get worse.¹¹

With respect to financial stability in the context of climate change, the Financial Stability Board found that cross-border lending may amplify climate-related risks in recipient countries, where the crystallization of physical risks may prompt abrupt and largescale withdrawals of foreign investments. In these developing economies, already existing macroeconomic vulnerabilities such as rapid exchange depreciation and wider capital outflows may aggravate the effects. On the other hand, contrary to many traditional risk management approaches, this research considers that for lending countries in the Global North, cross-border bank lending may diversify climate-related risks and would likely not led to material risk concentrations.¹² Yet a drawbridge approach for short term financing needs would also make sucking capital flows more likely in cases where the Global North would need needs capital most.

Moreover, risk mitigation measures have been pushing the burden of risk mitigation from the Global North to the Global South. For instance, passing policies preventing certain extractive activities due to their environmental impact in the Global South, without providing the funding for entities conducting those activities to make necessary changes, ultimately pushes the burden to the Global South. A policy that prevents cutting down all of a country's trees may force its stakeholders to adopt alternative activities with less economic rewards. This would merely recreate the same dynamics and resulting problems, and the status quo continues without an alternative workable model. Moreover, without global action and convenings requiring sustainability commitments, the mindset of regulators and decision makers has been to leave problems outside their borders, which can perpetuate a disposability mindset seeking low-cost labor or finding interchangeable parts elsewhere.



Imbalanced power dynamics

Despite having valuable natural resources, weak institutions and corruption in the Global South, coupled with weak domestic financial markets, form a detrimental combination that compounds the current cycle. As the Global South experiences value extraction toward the Global North, a disparate distribution of power dynamics and social design ensue. These power dynamics pose a number of challenges for the Global South's positioning in global commercial relationships, perpetuating current issues.

Weak institutions in many Global South countries may also repel financial resources and prevent them from being recycled domestically to address climate mitigation and adaptation. Weak institutions allow for counterfeiting and other forms of fraud within supply chains. The fact that payments from the import to export side get channeled back through the financial sector back to the Global North, and that a portion of those capital flows get lent back to the Global South in higher interest rates, often becoming more of a burden than a source of support, can also be attributed to weak domestic institutions.

There is a two-way problem with customers of financial institutions not currently being able to access data and its provenance within supply chains, and therefore not being able to provide climate financing resources to incentivize target-setting and progress reporting down the supply chains. Legal and commercial barriers to information sharing may interrupt data flow and sever the path for financial resources to travel down to the Global South. These data flow challenges create further problems, where what is happening on the ground (e.g., with primary commodities) and how information makes its way to people may not fully reflect itself in the price of final products. Therefore prices would not reflect whether a product is sustainably sourced and produced across the entire supply chain – a key aspect that consumers are willing to pay for. These legal data sharing limits create barriers that technological innovation alone will not solve.

Inefficient supply chains

The inherent imbalance of power from the extractive approach to commerce has also impacted resource allocation in supply chain agreements between the Global North and the Global South. Moreover, supply chains cast light on the imbalance of power and disparities, highlighting the contrasts between the Global North and the Global South. Moreover, lack of resilience makes supply chains vulnerable to disruption. The bottlenecks and delays experienced during the Covid pandemic are indicative of these issues, where lack of traceability aggravated supply chain concerns.

In the food sector alone, one-third of all food produced globally for human consumption is either wasted or lost – amounting to 1.3 billion annual tons, and worth \$1 trillion. This wasted food could feed 2 billion people, more than two times the number of undernourished individuals, and the food wasted in developed nations amounts to the entire net yearly food production in sub-Saharan Africa. Moreover, if all wasted food were a country, it would be the third largest carbon emitter after the United States and China. While 40% of these losses occur after harvest and processing in developing nations, for industrialized nations over 40% of food waste occurs at retail and consumer stages of the supply chain.¹³

For the United States, nearly 40% of all food is wasted, amounting to **119 billion pounds** of food each year, which equates to 130 billion meals and over **\$408 billion in food** thrown away. of food are wasted, equating to 130 billion meals and over thrown away.¹⁴

The problems with supply chain waste are vast and complex, and they can be boiled down to a few key issues:

- **Wasted resources:** The production and distribution of goods often results in the waste of raw materials, energy, and water.
- **Pollution:** Manufacturing and transportation can also generate air, water, and land pollution.
- **Deforestation:** The clearing of forests to make way for agriculture and other development is a major source of greenhouse gas emissions.
- **Social and economic inequality:** The extraction and processing of resources often takes place in developing countries, where workers are often paid low wages and work in dangerous conditions.
- **Greenhouse gas emissions:** If food waste ends up in landfill it produces methane, a potent greenhouse gas. The global food system emits around one-third of total greenhouse gas emissions, and food waste causes approximately half of this.¹⁵

These problems are exacerbated by the fact that the global supply chain is highly complex, with goods often traveling thousands of miles before they reach consumers. This makes it difficult to track and manage waste, and it also makes it difficult to hold companies accountable for their environmental and social impacts.

The combination of consumer willingness to pay more for sustainable products, and lack of verification of supply chain practices, leaves open the possibility of greenwashing by consumer-facing companies. It also produces an outcome where more of the value from the sustainability premium remains in the Global North and doesn't reach all the way down the supply chain to producers of primary inputs.

Environmental costs are also transmitted through supply chains to the most vulnerable communities. Companies are facing up to US\$120 billion in costs from environmental risks in their supply chains within the next 5 years, and on average, supply chain GHG emissions are estimated to be 11.4 times as high as operational emissions.¹⁶ Broader than supply chains, value chain emissions, which include activities to provide value to customers throughout the customer journey, are often 90% of an organization's entire carbon footprint.¹⁷

Current financing is either insufficient or has the wrong lens – hence most supply chain financing goes to areas we don't need. While supply chain finance overall amounts to **\$7.3 trillion**, most of it is in the form of traditional letters of credit, guarantees, etc. which are generally not the type of supply chain financing of most relevance for these purposes. Finally, rather than keeping financial resources in the Global South, they are often exported to low-return savings accounts in financial centers in the Global North and returned with much higher return expectations.

Undervalued Natural Capital

Much of the problem facing our current economic model originates in our relationship with what we value in our natural capital. The value of natural capital is currently not able to be rewarded except through the traditional extractive model, and while voluntary carbon markets (VCM) have emerged as a vehicle to channel funding toward conservation and natural capital, they have faced major existential credibility issues because of the challenges in providing evidence to funders on actual impact, and payments going in the other direction.

Existing models of economic growth value resources in their extracted form, while undervaluing the benefits provided by natural capital. Now that the issue of climate change and nature loss is impacting the world at large, the response is a mandate to turn back to the inputs to the problem. Yet failing to recognize the costs required to do so (e.g., valuing natural capital assets, compensating for loss and damage, social and developmental costs accrued throughout extractive model duration) creates hesitancy or barriers to transparency and traceability. Early implementations of voluntary carbon markets, for instance, have collapsed due to undervaluing natural assets and lack of transparency.

Extractive models have separated the stock and flow of resources, undervaluing the stock of natural capital assets which have a particularly [high concentration](#) in the Global South (e.g., land under the stewardship of indigenous people). Monetary value is assigned only to the flow of extracted resources and commodities. Because the economic rewards for this value are only realized when resources are extracted or harvested, there is a pressure to do so because of the need to address high rates of poverty in many of these regions.

While **50%** the global GDP depends on natural capital assets (natural resources and biodiversity that can serve as raw materials for production),¹⁸ the sources of essentially all supply chains are renewable and non-renewable natural resources. The global supply chain turns that natural capital, often from the Global South, into GDP that is quantified reflected economically toward the end of the supply chain. Undervaluing or not valuing natural capital assets at all, further perpetuates existing inequalities, shortage of financial resources in the Global South, and the risk that they'd lose access to financial resources in the future when climate risks materialize.

