BLOCKCHAIN RESEARCH INSTITUTE

BLOCKCHAIN FOR PLANETARY STEWARDSHIP

Using the Disruptive Force of Distributed Ledger Technology to Fight Climate Disruption

Tom Baumann
ClimateCHECK

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A BLOCKCHAIN RESEARCH INSTITUTE BIG IDEA WHITEPAPER

Realizing the new promise of the digital economy

In 1994, Don Tapscott coined the phrase, "the digital economy," with his book of that title. It discussed how the Web and the Internet of information would bring important changes in business and society. Today the Internet of value creates profound new possibilities.

In 2017, Don and Alex Tapscott launched the Blockchain Research Institute to help realize the new promise of the digital economy. We research the strategic implications of blockchain technology and produce practical insights to contribute global blockchain knowledge and help our members navigate this revolution.

Our findings, conclusions, and recommendations are initially proprietary to our members and ultimately released to the public in support of our mission. To find out more, please visit www.blockchainresearchinstitute.org.

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Foreword

Why develop new technology and innovative business models if our species will ultimately not survive the environmental consequences of these inventions on our planet? Anyone who combs through NASA's latest scientific data cannot help feeling a sense of urgency around reversing these environment trends:[1]

- Earth's average surface temperature has risen about 2°F (1.1°C) since the end of the First Industrial Revolution, which introduced not only the use of materials such as iron and steel, energy sources such as coal, machines such as the power loom, factories as a means of organizing labor, and steam locomotives as transportation but also the release of human-generated CO_2.[2] That said, much of the warming has occurred in our lifetime, with sixteen of the 17 warmest years on record occurring since 2001.[3]

- The upper layers of our oceans are really taking a hit. Their acidity has increased approximately 30 percent since the First Industrial Revolution.[4] The amount of CO_2 they absorb is increasing by some two billion tons per year.[5] And the topmost 700 meters (~2,300 ft.) have warmed 0.3°F since 1969.[6]

- In the Northern Hemisphere, snow is melting earlier, and spring snow cover has decreased over the last fifty years.[7] From Africa to Alaska, glaciers are shrinking—in the Alps, the Andes, the Himalayas, and the Rockies.[8]

- The mass of Antarctic and Greenlandic ice sheets has decreased at a minimum rate of 36 cubic miles per year. The mass of Arctic sea ice has declined rapidly, too.[9]

- In the last century, the global sea level has risen by eight inches. In the last twenty years, the rate of change has nearly doubled.[10]

- Since 1950, the number of record high temperatures and intense rainfall events has been increasing in the United States, whereas the number of record low temperature events has been decreasing.[11]

Why develop new technology and innovative business models if our species will ultimately not survive the environmental consequences of these inventions on our planet?

The list of effects on human beings reads like a catalog of plagues of biblical proportion: drought, reduced crop yield, increased insect outbreaks and tree diseases, heat waves and wild fires, increasingly destructive hurricanes, greater coastal flooding and property erosion, and increased malnutrition, water contamination, diarrhea, cardiorespiratory illnesses, and other infectious diseases.[12] Technologists must not only understand the impact of their innovations on our global ecology but also provide leadership on how to counter it.

Critics may scoff at a blockchain project on climate change. After all, the Bitcoin blockchain alone uses more energy than Hong Kong (Figure 1).

This project explains what the community is doing to improve this situation, such as developing less computationally demanding algorithms. Improve it we must. By one estimate, blockchain may require more energy in 2020 than is currently available.[13] Some are casting doubt on that forecast. Jonathan Koomey, an expert in studying the energy usage of information technology, told CNBC that blockchain "is a tiny, tiny part of all data center electricity use."[14] MIT's Christian Catalini questioned whether anybody could "make a credible claim . . . without actually having data from the miners."[15] He told *The Independent* that "different miners will have different cost structures depending on how advanced their hardware is" and where they are located.[16]

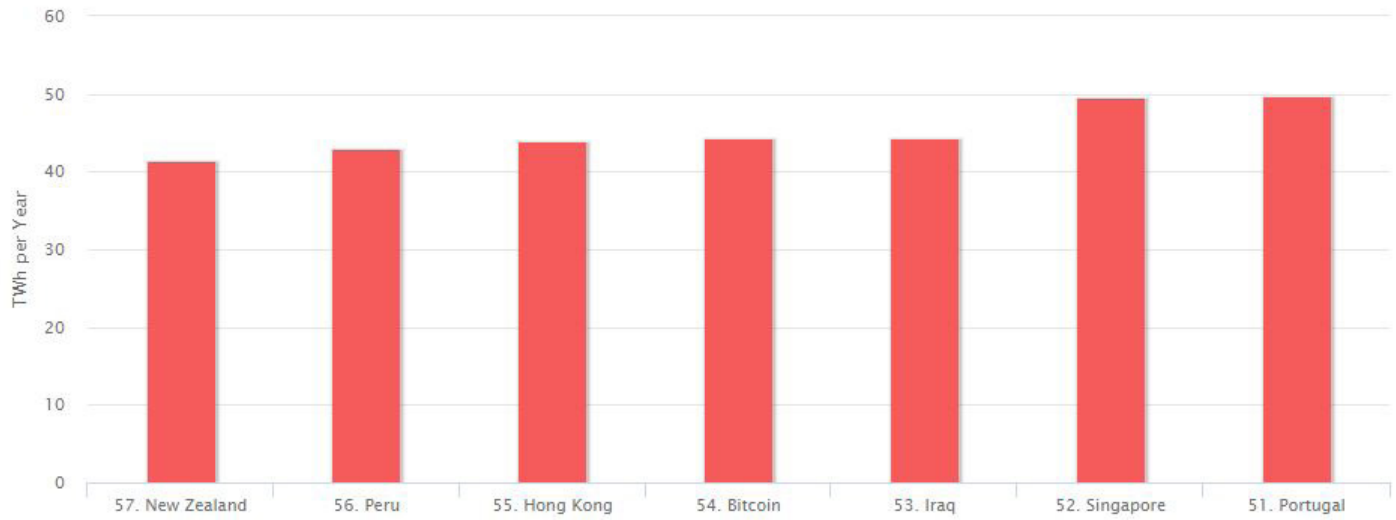
Outside of this (sizeable) problem, technological innovation can help to coordinate stakeholders at a larger scale to address global crises. Someone who understands the magnitude of the challenge before us and has dedicated his career to addressing it is Tom Baumann, director of this research project. Tom astutely lays out the key goals and difficulties of using blockchain to address climate change. He also profiles a number of start-ups in the space.

Technological innovation can help to coordinate stakeholders at a larger scale to address global crises.

Let's join in deploying blockchain to face this existential threat and, in so doing, improve market integrity, mobilize and monitor the vast resources required to preserve our environment, and spare our species and those already imperiled by climate change.[17]

DON TAPSCOTT
Co-Founder and Executive Chairman
Blockchain Research Institute

Figure 1: Energy consumption by country



Source: Digiconomist, digiconomist.net/bitcoin-energy-consumption, 24 Jan. 2018.

Idea in brief

- Blockchain in combination with other digital innovations (e.g., artificial intelligence, sharing economy, Internet of Things, big data analytics) and supported by governance mechanisms such as *global solution networks* (GSNs) can help overcome market and government failures that impede scalable climate and sustainability solutions.[18]
- As a community, we need to address the elephant in the room: the energy consumed by Bitcoin and other blockchains using proof-of-work consensus schemes is unsustainable. It is currently estimated to be equal to a mid-sized country and forecasted to exceed global energy availability by 2020—only 24 months away.[19]
- Since Satoshi Nakamoto launched the Bitcoin blockchain in 2008, the energy efficiency of computing technology has improved significantly, and we have many reasons to be confident in that trend's continuing. Furthermore, the emergence of less computationally demanding forms of *distributed ledger technology* (DLT) will significantly reduce energy demand.[20] Still, to ignore or to rationalize blockchain's energy consumption would be irresponsible.
- The Paris Agreement—its provisions for *nationally determined contributions* (NDCs) to address climate change—and the multitude of *sustainable development goals* (SDGs), each with its own approach to *measurement, reporting, and verification* (MRV) and *monitoring and evaluation* (M&E), shape the landscape of challenges and opportunities to deploy blockchain solutions for planetary stewardship.[21]
- Informed by the Paris Agreement, blockchain can support a bottom-up approach to collaborating, innovating, and implementing climate solutions.[22] During the COP23 UN climate conference in November 2017, climate and blockchain experts announced new blockchain-based climate initiatives; and the conference hosted the world's first blockchain hackathon to fight climate change, Hack4Climate.[23]
- Governance innovation—such as decentralized collaborative systems to establish standards and rules necessary for a cohesive system of blockchain solutions—can support climate actions (e.g., clean energy technologies), carbon markets (e.g., carbon credit trading), and climate finance.[24]
- The combination of digital innovation and governance can
  - Scale stakeholder coordination, increase speed to market, and radically reduce costs
  - Increase integrity of markets and the environmental performance
  - Mobilize the trillions of dollars needed annually to achieve the Paris goals

Informed by the Paris Agreement, blockchain can support a bottom-up approach to collaborating, innovating, and implementing climate solutions.

