DECEMBER 2021

Navigating Blockchain and Climate Action

2021 STATE AND TRENDS

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The Climate Ledger Initiative (CLI) would like sincerely to thank the donors, authors, interview and other partners, and contributors who helped to create this fourth report on navigating blockchain and climate action. This work also greatly benefited from discussions with and input from participants from the 50-plus workshops and presentations held since the Climate Ledger Initiative began in early 2017, as well as from experience shared from numerous use cases.

climateledger.org

In memory of Sven Braden

CLI Co-Founder and Programme Manager Sven Braden died unexpectedly this summer from COVID-19. Without Sven, CLI would not exist in its current form. His enthusiasm for the use of new technologies in climate action, and his unflinching forays into the details of digitalisation and the related, intractable, governance issues made him the perfect ambassador for the CLI cause. Sven’s huge international network connected climate policy-makers with start-up entrepreneurs and techies.

Always combining the visionary with the down-to-earth, Sven initiated and helped implement several of the CLI use cases. With the Wood Tracking Protocol (chapter 2.3), he pioneered the use of digital tools in sustainable logging, and laid the groundwork for a tamper-proof system to track wood along the value chain, thus preventing illegal logging in Peru.

We have lost an outstanding colleague and a dear friend. Sven was taken far too early, leaving behind his young family, Rocío García with Camila and Guillermo. We are glad and grateful that Rocío will be stepping into Sven's shoes to continue his project management work for CLI. We miss him enormously.

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Table of Contents

Foreword

> **In its Sixth Assessment (2021), the Intergovernmental Panel on Climate Change, IPCC, concluded unequivocally once again that the effects of climate change are rapid, unrelenting and in some respects already irreversible. Its impact is felt all the more heavily in low and lower-middle income countries, which have contributed the least to anthropogenic greenhouse gas emissions. Action on the climate is urgently needed.**

CHRISTIAN FRUTIGER
Ambassador, Assistant Director General and Head of Global Cooperation
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION, (SDC)

In its Sixth Assessment (2021), the Intergovernmental Panel on Climate Change, IPCC, concluded unequivocally once again that the effects of climate change are rapid, unrelenting and in some respects already irreversible. Its impact is felt all the more heavily in low and lower-middle income countries, which have contributed the least to anthropogenic greenhouse gas emissions. Action on the climate is urgently needed.

Digitalisation offers an opportunity to accelerate this action. Starting from the 1950s, our economic and social lives have become more and more digital. Fuelled by the COVID-19 pandemic, the recent advance of videoconferencing tools is a case in point. Many of the technologies, from the internet of things (IoT) to blockchain, are well placed to support climate policies. Their application is not risk-free, however.

The Climate Ledger Initiative (CLI) seeks to leverage these technologies to accelerate climate action in line with the Paris Agreement and the Sustainable Development Goals (SDGs). This year's edition of the CLI Navigating Report focuses on diverse use cases. They demonstrate how digitalisation can support low and lower-middle income countries to strengthen climate resilience.

One example is Kenya, where smallholders are particularly exposed to crop damage and livestock losses as a result of climate change. The tech in this case combines remotely sensed local weather data with blockchain-based smart contracts that are accessible through simple mobile phones. In a transparent, automated procedure, smallholders taking part in the CLI-sponsored Climate Risk Insurance project receive pay-outs for losses caused by droughts and other extreme events.

These innovations lower the transaction costs of insurance, allow a much higher share of the premiums to be paid out as indemnities, and ultimately provide better protection for the smallholders themselves. Meanwhile, in the Amazon region, illegal logging is impacting on land and soil degradation, biodiversity loss and indigenous territories and livelihoods in ways that will last for decades. The Wood Tracking Protocol combines smartphones and blockchain technology to track illegal logging in the Peruvian Amazon.

Digitalisation is clearly not a one-size-fits-all solution to the many challenges of climate action. As the 2021 CLI report on Blockchain for Climate Action and the Governance Challenge demonstrated, technological applications always become entangled in their socio-political contexts. They rarely work unless embedded in off-chain governance structures.

We should also be mindful that digitalisation does not come without risks. Artificial intelligence (AI) can magnify human bias, and energy-intensive activities such as bitcoin mining have their own environmental implications. CLI seeks to apply these technologies wisely, harnessing their opportunities for climate change adaptation and mitigation while managing potential hazards. It advances the real-world applicability and scalability of digitalisation to leave no one behind in the face of the climate crisis.

The Swiss Agency for Development and Cooperation (SDC) is pleased to support CLI and the 2021 Navigating Report. It presents some thought-provoking ideas for more resilient and just climate change solutions at scale, shedding light on how low and lower-middle income countries can use digital technologies to cushion the impact of climate change.

"Digitalisation is clearly not a one-size-fits-all solution to the many challenges of climate action."

Preface

The Climate Ledger Initiative and its mission

The mission of the Climate Ledger Initiative (CLI) is to accelerate climate action in line with the Paris Agreement and the Sustainable Development Goals (SDGs). It does this through blockchain and other digital innovations applicable to climate change mitigation, adaptation, and finance. The Climate Ledger Initiative was started in 2017 by Nick Beglinger of Cleantech21 and is operated jointly by INFRAS and the Gold Standard Foundation. CLI is supported financially by the Swiss federal government and the government of Liechtenstein, and maintains an ever-expanding platform of donors, partners, and collaborators. The Initiative sits at the nexus of one of the world's most pressing problems – climate change – and the world's most promising technological innovations – blockchain. More broadly, this refers to distributed ledger technology, the internet of things (IoT) and artificial intelligence (AI). CLI addresses policy and research questions and identifies specific opportunities for innovation where climate and digitalisation meet. Over the past two years, its work has benefited greatly from the contributions of participants in various workshops and events, and from the support of partner use cases. CLI itself selected and supported several use cases in an open call.

For more information, to register for our newsletter or to pursue an interest in partnerships and collaboration, please visit climateledger.org

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The Climate Ledger Initiative's fourth edition of Navigating Blockchain and Climate Action

This year's edition of the Navigating Report[1] presents key observations from an array of CLI activities, especially CLI-funded use cases all over the world and their contribution to climate action and the UN Sustainable Development Goals.

We are grateful to the authors and interview partners who have contributed their vision and experience in the novel applications of digital technologies. These technologies are developing fast, and innovative business models are emerging and being tested in real-life use cases. We hope that this edition of the Report helps practitioners and policymakers alike to navigate this rapidly evolving field, and be inspired by actors that already using blockchain to achieve the Sustainable Development Goals.

> "It will be increasingly important to have climate data correctly and robustly attributed to its sources and responsible entities."

1 For previous editions please refer to the CLI website.

Summary and key findings

> **Blockchain grew in popularity once again in 2020 and 2021. Businesses from a multitude of sectors are embracing new information technologies and seeking to improve the efficiency and trustworthiness of their business processes, not to mention identify new business models.**

As we saw, COVID-19 remained a dominant factor in 2021. This not only accelerated the digital transformation that was already in progress, but also took digitalisation into new domains. The global blockchain market is expected to expand from USD 3 billion in 2020 to approximately USD 40 billion by 2025 (Finextra, 2020).

In a recent survey, CLI members expressed their belief that blockchain and Distributed Ledger Technologies (DLT) solutions hold great potential to increase supply chain transparency to track and measure impact on their products. This issue has gained increasing attention over the past year. Another rapidly developing field of application is the generation and distribution of renewable energy, including those countries with energy supplies inadequate for their low-income populations. Emerging from all of CLI's activities is an overarching need to define legal and regulatory frameworks for the use of blockchain and other digital technologies. This resulted in the publication in 2021 of the CLI Governance Report.

As the general tenor in the blockchain and DLT sector shifts away from the question of what the technologies are and how they work, and towards effective implementation projects, CLI has also stepped up its efforts to support specific use cases. The use of innovative digital technologies in a developing country context for climate action and sustainable development presents considerable challenges, and the importance of implementing actual use cases in the field can hardly be overstated, as some of our partners have found. Their recent experience shows that too many ideas and technical concepts that look good on paper fail when applied in the real world, particularly in a developing country context. The use cases outlined and discussed in this report are described below.

TABLE 1: CLI has established a strong portfolio of CLI use cases. These employ blockchain and a range of IT innovations including sensors and the internet of things (IoT), remote sensing, and artificial intelligence (AI) and big data. The use cases focus on climate change mitigation, adaptation and environmental protection. Some contribute to the circular economy, and all build on use cases being implemented by private-sector actors in close cooperation with NGOs, government bodies, and local communities. In the table you can see to which UN Sustainable Development Goal (SDG) the use case is contributing to. Refer to page 13 for the explanation of the SDGs. Source: CLI

PROJECT	SECTOR	TECHNOLOGY	FOCUS
Climate Risk Insurance, Kenya Mobile phone and blockchain-based index insurance against climate impacts for 50,000 smallholders. Satellite weather data (e.g. on drought) triggers direct payments. Collaboration with farmers' organisations and VanderSat. SDG1 SDG2 SDG5 SDG8 SDG10 SDG11 SDG13 SDG15 SDG17	Smallholder agriculture	Blockchain Sensors and IoT Remote Sensing	Adaptation
OpenHAP low-cost sensors, Kenya Kenyan team locally developing and manufacturing low-cost air pollution sensors. These monitor indoor air quality related to different cookstove technologies in about 100 slum dwellings in Nairobi. Collaboration with local university and Berkeley Air. SDG3 SDG7 SDG13	Low-income households	Sensors and IoT	Mitigation Environment
FairClimateFund, India Supplying 100 households in Raichur, India, with clean cook-stoves equiped with cost-effective sensors to monitor cooking practices and transfer the data automatically to a DLT platform to calculate and validate climate impacts. SDG1 SDG5 SDG13	Low-income households	Blockchain Sensors and IoT	Mitigation Environment
Wood Tracking Protocol, Peru Digital platform for forest management companies, using the features and technical possibilities of smartphones and blockchain technology. Together, these fight illegal logging and reduce deforestation in the Amazon by bringing transparency and traceability to the timber industry in Peru. SDG9 SDG13 SDG15	Forestry	Blockchain Remote Sensing Private Sector	Adaptation Mitigation Environment
Green Traker, Chile The Green Tracker blockchain platform supports appropriate MRV practices by tracking greenhouse gas emissions and resource savings from green action, such as renewable energy generation, e-mobility, and waste recycling. SDG7 SDG9 SDG11 SDG12 SDG13	Energy Transport Waste	Blockchain Sensors and IoT AI and Big Data	Mitigation Environment

Robust data and facilitated data-sharing are essential for effective climate action. That is one of the principal lessons of Gold Standard's efforts to revise its standards and procedures to support digital approaches. It was also the conclusion of Sweden's pilot registry scheme, in which is considering how to digitalise its electronic registry infrastructure under Article 6 of the Paris Agreement. Furthermore, the most recent UN Climate Conference, COP26 in Glasgow, demonstrated the need to move *from pledge to plan to performance*. As the international community shifts the conversation along towards the implementation of climate pledges, it will be increasingly important to have climate data correctly and robustly attributed to its sources and responsible entities. In turn, this can help to ensure that funding is deployed efficiently, and that those who are accountable exercise their responsibility transparently. While it is possible to do this without blockchain and the other technologies covered by this report, they are useful in handling the complexity of where exactly the information has come from, and who is in charge of it.