A “resource curse” occurs where countries that have an abundance of natural resources experience less economic growth, less democratic governance, and overall lower development outcomes relative to countries with fewer natural resources. The impact of these commercial dynamics on export sectors stunts domestic economic growth, paired with additional troubles in other sources of financial resources, such as voluntary carbon markets, which despite being designed to invest in natural capital and support the Global South, have experience major credibility issues and lack of trust. This contributes to others crises driven by volatility of natural capital assets in the current model. Ultimately, exporting countries have difficulty developing other parts of their economies beyond the exporting their natural resources and feeding into the extractive commercial model and its implications.



SOLUTIONS: RE-EVALUATE OUR ECONOMIC MODELS

It's hard to conceive true improvements in the common good (economic, social conditions, climate, overall justice especially for the poorest among us) - without considering innovation in support of wellbeing. Emerging tech like blockchain can be a conduit to facilitate these better relationships, through inclusive models of exchange and win-win situations that benefit all.

The fact that six of the nine planetary boundaries have now been transgressed, as stated earlier, calls for an urgent, and simultaneous implementation of multiple solutions that bring drastic changes to existing commercial models. Solutions lie in rethinking our current economic models, providing financial resources that are widely shared and not eroded by transaction costs from intermediaries, or diverted to those parties who control the opaque channels used in data, capital, and resource flows.

Role of blockchain based solutions

Blockchain, as an immutable ledger that is visible to all cannot be changed by any network participant, provides transparency and data integrity into sustainability initiatives. It can be used to create a more transparent, efficient, and secure supply chains. This can help to reduce costs and improve efficiency, as well as identify and address potential problems, anticipating before they occur and taking action accordingly. Transparency can also address counterfeiting and other forms of fraud, while making it easier to track and trace goods.

Finally, blockchain technology can be used to reduce the environmental impact of activities across their supply chains, while tracking and measuring progress towards sustainability goals. For instance, tokenization of assets can help to track the provenance of goods and materials, ensuring and proving that they are sourced from sustainable and ethical suppliers. This can reduce the risk of fraud and ensure that companies are meeting their sustainability commitments. It can also reduce instances of greenwashing.

The assumptions going into climate stress tests also need to be more realistic for both qualitative and quantitative aspects of climate change scenarios, and better anticipate risk drivers, impacts, and areas of uncertainty. Blockchain and data integrity can also have a role in developing more realistic assumptions, and ultimately more credible net zero and transition plans.

Need a new model of generative relationships

We need to attract investments toward building traceable and transparent systems designed to overcome climate risks through an equitable and reciprocal relationship between the Global North and the Global South, rather than an extractive, hands-off approach. Data can draw light to the problems, helping companies monitor and measure impacts, and evaluate effective solutions. For instance, many blockchains offer climate friendly ledgers that run on energy-efficient proof-of-stake mechanisms, such that climate mitigation solutions built on their platforms can provide useful data records for the use cases at hand, in a way that produces minimal carbon emissions.

When Ethereum transitioned from a proof-of-work validation mechanism to a proof-of-stake mechanism, all of the applications built on it dramatically reduced emissions, and it was reported that the entire Ethereum blockchain eliminated over 99% of its carbon footprint overnight. In addition to low-carbon proof-of-stake models, many blockchains have further allocated additional resources to carbon offsets. In the case of Ethereum, additional funds toward carbon offsets are meant to reverse the environmental footprint of past operations during the period when it relied on proof-of-work. In the case of Algorand, an intentional decision to commit additional funds to carbon offsets are meant to create a climate-positive footprint that goes beyond its basic carbon neutral operations in order to have a positive environmental impact. Ripple has also committed to net zero by 2030, having taken proactive measures committing funds toward carbon offsets that make net zero more likely by 2028. Ripple's XRP Ledger has positioned itself as a public blockchain that is among the fastest, low energy, and carbon neutral.



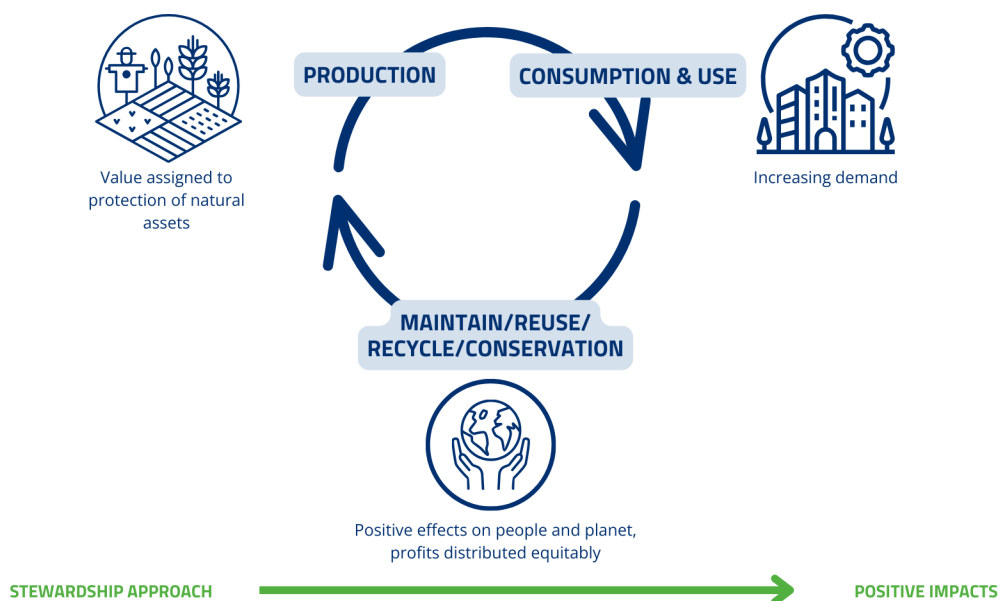
These endeavors, which originate at the governance level of blockchain platforms, trickle down across all activities and applications built on them and can create a culture of environmental consciousness that shows how it is possible to embrace innovation while having a positive impact on the planet. Blockchain technology can deliver the most promising solutions with respect to sustainability when there's a dual system of data integrity and payment flows to rebuild the stock of natural capital assets, which can also compensate for loss and damage embedded in extractive economic activities. Valuing natural capital assets by assigning funds to their preservation is an important source of climate change mitigation.

Overall, generative relationships between producers and buyers requires an upgraded approach during a time of climate crisis, adjusting relationships between the Global North and the Global South to bring climate resilience. Meeting both company and consumer demand requires a more equal distribution of wealth. Given that impacts of climate risks are felt more in the Global South where most of the resources originate, we need to work together to find ways that innovative solutions including blockchain technology can better ensure critical production lines, compensation structures, and incentives are better distributed to players in the system.

We need to shift away from short term goals for company bottom lines, which can be problematic for both the Global South and the Global North. Economic development in less wealthy nations is convenient also for wealthier nations through better products, trade relationships, opportunities, and peace through commerce, and also better alignment and coordinated progress toward global goals such as the Paris Agreement, SDGs, etc. Rather, by building toward longer term generative relationships that maintain ecological balance and harmony between human civilization (e.g., societies & economies) and the planet, the "pie" of opportunity can expand toward more win-win situations.

These conditions can support the longer term health and distribution of supply chains, where blockchain solutions can support a model where value can travel alongside data. We need to ensure security and proper data management. This way we can effectively push toward sustainability and net zero, and even net positive operations. Blockchain technology has the potential to build models that create inclusion, benefiting all parties involved.