Fighting disruption with disruption

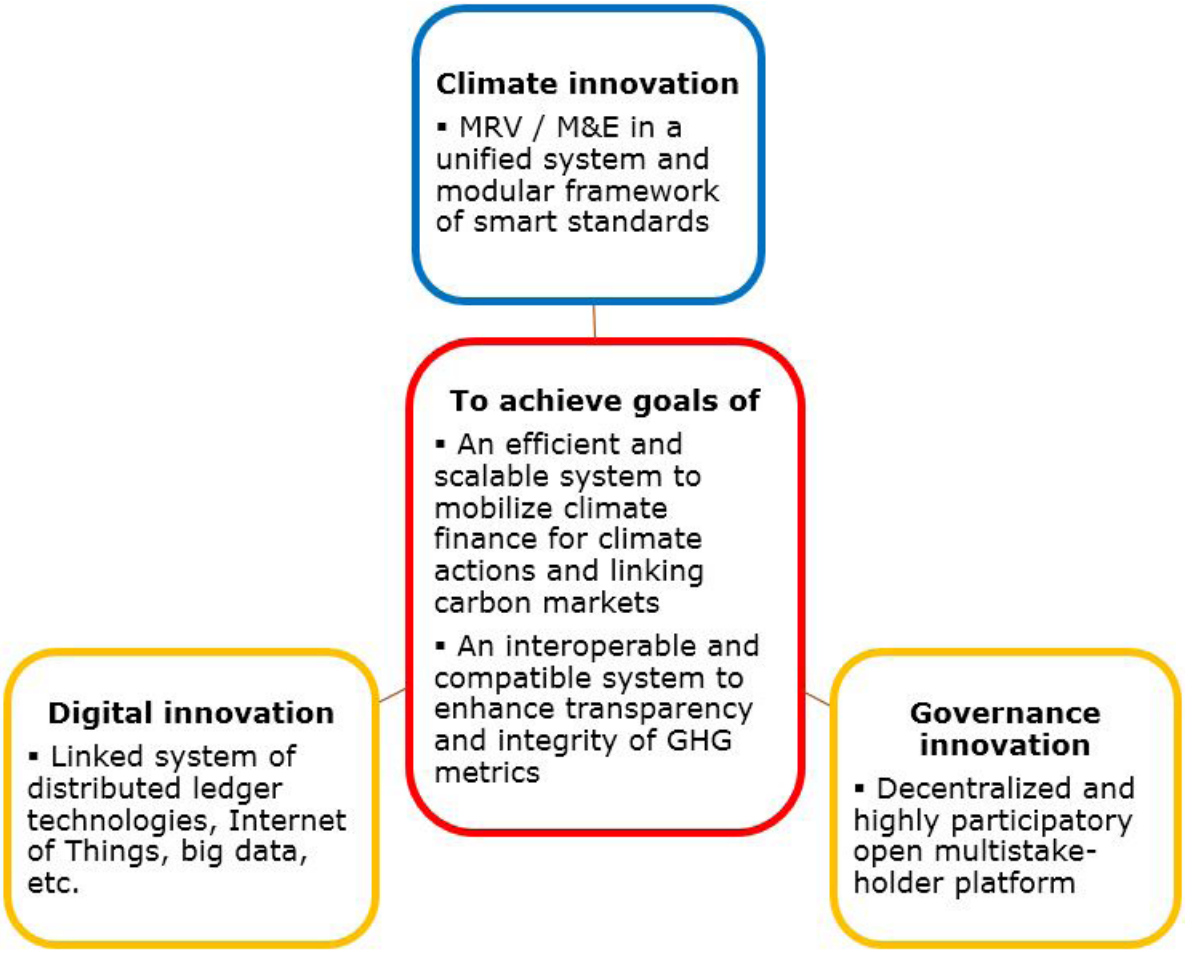
Smart standards *are precursors to smart contracts, software applications that formalize and secure the terms of commercial agreements and that run over distributed computer networks in a trust-minimized manner.*

To develop a framework, this research included an assessment of the landscape of blockchain initiatives (e.g., alliances, networks, and applications) for climate and sustainability within a framework of the scope of initiative (e.g., carbon credit trading, renewable power), level of maturity (e.g., proof of concept, partnership ecosystem, ICO), and links with GSNs (Figure 2).

New governance platform and restructured MRV system guides digital infrastructure to assure data needed for climate finance/actions/markets has the necessary end-to-end integrity. *Smart standards* are precursors to *smart contracts,* software applications that formalize and secure the terms of commercial agreements and that run over distributed computer networks in a trust-minimized manner.

Figure 2: Combining innovations for climate, blockchain, and governance

New governance platform and restructured MRV system guides digital infrastructure to assure data needed for climate finance/actions/markets has the necessary end-to-end integrity. Smart standards are precursors to smart contracts, software applications that formalize and secure the terms of commercial agreements and that run over distributed computer networks in a trust-minimized manner.



The climate challenge

Carbon pollution (greenhouse gas emissions) is often referred to as a *negative externality* by economists and politicians, meaning economic activities that cause carbon pollution are not including those pollution costs in the markets (i.e., these costs are *external* to market transactions).[25]

But the physical reality is that anthropogenic greenhouse gas (GHG) emissions (i.e., from human activity) are accumulating in the Earth's atmosphere and have increased 46 percent above pre-industrial levels. Carbon pollution, including industrial gas with over 10,000 times the environmental impact of carbon dioxide (CO_2), is contributing to the climate disruption being experienced in the form of massive hurricanes, longer droughts, devastating forest fires, and the spread of diseases and invasive species.

According to the International Monetary Fund,

> *Most externalities fall into the category of so-called technical externalities; that is, the indirect effects have an impact on the consumption and production opportunities of others, but the price of the product does not take those externalities into account. As a result, there are differences between private returns or costs and the returns or costs to society as a whole.*[26]

The province of Quebec in Canada suffered an enormous one-in-a-hundred-year flood in 2017; it was the third year in a row it had occurred. Meteorological models are being updated and the occurrence of the one-in-a-hundred-year level of flooding has been revised to a one-in-five-year frequency. The 2017 flood cost Quebec $350 million in damages. These costs are huge and increasing. Other parts of the world such as the Middle East and India are experiencing prolonged extreme heat in excess of 45°C (> 110°F), putting added pressure on mass migration of environmental refugees happening in many parts of the world.

Carbon pollution is contributing to the climate disruption being experienced in the form of massive hurricanes, longer droughts, devastating forest fires, and the spread of diseases and invasive species.

During Climate Week in New York City in September 2017, Ambassador Nazhat Shameem Khan, the chief negotiator of UNFCCC COP23—the UN climate conference in November 2017—emphasized the urgency for immediate global action to start the low carbon transition toward the Paris Agreement goal to contain global warming to 1.5°C. Ambassador Khan is from the Pacific island of Fiji, which is already experiencing the impacts of rising sea levels—an existential threat to small island states.

In stark contrast to treating carbon pollution as a market externality, with the goal to limit human impacts on the climate to an increase of 1.5°C, it is simple to reason that there is a limit to how much more carbon pollution can go into the atmosphere. In other words, the planet has a carbon budget expressed as metric tons (tonnes) of carbon dioxide that can be emitted into the atmosphere by 2050.[27] As of December 2017, the upper estimate of the total carbon budget

remaining within the 1.5°C target that can be shared among all nations and citizens of the world is estimated at 135 billion tons of CO_2.

At current levels of annual emissions (approximately 40 billion tons of CO_2), the number of years left before exhausting the carbon budget for 1.5°C is fewer than four years—occurring in 2020, and that's the upper estimate of the amount of time left.[28] Many are already acknowledging this goal to limit global warming to 1.5°C is not achievable and instead look at 2°C as a possible goal to be achieved by 2035.

Apart from the underlying carbon pollution changing our planet's climate, our political-economic system, with the lack of appropriate and stable market pricing mechanisms and government controls, as well as capricious bureaucracy, stifles an adequate effort to address the climate crisis at the rates and scale necessary to meet the goals of the Paris Agreement, which was negotiated at the COP21 UN climate conference in December 2015:

> *The United Nations Climate Change (UNFCCC) secretariat recognizes the general potential of blockchain technology. In particular, transparency, cost-effectiveness and efficiency advantages, which in turn may lead to greater stakeholder integration and enhanced creation of global public goods are currently viewed as the main potential benefits. The secretariat, therefore, specifically supports initiatives that lead to innovation at the intersection of blockchain and climate.*[29]

Although we have experimented with government-coordinated market mechanisms to address carbon pollution, the results have been disappointing in environmental terms and business terms.