The past work of CLI and others has demonstrated that an innovative approach to the digital transformation can prove an important lever, helping efficiently to scale up and multiply the necessary climate action at the global level. Meanwhile governments, policymakers, multilateral development banks and development agencies do not yet seem to have fully embraced the potential of digital technologies. To respond to present and future needs, CLI is currently working on a new programme that will take effect as of 2022. It places even greater emphasis on the development, scaling and market launch of specific use cases that tap digital innovation for climate action and sustainable development in developing countries.

"The most recent UN Climate Conference, COP26 in Glasgow, demonstrated the need to move *from pledge to plan to performance.*"

Abbreviations

AI	Artificial Intelligence
CLI	Climate Ledger Initiative
COP	Conference of the Parties
DLT	Distributed Ledger Technology
FCF	FairClimateFund
GPS	Global Positioning System
GSIQ	Gold Standard Impact Quantification
HAP	Household Air Pollution
ICS	Improved Cookstoves
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
ITMO	Internationally Transferred Mitigation Outcomes
MRV	Measuring—Reporting—Verification
PM	Particulate Matter
SDC	Swiss Agency for Development and Cooperation
SEA	Swedish Energy Agency
SDG	Sustainable Development Goals
WTP	Wood Tracking Protocol

SUSTAINABLE DEVELOPMENT GOALS*

SDG1	No Poverty
SDG2	Zero Hunger
SDG3	Good Health and Well-Being
SDG4	Quality Education
SDG5	Gender Equality
SDG6	Clean Water and Sanitation
SDG7	Affordable and Clean Energy
SDG8	Decent Work and Economic Growth
SDG9	Industry, Innovation and Infrastructure
SDG10	Reduced Inequalities
SDG11	Sustainable Cities and Communities
SDG13	Responsible Consumption and Production
SDG13	Climate Action
SDG14	Life Below Water
SDG15	Life on Land
SDG16	Peace, Justice and Strong Institutions
SDG17	Partnerships for the Goals

* The 2030 agenda for Sustainable Development, adopted by all United Nations Memeber States in 2015, provides a shared blueprint for piece and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. The use cases supported by the CLI contribute to the achievement of different SDGs.

1

Blockchain and climate action state and trends

Blockchain and climate action state and trends

Blockchain technology grew in popularity once again in 2020 and 2021. Businesses from a multitude of industries are embracing new information technologies. They are seeking to improve the efficiency and trustworthiness of their business processes and to identify new business models. Although blockchain has proven to be more than simply a passing fad, beyond cryptocurrencies it is difficult to make out how broad and mainstreamed its use has become in fintech and other sectors. Public perceptions of the technology are very much associated with cryptocurrencies, and governments often lack the capacity to assess the potential of blockchain where the climate is concerned.

As we have seen, 2021 continued to be dominated by the COVID-19 pandemic. This not only accelerated the digitalisation trends that were already in progress, but also generated new ones. The global blockchain market is expected to expand from USD 3 billion in 2020 to approximately USD 40 billion by 2025 (Finextra 2020). Furthermore, the pandemic has shown that companies need to step up their digital transformation processes to emerge strengthened from the crisis. Over the years to come it is highly likely that blockchain technology will be responsible for the most transformative and dramatic changes in the way in which businesses function (Finextra 2020).

With the UN Climate Change Conference (COP26) in Glasgow in November 2021, the conversation moved more determinedly towards the implementation of climate pledges. This is an issue for corporate frameworks, of course, but was also pushed into the spotlight with the approval of the Article 6 rulebook for international emissions trading.

In summary, it is becoming increasingly important to ensure that both positive and negative climate data is correctly and robustly attributed, especially also while adjusting current programmes. This is where blockchain and the other technologies captured in this report can help.

SUPPORTING CLIMATE ACTION: PERCEIVED POTENTIAL AND OBSTACLES FOR BLOCKCHAIN/DLT

CLI conducted a survey among its members to identify areas that offer the greatest potential for blockchain and distributed ledger technologies (DLT) to be applied to climate action, as well as the related obstacles that need to be cleared. Respondents identified the largest untapped benefits in applications for supply chains and renewable and clean energies. There is also potential in the land use and forestry sectors, as well as in agriculture and food (see graph on page 16).

Sectors with significant potential for blockchain/ DLT applications to support climate action

CLI Network Survey, July 2021. N:50, each participant had three votes. Source: CLI

The CLI community sees the greatest potential for DLT solutions as a means of improving supply chain transparency so that mitigating activities and products can be measured, tracked and properly attributed, as can the emissions data associated with them. The transparency of supply chains for various consumer products has been attracting increasing attention.

Consumers want to know where products and their ingredients come from, whether they are sustainably sourced, and what carbon footprint they produce. Blockchain/DLT-based value chain tracking systems may serve as a valuable tool here. They trace goods along the chain, even beyond company and country borders, and allow for customised levels of confidentiality to mitigate competitiveness issues.

Considerable potential is also seen in the generation and distribution of renewable energies, as one of the most important means of achieving the objectives of the Paris Agreement. Blockchain technology permits transparent peer-to-peer energy transactions, and may help to disrupt traditional ways of generating and distributing power. The decentralisation of energy markets is becoming increasingly important here. The growing use of small, renewable-energy installations, such as rooftop solar panels, can create stress on electricity grids that were designed with large, centralised power plants in mind.

By allowing peer-to-peer energy trading and incentivising local consumption at the time of production, blockchains can help stabilise these grids and further localise energy production. Furthermore, blockchain technology makes it easier to monetise the impacts of renewable energy generation, for example by tokenizing carbon reduction units, which may further lower future costs of the energy transition (CLI 2019).

Chapter 2.2 provides insights into CLI-funded use cases that support blockchain/DLT applications for renewable and clean energies. These are still in their infancy, however, and we are nowhere near

Obstacles to the dissemination of blockchain/ DLT applications that support climate action

CLI Network Survey, July 2021. N:50, each participant had three votes. Source: CLI

the point at which we could think about applying blockchain/DLT to nationwide smart grids, for example. But for developing countries, especially, there are opportunities to harness climate finance to improve decentralised power supplies and improve access to clean cooking solutions.

Many barriers still exist to applying blockchain/DLT technologies to climate action. Participating CLI members identified four major obstacles to upscaling here: the absence of a defined legal and regulatory framework, limited knowledge about these technologies, interoperability, and high energy consumption (see graph above).

Blockchain applications for climate action all face similar challenges when it comes to legal and regulatory frameworks and governance issues. At the national level, especially, blockchain/DLT disrupts existing economic, social and political structures. Its fundamental characteristics – decentralisation, anonymity, immutability and automation – give rise to difficult legal and regulatory questions. These include data privacy, the right to be forgotten, the digital identification of participants, and the enforcement of smart contracts (CLI 2020).

Blockchain governance issues also revolve around protocols. Put simply, there are essentially three distinct blockchain architectures: public/permissionless, federated/consortium, and private/permissioned (CLI 2020). Private blockchains are emerging as the main contributor to growth in the blockchain market. These offer corporate users greater scope to use the technology for business-to-business use cases, and give the blockchain owner more control. They deliver higher efficiency, privacy, reliability and transparency (Finextra 2021). By contrast, public/permissionless blockchains are the 'pure' blockchains, as only fully public systems can provide full anonymity and immutability. Sharing knowledge about blockchain and distributed ledger technologies seems to be key to further disseminating the technology among stakeholders. This goes hand in hand with the need to overcome a lack of awareness and blockchain talent. Since blockchain is becoming ever more relevant, specialists in this field will be in enormous demand and will dominate the general employment market (Merehead 2021). However, anecdotal evidence suggests that some developing countries have a rich local pool of coding and technology talent, as demonstrated by CLI use cases in Kenya, India, Costa Rica, Peru, and Chile, for example.

The issues of interoperability between different digital systems will remain key in blockchain and DLT technologies going forward. This means more than the capacity of disparate blockchain systems to communicate with each other. Above all, it is the ability to share, see and access information across different blockchain networks without the need for an intermediary such as a centralised exchange.[2]

Blockchain technology is generally associated with high power consumption and the need for considerable computer processing and storage capacity. However, these associations are linked only to the patterns of one specific consensus mechanism (proof of work mechanism). This powers the first network of its kind, the Bitcoin blockchain, which consumes an enormous amount of energy. It is not an inescapable element of blockchain technology in general. At this point of time there are many consensus mechanisms in operation that consume much less power (CLI 2018).

Overall, responding CLI members identified opportunities for digitalisation in developing countries in particular, using blockchain technologies but also less costly and less technical alternatives. It is therefore vital to extend the practical use of the technology and gain experience in the field to further upscale the best and most suitable solutions.

BLOCKCHAIN/DLT-BASED SOLUTIONS TO ACHIEVE THE SUSTAINABLE DEVELOPMENT GOALS

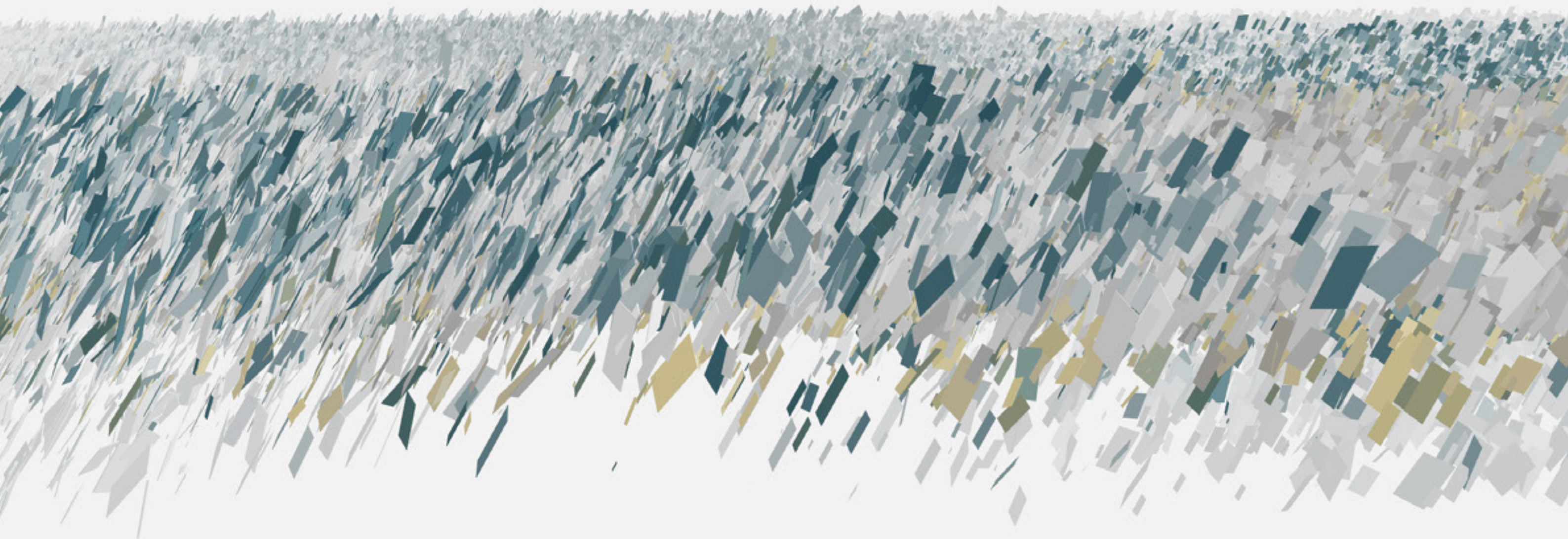
The COVID-19 pandemic has caused great disruption, affecting life-sustaining sectors all over the world. The magnitude and unequal nature of its impact on livelihoods has delivered an enormous setback to recent development gains made by the poor, affecting vulnerability in general, as well as unemployment, poverty and inequality (UNCTAD 2021). COVID-19 will continue to increase vulnerability, poverty and the ability to cope with climate shocks in 2021 and the years that follow. The Global South is especially exposed to these developments. Forecasts suggest that COVID-19 and its aftermath will have impoverishing long-term effects, adding to the likelihood that the 2030 poverty reduction targets will not be reached (World Bank 2021).