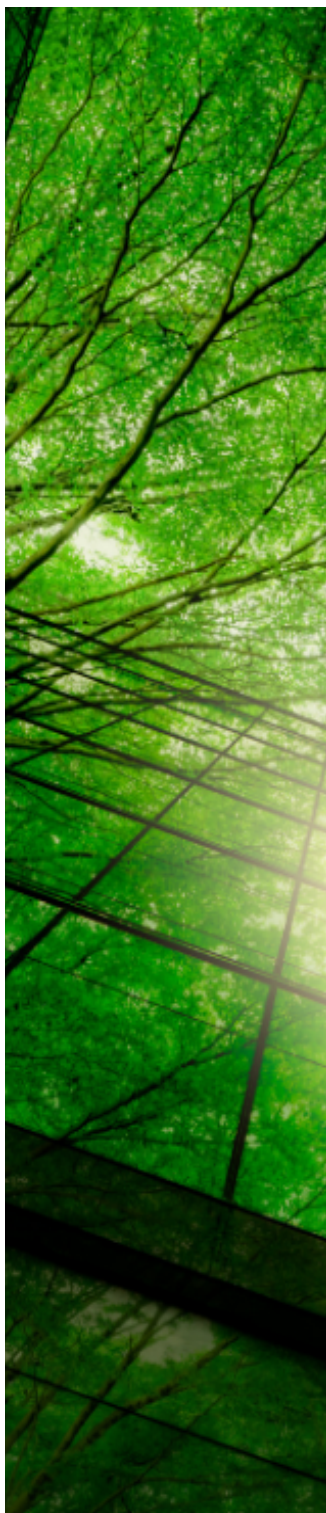
Figure 4: Regenerative, Sustainable, and Circular Economy



Inclusive finance

There is a need for financing models where benefits can reach inclusive levels, where blockchain has the potential to contribute. Simply put, it will not be possible to flow finance into emerging and developing countries in the volumes and with the speed required through current mechanisms alone. There will need to be three major and interrelated changes where blockchain has demonstrated potential to ensure fund flows toward sustainable outcomes at scale.

Inclusive finance can be sustained through mechanisms that support regenerative financial models, sustainable supply chains, and domestic resource mobilization in the Global South.



1) REGENERATIVE FINANCE (REFI) FOR NATURAL CAPITAL -

ReFi often considered an offshoot out of decentralized finance (DeFi, proposes a new model of a financial system focused on inclusivity, transparency, and mutually beneficial commercial relationships. The benefits of these commercial exchanges should expand to both society and the environment, by integrating financial practices with sustainability. This involves responsibility relative to society and environment, and ultimately aims to create net positive effects through regeneration of natural resources.

ReFi proposes an alternative to traditionally extractive commercial relationships, especially between the Global North and the Global South, such that value and capital flows can allow economic benefits to remain in the Global South where much of the resources we rely on originate. Emerging technologies such as blockchain are fundamental to ensure the data transparency and reliable accounting systems on which ReFi is designed to operate.

A regenerative economy supported by ReFi consists in an economic system that goes beyond merely generating financial returns, but focuses on ensuring and restoring social well-being, economic prosperity, and environmental well-being through restoration, renewal, and sustainability of resources. The circular economy, with a holistic view of value, is fundamental to a regenerative economy, which lies in contrast to traditional economic models based on extraction, consumption, and waste.

Restoration of environmental, social, and financial stability bring a holistic series of benefits alongside monetary gains. Therefore, the movement to mitigate climate change is integrated with improving equality. ReFi recognizes the value of resources in the Global South and ensures that its population is adequately remunerated, as opposed to traditional systems where value is placed on production and end products after extraction of raw materials from the Global South.

ReFi has found acceptance in the blockchain/digital assets ecosystem, with models of decentralized finance (DeFi) leveraging transparency, low-cost transactions, and global liquidity pools with immediate settlement to facilitate access to financial services for unbanked and underbanked communities. The openly available data on the blockchain ensures a level of transparency that can allow a granular level of impact measurement, monitoring, and evaluation that is also secure and immutable (e.g., dMRV).

Tokenization allows representations of value to be exchanged on a blockchain, benefitting from low cost transactions with immediate/close to immediate settlement. This can revolutionize carbon markets, renewable energy accounting systems, and access to alternative financial services for underserved communities (e.g., DeFi).

2) SUPPLY CHAIN FINANCING –

Supply chains are a major economic link between the Global North and Global South by connecting the pathway of value transfer across all points of exchange, where equal or unequal relationships can be perpetuated through the dynamics of capital flows in exchange for goods. Supply chain finance is connected to other financial activities, making it critical to advance sustainable practices with respect to voluntary carbon markets, compliance markets, certifications, consumer finance, and all areas of market activities.

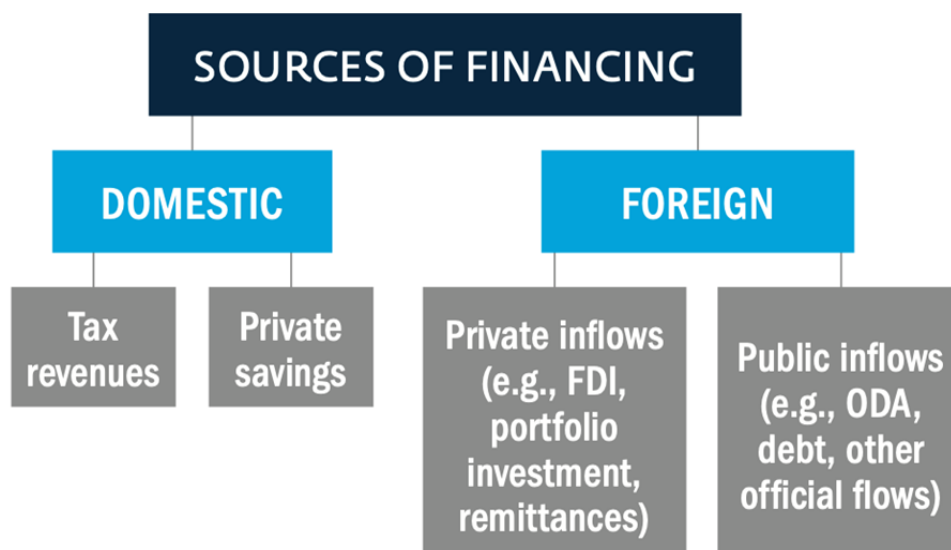
If supply chains can support increasing resource flows toward the Global South and equitable governance, they can become a systemic disruption point with ripple effects throughout the ecosystem. Therefore revising current models of economic activity supported by supply chains can be key to driving equitable solutions.

Blockchain technology can both facilitate access to global markets through peer-to-peer, inclusive, and low-cost transactions, while also recording data on sustainable practices across supply chains. Ensuring trust and access to data can support companies' claims to end consumers, who want more sustainable products and are willing to pay more for them, regarding their labor practices, emissions generated from production and transportation of goods, and other indicators about the sustainability of their supply chains.¹⁹

Embedding supply chain finance with technology for resource distribution toward climate resilience is key to ensure trust and effectiveness. Blockchain technology can bring light to gaps along the supply chain where there may be difficulties meeting sustainability goals, especially upstream closer to the points of extraction of raw materials where there can be little visibility, so as to facilitate a targeted course of action.