Few tools for managing complexity and ambiguity

Although we have experimented with government-coordinated market mechanisms to address carbon pollution (e.g., GHG emissions trading), the results have been disappointing in environmental terms and business terms.

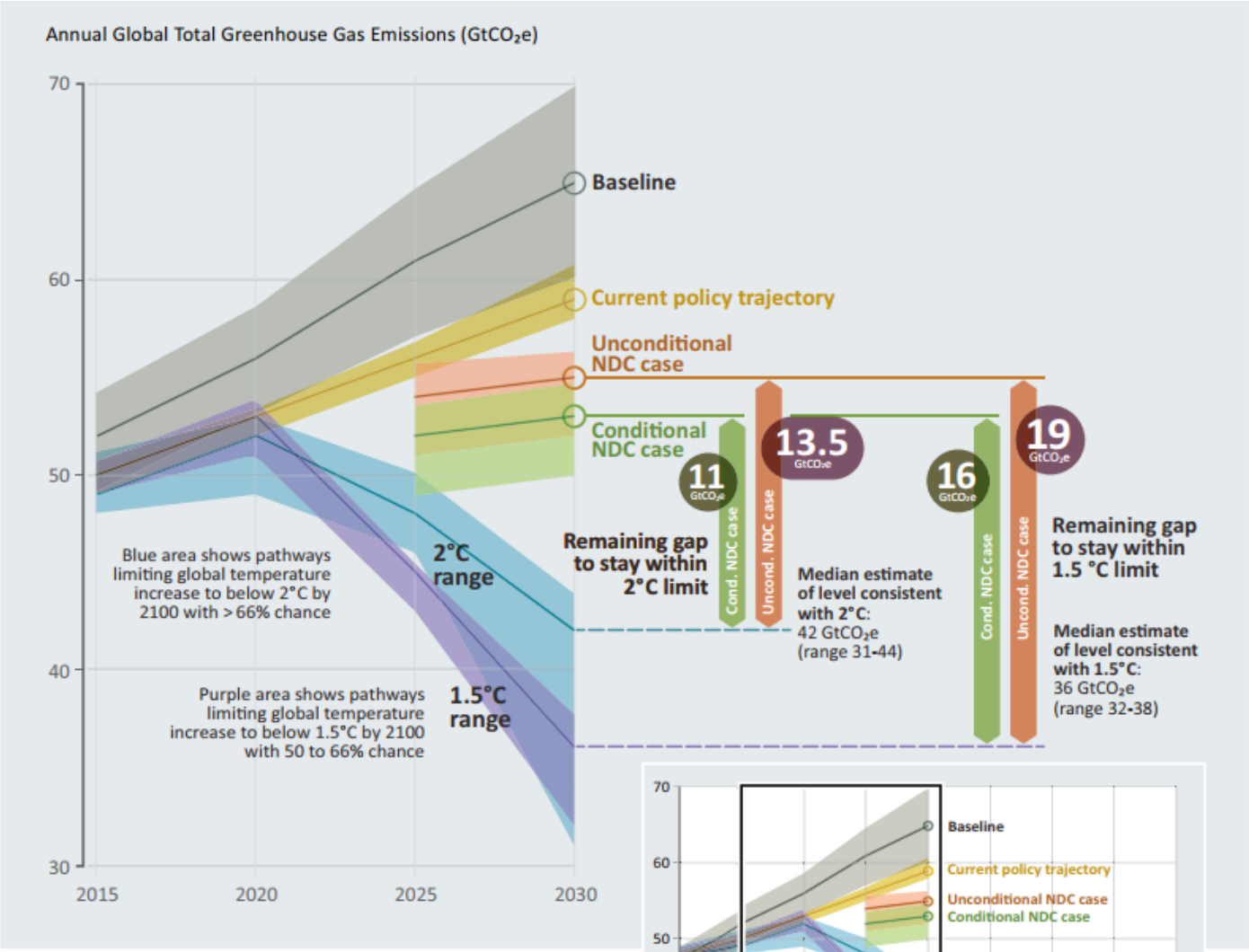
There are many reasons why these experiments have failed, including but not limited to inadequate knowledge and tools resulting in inefficient program design and implementation, high administrative costs, as well as insufficient resources (e.g., expertise, data) to scale the market.

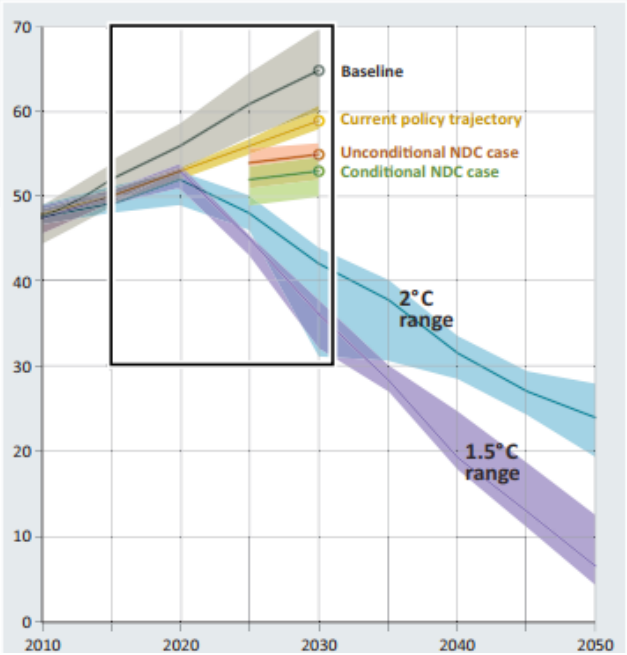
Beyond individual program problems, at the aggregate level there are fragmented approaches such as different standards across different regions resulting in different carbon accounting units. For example, a ton of CO_2 reduced in Canada does not necessarily have an equal "mitigation value" to a ton of CO_2 reduced in India.[30]

With that context, the goals of the 2015 Paris Agreement represent a major "moon shot" to decarbonize and shift to a clean economy by 2050.[31] For example, the average Canadian that currently causes 20 tonnes of CO_2 emissions per year will be limited to just two tonnes of CO_2 per year—that's a 90 percent decarbonization.

Figure 3: Emissions gap in 2030

Global greenhouse gas emissions under different scenarios and the emissions gap in 2030 (median estimate and 10th to 90th percentile range).





Note: the emissions range for 1.5°C is smaller than for 2°C, as a smaller number of studies for 1.5°C are available. For current policy, the minimum–maximum across all assessed studies are provided.

© 2017 UNEP. The Emissions Gap Report 2017. United Nations Environment Programme, Nairobi. Used according to its guidelines.

Existing commitments in NDCs do not get close to the Paris goals, which require signees to reallocate trillions of dollars annually into climate-smart investments and actions. We need expanded MRV tools that utilize digital technologies and market-based solutions to facilitate the deployment and monitoring of all these financial tools (including results-based finance, climate bonds, peer-to-peer and crowd-sourcing climate finance, etc.).[32]

According to the Centre for International Governance and Innovation:

> *To reach an agreement in Paris, many issues were left reasonably ambiguous, and this is especially true with respect to the issue of governance of Article 6. Consequently, there remain significant amounts of work to do, and many issues to negotiate.*[33]

In other words, the challenges have increased significantly for stakeholders to adapt to a more ambiguous and complex MRV landscape of the Paris Agreement. Furthermore, stakeholders are challenged to adopt the emerging digital solutions in the climate space for several reasons:

- Established or entrenched interests
- A lack of understanding about the applications for digital technologies across the data trail from meters through standards, programs, and markets
- A lack of rules to support the adoption of digital technologies in general
- A lack of rules in the climate space for implementing the Paris Agreement[34]

We can sum up the challenge of a more ambiguous and complex MRV landscape for the Paris Agreement's bottom-up approach of NDCs as

- Increasing diversity of regulations, MRV systems, carbon assets, and mitigation values (i.e., environmental benefit) of the assets within and across jurisdictions
- Increasing need for more robust MRV systems corresponding to needs of climate finance for climate actions and *internationally transferable mitigation outcomes* (ITMOs)
- Potential for an increasing size/scale of post-2020 carbon markets, as well as linkages with related sustainability actions and markets
- New linking arrangements (e.g., clubs, regional trading schemes, sectoral trading schemes)
- Increasing types of financial flows and transactions such as peer-to-peer and results-based finance

"Regulation through penalties and accidental leadership have both set the industry's standards to date," wrote Josh Garcia, a fintech and blockchain lawyer at Cooley LLP. He continued:

"Regulation through penalties and accidental leadership have both set the industry's standards to date."