In the aftermath of COVID-19, blockchain/DLT technology has the potential to restore trust. It offers the means to protect data, simplify service delivery, clarify outcome measures and improve accountability. This could hold increasingly appeal as a way of supporting the attainment of the UN Sustainable Development Goals (SDG). That said, despite blockchain's promising potential, the reality can be challenging. Blockchain-backed applications to create social impact are under-studied, for instance. However, in the wake of the COVID-19 pandemic especially, several use cases may be replicable in different parts of the world where digital solutions are gaining in importance. The potential of CLI use cases to support the various SDGs is discussed in chapter 2.

2 See also chapter 2 of the CLI Navigating Report 2020, 'Interoperability'.

2

Experiences from regional use cases



Experiences from regional use cases

Working with specific use cases demonstrates the usefulness and limits of blockchain and other digital innovations in driving climate action. CLI was early to realise the value of real-life use cases that validate the feasibility of IT-related concepts and ideas in the field. CLI supports those that provide digital innovations that have a strong climate impact. All CLI-supported use cases must demonstrate their upscaling capability by developing sound business models while interacting with regulators and policymakers, and helping to shape policies at various levels that facilitate climate action. The use cases always include engagement with government, be it national or a village head. A thorough open call and selection process ensures that they are based on solid concepts and robust partnerships, and that learnings can be extracted systematically for the benefit of other practitioners in the field, technology developers, and policymakers. The core objectives here are to approve concepts, enable road testing and implementation, and to support outreach and the exchange of lessons learned with peers and policymakers. This chapter outlines experience and knowledge gained from recent CLI-supported use cases.

CLI has established a strong portfolio of such cases, as this chapter shows. The projects employ blockchain and a range of IT innovations, including sensors and the internet of things (IoT), remote sensing, artificial intelligence (AI) and big data. The use cases focus on climate change mitigation, adaptation and environmental protection. Some contribute to the circular economy, and all build on private-sector implementation in close cooperation with NGOs, government bodies and local communities.

“CLI was early to realise the value of real-life use cases that validate the feasibility of IT-related concepts and ideas in the field.”

Geographic distribution of use cases

- **India**
  FairClimateFund
- **Peru**
  Wood Tracking Protocol
- **Kenya**
  Climate Risk Insurance
  OpenHAP low-cost sensors
- **Chile**
  Green Tracker

The Dymaxion map or Fuller map is a projection of a world map invented by Buckminister Fuller. The map is projected onto the surface of an icosahedron which can be unfolded and flattened to two dimensions. The Fuller map is considered very accurate and transparent: It has less distortion of relative size of areas, most notably when compared to the Mercator projection; and less distortion of shapes of areas, notably when compared to the Gall–Peters projection.

2.1

Digitalisation potential in the agricultural and food sectors

Among innovative digital technologies, blockchain has been thought to offer a unique opportunity to bring greater efficiency, transparency and traceability to the exchange of data and information in the agricultural sector (Van Wassenaer 2021). According to Van Wassenaer, it can help to improve transparency and accountability in climate change adaptation and mitigation activities. By supporting adaptation strategies, blockchain can create opportunities for new value chains, as well as platforms for smallholder farmers by offering rural credit (through tokens), crowdfunding, crowdlending and microinsurance.

Blockchain/DLT can also help to track the investments and outcomes of improved climate change adaptation management practices. Where climate change mitigation is concerned, the technology can enable better monitoring and evaluation of mitigation activities and support growth in the carbon market. Blockchain/DLT can also help to track SDG indicators for mitigation and adaptation activities in or associated with agriculture, such as those that are gender-related. This data supports decision-making by public and social actors.

According to Etherisc, a further obvious use case for blockchain in agriculture is parametric insurance[3], which is especially effective in combination with micro-finance instruments. Early-warning systems for climate hazards or natural disasters are another. In relation to food production, the most promising use cases are product origin tracing (documenting and linking the production, processing and distribution of food products and ingredients), decentralised independent marketplaces, and supply chain management applications.

2 Parametric, or index-based, insurance covers the probability of a predefined event (e.g. drought) occurring, instead of indemnifying the actual loss. The payouts follow a predefined scheme and are related to an index (e.g. amount of rainfall). When the index hits a predefined threshold for the event (e.g. certain amount of rainfall in a month is not reached) a payout is issued. Since the payout is based on a defined and independently verifiable parameter, there is no need for a loss assessment and the payout can be settled quickly.

Kenya

Climate Risk Insurance

Mobile phone and blockchain-based index insurance against climate impacts for 50,000 smallholders. Satellite weather data (e.g. on drought) triggers direct payments. Collaboration with farmers' organisations and VanderSat.

SDG1 SDG2 SDG5 SDG8 SDG10
SDG11 SDG13 SDG15 SDG17

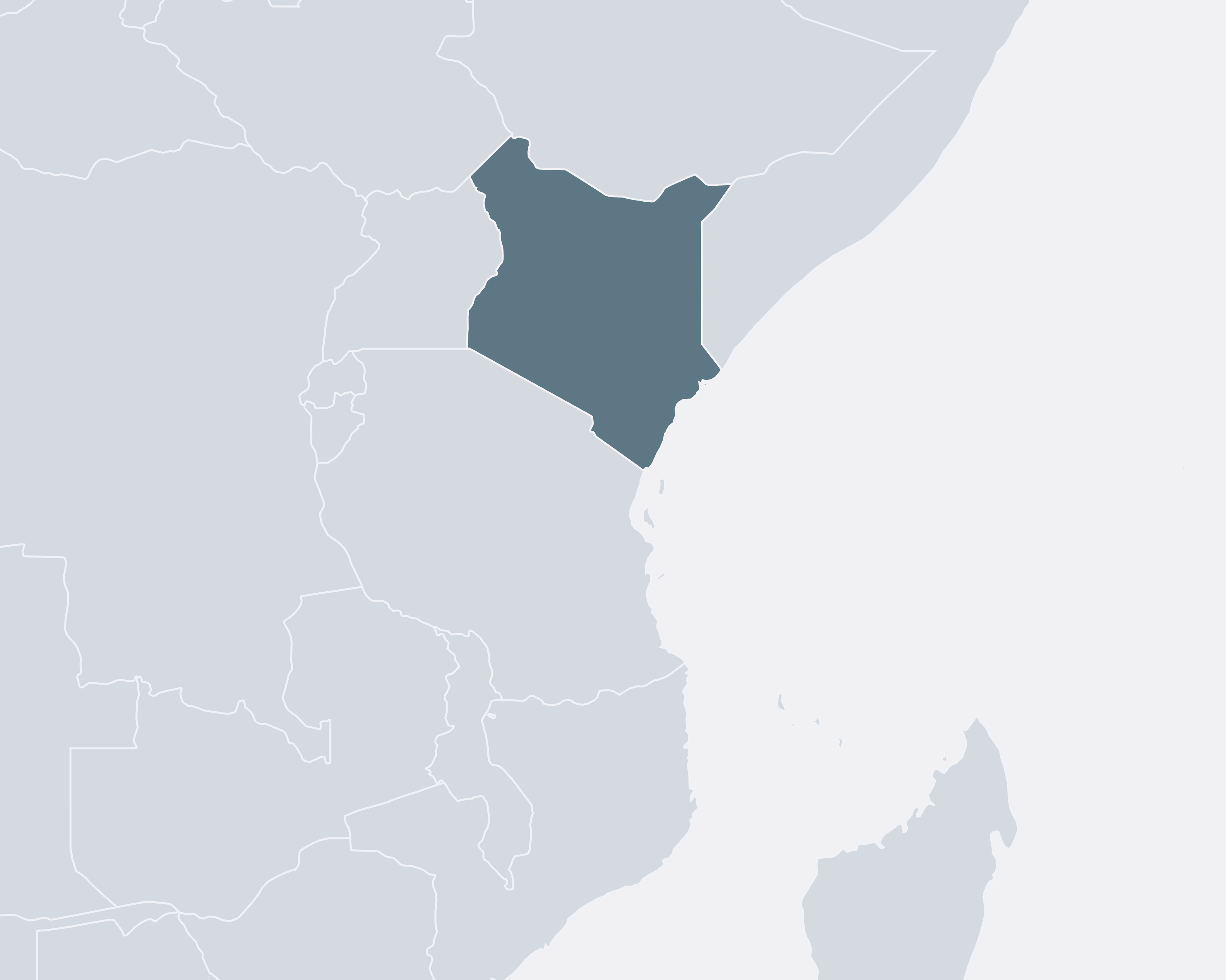
Sector
Smallholder agriculture

Focus
Adaptation

Technology
Blockchain

Sensors and IoT

Remote Sensing



USE CASE EXPERIENCES

Insight from
JAN STOCKHAUSEN

Jan Stockhausen is the chief legal architect at Etherisc, provider of a decentralised insurance protocol. Here, he helps the team to navigate the legal and regulatory frameworks surrounding blockchain technology. He is also a Director of Etherisc Impact B.V., the entity in the Etherisc ecosystem dedicated to projects in the areas of sustainable development, inclusive insurance, and agricultural solutions. Together with ACRE Africa, Etherisc has developed a blockchain-based parametric microinsurance solution for farmers in Kenya. Over 17,000 smallholders were insured on chain during the first season (the long rains of 2021). With policy reviews based on local weather data, which is processed in near real time by the software, the first payouts could be made even before the season ended. This restored farmers' trust in the ability of insurance companies to deliver in times of adverse weather, and thus improve the financial resilience of those on low incomes.

Q: How is Etherisc helping smallholder farmers in Kenya to adapt to climate change?