The volume of supply chain finance enabled by blockchain has been estimated at \$16 billion in 2021, with a yearly growth rate projected at 32%. This would account for only 0.2% of the total supply chain finance market today, indicating a significant opportunity.²⁰

Figure 5: Potential sources of financing for the SDGs (Source: World Bank)



SHORT TERM SOLUTIONS - In the short term, even within the existing status quo, supply chains can be made more sustainable. As long as the traditional financing model continues, an alternative model to channel funding to the Global South consists in financing linked to sustainability performance at the base of the supply chain.

Although the problems facing our current economic model originate in the relationship of what we value in our natural capital, even within the status quo, supply chains can be made more sustainable. As long as the traditional financing model continues, another model to channel funding to the Global South is financing linked to sustainability performance at the base of the supply chain, supporting in-setting beyond merely off-setting.

Several applications of blockchain have focused on improving supply chain traceability, and there is a significant opportunity, largely untapped, in using data from traceability initiatives to provide supply chain financing where pricing is linked to sustainability practices. Often, these types of supply chain finance require transparency of supply chains, which may not be accessible for commercial, legal, or regulatory reasons, leading to gaps in the ability to trace sustainable practices back to the primary inputs. Despite lacking more robust data from across an entire supply chain, sustainability-linked supply chain finance focuses on sourcing sustainability certified inputs and the sustainability practices of Tier 1 suppliers. This works primarily by providing faster access to payment for suppliers who can meet sustainable sourcing requirements and who engage in sustainable operational practices.

Yet the benefits from this approach are likely to be more captured by Tier 1 suppliers who deliver final products, due to the lower capacity to validate and differentiate between different degrees of sustainability from sourced inputs from stages of the supply chain closer to the raw materials. If the objectives are improving supply chain practices and channeling funding towards suppliers of primary inputs who are more likely to be located in the Global South, then current practices are likely to only have limited efficacy.

EMERGING TECH-ENABLED SOLUTIONS -

On the other hand, pairing supply chain financing with supply chain traceability, including blockchain-based approaches within sustainability certifications, can enable greater transparency of data to validate sustainable practices among primary input suppliers, ultimately justifying financial incentives to reach them. This can have positive impacts even if sustainability-linked financing isn't extended all the way down the supply chain. Intermediate buyers, who may face working capital pressure from buying more expensive inputs, can be incentivized with better terms and alleviation of some working capital pressure through supply chain financing supported by the end buyer.



End buyers may also have an incentive to participate in this system for a number of reasons, including mitigating their supply chain due diligence regulatory risk, minimizing greenwashing risk related to failures within certification programs, or they may have stronger pricing power when they are able to demonstrate full traceability behind their sustainability claims. By alleviating working capital concerns of intermediate suppliers, greater traceability for sustainably-sourced inputs may enable suppliers to command a higher price than they get using certifications that rely on manual processes. Intermediate suppliers may also have a similar rationale for partnering with financial institutions to offer sustainability-linked supply chain financing to their suppliers. If they do so, then the direct financial incentives of sustainability-linked financing are provided more directly through their supply chain. In turn, this means less of the financial incentive for suppliers is reliant on the ability to get better prices for fully-traceable verification of sustainable sourcing practices.

Moreover, sustainable supply chain financing supports in-setting, which goes beyond merely offsetting and can be interpreted as a means for companies and organizations to buy themselves time as they devise ways to reduce emissions from their core operations. When early iterations of voluntary carbon markets have collapsed as a means for off-setting, many companies and organizations turned to the approach of reducing and avoiding emissions in their very operations through in-setting across the supply chain. In-setting becomes even more important as a long-term strategy that companies should aim toward, as they integrate sustainable practices into the core of their business models.



A generalized future model for sustainable supply chain financing:

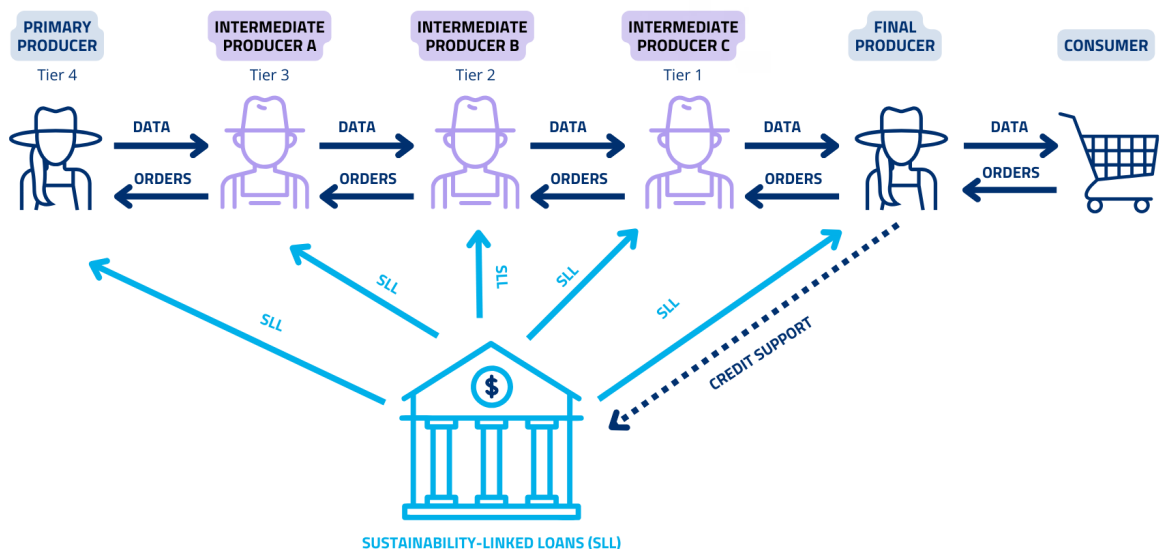
Exchange of information for financing through a supply chain is portrayed below. This example uses a model where a financial institution offers sustainability-linked loans to the buyer and its suppliers, whose credit risk for the supply chain finance are more closely related to the credit risk of the buyer, adjusted by a margin related to their achievement of climate-related targets.²¹

In this process, the likely steps that will take place will be:

1. Financial institution works with the buyer on the basis of the buyer's credit risk and ESG-related risks to identify specific KPIs to measure financially material improvements from their suppliers that would mitigate specific climate-related supply chain risks.
2. Financial institution would make available a financing facility for the buyer priced on the basis of its current ESG risk, with discounts linked to supply chain and buyer's operational improvements to lower its climate risk exposure.
3. Buyer provides opportunity for its suppliers (as far as it can have visibility) to work with the same financial institution, for financing used to improve its cash flow related to the sales to the buyer (or Tier 1 direct suppliers, or Tier 2 or 3 indirect suppliers, respectively) conditioned on sharing the data with intermediate producers and the end buyer.
4. Suppliers work with the financial institution to develop KPIs specific to their business related to the overall KPIs relevant to the buyer to receive sustainability-linked supply chain finance, to receive access to financing at all / on terms that they may be unable to get on their own.
5. Suppliers and financial institution pass data to end buyer for their disclosures & audit / external assurance related to progress on their climate-related targets.

The GDF ESG working group was focused on upstream value chain emissions within the digital asset space. This working group covers downstream value chain emissions measurement and finance for mitigation.