JOSH GARCIA
Fintech and Blockchain Lawyer
Cooley LLP

This coming year presents an opportunity for a third way forward, where key contributors develop principled standards and encourage their use through a self-regulatory organization (SRO), a certification entity, via new law drafted with regulators and lawmakers or through new frameworks that creatively navigate old law.[35]

Too little coordination of governance and standards

In addition to this sizeable challenge, since the 1990s, another has quietly manifested in the proliferation of a fragmented landscape of MRV standards.[36] Over a thousand have been developed by such stakeholders as

- National (US, UK, EU) and sub-national (California, Alberta) government programs
- Industry associations (oil and gas, transportation, waste)
- Voluntary initiatives (GHG Protocol, Gold Standard, Verified Carbon Standard, American Carbon Registry)
- International organizations (Intergovernmental Panel on Climate Change)
- Standards bodies (International Organization for Standardization [ISO], Canadian Standards Association)
- Research institutes and academia (life cycle, sector, and macro-economic models)

The Paris goals are very challenging to achieve with current national commitments.

The UNFCCC (United Nations Framework Convention on Climate Change) Clean Development Mechanism (CDM) includes over 200 MRV methodologies for large-scale projects, small-scale projects, and standardized baselines.

Although implementing policies and establishing efficient, credible markets cannot happen without good standards and rules, most MRV standards were developed by various actors during the early phase of climate policies and carbon markets, and sadly the standards are not harmonized into a user-friendly system.[37] Rather, the markets are fragmented—as documented by the World Bank.[38] Companies expend major resources to apply the standards, and yet the results vary from jurisdiction to jurisdiction.

Furthermore, an MRV methodology can cost hundreds of thousands of dollars to develop, and an international standard can cost $1 million per page to develop as well as three to four years to get published. This is simply not aligned with the realities of the world today with accelerating rates of clean technology innovation and transformational change.

In other words, the Paris goals are very challenging to achieve with current national commitments, and regretfully the MRV rules needed to unlock investment and support climate actions are causing as many problems as they were intended to solve. We need to re-tool

the system that develops and deploys MRV rules, that is, a next generation governance system.

According to the Centre for International Governance and Innovation,

> *Providing for every possible combination of NDC [nationally determined contribution] for elements such as accounting, and the avoidance of double counting in transfers between parties, may render the exercise for writing the rulebook for Article 6 a matter of enormous complexity, if not an impossible task. The carbon market framework under Article 6.2 is designed to have more decentralized governance, with parties engaged in collaboration being able to establish their own governance. The temptation to create centralized governance for Article 6.2, through backdoor provisions, should be resisted, at least at this stage.*[39]

In September 2015, the United Nations established 17 Sustainable Development Goals (SDGs) and an agenda for transforming our world by 2030.

Transition to a sustainable world

In September 2015, the United Nations established 17 Sustainable Development Goals (SDGs) and an agenda for transforming our world by 2030.[40] The UN call to action, including the Paris Agreement, for transforming our world is growing louder and more urgent. It is appropriate to quote Charles Dickens's famous opening line: "It was the best of times, it was the worst of times."[41]

As noted already, at current rates of GHG emissions there are only 17 years remaining to limit global warming to 2°C, that is expected to limit "the worst" of the climate change impacts (as if three years in a row of one-in-a-hundred-year floods is not yet bad enough). Even if carbon pollution was completely stopped today, the already emitted carbon pollution will continue to affect the climate for the foreseeable future. We need action now.

Yet, there is momentum building to redirect investments away from the fossil fuel economy and into the clean economy. For example, the long awaited acceleration of cost-efficient renewable energy is now about to overtake nuclear power in market share; digital technologies also are enabling efficiencies throughout the economy and society.

Already developing countries, with over 80 percent of the global population, are adopting new technologies (e.g., ICT, low-cost renewable power) needed to leap-frog developed countries for modernization and low emission development strategies. For example, African countries have over 600 million mobile smart phone users with telecommunications and Internet access, and without substantial investment in landlines and power lines.

By 2020 there will be over 50 billion Internet-connected devices generating immense amounts of data and fully making data a new asset class.[42] Already, the most valuable companies in the world are IT and data companies. The Internet of Things (IoT) and artificial intelligence (AI) are supporting the data-driven transformation of industries and inventing new businesses.

Recognizing how these new digital technologies are actually creating new industry leaders (e.g., Google, Facebook, Uber, and Airbnb in media, transportation, and accommodation—just to list some well-known examples), it is simply a matter of time until digital technologies transform other industries including finance, health care, energy, and commodities; environmental applications will be no exception.

Digital solutions provide new capabilities and advantages in terms of efficiency, transparency, accountability, extensibility, scalability, inclusiveness, integrity, and innovation to facilitate finance and climate actions.

The Global e-Sustainability Initiative has a vision to create a sustainable world through responsible, digital transformation. Its *SMARTer2030* report highlights the many opportunities for digital solutions across the economy (e.g., industry, transportation, energy, agriculture, cities) to decouple economic growth from carbon pollution and improve resource efficiency.[43]

Digital solutions provide new capabilities and advantages in terms of efficiency, transparency, accountability, extensibility, scalability, inclusiveness, integrity, and innovation to facilitate finance and climate actions. Examples of digital solutions that can help address the challenges include:

- Connected devices combined with big data analytics can structure and refine the data flows in accordance with the consensus-built smart standards implemented on the blockchain, which also help to automate processes that are otherwise subject to the limitations of manual and bureaucratic processes.
- Blockchain which provides transparency and consistent rules enforcement with smart contracts to implement the array of regulations and standards, and provide the accountability needed for regulators and investors.
- Decentralized collaborative governance systems (mass collaboration consensus-based rule-making) to enable more efficient development of MRV smart standards that are

Figure 4: Blockchain benefits for climate

structured as a unified system of modular, scalable, and interoperable rules (capable to expand beyond climate to SDGs and associated market and finance applications).

Our definition of smart standards as precursors to smart contracts builds on the work of Nick Szabo, originator of the smart contract.[44] We see smart climate standards as applications that formalize and secure the terms of climate agreements and that run on global public blockchains.

There is growing global interest at all levels, from the United Nations to governments, cities, and industries in blockchain and related digital solutions to address global issues like climate and sustainability.

To some extent, the continuous advancement of digital technologies over the last 10 years has started to be adopted for MRV of data for operations and associated metrics/claims/assets related to climate actions. Despite the modest uptake of digital technologies within existing climate markets, most GHG MRV activities continue to involve manual processes that rely on disconnected data trails, spreadsheets, and static PDFs. Hundreds of online collaborative platforms have been built to enhance knowledge sharing and capacity building, however many websites are "stranded" and the overall the results are mixed at best.[45] These examples are precursors in the evolution to the increasingly interconnected, highly transparent digital paradigm that is emerging globally.

Blockchain: A new paradigm for sustainability

There is growing global interest at all levels, from the United Nations to governments, cities, and industries in blockchain and related digital solutions to address global issues like climate and sustainability.[46] For example, by leveraging existing IT infrastructure like mobile devices, blockchain can be used to provide access to financial services in developing countries where billions do not have access to the financial industry. As of August 2017, 15 UN agencies were investigating a range of blockchain applications. In April 2017, the UN World Food Programme (WFP) used blockchain with 10,000 participants to deliver financial aid to impoverished areas in developing countries.[47]

Driving the interest in blockchain are such potential benefits as lowering MRV transaction costs for carbon units, improving the

Figure 5: Opportunities for blockchain initiatives for climate

overall transparency, market integrity, and environmental integrity of carbon programs such as emission trading, and enabling new types of climate solutions in combination with other sustainability solutions (i.e., SDGs).

It is a "greenfield" opportunity for blockchain initiatives to innovate solutions for climate and sustainability—and such efforts should be strongly supported. Yet there is a need and benefit to provide coordination support among these initiatives to optimize their synergy, and without slowing progress.

International organizations (e.g., International Energy Agency) have estimated achieving the Paris goals will require several trillion dollars per year in climate finance for low carbon development and for climate proofing our cities and infrastructure to be more resilient to climate impacts. We have countless opportunities to create blockchain applications for

- Carbon emission trading
- Energy management
- Registries for carbon reporting (e.g., NDCs)
- Sustainable and low carbon supply chains
- Low carbon differentiated products in commodity markets
- Green power
- Emission reduction projects
- Facility emission reporting
- Waste management
- Circular economy
- Wildlife conservation
- Land management
- Adaptation and vulnerability reduction to climate impacts
- Green finance

It is a "greenfield" opportunity for blockchain initiatives to innovate solutions for climate and sustainability—and such efforts should be strongly supported.