A: Our use case focuses on mitigating climate risks by providing farmers with accessible and transparent crop insurance that runs on blockchain. Farmers buy the 'Bima Pima' microinsurance offered by ACRE Africa as a scratchcard with a bag of seeds or fertilizer at the beginning of the crop season. They register and activate their insurance with their phone by sending a simple text message with the activation code from the purchased scratchcard. Once a farmer registers, the weather conditions of the farm are monitored using open-source weather data from the ARC2 satellite. Should the farmer suffer adverse weather conditions (excess rainfall or drought), the blockchain-based smart insurance contract can immediately issue a payout through a mobile payment network.

And why is such an approach needed?

Traditional crop insurance is not working for most farmers in developing countries, as manual workflows for insurance products are inefficient and lead to high costs. Insurance payments can take months to process, which forces farmers into poverty after climate disasters even if their crop was insured. This has naturally eroded trust among those farmers. Blockchain technology can automate the lifecycle of the insurance product and thus reduce costs by up to 41%, according to a study conducted by ACRE and Etherisc with the Global Innovation Lab for Climate Finance in 2019. Processing can be sped up to allow payments in near real time. Immutability brings back the transparency which farmers need to trust the process and product.

Farmer using the USSD code from a scratchcard to activate his policy. Source: Etherisc

Please describe where you stand with implementation, and what you have learned so far?

We have successfully built a fully automated end-to-end solution to process ACRE's Bima Pima insurance. One of the core objectives was to ensure prompt payouts – not only at the end of the season, but also during it. In the future, we plan to add wallet and identity management solutions, secure oracles (from Chainlink, connecting smart contracts with the outside world), and decentralised risk pools in which communities of investors will be able to stake cryptocurrencies (lock tokens to a particular smart contract) to cover farmers' risk.

In the first season we had 17,000 farmers insured on our platform. We learned that in a highly regulated environment such as insurance, the speed of technological development can overtake the pace at which organisations such as regulators, insurance partners, and reinsurers are able to adapt their business processes. For example, there was a reluctance to allow the software to trigger payments without final verification by a member of staff.

Why is blockchain-based crop insurance not yet common practice?

There is a lack of trust in insurance companies. This means that one major challenge in inclusive insurance in the agricultural sector is getting to scale in terms of onboarded/insured farmers. It is often costly. This also makes it difficult for micro-insurance solutions to become profitable. Regulatory structures that are there to protect the consumers, like high capital requirements, complex governance structures, and costly compliance frameworks, create high barriers to entry. It is tough for new innovative tech solutions to enter the market. As a result, the most vulnerable customers, such as smallholders, are denied access to insurance products they desperately need to protect them from the effects of climate change.

More flexibility and faster response times on the side of the regulator would help to speed up the scaling process. Furthermore, government-assisted farmer training on the benefits of agricultural insurance would also be very important. Educating smallholders cannot be left to microinsurance providers alone if such products are expected to operate sustainably. Lastly, to leverage economies of scale, the more widespread use of mobile phones and mobile payment systems is important in enabling technologies to reach farmers in remote regions.

Etherisc focuses on the Kenyan context. Does this mean that the application will remain a domestic solution, or do you see potential for applying it in other countries?

An estimated 270 million farmers globally have no access to insurance. If we had flexible regulation that recognises the technical certainty provided by blockchain technology, tech players could bring novel solutions to market. We believe that they are just as reliable for the consumer as traditional compliance with licensing requirements. In our opinion, decentralised finance can open up new sources of risk capital. The widespread adoption of mobile phone use and mobile payment technologies will be key, however.

It seems that your use case addresses a whole variety of SDGs. Which are they?

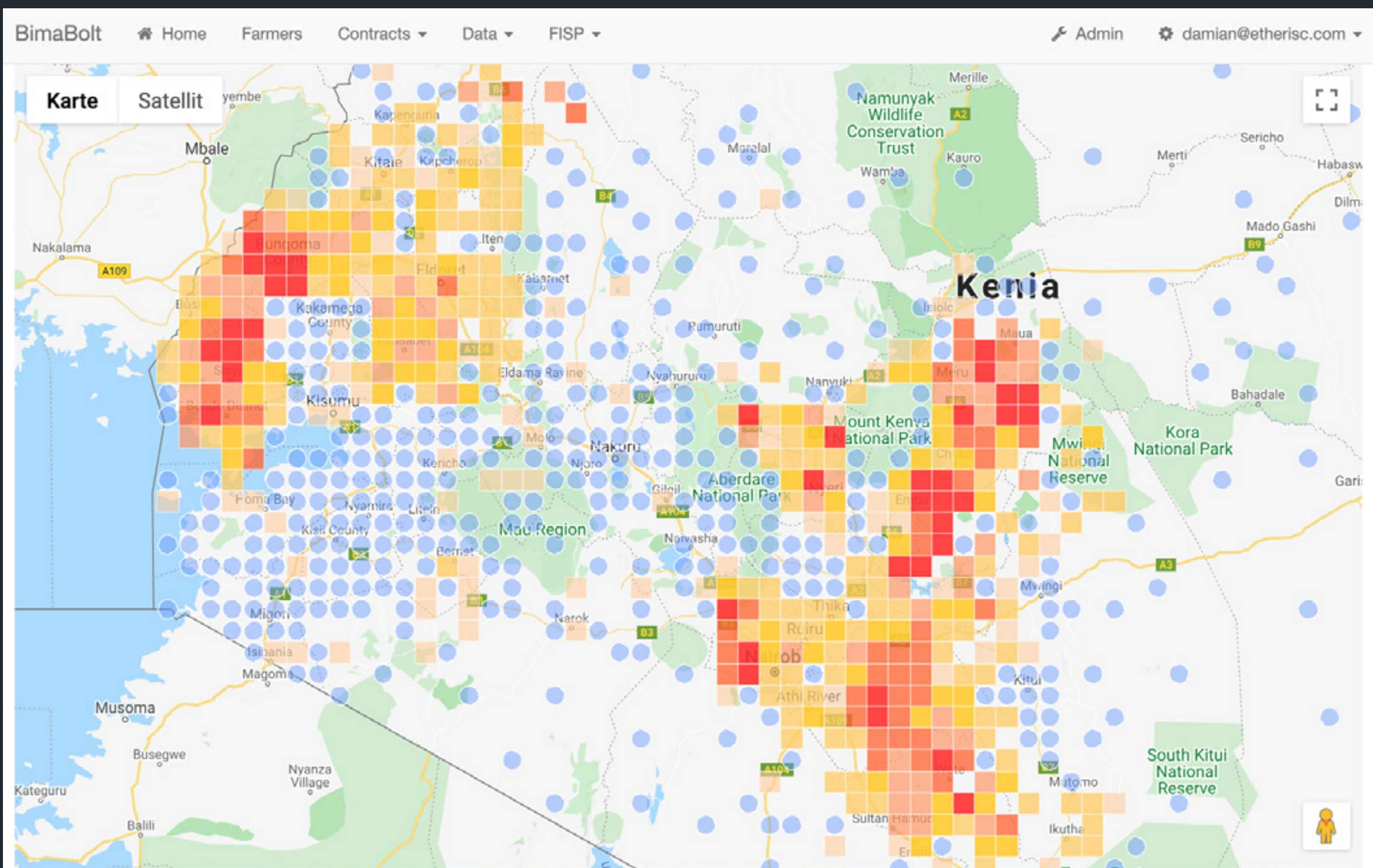
That is true. Digital crop insurance addresses many different SDGs simultaneously: SDG 1 No poverty, since it avoids farmers falling below the poverty line; SDG 2 Zero hunger, as insurance payments replace the food that subsistence farmers grow themselves; and SDG 13 Climate action, as it helps to mitigate the effects of climate change. Other SDGs that the use case touches upon are: SDG 5 Gender equality, because 60% of smallholder farmers are women; SDG 8 Decent work and economic growth; SDG 10 Reduced inequalities; SDG 11 Sustainable cities and communities; SDG 15 Life on land; and SDG 17 Partnerships for the Goals.

Where does the blockchain-backed solution provide clear benefits compared with conventional microinsurance?

Compared with non-digital parametric agricultural insurance, automated end-to-end insurance policies based on smart contracts eliminate the need for human processing during their lifecycle. This makes agricultural insurance cheaper,

Use of mobile phone application in the field.
Source: Etherisc

and allows for almost instant payouts when the farmer incurs a loss. Compared with centralised (non-blockchain) digital solutions, our application provides tamper-proof data from verified oracles. There is also a full audit trail with all details of the blockchain, providing a higher level of transparency than with regular digitalisation. These features eliminate trust issues on the farmer's side, and therefore remove one major obstacle to mass adoption. Accessing the capital available in the decentrelized finance space through innovative staking models will mobilise the necessary risk capital that traditional investors and insurers may not yet be prepared to invest. Eventually the regular, centralised digital solutions will not be able to match the interoperability offered by blockchain-based solutions.



The activations map produced by Etherisc's software visualises how many policies have been activated in different areas.
Source: Etherisc

2.2

Digitalisation potential in the renewable energies sector

Alongside the rollout of smart meters and the continued development of demand-side response measures, new digital peer-to-peer platforms are starting to emerge. These cut out the middleman and seamlessly connect producers of green energy with those wanting it. What we are witnessing is a power shift – the advent of an energy-sharing economy. These changes are empowering consumers to take control of their energy usage and reduce energy bills[4].

The need for an upfront capital investment in clean energy and renewables is one of the most important challenges within this ecosystem. In developing nations especially, low-income households lack access to mainstream financing to make the shift to energy-efficient and/or renewable technologies. Certain validated market approaches, such as those under the SDGs and carbon financing, are targeted specifically to help marginalised users overcome these financial barriers. A lack of transparency, and less-than-seamless monitoring, mean that these mechanisms are not scaled up, however. The situation is compounded by the absence of market pricing based on the cost of achieving carbon emissions reductions in pro-poor projects. Carbon is aggregated across a large number of households and locations, rather than for industrial sites, so the cost of monitoring is naturally higher. Blockchain technologies can address these challenges by creating transparency and accountability about the impacts that are actually achieved. This would act as a further catalyst to upscale market mechanisms such as carbon trading.

CLI-supported use cases in the renewable energies sector focus on sources of clean energy at the household level. We are working to improve indoor air pollution while also supporting the use of impact contributions to finance the more widespread use of clean cookstoves.

| 4 EY Global, Why the energy sector must embrance blockchain now

Kenya

OpenHAP low cost sensors

Kenyan team locally developing and manufacturing low-cost air pollution sensors. These monitor indoor air quality relat- ed to different cookstove technologies in about 100 slum dwellings in Nairobi. Collaboration with local university and Berkeley Air.