Figure 6: Sustainability/ESG linked supply chain finance



As a flip side of the coin of environmental concerns being translated through supply chains, positive environmental impacts are also translated through supply chains. Supply chain financing linked to sustainability not only benefits input providers with financial incentives, but it is also beneficial for corporates. Blue chip companies like Google, L'Oréal, Walmart, Braskem and Toyota are among 150+ major buyers to call for transparency and action from suppliers to tackle sustainability risks. Cutting emissions also cuts costs. Suppliers in a Carbon Disclosure Project (CDP) survey that undertook activities that cut emissions by 619 million tCO₂e were able to save US\$33.7 billion in the process.²²

Reverse factoring, for instance, provides financing from the buyer to the supplier (where the interest rate charged could be linked to climate-related outcomes). Then Dynamic Discounting is set up to reward faster payments from the buyer to the seller with lower prices paid, and presumably there could be some step-up of higher prices paid conditional on achievement of climate-related KPIs where an automatic formula can adjust prices depending on pre-agreed events. If the general use case is with speed of payment to supplier, there may be an easy addition of ESG or climate targets as well.²³ Buyer-led supply chain financing, where most sustainability-related financing is likely to occur, currently provides amounts to approximately \$500 billion annually (\$400 billion in reverse factoring, growing at a yearly rate of 15-20%, and \$100 billion in dynamic discounting, growing at a yearly rate of 25-30%.

3) DOMESTIC RESOURCE MOBILIZATION -

One of the main ways blockchain has been used in lower income countries has been to address institutional weakness. In relation to climate finance in these developing economies, every dollar that stays in local markets is one fewer dollar that needs to flow from developed markets. Keeping resources generated by supply chains working within the Global South enhances domestic resource mobilization for sustainable investments that disintermediate offshore / financial centers.

For example, one of the exceptions to the norm of the status quo stated above is Malaysia, which proactively worked to build a domestic capital market as a government priority following its contrarian response to the Asian Financial Crisis in 1998.²⁴ In the years since, it has become a high-middle income country and aspires to become a high-income country between 2024 and 2028. The strength and development of its local capital market can be directly attributed to its greater domestic level of control over its natural resources.

Domestic resource mobilization is key for ensuring revenues to the Global South remain in the Global South. This is an area where other blockchain applications related to climate finance come into play if they can help mobilize resources at a local level that would otherwise be recycled through developed market financial centers and would then need to be attracted back to the Global South as "climate finance" if not retained domestically.



The cycle will be most effective if funds from developed market buyers and financial institutions are channeled into ReFi and projects connected to primary products within the global supply chain to meet buyers' regulatory compliance needs, in ways that result in financing that ends up staying in lower income countries. The only way to change the status quo perpetuated by extractive low cost labor and export for domestic resources in lower income countries is for financial flows to acknowledge value of natural capital assets. Sustainability-oriented supply chain finance can cut out the round trip of capital back to the Global North, while blockchain technology can validate the use of funds and increase transparency. This can help retain funds in lower income nations, which therefore can dramatically cut the costs of climate finance in the Global South.

This process of local retention of capital to strengthen domestic capital markets, which can be largely driven by supply chain financing, is a private sector complement to national carbon credit sales under the Paris Agreement. Both financing models bring financial resources within the Global South, which is particularly important as voluntary carbon markets face and related challenges. This is also complementary to the extent that national flows may support conservation and protection, while sustainable supply chain finance should provide additional financial incentives towards practices that put less pressure on depletion of natural capital.



USE CASES



Blockchain technology can provide a verified data layer, adding security, and trust to a wide range of sustainability-focused initiatives. It can integrate with other existing and emerging technologies to optimize processes through trusted accounting systems and efficient, cost-effective infrastructure for transactions. For instance, blockchain technology can record data captured by the Internet of Things in an immutable manner, and it can provide a reliable and decentralized source of data going into AI algorithms. A wide range of activities that already contribute to sustainability can rely on trusted data on a blockchain, alongside financial solutions provided by digital assets. For instance, unmanned aerial vehicles (UAVs) for asset inspections and maintenance, or other uses of drones from food delivery to emergency response, can be optimized. As for decarbonization, initiatives such as Carbon Capture, Use and Storage (CCUS),²⁵ where carbon emissions can be captured from the environment to produce materials such as concrete, plastics, and biofuels,²⁶ can also benefit from a trusted ledger across the lifecycle of inputs and materials. While many of these use cases have yet to be deployed at scale, solutions are already being built and tested.

- Creating new financial flows to support conservation and regeneration of natural capital
- Adding traceability to supply chains and linking them to supply chain finance from developed markets
- Developing sustainable capital markets in lower income nations to absorb and recycle funds from primary production

Below is a stakeholder mapping to identify Web2 and Web3 use cases, helping to identify market gaps that blockchain applications could fill. These solutions play a role to fit into developing Transition Plans for corporates and financial institutions – either as examples to follow or tools companies can use.

Web 2 models being optimized with blockchain

TRADITIONAL FINANCE & FINTECH:

Traditional finance use cases embracing sustainability include initiatives toward tokenization of green assets, sustainable finance, and green bonds. This intersection of finance transformation, digital finance, and ESG can take many forms. These use cases to demonstrate inclusive and green finance are already being deployed to overcome challenges that exist today. Green finance is increasingly embracing digital and tokenized bonds and loans. Blockchain could then also be used for verification that the green objectives claimed have been achieved. Data transparency within green finance and FinTech, including coding of assets against taxonomies including digital asset value chain emissions, can be of great value.

Because of the costs involved in issuing bonds in general many smaller companies are effectively excluded from the green bond market. Such high transaction costs and minimum investment size may make it especially difficult for emerging markets to support a thriving green bond market. Many companies will most likely struggle to find projects that are large enough to warrant issuing green bonds. This may lead to a lack of green projects for investors to invest in. Issuing tokenized bonds using blockchain is less costly, and more widespread adoption of the technology would perhaps open up the market for more projects to be financed in this way. Tokenization can also help issuers reach new investor bases by allowing companies to list their green bond on a cryptocurrency exchange in addition to a regular listing on a traditional marketplace.

Moreover, some of the problems associated with green bonds, such as greenwashing and lack of on-going verification may be tackled through regulatory and policy initiatives. However, it is possible, perhaps necessary, to use technology as a to enable and accelerate such efforts. While (blockchain) technology will not in and of itself help create consensus what constitutes a green activity and the criteria that should be used to measure such activities, it can be used to operationalise these definitions and goals. Using blockchain for issuing green financial products will also streamline and simplify the process. In addition to such efficiency gains, tokenization and smart contracts may also be used to increase transparency and to demonstrate alignment with regulatory developments for sustainable finance.





These products can also allow retail banking customers to participate in the green economy. A few examples of blockchain-based green bonds are below:

Green Bonds

SoBond is a platform for issuing digital bonds on a blockchain with a “Proof of Climate Awareness” feature that incentivizes participating nodes to improve their environmental footprint. SoBond was developed by Sweden’s SEB and Credit Agricole CIB, and it can be applied for green or sustainability-linked bonds, where blockchain technology both makes climate finance more accessible. The European Investment Bank has for instance issued its first digital bond using the platform (Climate Awareness Bond – June 2023 – digital green bond on a blockchain platform).²⁷

Evercity

Evercity has also launched a platform for green bond origination using blockchain.

Bank for International Settlements (BIS)

BIS developed Project Genesis 1.0, as a prototype for digital platforms for green bond tokenization.²⁸ This has moved to complete phase 2.0 involving HKMA, who want to issue green bonds.²⁹

Hong Kong’s SAR

Hong Kong’s SAR Government **HK\$800 million** offering is the first tokenized green bond issued by a government globally.³⁰

Green Assets Wallet

Green Assets Wallet aims to scale the market for green investments that are credible, validated, and trusted, especially in emerging markets. Blockchain technology validates green investment claims and also provides immutable validation of impacts.

Fintech Players

Major fintech players like PayPal are prioritizing environmental sustainability initiatives at PayPal, aligning the company’s net-zero objectives with their work in blockchain, cryptocurrency, and digital currencies.