At this early stage of blockchain, it is important to keep an open mind and not assume there will (or should) be "one blockchain to rule them all." The blockchain applications being developed all around the world are based on very different approaches such as (but not limited to):

- Different blockchain (DLT) protocols (e.g., Bitcoin, Ethereum, EOS, Ripple, IOTA, Stellar, Hashgraph)
- Combination with other digital technologies (e.g., AI, IoT, big data analytics)
- Different types of digital tokens or coins (e.g., utility tokens, tokenized securities, coins)
- Permissioned and public access

» Different rules and rules-setting processes to structure and operate the blockchain application

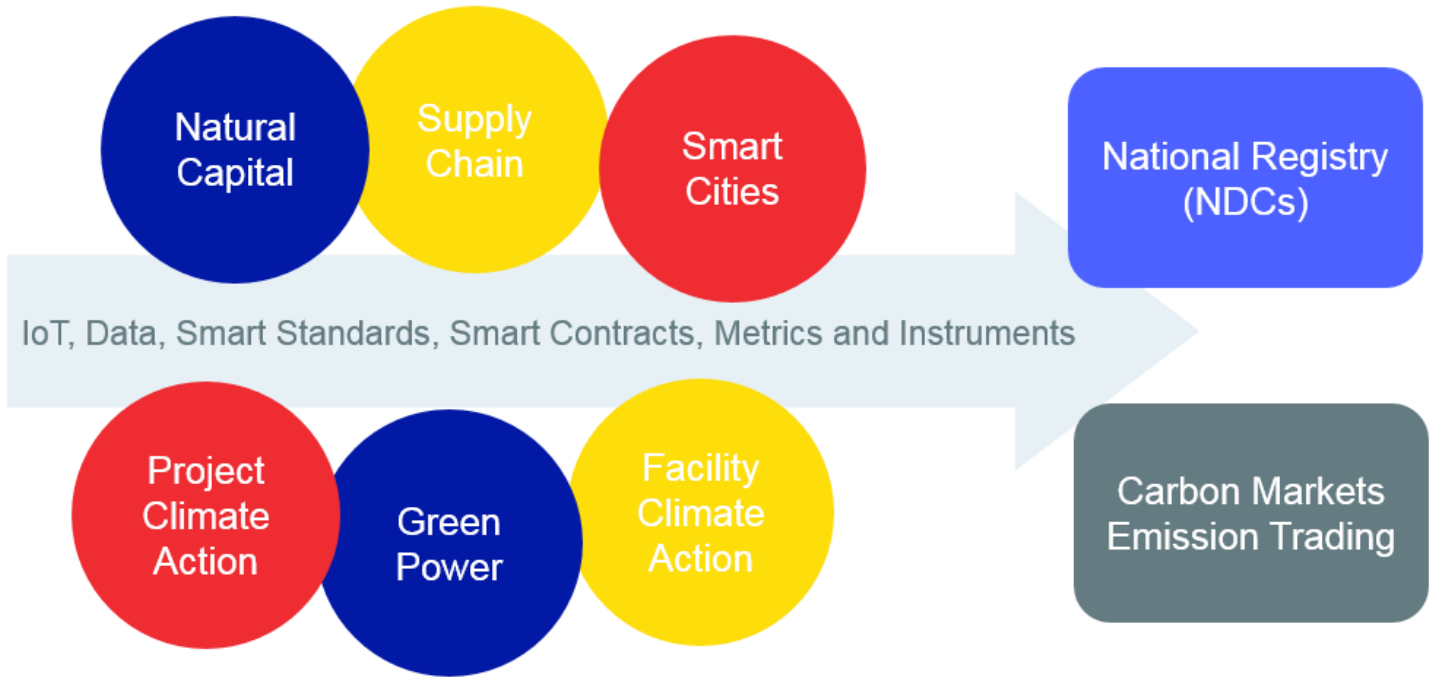
There is increasing attention on the issue of governance innovation for climate, including proposals for blockchain to support transparency, equity, and stability of new platforms and systems to implement the Paris Agreement.[48] Linkages of blockchain and collaborative governance systems can help achieve the goal of 90 percent decarbonization by 2050.[49]

If we combine the diversity of blockchain applications and user needs along the value chain with the potential for linking blockchain applications—for example, a company purchases electricity via a green power application, which reports carbon pollution to another application such as a carbon registry—then we will have major interoperability and governance issues to address.

Blockchain initiatives for climate and sustainability

Since 2014, a variety of blockchain initiatives has emerged within the climate and sustainability space. Carbon credits generated from carefully managed forestry projects that sequester carbon dioxide from the atmosphere, renewable electricity, waste management, and sustainable supply chains are a few examples.

Figure 6: Linked and nested blockchain initiatives for climate



During 2017, the number of blockchain climate initiatives has more than doubled to over 100—and the rate of growth is accelerating.

This page contains our taxonomy for analysis and discussion of initiatives.

During 2017, the number of blockchain climate initiatives has more than doubled to over 100—and the rate of growth is accelerating. In addition to the specific issue of focus (e.g., carbon credits, waste), the initiatives vary according to their use of digital technologies and partner ecosystem.

In a survey of the landscape, we developed a taxonomy for analysis. There are three overarching categories:

- Scope for climate and sustainability (market focus)
- Relation to global solution networks (governance)
- State of maturity

The scope spans these core categories:

- Climate change
- Clean energy
- Sustainability (social, humanitarian, natural capital, ecosystems, etc.) related to the Sustainable Development Goals)
- Sustainable supply chains and commodities

Relation to GSNs uses the seven network categories:

- Standards
- Knowledge
- Policy
- Advocacy
- Operation and delivery
- Networked institutions
- Watchdog

State of maturity categories include:

- Launch announced
- Organization and partner ecosystem established
- Proof of concept underway or completed
- ICO underway or completed
- Commercial implementation underway or completed

Here is a representative sample of climate and sustainability blockchain solutions—two initiatives, Climate Ledger and Hack4Climate, and two blockchain applications, Veridium and Xpansiv—that enables us to compare and contrast their approaches.

Climate Ledger Initiative

Nick Beglinger, Initiator

The Climate Ledger Initiative (CLI) is a joint program supported by the LIFE Climate Foundation, Cleantech21, Climate-KIC, INFRAS, Gold Standard and other partners. CLI was formed following the launch of ClimateBC during the UN climate events in May 2017.

CLI's mission is to accelerate the momentum for climate action under the Paris Agreement by systematically strengthening the intersection between the field of climate change and blockchain/DLT. CLI has three parallel tracks of focus:

- Research to fill the knowledge gaps in key areas regarding climate and relevant DLT
- Innovation use cases to show DLT's potential and allow learnings from the field
- Innovation call-outs to raise awareness, build capacity, convene and mobilize climate and DLT talents

Climate Ledger Initiative's mission is to accelerate the momentum for climate action under the Paris Agreement by systematically strengthening the intersection between the field of climate change and blockchain.

Priorities of CLI research include emissions data capturing and GHG inventories, corporate carbon pricing and environmental, social, and governance (ESG) issues reporting, and research related to climate specific aspects of DLT.

CLI's innovation call-out activities include capacity building on climate action for the implementation of the Paris Agreement and the role of DLT, ideation workshops, prized contests, selection challenges, targeting coaching, and demo days.

CLI commissions research according to its research charter and agenda, which is managed by CLI's coordination committee and subject to approval of its oversight board. CLI's calls for proposals are mandated to research partners and the approach is technology neutral.

CLI develops a minimum of five innovation use cases each year to learn from implementation on the ground. CLI use cases are funded according to its innovation charter and agenda. Funding for use cases do not have to be technology neutral but must focus on pragmatic solutions for climate actions (i.e., mitigation, adaptation, finance).

The objective of CLI's innovation call-outs is to raise awareness, build capacity, convene and mobilize climate and blockchain/DLT talent, and select talent in hackathons.

Hack4Climate

Nick Beglinger, Project Lead

Hack4Climate is a blockchain hackathon focused on climate change. Its aim was to inspire the blockchain/DLT community to get engaged

and to contribute to climate actions. The first Hack4Climate happened 12-16 November 2017 in parallel to the COP23 UN climate conference in Bonn, Germany, near the UNFCCC headquarters. Hack4Climate challenged participants across six areas including:

Hack4Climate was a success and achieved high profile both within the COP23 and internationally by engaging 50 partners and 100 hackers from over 30 countries.

- Identification and tracking of emissions (IoT, supply chains, NDCs/inventories)
- Carbon pricing (markets, carbon tax, linking across borders, P2P exchange)
- Distributed energy (developed and developing markets, operation and finance)
- Sustainable land use (accounting and finance, forests and agriculture, clean cities)
- Sustainable transport (mobility and logistics, private and public)
- Anything goes (as per participants, partners)

Hack4Climate was a success and achieved high profile both within the COP23 and internationally by engaging 50 partners and 100 hackers from over 30 countries.[50]

Veridium

Todd Lemons, CEO

Veridium Labs is an environmental fintech company as a collaboration by EnVision Corporation, ConsenSys AG, BK Capital Management, EcoSmart Labs, and InfiniteEARTH. The Veridium ecosystem is governed by the Veridium Foundation, a nonprofit organization based in Canada. It is creating an open, public marketplace for digital issuance of environmental assets/natural capital using the ERC20 (Ethereum token standard). Veridium uses blockchain technology with cryptographic environmental mitigation offsets issued through the Veridium Network to create commodities with net positive environmental impacts.