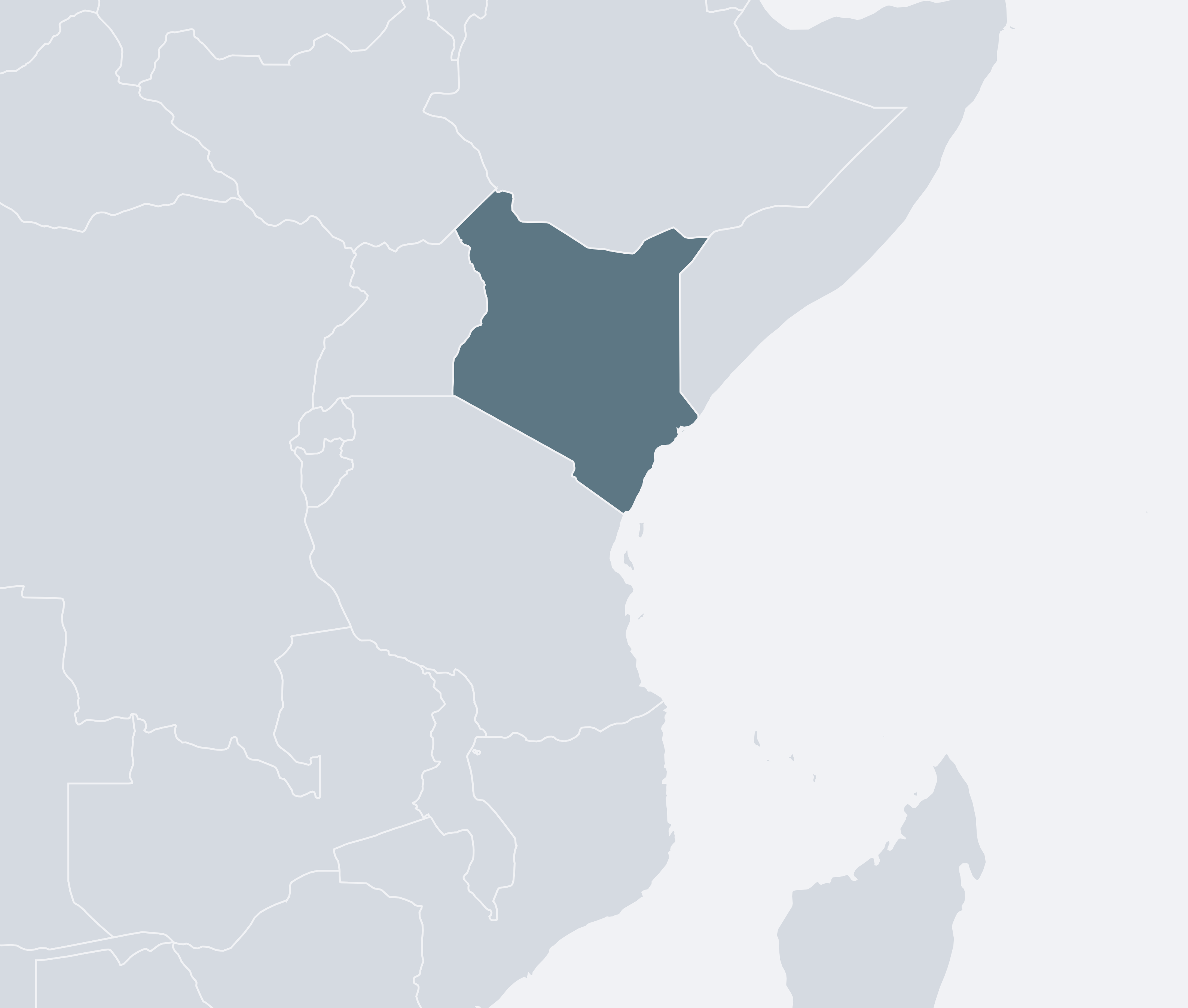
SDG3 SDG7 SDG13

Sector
Low-income households

Focus
Mitigation

Adaptation

Models
Sensors and IoT



USE CASE EXPERIENCES

Insight from
MARTIN KITETU

Martin Kitetu is a manager at EED Advisory, a pan-African consulting firm located in Nairobi, Kenya. It develops innovative solutions to challenges in energy, digitalised water metering, and climate change using IoT technologies. One of the solutions currently in development is the OpenHAP indoor air quality monitoring system. Martin manages the project, which is exploring whether low-cost air pollution sensors can be used effectively to monitor indoor exposure levels in Kenyan households.

Q: How are indoor air pollution and climate action connected, and how can digitalisation help to improve things?

A: Our use case seeks to address the limitations of current household air pollution (HAP) monitoring solutions by demonstrating a low-cost, locally developed, IoT-enabled monitoring device known as OpenHAP. Household air pollution is a severe health problem in Kenya, causing an estimated 14,000–21,000 deaths annually. The use of traditional forms of cooking fuels, such as wood, crop waste and charcoal, is a main contributor. In Kenya, HAP-related deaths are higher than those attributed to traffic accidents and malaria combined. However, policymakers lack comprehensive and reliable information on household air pollution concentrations and exposure levels. Without it, they cannot take appropriate policy action to reduce that exposure.

The data is limited in particular because of the high price of measuring equipment. At approximately USD 200, our OpenHAP solution is significantly less expensive, not to mention smaller, than traditional HAP measurement devices costing up to USD 3,000. Offering similar functionality, our HAP devices allow monitoring at several locations and over longer time periods. Furthermore, the device was fully designed and manufactured in-house by EED staff. The OpenHAP device uses a Bluetooth beacon, which is worn as a bracelet and records the personal exposure of various household members. Our low-cost OpenHAP device combines different instruments that measure the concentration of fine particulate matter (PM 2.5) in the room where the cookstove is used, the proximity of household members to the cookstove, and cookstove usage time.

This allows a correlation to be drawn between the PM 2.5 concentration and the duration and intensity of the individual's exposure, and between the PM 2.5 level and stove usage. PM 2.5 is measured because it is produced by the combustion of fossil fuels and wood, while PM 10 is associated with environmental pollution such as dust, pollen, and fragments of bacteria. Inhaling PM 2.5 is linked to adverse effects on health because it affects the lungs.

Our low-cost OpenHAP device measures pollution levels in several households with different stove types and fuel sources over several days. Gathering information on factors such as cooking habits, stove technologies, fuels and the design of the cooking area, it therefore provides empirical data on different parameters that contribute to high pollution levels. The information gathered through this study will inform policymakers in the cooking and clean energy sector, and enable them to launch targeted initiatives to reduce exposure to HAP.

What have you implemented in your use case, and what is still planned?

In 2020 we completed a preliminary study that tested different kinds of low-cost air pollution concentration instruments from different manufacturers, and compared them with a (much more expensive) reference instrument. This allowed us to draw conclusions about the accuracy and applicability of HAP monitors. Based on the best-performing low-cost instrument from the earlier study, we manufactured 20 OpenHAP devices at the EED workshops in Nairobi and calibrated them using the Berkeley Air Monitoring Group chamber co-location protocol. We also held a workshop for industry stakeholders to outline the goals of the project. We are currently rolling out a large-scale study in which OpenHAP will measure pollution levels in 100 lower-income households around Nairobi. At the same time, information on several parameters such as the number of household members, number of rooms, cooking habits, stove type and fuels used, etc. is being assessed based on a questionnaire.

What are your preliminary results and key learnings so far?

We successfully designed and constructed 20 OpenHAP devices and calibrated them using the Berkeley Air Monitoring Group chamber co-location protocol. We learned that low-cost air pollution measurement devices are a feasible option to assess levels of indoor air pollution and enable it to be measured on a large scale.

Placement of the OpenHAP devices within the cooking area of one-roomed households during fieldwork.
Source: EED Advisory 2021

During the preliminary test, the OpenHAP data from one of the households was analysed to identify the difference between cigarette smoke pollution and cookstove pollution with respect to personal exposure. This was based on cookstove use data versus measured pollution. This is a key result, because it means that the OpenHAP device data and survey method can distinguish between sources of ambient pollution. When compared with the data on stove type gained from the survey, the air quality data should allow the impact on household air pollution to be quantified, and thus also the impact on the health of respondents from the use of different cookstove types. This may help to inform government initiatives to promote clean cookstove practices in Kenya. It will also help clean cooking stakeholders enhance programmes to reduce HAP.

Why are low-cost sensors not widely known and implemented yet?

Currently, the main limitation of low-cost sensors is their accuracy. Low-cost instruments have proven to be useful, and provide important information, particularly as they can be applied on a broad scale, at several locations over long time periods. However, they are not a substitute for more expensive equipment in applications that require high accuracy, and where the results are compared with legally binding air quality standards. At the same time, low-cost instruments do allow the collection of indoor air pollution data to be scaled up, forming the basis for informed policymaking on improving indoor air quality and therefore the health of inhabitants.

Which SDGs are you addressing with OpenHAP?

We anticipate that the outcome of this study will provide policymakers with comprehensive information on the causes of high HAP exposure. It will thus enable them to launch targeted initiatives and regulations to increase the use of clean energy for cooking and to reduce that exposure. OpenHAP supports SDG 7 Affordable and clean energy, SDG 3 Good health and wellbeing and, of course, SDG 13 Climate action.

The external surroundings of a respondent's house in a low-income settlement. A stack of wood for fuel is seen in the foreground.
Source: EED Advisory 2021

India

FairClimateFund

Supplying 100 households in Raichur, India, with clean cook- stoves equiped with cost-effective sensors to monitor cooking practices and transfer the data automatically to a DLT platform to calculate and validate climate impacts.