SUPPLY CHAIN SOLUTIONS:

BNP Paribas CIB

BNP Paribas CIB³¹ has developed a solution for traceable and green supply chain finance, which can incentivize data collection. Collection, validation and management of data are needed for supply chain due diligence & deforestation validation (e.g., palm oil, beef, wood coffee, cocoa, soya, rubber, and downstream products (furniture, leather, chocolate, charcoal, tires, printed paper) plus other commodities like maize and rubber, livestock other than beef, and waste & plastics).

The Forest Stewardship Council (FSC) International

The Forest Stewardship Council (FSC) International is integrating blockchain technology to enhance traceability and verification for products within the forestry sector. With the FSC Blockchain, FSC is establishing an immutable and verified ledger of trade transactions of wood and wood products (with volumes, species, and fundamental point-of-trade data), ensuring that their sources are sustainably managed and supporting FSC-certified companies with demonstrating compliance with regulatory requirements. The forthcoming version of the FSC blockchain platform is anticipated to enhance its analytical capabilities, providing insights such as trading partner analysis, origin verification, and broader sustainability metrics, such as supply chain efficiency and carbon footprints.³²



DECARBONIZATION:

Mitigating the release of carbon into the atmosphere is the single most important factor to stop climate change; especially as the world generates 51B tons of greenhouse gases per year. Carbon markets can benefit from blockchain technology through interoperable global marketplaces, price discovery for offset quality, and emissions tracking across supply chains.

- Demia (formerly Digital MRV)

Solving the lack of trust in carbon and sustainability markets through an ecosystem of organizations developing standards and guidance for new digital infrastructure. Pilots in Copiulemu and Molina reflected to targets toward Paris Agreement goals in Chile and Canada.

TerGo

Provides solutions for individuals and companies to reduce their emissions, connecting them to carbon markets to purchase offsets and also providing a carbon calculator to measure and monitor their impact. Its mobile app can quantify and monetize sustainable actions, rewarding users for good behavior. With blockchain-based data management, Tergo is helping companies and their supply chains automatically track employee transportation emissions and supply chain emissions.

Zumo

Deploying blockchain technology to democratize access to sustainable finance for all. It offers an enterprise-focused digital-asset-as-a-service platform and a direct-to-consumer solution to help companies across sectors integrate solutions in digital assets sustainably.

EY OpsChain ESG

Offers a platform for trusted emissions and carbon credit traceability.

Hyphen Earth

Dedicated to institutionalizing and de-risking natural capital assets to improve certainty of environmental claims and value of carbon credits. It tracks greenhouse gas concentrations, fluxes, and observations from global to regional sources.

PUBLIC SECTOR CIRCULAR ECONOMY INITIATIVES:

Waste management and the circular economy through data collection can be great tools to create effective action. Blockchain technology is also being used for better reporting and accountability on the use of resources, and increasing efficiency in public services such as education. Other initiatives are integrating sustainability into national planning, with a focus on applying blockchain technology for various models aimed at achieving a circular economy.

RECYCLING:

Project TRACKCYCLE and RecycleGo are advancing a circular economy for recycling by embedding blockchain technology into the advanced recycling value chain, with the aim of providing a fully traceable and accurately labelled record of recycled materials, from the waste sourcing up to the use of recycled materials in new production streams.



Web3 native models

PARTNERSHIPS:

Consistent with peer to peer and decentralized governance concepts, sustainability initiatives in the Web3 ecosystem are gathering forces toward collaborative solutions. This is fundamental to deploy the technology under common standards, and interoperable platforms to allow for scaled solutions.

Blockchain x Climate (BxC)

BxC is an activist-to-industry network of global stakeholders working together to define and agree on common principles, shared understanding, and narratives to govern climate-related blockchain efforts. The goal is to design tangible and meaningful cross-chain and cross-industry initiatives and solutions to address climate change. It is largely a response to prior limited actions and siloed efforts in the climate space, which have contributed to a lack of trust. With a consolidated perspective, it is more feasible to work on real solutions, and create opportunities through collective actions.

Ethereum Climate Partnership

Ethereum Climate Partnership is a collaborative initiative to offset the Ethereum ecosystem's emissions prior to its transition to proof-of-stake.

ReFi DAO

ReFi DAO is a decentralized autonomous organization that gathers players around the world to share knowledge and collaborate on regenerative finance developments.



NET ZERO & TRANSITION PLANS FROM WEB3 PLAYERS:

These plans can take several forms, depending on the focus areas of Web3 players across industries.

Ripple

In addition to having deployed a net zero plan by 2028 and deployed significant investments into carbon markets, Ripple has built a climate friendly Ripple Ledger on which further Web3 solutions can be deployed. Its acquisitions into market infrastructure can also be deployed for carbon markets. For instance, Ripple's acquisition of Metaco as a custody solution can allow users to custody tokenized carbon credits.

Zumo

In addition to having implemented its own net zero strategy, Zumo's Oxygen solution is being deployed to support companies transitioning to net zero. Oxygen allows companies to align their digital asset activities with ESG principles, calculating the electricity consumption associated with crypto activity and providing a solution for the procurement of renewable electricity to match this.

Algorand

Algorand has developed a carbon-positive footprint by running a carbon neutral platform that, in addition, funds further climate action.

Ethereum

Ethereum has reduced over 99% of its emissions by transitioning from proof-of-work to proof-of-stake.

Polygon

Polygon runs a carbon neutral platform, with the broader goal of driving the Web3 ecosystem to become carbon negative, having purchased additional carbon credits and supported overall sustainability initiatives as described in its Green Manifesto.



MARKETPLACES & INFRASTRUCTURE FOR BLOCKCHAIN-BASED CARBON MARKETS:

Web3 technology is being deployed to bring trust for carbon credits. Tokenizing natural capital with a social and ecological impact often includes the in support of indigenous land stewards.

Regen Network	Offers a blockchain-based fintech solution for ecological claims and data, at the intersection of remote sensors and blockchain technology to monitor ecological data. The platform offers tokenized carbon credits, a public ecological accounting system, and a registry where land stewards can sell directly to buyers globally.
Toucan Procol	Provides the digital infrastructure for tokenized carbon credits to operate.
Blockchain Laboratories	Provides a Web3 Software-as-a-Service infrastructure to support blockchain technology and digital assets solutions with a tripple bottom line. This is a tokenization platform for sustainability-minded projects including carbon markets.
LOA Labs	LOA Labs is an integrated product and marketing studio for Web3, focused on advancing use cases of blokchain with a positive impact, such as tokenizing social and ecological impact.
Thallo	Developed a blockchain-based infrastructure to revolutionize and democratize the process of buying, selling, and trading carbon offsets for individuals and businesses.
Reneum	Decentralized marketplace that aims to catalyze the energy transition through tokenized renewable energy credits on a platform accessible for businesses and individuals to offset emissions.
KlimaDAO	KlimaDAO built a carbon-backed digital token, with each token backed by a ton of verified tokenized carbon reduction or removal.
NFT Marketplaces	NFT marketplaces are also deploying funds into conservation in partnership with wildlife organizations and other ecological foundations. Revenue from NFT sales is deployed to supporting conservation, recycling activities, and biodiversity protection. ConservatioNFT and Plastiks are examples.
Powerledger	Deployed blockchain technology to streamline operations of decentralized renewable energy systems, enabling tracking, tracing, and trading of renewable energy.