It published its whitepaper in November 2017 and is in the process of developing its blockchain ecosystem proof of concept, as well as preparing for a token sale. Veridium states its main objectives are to:

- Create liquidity for carbon credit and environmental asset (i.e., natural capital) markets
- Decentralize environmental asset ownership
- Redefine sustainable supply chains by embedding environmental offsets backed by natural capital that can be traced and audited by the consumer
- Develop risk mitigation tools against systemic environmental liabilities risk
- Unlock the full value potential of environmental assets

Veridium is creating enterprise solutions for corporations that will drive demand for the tokenized environmental assets issued on the blockchain through the Veridium Network. It is currently working on climate change risk mitigation products for institutional portfolio management companies, pension funds and endowments, as well as creating sustainable supply chain solutions for *Fortune 500* companies—all incorporating the natural asset tokens issued through the Veridium Network.

Veridium is creating enterprise solutions for corporations that will drive demand for the tokenized environmental assets issued on the blockchain through the Veridium Network.

Its platform will include multiple types of environmental asset tokens that can be tokenized on the blockchain through the Veridium Network. The first to be issued, TGRs, are backed by Triple Gold REDD+ (reducing emissions from deforestation and forest degradation) as the underlying natural capital asset.[51]

Xpansiv

Joe Madden, Co-Founder and CEO

Xpansiv Data Systems (Xpansiv), based in the United States and Canada, is a technology company changing the face of the commodities ecosystem through first of its kind technology and innovative business models backed by industry leading enterprises. Xpansiv is led by a world-class team of experts in information technology, markets, exchanges, finance, standards and policy, and sustainability.

Xpansiv addresses two major challenges in commodity markets:

- Antiquated business processes (settlement, tracking, reporting, visualization) due to reliance on outdated, manual processes
- Enables the seamless inclusion (pricing/trading) of externalities (climate, water, land use, social impact, etc.) within *existing market* structures

The origins of Xpansiv as a digital commodities platform were launched with a concept paper published in the *Journal of Environmental Investing* and presented at the COP21 UN climate conference in Paris in December 2015.[52] The Xpansiv platform combines IoT and big data analytics with DLT to transform operational data into Digital Feedstock, a real-time digital representation of each unit produced (Figure 7, next page).

The Xpansiv platform combines IoT and big data analytics with DLT to transform operational data into a real-time digital representation of each unit produced.

Digital Feedstock helps commodity producers unlock the value hidden in their operational data through enhanced visualization and analytics, business process optimization, product differentiation, and access to new markets.

Commodity producers can reduce their operating and finance costs, gain increased visibility into their operations, differentiate their production in the marketplace, and interact more efficiently (directly with customers).

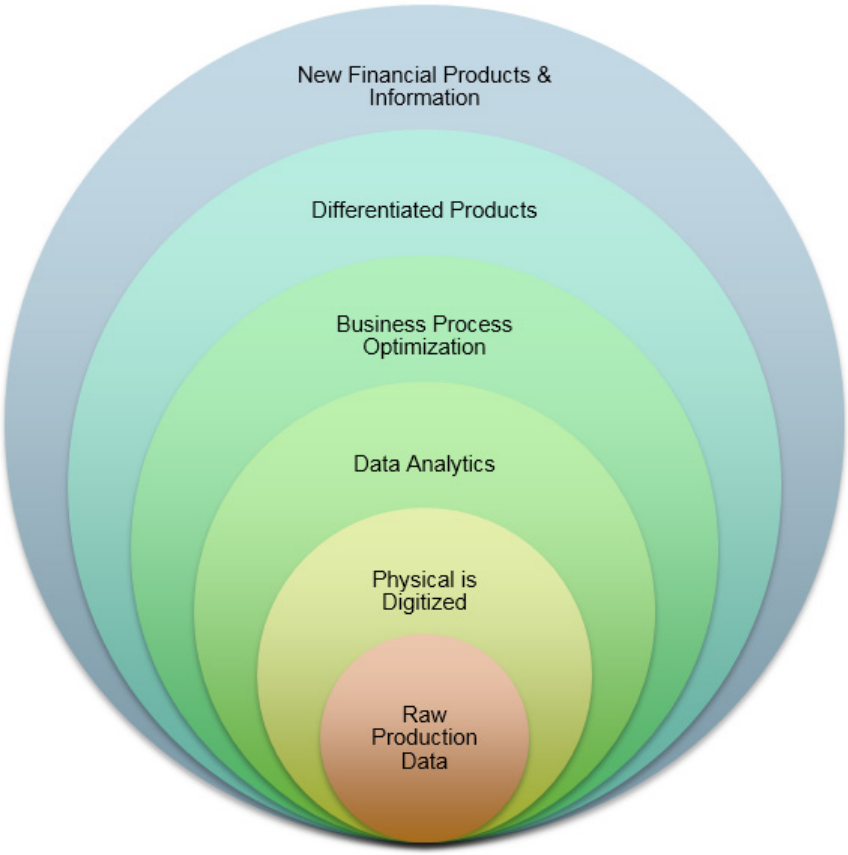
Downstream market participants can increase transparency in their supply chain, decrease their exposure to risk (investor, customer, regulatory), demonstrate their responsible sourcing, and reduce distance from producers (direct contracts, etc.).

Market participants can increase transparency in their supply chain, decrease their exposure to risk, demonstrate their responsible sourcing, and reduce distance from producers.

Xpansiv is commercially active in the oil, gas, and renewable fuels sector. Xpansiv's proof of concept was performed in May 2017, capturing data from approximately 5,000 natural gas production wells, each instrumented with dozens of meters, and structuring the data for both operational optimization and tokenization into its DLT platform. The super clean natural gas tokens were subsequently transacted to commercial consumers.[53]

Figure 7: How Xpansiv turns raw data into a digital asset class

The Xpansiv platform seamlessly converts raw commodity production data into a digital asset class for global commodities that provides a complete, immutable digital representation and title for each unit of commodity production using distributed ledger technology.



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Conclusion

Regarding the scope of the blockchain initiatives assessed, the findings suggest about half are focused on multi-issue opportunities for sustainability. Just over a quarter are focused on clean energy, and the remainder focus primarily on climate. Blockchain initiatives were identified as either networks (e.g., Climate Ledger Initiative), representing about a quarter, or applications (e.g., Climatecoin), representing about three-quarters.

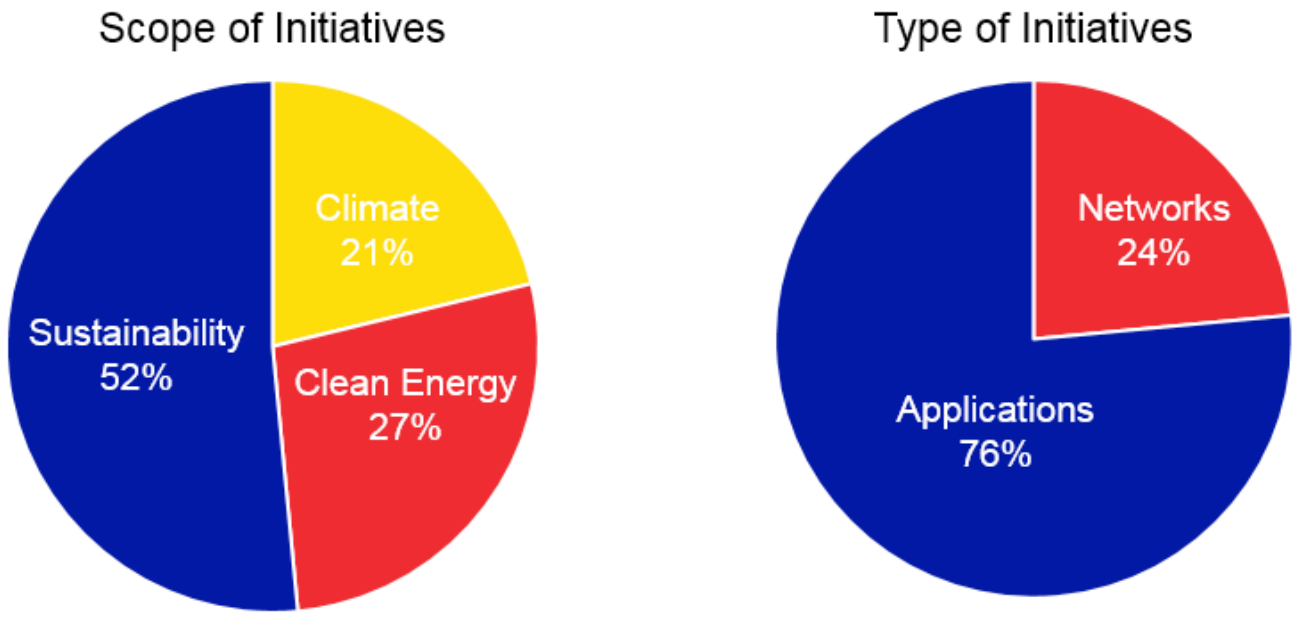
To date, few blockchain applications are able to present compelling evidence of successful proofs of concept of the technology and business case. Although there continues to be very high levels of hype, and concerns about "fast buck" blockchain applications that could lead to a crisis of confidence, the trend for new blockchain applications shows greater sophistication in the design of the blockchain business plans and more advanced partner ecosystems supporting ICOs.