SDG1 SDG5 SDG13

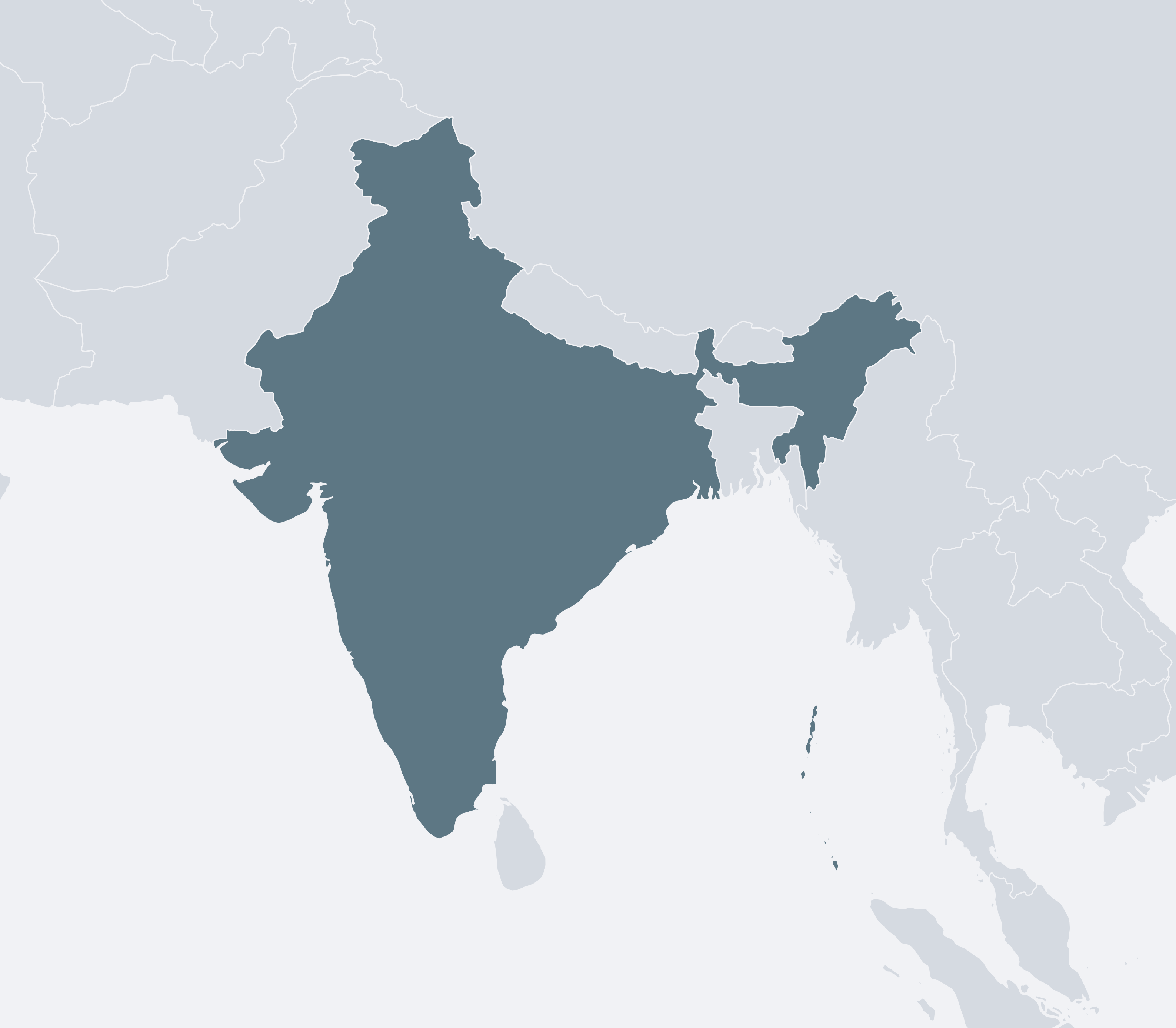
Sector
Low-income households

Focus
Mitigation

Adaptation

Technology
Blockchain

Sensors and IoT



USE CASE EXPERIENCES

Insight from
JASMEET SINGH

Jasmeet Singh is the India Office Director of the FairClimateFund (FCF), a Dutch-based social enterprise. It aims to demonstrate that the carbon market can benefit those who are most vulnerable to the effects of climate change in a fair and effective way. Cooking on traditional open fires contributes to health problems, deforestation and climate change, and imposes a huge burden, especially on women. The FairClimateFund intends to use climate financing to give households that are most vulnerable to the impacts of climate change access to clean ways of cooking.

Q: What is the FairClimateFund, and how does it address shortcomings in the way that renewable energies are applied at the household level?

A: The technological innovation in this use case is defined within the framework of 'cooking as a business.' FCF will install improved cookstoves (ICS) in rural households that presently cook using firewood. These stoves will be fitted with heat sensors that can detect when someone is cooking and therefore track stove use in real time. The data will be stored temporarily in a cache attached to the sensor. From there, it is extracted and uploaded to a backend server in the cloud. Cooking data received from the IoT platform will be written into a blockchain, providing a real-time carbon inventory. Blockchain will make the entire process accountable. Impact buyers can trust the data source, and also make sure that the money is transferred directly to the impact generator. The process shortens the payment period compared with the traditional approach to climate financing. Monitoring cookstove use remotely also eliminates the costs and biases involved in conventional data-collection.

Where are you with implementation?

So far, we have deployed 110 clean cookstoves with sensors in two villages in the Raichur district – Ramanhal and Chickhonkuni. These households typically cook using firewood on traditional mud stoves. As part of a carbon project FCF has installed clean cookstoves in more than 18,000 households in Raichur since 2011. Their design has proven efficient in terms reducing smoke and fuel use compared with traditional mud stoves, and there is also a difference in their thermal efficiency. It is especially important that we train local implementation partners in sensor installation and data collection. We are currently raising awareness of the use case among local households, and are about to conduct a survey in which we highlight knowledge levels, cooking behaviours and relevant information on SDGs 1, 5 and 13. The target households have been using traditional stoves from decades, so it is crucial that we remember cooking habits and user convenience when introducing new technologies. We will achieve an impact if these households move entirely from the traditional stove to the ICS. Data on these SDGs will help determine the amount of cooking time that women save, and also if the consumption of wood as fuel falls after the new stoves are introduced. This would help establish carbon savings and thus sell these impacts to interested buyers. What's more, we have developed the technology architecture and blockchain-based carbon inventory platform with an intuitive dashboard.

Have you encountered any obstacles so far, and what are the factors that stop your solution taking off or becoming common practice?

The costs of remote data capture need to be reduced further. High sensor costs seem to be a major factor preventing data monitoring being scaled up. It is extremely important that low-cost solutions are available. They must be affordable to achieve high penetration at the household level. We firmly believe that lower costs will expedite upscaling.

Secondly, the lack of financial policies at national level (especially policies related to blockchain and regulation for crypto-currencies) is an obstacle to cross-border carbon purchasing and cookstove user transactions. There has not yet been any policy-level intervention to introduce DLT/blockchain technologies into carbon financing, but this is just what is needed to make this process more transparent and to avoid double counting.

Thirdly, it is important that data monitoring and blockchain technologies are approved by a carbon standard such as Gold Standard (GS) to ensure greater acceptance on the market. With its partners, GS is already working on exploring the potential of blockchain and other DLTs in robust climate action. We have also initiated discussions with GS on the present use case. However, it is still too early to fully understand issues concerning implementation and replication. Very generally, the investment needed to scale up such technologies is broadly lacking. Our use case would be helped if the private sector were more committed to net zero development.

Chulika stove with sensor installed in the field. Source: FairClimateFund

By introducing clean cookstoves, your work helps to cut greenhouse gas emissions. What other benefits are expected?

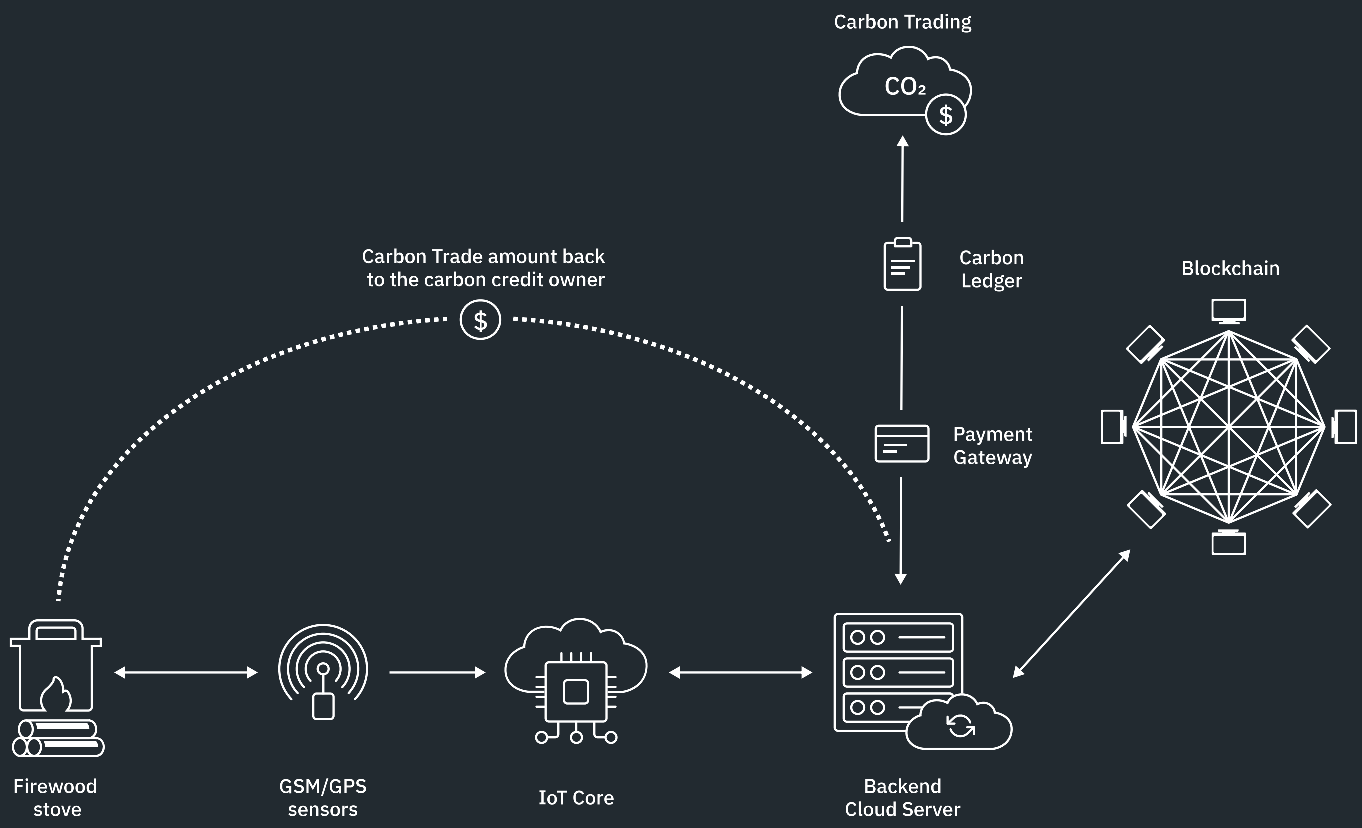
The use case technology addresses the difficulty of monitoring and verifying the quality of data on cookstoves so that their real impact can be measured. Impact buyers are able to finance the improved cookstove interventions directly in lieu of their own SDG impacts. The system will calculate cookstove impacts automatically using the international GS methodology for estimating emission reductions. Our use case supports SDG 13 Climate action, curbing carbon emissions by using cleaner and more efficient cooking solutions and saving wood and thereby preventing deforestation. It also supports SDG 5 Gender equality, as less time is spent cooking, especially by women. Furthermore, income is generated for women to purchase or replace a cookstove, so the use case also contributes to SDG 1 No poverty.

Where do blockchain-backed monitoring solutions provide clear benefits compared with conventional monitoring solutions?

First of all, they make monitoring safe and reliable. Transactions between network participants are recorded transparently in a shared ledger, and the data cannot be changed. Secondly, it improves efficiency. In the first phase we use blockchain to store cooking data in an immutable ledger to ensure transparency and accountability. Carbon savings are calculated based on actual ICS use, as per the GS algorithm. The blockchain-based (digitalised) solution makes it easier to track the positive impacts on carbon emissions that projects such as improved cookstoves in India produce.

These solutions can provide more transparency and accountability for impact consumers, so they are better able to claim a contribution to the global SDGs under the Paris Agreement. Meanwhile, impact producers can be rewarded directly, which has the potential to transform their socio-economic status. Overall, blockchain-backed monitoring solutions make climate financing robust and efficient, and thus lead the way to massive upscaling.