SUPPLY CHAIN SOLUTIONS:

Triangle Digital

Triangle Digital uses blockchain for supply chain-related sustainability-linked loans³³

Hedera

Hedera entered into a partnership with Guardian, in order to further credible carbon markets and other supply chains.³⁴ The aim is to enable carbon accounting and tokenization for brands through blockchain networks to understand their carbon impact across the supply chain. In addition, they aim to support brands offering additional carbon reduction measures to achieve net neutrality and move towards carbon net positivity. They also leverage the technology to bring credibility and transparency across all activities and transactions. They also facilitate carbon reduction through the new online marketplace, powered by atma.io

HBAR Foundation

HBAR Foundation also partnered with FSCO, connecting to the Mastercard network.³⁵ They offer a payment trigger functionality that Continuity provides, which is a core component of FSCO's product offering on the Hedera network – the tokenization and financialization of Real-World Assets (RWAs) and events throughout the agricultural supply chain. As items move across locations, payments must be released only when their pre-approved conditions are met. For instance, if 250 2.5m x 6m shipping containers are received instead of 500 2.5m x 6m, the payment should not go through. If conditions are met, they should. Here, payment triggers combined with Internet-of-Things (IoT) devices automate this process, greatly improving efficiency. Historically, supply chain management has been opaque. By leveraging Hedera, FSCO also brings unprecedented transparency, providing rich data to financiers who need to calculate their credit-risk assessments.

HUMANITARIAN AID:

United Nations High Commissioner for Refugees (UNHCR)

One of the most recent and useful applications of blockchain to support sustainable finance initiatives for vulnerable populations is a first-of-its-kind integrated blockchain payment solution powered by the Stellar network and launched by United Nations High Commissioner for Refugees (UNHCR). Deployed in 2022 in a pilot phase designed for Ukraine, this payment solution is meant to be adapted in the future for worldwide adoption. It utilizes Circle Internet Financial's USD Coin (USDC), a stablecoin equal to one US Dollar in value, to disburse funds directly into recipients' digital wallets, which are downloadable onto smartphones. Recipients can safely hold their funds within Ukraine, and cross borders if needed, without having to carry cash.³⁶

Algorand Foundation

Algorand Foundation has deployed its Kokua Wallet for humanitarian aid. Its HesabPay solution in Afghanistan also enables digital payments and relief funding with digital wallets that hold digital assets.

REGULATORY DEVELOPMENTS & VOLUNTARY INITIATIVES

With the view of meeting the Paris Agreement, regulation focused on environmental and social impacts is a key driver of transition plans affecting non-blockchain native companies and organizations, which may consider blockchain solutions to facilitate data validation and transparency for reporting, as well as blockchain-native entities that would be subject to the same rules. Financial institutions face regulations about their sustainable finance claims, stress tests about their climate-related financial risks, disclosure requirements about climate, nature and other ESG risks. In addition, their customers also face regulatory requirements on climate-related disclosures and their sustainability practices, including requirements around supply chain due diligence and anti-deforestation requirements for primary inputs.

There has been a huge increase in regulations around sustainable finance and many of them relate to climate change. In this context, the European Union and several member states within the EU have been among the most aggressive in mandating specific due diligence requirements relating to supply chains and commodities whose production frequently leads to deforestation. Examples of regulatory developments include:

- In the blockchain and digital assets ecosystem, the comprehensive EU regulatory framework with Markets in Crypto-Assets Regulation (MiCA) has also set sustainability requirements.
- The EU's Corporate Sustainability Reporting Directive (CSRD) requires companies to report on the impact of their activities on the environment and society, including audits of the reported information.
- The "Green New Deal" in the United States, reintroduced in 2021, calls for public policy to address climate change while achieving other social aims like job creation, economic growth, and reducing economic inequality, toward secure and sustainable future growth.
- The EU Taxonomy, which is fundamental to create alignment and trust in definitions around sustainability.
- The EU Green Bond Standard (GBS) was adopted on 5 October 2023, and is a voluntary standard that issuers may use to "label" their bond as green. The standard uses the criteria of the Taxonomy to determine if bonds are to be considered green.
- The International Sustainability Standards Board (ISSB), an independent private sector entity that develops and approves IFRS Sustainability Disclosure Standards (IFRS SDS), provides a global baseline for sustainability disclosures that jurisdiction-specific reporting requirements may refer to and mandate.



Taxonomy-alignment could potentially be calculated automatically based on input data provided by the companies seeking alignment and the technical screening standards of the Taxonomy itself. Due to its highly technical nature, the Taxonomy should lend itself to coding. If a green bond is meant to finance a project developing new housing for instance, a smart contract could contain criteria for the materials to be used, and the way the materials have been transported to the building site. The information needed to determine whether the criteria have been met could (ideally) be collected via sensors in the physical world, or through manual recording and input. The energy efficiency of the finished building could be measured and recorded on a DLT database and made instantly available to the investors. If the issuer fails to deliver on agreed-upon metrics, such as achieving a specific Taxonomy-alignment percentage, this could trigger the smart contract to automatically execute a corresponding action, such as higher interest payments to the investors.

International organizations such as UN international energy agencies also play a role mobilizing efforts to create alignment, foster collaboration, define metrics and gaps, and calling to major stakeholders to action. Alongside international organizations, several voluntary disclosure bodies have also set standards to advance climate action. To make transition plans more effective, education is needed on the assumptions underpinning the models and their limitations, such as the AIGCC open letter to Asian banks,³⁷ the Exeter University / IFoA report,³⁸ which cite Carbon Tracker research and others.

Stronger stakeholder expectations for emissions disclosures, target and reporting on progress towards targets will make traceability a more important issue. Blockchain has both an opportunity and a responsibility to play a role in this process. First, it has the responsibility of improving its own emissions reporting, for its operations as well as relating to its financed and facilitated emissions, as addressed in the GBBC Digital Finance Guidance on ESG Reporting for Digital Assets.³⁹ Second, it has the opportunity of supporting better traceability and information integrity for operations across all sectors of economic activity, such as real economy supply chains.

In addition to regulatory requirements, standards setters and voluntary initiatives like the Science-Based Targets Initiative (SBTi) have been set up to provide frameworks for companies and financial institutions. Their framework provides a way for these entities to have emissions reduction and Net Zero claims validated in relation to their level of ambition compared to what is required to meet Paris Agreement targets or to limit warming to 1.5° C. Other voluntary frameworks such as the International Capital Market Association (ICMA) Green Bond Principles and the Climate Bonds Standard and Certification Scheme have also gained acceptance in the space, highlighting the importance of data to monitor and measure impact.

Within the crypto and digital asset sector as well, similar voluntary guidance exists for disclosing emissions based on the methodology published by the Crypto Carbon Ratings Institute (CCRI) and South Pole.⁴⁰ The sustainable finance digital assets working group at Global Digital Finance (now GBBC Digital Finance) compiled guidance for digital asset companies to set climate targets incorporating guidance for technology and finance sectors to include a wider range of value chains.

These requirements are designed to ensure that claims made about sustainability and climate change mitigation are accurate and not misleading, and that the intent of the regulations cannot be circumvented by outsourcing responsibilities to those who are not subject to the requirements.

Supply Chains

This topic is important in the context of many climate (emissions) risks being buried in supply chains and currently not visible, and that regulations (e.g., European Deforestation Regulation, EU Supply Chain Due Diligence Directive, etc.) are making this a topic of focus.

Beyond the scope of whether the targets meet the required level of ambition, there have also been issues in measurement of progress towards these targets. For climate targets in particular, the ability of companies to measure emissions in their value chains has been one of the weak spots in terms of validating whether targets have been met.

Currently, most regulations for financial institutions in particular either do not require value chain emissions (in the case of financed emissions) or allow for the use of proxy data for value chain emissions data (for example in the IFRS Climate Disclosure Standard S2 which is based on the Greenhouse Gas Protocol).