The expectation for 2018 is to see more applications emerge, with larger implementations, and even larger ICO funding. Furthermore, the growth of blockchain networks to support a good foundation (e.g., with research, capacity building, communities of practice) will enhance the chances of success of the blockchain applications.

The expectation for 2018 is to see more applications emerge, with larger implementations, and even larger ICO funding.

In the case of climate and sustainability opportunities, as described in previous sections of this report, the uncertainty and complexity of policies and rules represents a major challenge. In most cases, there are limited links between blockchain applications and GSNs to support the scalability and credibility of the blockchain application

Figure 8: Summary findings on blockchain initiatives



within its market. This lack of sufficient coordination with governance systems to support blockchain applications, considered as a non-technical challenge, is a greater risk to success than are the technical challenges.

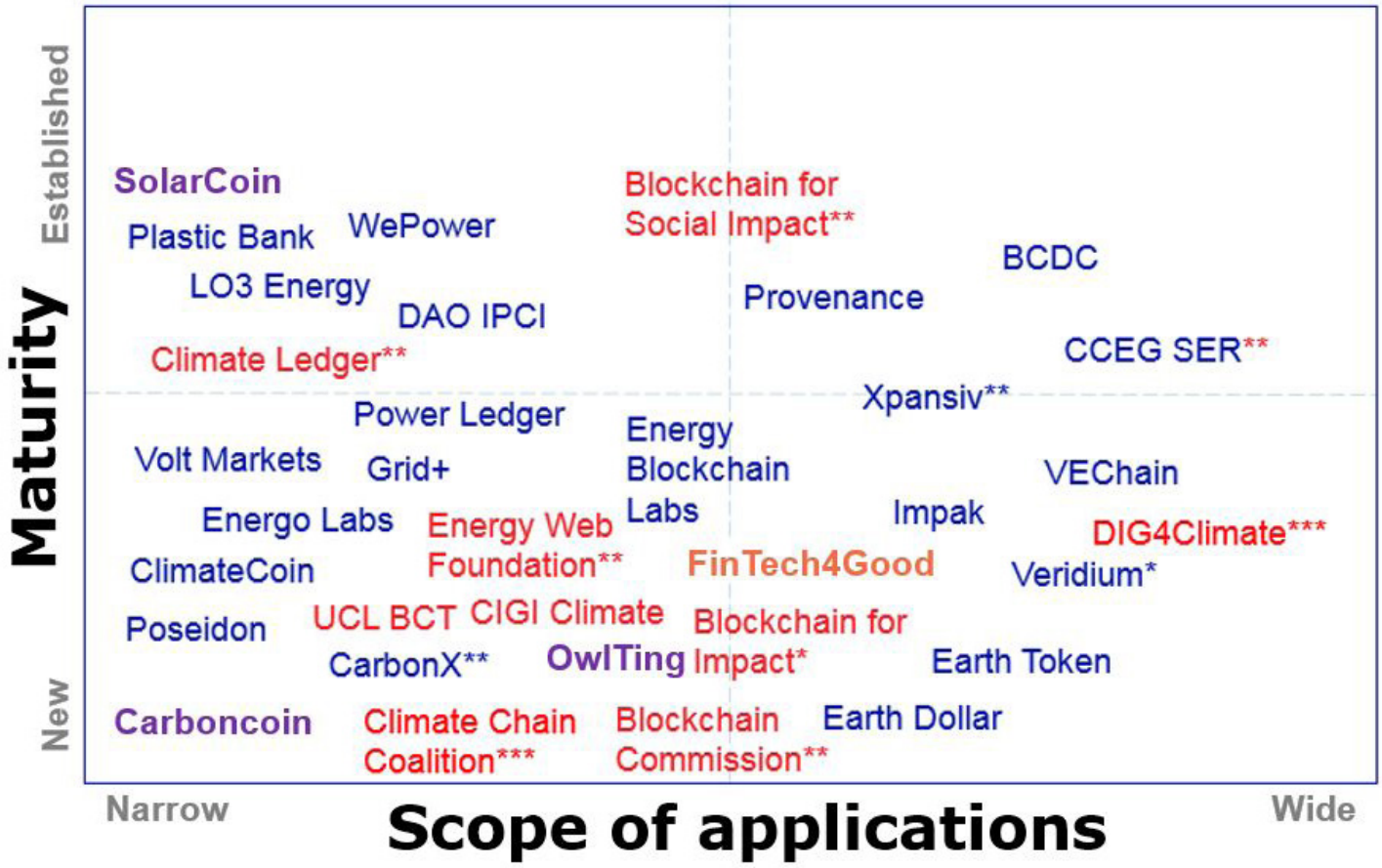
Figure 9 presents a snapshot as of December 2017 for the blockchain initiatives based on scope and maturity. The landscape is changing rapidly, and the reader should check the web links provided for the most recent information.

Balancing innovation and interoperability of blockchain solutions for climate

Although great progress is being achieved in the development and proofs of concepts (POCs) of blockchain/DLT applications for climate and sustainability, overall, it is still at an early stage and inundated with hype and "wild west" competition. As such, it is difficult to obtain in-depth and reliable evidence to substantiate technical and business POCs described in the plethora of whitepapers from blockchain applications.

Figure 9: Landscape of blockchain initiatives for climate and sustainability

Networks in red, applications in blue, asterisk (*) indicates relation with GSN.



However, based on our initial findings and study of evolving trends, we believe that entrepreneurial innovation should continue as "a 1,000 flowers blooming." Some of these will become successful use cases in various sectors such as forestry, agriculture, energy, waste, transportation, and industry. In parallel, blockchain networks will continue to provide support in terms of research, capacity building, networking, and coordination.

With blockchain, climate solutions are evolving traditional policies, and market-based solutions are now able to engage directly with existing markets (e.g., capital markets and commodity markets). Piggybacking on these existing markets (e.g., differentiated goods and services such as lower carbon energy) is both an efficient option as well as less susceptible to policy uncertainties and risks that have impeded or disrupted climate solutions to date.

A near-term challenge will be harmonizing the links between blockchain applications regarding data interoperability (e.g., GHG emission metrics for a product and ensuring the environmental integrity necessary to earn the trust needed by investors, markets, and governments).

Combining innovations for climate, blockchain, and governance

Our research surfaced the emerging blockchain innovations for climate and sustainability as well as emphasized the need for innovative governance solutions to address climate challenges, specifically the scale and urgency to achieve the goals of the Paris Agreement, as well as the complexity of the new bottom-up approach to climate governance.

During the COP23 UN climate conference in November 2017, at which many days of blockchain events for climate were conducted (e.g., Hack4Climate), the Government of Canada announced funding for a multi-year project collaboration with the Pacific Alliance to work together to develop a next generation platform for "MRV smart standards," serving as precursors to smart contracts operating in blockchain applications. This project includes capacity building and a structured multistakeholder engagement process to develop and road-test MRV smart standards with climate action pilot projects.

The goals of the coalition are to support knowledge sharing, capacity building, coordinating efforts and resources, and facilitating good governance to maximize the environmental integrity and results of blockchain for climate.

Following the UN climate conference COP23, several blockchain and climate initiatives from over 12 countries agreed to gather again in Paris on the second anniversary of COP21 and the Paris Agreement (12 December 2017). They met to launch a new global collaboration, the Climate Chain Coalition. In response to shared governance interests, the coalition established shared principles and values that would guide members and support the adoption of blockchain for climate and sustainability. The goals of the coalition are to support knowledge sharing, capacity building, coordinating efforts and resources, and facilitating good governance to maximize the environmental integrity and results of blockchain for climate.

Summary of issues and recommendations

Reversing climate change is a Mars shot. Solving the climate challenge is akin to collaborating globally to put people on Mars, and the underlying tools (e.g., MRV standards) to support the new climate governance system being developed are a fragmented foundation and insufficient for the needs of investors and markets, as well as the needs of the fast-moving digital innovations.

We need implementation and coordination at all levels. The Paris Agreement was a major milestone for international cooperation. Since then, the parties (i.e., nation states) have been busy developing the "Paris Rulebook" to be ready for COP24 in December 2018, which elaborates on general implementation modalities and procedures. Subnational actors (e.g., cities, provinces, corporations, and finance) need to adopt this rulebook and do their part. In principle, the distributed nature of blockchain technologies pairs well with this bottom-up approach to implementation supported by the Paris Agreement.