NextGen Platform: Extend Foundational Technology Component with AI Services, Connected IoT Core and Analytical Reports



Schematic view of the carbon inventory monitoring infrastructure. IoT sensors will be attached to improved cookstoves that are deployed in rural households. The IoT sensor monitors cookstove usage and sends the data to the backend server in the cloud. Cooking data received from the IoT sensors will be written into a blockchain – an immutable digital ledger to ensure that it is not altered in any way. The system monitors the carbon inventory in real time. The next version will incorporate a basic trading platform on which accrued carbon credits can be sold. It will also enable the blockchain to issue carbon certificates. A portion of the funds generated from carbon is transferred by the system directly to the cookstove users' accounts. Source: FairClimateFund

2.3

Digitalisation potential in the forestry sector

The most common factors causing deforestation and severe forest degradation are agriculture, unsustainable forest management, mining, infrastructure projects, and an increase in fire incidence and intensity. Some infrastructure activities, such as road-building, have a large indirect effect by opening up forests to settlers and agriculture. Poor forest management and unsustainable wood collection degrade forests and often instigate a death-by-a-thousand-cuts form of deforestation[5].

The main cause of deforestation in Peru is the advance of small agriculture, followed by illegal activities such as mining, logging, and drug production. While technology can help deal with both causes, blockchain technology may be more relevant in reducing illegal activity. In this sense, the technology's principal characteristics can help to improve traceability mechanisms for different products, ensuring that their origin is legal.

| 5 Deforestation causes | WWF

Peru

Wood Tracking Protocol

Digital platform for forest management companies, using the features and technical possibilities of smartphones and blockchain technology. Together, these fight illegal logging and reduce deforestation in the Amazon by bringing transparency and traceability to the timber industry in Peru.

SDG9 SDG13 SDG15

Sector
Forestry

Focus
Mitigation

Adaptation

Environment

Technology
Blockchain

Remote Sensing

USE CASE EXPERIENCES

Insights from
ROCÍO GARCÍA
Programme Manager,
Wood Tracking Protocol

MICHAEL FABING
IT Lead,
Wood Tracking Protocol

Michael Fabing has led the technical development of the Wood Tracking Protocol (WTP) since 2018. In the summer of 2021, Rocío García assumed the legacy of her husband Sven Braden to become WTP Programme Manager. WTP provides a tool to document the work of actors in the wood processing chain in the Amazon region of Peru. The project combines a smartphone application with a digital platform that includes a gateway to a blockchain network. The tool is currently being rolled out in the field. It is the aim of the WTP team to collaborate with similar initiatives to increase traceability and transparency in the Peruvian forestry industry. In this context, interoperability may prove crucial to WTP's future.

Q: What exactly is the Wood Tracking Protocol, and what have you already implemented?

A: The Wood Tracking Protocol is an IT-based approach using the features and technical possibilities of today's smartphones. Combined with blockchain/DLT technology, WTP addresses illegal logging by bringing transparency and traceability to the timber industry in Peru. Work on WTP started in 2018 with a set of interviews with experts from the Peruvian forestry sector, along with the associated conceptual considerations, such as how to transfer certain processes into the digital space.

Now, in 2021, WTP provides a working smartphone application for Android devices. This is connected to the WTP platform – a centralised database with a gateway to a private blockchain (public blockchain is planned). Both smartphone application and platform were tested in the field during the earlier pilot phase in 2020. Field testing was limited, however, by travel restrictions owing to the COVID-19 pandemic. WTP's IT-based workflow was tested at a number of sites in Madre de Dios by a variety users, such as loggers, wood transporters and the staff of a checkpoint in Puerto Maldonado. Working from the feed-back we received, we were able to improve both workflow and user-friendliness. The outcomes of the pilot project in 2020 now serve as the basis for application testing in the current phase.

Can you explain a little more about why it is better to use a blockchain-based solution than to track logging in a conventional way?

Digitalisation can be defined as the conversion of text, pictures, and sound into a digital form that can be processed by a computer. Currently in Peru, much of the wood tracking and tracing process is done on paper and using Excel spreadsheets. These require neither internet nor mains electricity, which is not always available in some areas of the country. The problem is that Excel spreadsheets and paper can easily be modified, duplicated, and falsified, and people cannot be sure that the document and the information it contains are correct. That is where our platform comes in. Not only do we collect information that is difficult to fake, such as the Global Positioning System (GPS) data and the timestamp of an operation, but this information cannot be changed or duplicated by users. Furthermore, once the information is digitalised, the platform can easily scale up, handling billions of records from thousands of companies simultaneously without any human supervision. Currently, our WTP platform uses a 64-bit identification system, which means that in theory we can track the origin of 18,446,744,073,709,551,616 pieces of wood.

Where do you encounter obstacles to implementing the application in remote areas, and what do actors see as the advantages?

First of all, internet access is a real problem in Peru, because in the forest there is no internet connection and no mobile phone reception either. That makes it hard to work on providing technological solutions. Modern timber companies have installed satellite internet at their camp sites, but smaller companies have no internet connection at all. Secondly, loggers do not carry their smartphones in the jungle as there is no practical need to do so. With this in mind, asking them to carry phones to document their work is not as easy as it seems. Thirdly, digitalising the paper trail ensuring the traceability of wood in Peru is seen as an attractive means of making the process more efficient. It is chaotic at present because many forms have to be filled in by different stakeholders along the production chain. Any tool that would help to reduce that burden is much appreciated.

Why is it still difficult to roll out the application nationwide?

The main challenge nowadays is getting authorisation to adopt the application. Peru already has a national system that tracks timber. Although imperfect and burdensome, it has been operating for years and it is what private companies know. One of the biggest challenges for private timber companies in adopting our application is that they do not want twice the work. Starting in October 2021, companies are required to complete forms on which they disclose their work to the

WTP smartphone application
Source: Wood Tracking Protocol

authorities, and this is currently the only accepted means of submission. Asking a private company to use our application would mean an increase in their workload. They would need to enter the information on our platform in addition to filling out all of the paper forms that are required by the relevant authorities.

The WTP tool replicates the steps and information in the existing system, but adds a verification step in terms of geo-location, pictures, etc. to make the report more accurate. The project does not aim to ignore the existing system, but to complement it. However, without the proper acknowledgment from relevant authorities it will be difficult for the WTP tool to become common practice. These obstacles are also the reason that we want to network more closely with government agencies during the current phase. In the best-case scenario, we will also be able to influence government policy.

Identifying tree trunks using a QR code. Source: Wood Tracking Protocol

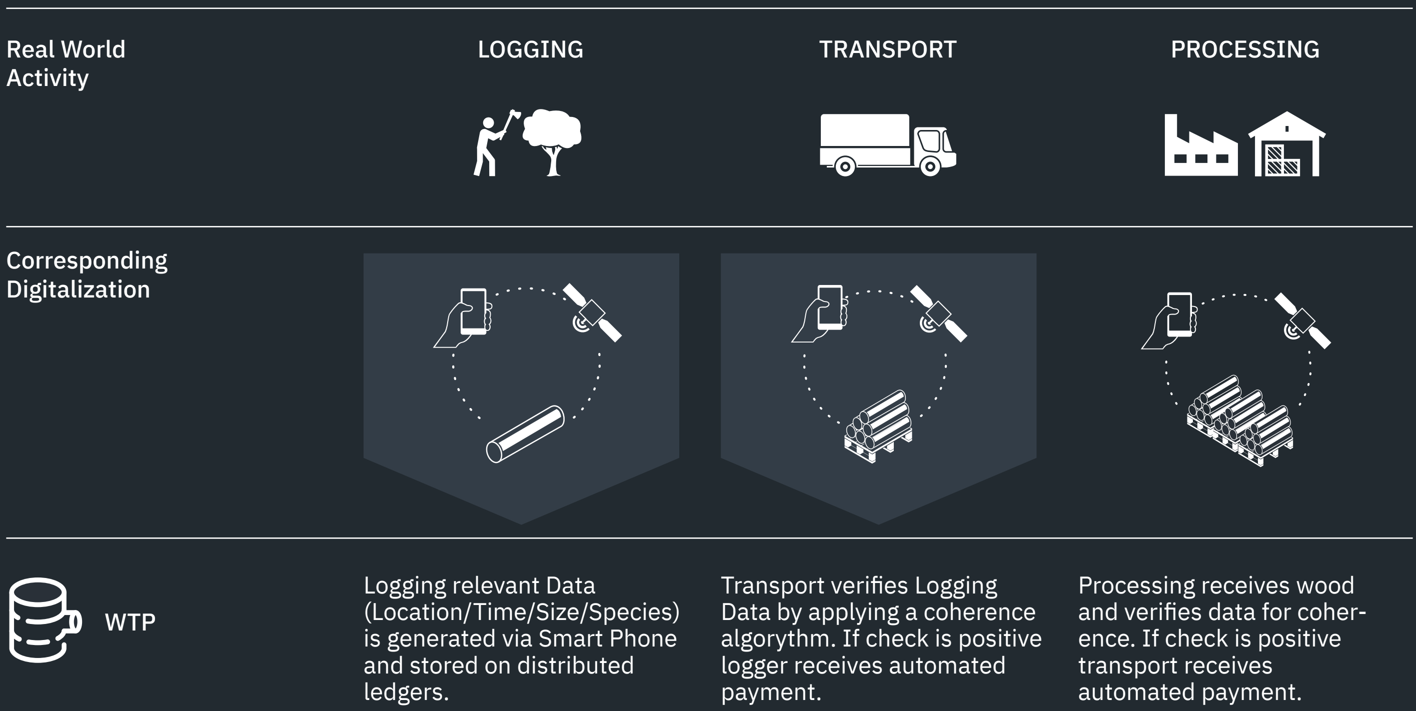
WTP is focused on the Peruvian forestry industry. Does this mean WTP will remain a local and domestic solution, or do you see potential to upscale your application?

The formal timber industry in Peru is relatively small compared with what it might be. National production is more or less absorbed by domestic demand. The traceability systems currently in place are fully focused on timber for export, which leaves ample scope for wood of illegal origin to be consumed within Peru itself. Reducing the costs of traceability and increasing national-level demand for legal timber would considerably increase the potential for scaling up the tool. This would also help to open up international markets that demand certificates of legal origin. It might even increase the private sector's appetite for the WTP tool.

WTP helps to reduce illegal logging, and thus also greenhouse gas emissions. Illegal logging is one of the main sources of deforestation in Peru, and the land use and forestry sector is responsible for the largest share of the Peruvian greenhouse gas emissions inventory. What other advantages do you see?

Our WTP tool also promotes sustainable industrialisation by helping the forestry industry in Peru to reduce illegal logging. We are therefore helping to achieve SDG 9 Industry, innovation and infrastructure. This seeks to build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation. As illegal logging is also a major cause of forest degradation, WTP contributes to SDG 15. This Goal seeks to protect, restore, and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, stop and reverse land degradation, and halt the loss of biodiversity.

Concept behind the Wood Tracking Protocol. Source: Wood Tracking Protocol



2.4

Digitalisation potential in the transportation and waste sectors

The transportation industry has a long history of digitalising processes, incorporating emerging technologies, such as the cloud and the IoT, and increasing connectivity and automation. Blockchain is a natural fit for inherently fragmented industries like this one, in which close coordination with multiple parties is essential. The technology provides a more transparent and secure way to do business, resulting in immutable transaction records, finality in tracing ownership and payment, and substantially improved coordination and efficiency. It has the potential to mitigate some of the transportation industry's most persistent challenges. For example, blockchain technology can help enhance security, increase trust in digitalised data, improve logistics management across the ecosystem, and provide more efficient industry interaction (IBM 2018).