Greenhouse Gas (GHG) Protocol has also produced standards, guidance, tools, and training for businesses and government organizations to measure and manage emissions, including calculation tools for emissions. Updates to the GHG Protocol are likely to include clearer guidance for use of estimated proxy data.

Other regulatory requirements and voluntary disclosure standards like the European Sustainability Reporting Standard (ESRS) and Partnership for Carbon Accounting Financials (PCAF) increase the requirements for value chain and financed emissions over time beyond what is currently possible for most companies to comply with.

Many supply chain risks go down to the level of primary inputs, where either destruction, conservation or regeneration of natural capital assets will be important information for final producers / consumers, and information isn't currently easy to get from one end of the supply chain to another, and one of the barriers is financing for those within the supply chain to collect information and invest in improving their practices to meet buyers' expectations.

For example, the recently enacted European Sustainability Reporting Standards (Annex 1, Section 5.2, Paragraph 71) is for now allowing estimation and proxy for Scope 3 emissions in a reporting entity's value chain, which is likely to be tightened over time to require more data collection from within supply chains (there are stronger requirements for Scope 3 emissions disclosures for financial institutions who sign up to the Partnership for Carbon Accounting Financials (PCAF):

“With reference to policies, actions and targets, the undertaking’s reporting shall include upstream and/or downstream value chain information to the extent that those policies, actions and targets involve actors in the value chain. With reference to metrics, in many cases, in particular for environmental matters for which proxies are available, the undertaking may be able to comply with the reporting requirements without collecting data from the actors in its upstream and downstream value chain, especially from SMEs, for example, when calculating the undertaking’s GHG Scope 3 emissions.”

TRANSITION PLANS

Impact measurement is needed to make transition plans more realistic. We need to produce a trail of evidence, especially to make transition plans realistic. Blockchain provides the data and traceability to do this. This will also contribute to increasing trust across companies and organizations making claims of transitioning to Net Zero, and it will attract additional investments.

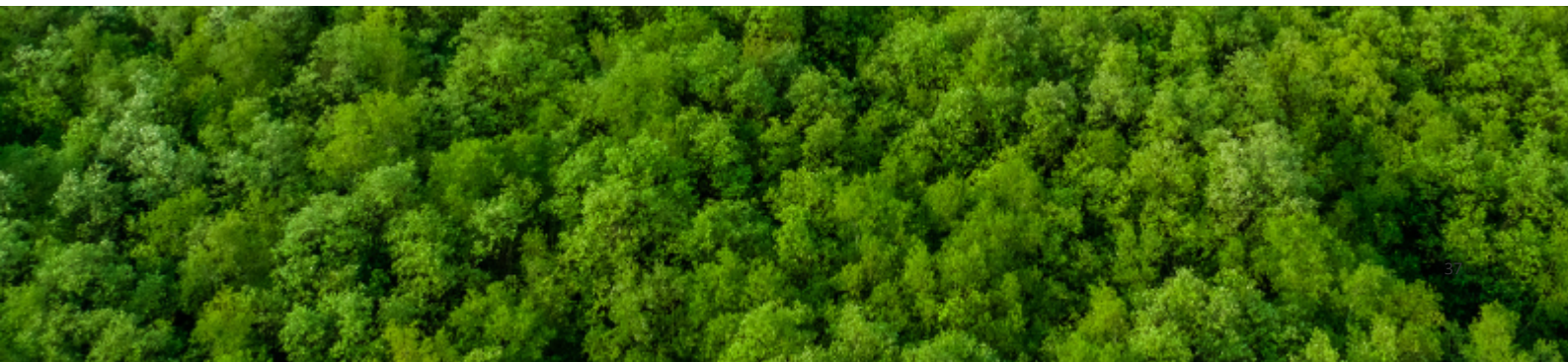
The connection between climate finance and companies making credible transition plans is quite direct. Important elements of creating a credible transition plan include a roadmap with actions needed, a capital allocation plan, governance for implementation of a transition strategy, independent monitoring, and progress reporting to show steps towards reaching interim targets.⁴¹

For many sectors where transition plans are especially relevant (e.g., high-emitting sectors), half or more of today's emissions are located in their upstream or downstream supply chains. Apart from a few sectors like transportation, shipping, and power generation, many high-emitting sectors like mining, oil & gas, agriculture and various forms of manufacturing have to mitigate either downstream or upstream emissions related to their suppliers or the use of their product. In either case, these Scope 3 emissions are created through the actions of suppliers or customers. A company has the ability to influence, through its choices, the behavior of these supply chain players (upstream), or may be subject to the priorities of others for whom they act as suppliers (downstream).

Access to financing is an important mechanism for influencing behavior across supply chains. However, in the context of a transition plan, as opposed to the case of corporate social responsibility programs, the objective isn't met merely by making financing available. Credibility of transition plans contains two elements:

1. Climate ambition, with a net zero target and ambitious trajectory to the objectives of the Paris Agreement
2. Robustness of ability to deliver, with an implementation strategy that enables tangible progress toward climate goals underpinned by consistent disclosures and monitoring

Having a science-based target can address (1) but does not guarantee (2). For the company's transition plan to be credible, there needs to be a cause-and-effect relationship between a company's provision of finance (e.g., directly or through an agreement with a financial institution) and resulting emissions reductions in its supply chain. The relationship needs to exist and must have data providing evidence that can be evaluated independently to demonstrate the capacity to deliver on the climate ambition in the transition plan. Supply chain traceability provided by blockchain technology, especially as it can underpin climate finance for suppliers, addresses a significant gap in the current ability to demonstrate the credibility of transition plans.



CONCLUSION

We must find ways to reverse the current paradigm where, for instance, it is only when a tree is cut that payments and rewards occur. We must collaborate across stakeholders to build systems that work to solve challenges first, and then apply multiple technologies within those new systems. Blockchain can be a tool to drive this change. As sustainability is becoming a strategy for competitiveness, more than merely a charitable aim, leveraging innovations like blockchain technology has shown that profitable business models can embrace net zero, and even climate-positive outcomes.

- This requires an acknowledgment that supply chains link global commerce and global finance together, even though there is often significant opacity throughout. Supply chains have developed in a way that is tied into an extractive economic model that benefits the Global North disproportionately over the Global South, undervalues natural capital and supports an unsustainable linear economy that produces high levels of waste. Blockchain has the ability to be additive to improving upon the status quo with a variety of business models.
- Certain approaches target the underlying extractive economic models, such as ReFi, and seek to value the stock of natural capital, such that markets can enable their participants to not only pay when resources are extracted. For supply chains, certain approaches that work link verified data together with financing of supply chains in order to improve the ability to support stages of the supply chain where mitigating emissions are needed, and make supply chain relationships more equitable.
- While many traditional approaches function adjacent to what happens with financial resources created from extraction and sale of resources, while both legal and illegal financial flows connected to resource extraction at the base of the supply chain often seek out developed market financial centers rather than being saved or invested domestically. This undercuts financial market development in these countries, helps weak institutions persist, which are often cited as the cause for the financial flight in the first place, and contributes to economic fragility of countries in the Global South. This is especially the case for those that are highly dependent on commodities and often subject to sharp boom-bust cycles where debt sustainability is a common concern.

Climate finance that brings or keeps more resources domestically can provide a counterweight to the economic cycles that have undercut countries' ability to generate sustainable development, let alone fund investments in climate adaptation. In these cases, blockchain provides a unique resource in contexts often characterized by weak institutions and low-trust markets with substantial leakage of financial flows connected to properly valuing natural capital assets and channeling supply chain climate finance toward conservation and regeneration of the planet, with positive outcomes for the people.



SUSTAINABILITY

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