Interoperability is key. Blockchain innovation for climate is flowering in a variety of ways (also refer to the accompanying landscape report), and trends appear to be toward more robust applications in terms of technology systems, business strategies, and partner ecosystems. However, coordination among applications is low. Interoperability among blockchain applications is essential.

Governance matters. Fred Ehrsam, a co-founder of Coinbase and former trader at Goldman Sachs, wrote, "So the value isn't in the chain of data, it's in the community and social consensus around a chain. Governance is what keeps communities together and, in turn, gives a token value."[54] We need to balance the needs of blockchain innovations (i.e., "let a 1,000 flowers bloom") with the governance innovations for a linked and interoperable digital system (i.e., market and environmental integrity).

The integrity and utility of blockchain applications depend significantly on the rules and standards that shape the design and operation of those applications.

We need innovation in rule making. The integrity and utility of blockchain applications depend significantly on the rules and standards (e.g., smart contracts) that shape the design and operation of those applications. To achieve synergy in practice, preferably as soon as possible, requires governance innovation so that we can scale consensus-based collaboration and incentivize participants to develop high quality rules quickly and cost-effectively.

We also need a unified framework for implementation. To develop and implement next generation MRV climate rules—that is, MRV smart standards for blockchain climate

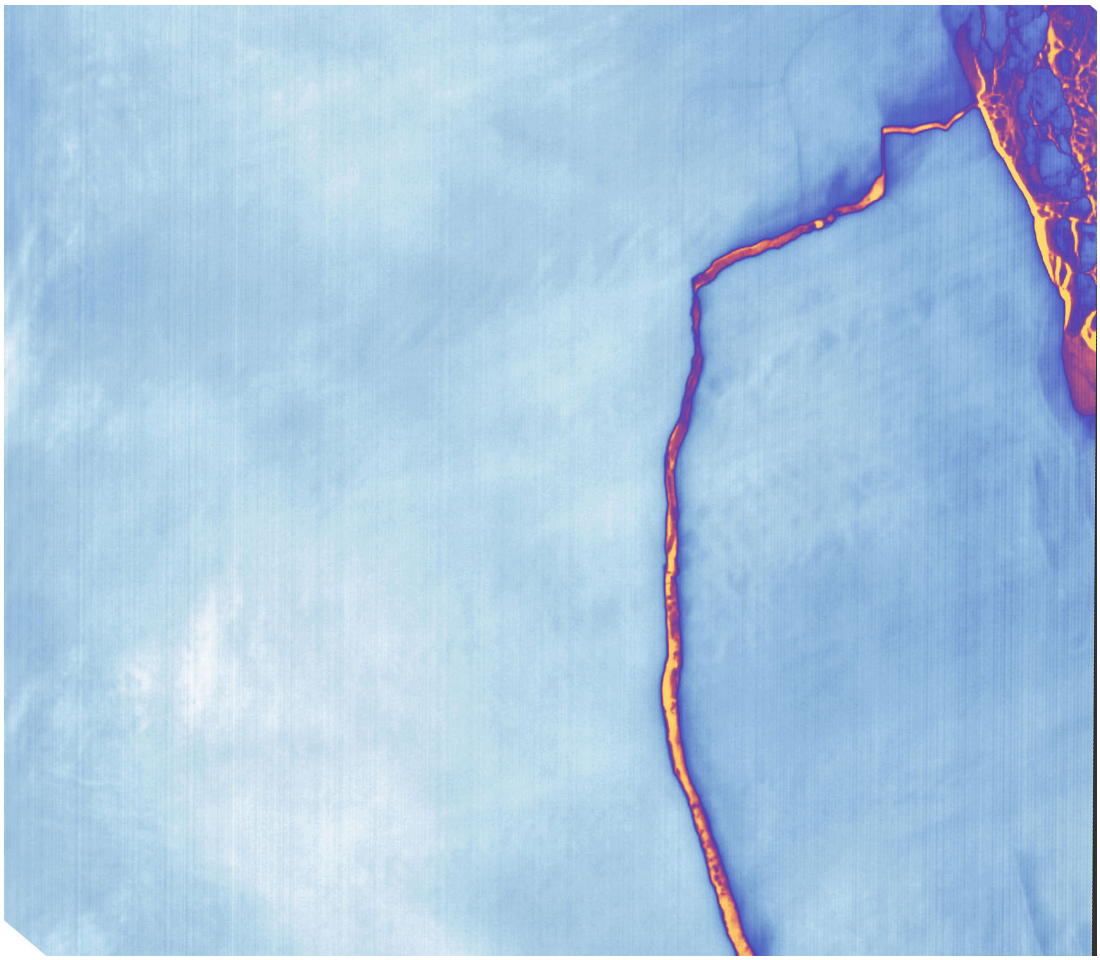
applications—we should supplement the rule-making process with a shared framework.

The race is on. Although the planet will survive another climate disruption, it will be an existential threat for humanity and our unsustainable lifestyles. In 2017, the planet has experienced an increased number of extreme weather events; and the costs are adding up—in economic, social, and environmental accounts.

The time for "enhanced ambition" is now. Blockchain can be a major part of the solution to value accurately and manage our planetary resources, including carbon pollution. As His Excellency António Guterres, UN Secretary-General, said, "Global climate action is not a luxury; it is an urgent necessity that requires enhanced ambition."[55] Let's engage global solutions networks for mass collaboration to realize the potential of blockchain for planetary stewardship.

Blockchain can be a major part of the solution to value accurately and manage our planetary resources, including carbon pollution.

Between 10 July and 12 July 2017, an iceberg roughly the size of Delaware broke off from Antarctica's Larsen C ice shelf, reducing its size by approximately 10 percent.



Massive Iceberg Breaks Off from Antarctica by Joshua Stevens/NASA Earth Observatory using Landsat data from the US Geological Survey, 2017, used under CC BY-SA 2.0.

About the author

Tom Baumann is an innovator at the convergence of digital innovation and governance for climate and sustainability. Tom is co-founder of ClimateCHECK, the GHG Management Institute (the world's leading GHG training organization with over 7,000 alumni and members in over 160 countries), Collaborase (an online collaboration platform for Standards 2.0 with over 5,000 experts supporting leading programs such as Gold Standard and the Natural Capital Coalition), and Xpansiv (a blockchain and digital technology company focused on sustainability).

Tom was the climate hub leader for the Global Solution Networks initiative—a resource for sharing, scaling, and connecting to global solution networks addressing climate change and stewardship of our planet for future generations.

Together with the International Emission Trading Association, Tom is leading a multi-year international project, Digital Innovation and Governance for Climate (DIG4Climate), to develop next generation governance systems and smart standards for blockchain and climate in support of climate actions, NDCs, carbon markets, and climate finance.

Tom is the international chair of the ISO Climate Change Standards Committee and leads the activities of over 80 national standards bodies in the development of standards for MRV, climate finance, and adaptation.

Tom started in the environmental sector in the early 1990s and previously worked at a climate technology investment fund and at the world's leading GHG certification company. Tom is a registered professional engineer and certified knowledge manager. He holds a BA in Environmental Economics and a BEng/MEng in Environmental Engineering.

Disclosures

Tom is co-founder of ClimateCHECK, the GHG Management Institute, Collaborase, and Xpansiv. Together with the UNFCCC Secretariat, Tom is co-convener of the Climate Chain Coalition, a global network of blockchain initiatives and companies, and co-author of the forthcoming World Bank report, *Digital Innovations for Post-2020 Carbon Markets*, to be published in early 2018 and covering the governance innovation already in motion.

About the Blockchain Research Institute

Co-founded in 2017 by Don and Alex Tapscott, the Blockchain Research Institute is a knowledge network organized to help realize the new promise of the digital economy. It builds on their yearlong investigation of distributed ledger technology, which culminated in the publication of their critically acclaimed book, *Blockchain Revolution* (Portfolio|Penguin).

Our syndicated research program, which is funded by major corporations and government agencies, aims to fill a large gap in the global understanding of blockchain technology and its strategic implications for business, government, and society.

Our global team of blockchain experts is dedicated to exploring, understanding, documenting, and informing leaders of the market opportunities and implementation challenges of this nascent technology.

Research areas include financial services, manufacturing, retail, energy and resources, technology, media, telecommunications, healthcare, and government as well as the management of organizations, the transformation of the corporation, and the regulation of innovation. We also explore blockchain's potential role in the Internet of Things, robotics and autonomous machines, artificial intelligence, and other emerging technologies.

Our findings are initially proprietary to our members and are ultimately released under a Creative Commons license to help achieve our mission. To find out more, please visit www.blockchainresearchinstitute.org.

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