Blockchain technology can also help to overcome some of the key challenges in the waste sector. Tracking data is key to compliance with existing laws and policies, and it also has the potential to inform regulators to further prevent waste being 'wasted' because it ends up in landfills or being incinerated. Tracking waste and monitoring its owners to generate this data is a complex undertaking, however. Blockchain technologies may help to overcome these challenges (Taylor et al. 2020).

According to Green Tracker, it is particularly challenging to create a system that gives a high standard of environmental traceability and is able to operate with different types of industries and technologies. The difficulties arise in automating the data collection process and in homogenizing the collected data to meet data requirements for further analysis. The collected data is generally very granular, which tends to overload the system. In the recycling sector, the challenge of implementing an efficient and trustworthy tracking system on an automated blockchain is even greater owing to the lack of data structures, unit conventions, and measurement and controlling points.

Chile

Green Tracker

The Green Tracker blockchain platform supports appropriate MRV practices by tracking greenhouse gas emissions and resource savings from green action, such as renewable energy generation, e-mobility, and waste recycling.

SDG7 SDG9 SDG11 SDG12 SDG13

Sector	Focus	Technology
Energy	Mitigation	Blockchain
Transport	Environment	Sensors and IoT
Waste		AI and Big Data

USE CASE EXPERIENCES

Insight from
CRISTIÁN MOSELLA
EnergyLab

Cristián Mosella is an engineer from Chile and Co-Founder and Managing Director of EnergyLab, a Chile-based Latin American start-up. EnergyLab further develops Green Tracker functionalities by incorporating automated monitoring, reporting and verification (MRV) systems. The use case aims to develop suitable MRV systems to monitor practices such as renewable power generation, sustainable transportation and recycling, and residues management in Chile. The monitored data will be integrated into the Green Tracker platform to calculate and track the resulting greenhouse gas emission savings, among other environmental benefits. The solution will help green action developers to eliminate most of their MRV-related burdens, and to capitalise their environmental contributions through the carbon markets.

Q: What is Green Tracker and what have you been implementing so far?

A: Green Tracker is a blockchain-based service for automating the MRV process for any kind of activity that produces measurable environmental benefits, like CO2 reductions originating from renewable power generation, e-mobility systems and residues recycling facilities. Our system allows users to build trust and confidence in their environmental performance, claims and/or environmental assets that may be created throughout our solution. Green Tracker uses state-of-the-art technologies to automate the data collection process and make it traceable, transparent, and immutable. It uses internationally approved methodologies to calculate and cross-check environmental benefits, and allows users to publish and exchange the results through a publicly available registry.

We are now monitoring, reporting and verifying the CO2 emission reductions produced by the development of renewable energy facilities and e-mobility projects that are active in Chile. At the same time, we are working in some additional features that will allow us to trace residues management in the recycling industry.

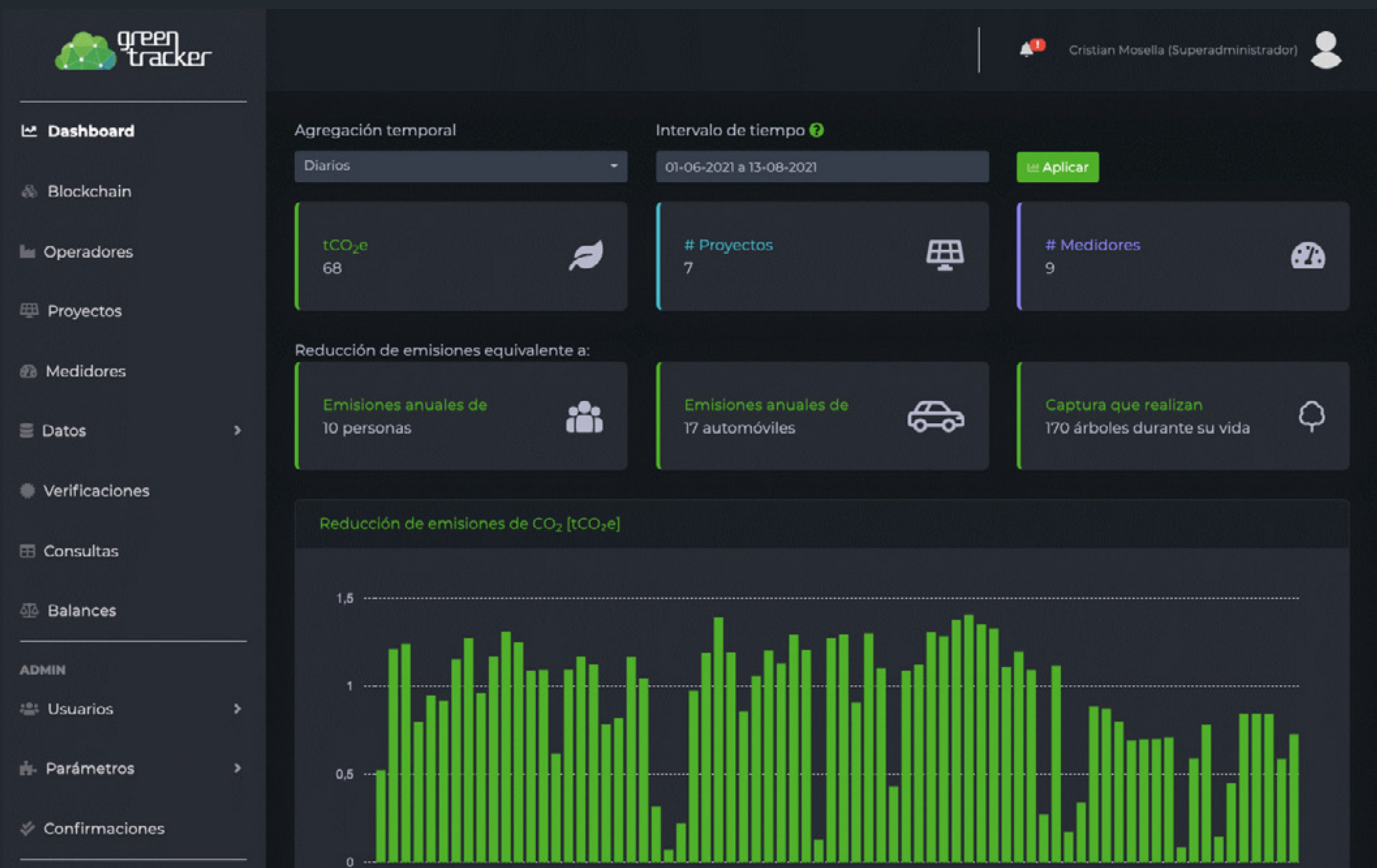
Where does Green Tracker provide clear benefits compared with a conventional solution?

Put simply, blockchain-based solutions enable users to trust the data that has been stored on our databases, because it can be proven that the data has not been tampered with, corrupted or modified. This is a crucial difference over old data and/or when the data is stored for prolonged periods in the project developers’ systems, where mistakes and conflicts of interest may arise. Additionally, the robustness of Green Tracker is potentiated through a direct connection to monitoring systems such as digital power meters, GPS, scales and other types of IoTs. This is complemented by calibration, a conservative approach, and cross-checking protocols.

What are your outcomes and key learnings so far?

Some of our key learnings are related to making blockchain technology more cost effective and environmentally friendly, and that is where our hybrid approach using both private and public chains is showing very interesting results.

Other key learnings are associated with data storage, updating protocols, and hashing policy. In the real world, system downtime and internet connectivity losses happen. That is where reasonable protocols are needed to allow data gaps to be restored, avoiding conflicts with data blocks that are already written, and taking care not to risk confidence about the whole data batch.



The screenshot shows Green Tracker's dashboard, from which the volume of CO2 reductions monitored in any period of time can be obtained. It also indicates the number of projects and IoT devices connected, the eco-equivalents of the CO2 reductions, and outcomes as an hourly, daily, or monthly average (the green bars).

Recycling Plant. Source: Green Tracker

Why are such MRV solutions not yet common practice?

First of all, even though there is plenty of interest in DLT, there is still a lack of understanding and erroneous expectations about its performance, usability and benefits. These must be explained to future users. Additionally, it is important to keep in mind that, while the Green Tracker system allows companies to trace, store and transfer their environmental results, it reaches its full potential when the processes are digitalised in the cloud.

Finally, I would again highlight the importance of interoperability and homogenisation in terms of the data itself and IoT connectivity options. These may still be a barrier to the seamless implementation of Green Tracker throughout different projects and sector. The more standardised the data and sensors, the easier and faster the system can be deployed. This is critical to achieving the desired scalability and environmental impact.

Where do you see the potential for upscaling your use case?

There are several types of opportunity to scale up, especially in the energy, industrial and transportation sectors. These are increasingly integrating sustainable technology which can be monitored, reported, and verified through Green Tracker. Users can then capitalise these achievements through their environmental balances (carbon footprint, water footprint and/or ecological footprint) and/or public reporting to authorities, communities and customers. Green Tracker is also focusing on certain niches where we see potential for its use to trace CO2 emissions and offsets, track materials, for circular economy programs and extended producer responsibility legislation, and to track the carbon footprint of the hydrogen production chain, among others.

Green Tracker might be a great ally of SDG13, since it aims to promote climate action within a wide range of project types and scales. Where do you see further benefits from the application?

Increasingly, Green Tracker has the potential to support the exchange of internationally transferred mitigation outcomes (ITMO), as provided for by Article 6 of the Paris Agreement. It gives issuers and buyers a greater level of confidence about the environmental outcomes that have been achieved. Green Tracker helps to break down barriers such as a lack of knowledge, capacity and climate-related procedures at the project site (especially relevant in non-OCDE countries), while also giving users the opportunity to adopt online monitoring and possibly also remote auditing processes. It ensures high standards in terms of CO2 calculations, data management, and storage at all times.

At a higher level, Green Tracker can be a great partner in enhancing sustainable industries and infrastructure (SDG 9), sustainable cities and communities (SDG 11) and more circular and sustainable ways of consumption and production (SDG 12).

3

Digitalising standards and registries for Gold Standard and Sweden

3.1

Experience from Gold Standard's digitalisation efforts

Several carbon standards, certification bodies, and registry operators are currently looking into revising their standards and procedures to facilitate digital approaches.

Insights from
OWEN HEWLETT
Chief Technical Officer
Gold Standard Foundation

Owen Hewlett is Chief Technical Officer at the Gold Standard Foundation, and leads Gold Standard's digitalisation efforts. The Gold Standard Foundation is about to fully digitalise its standard requirements and methodologies, making them intuitive, accessible, and easily cross-referenced with other third-party standards. Gold Standard wants to couple this with an intuitive, high-integrity assurance process that maximises automation through technology, thus reducing error and facilitating ongoing portfolio level analytics for the benefit of all.

Q: Where do you see the main challenges for registries and standards that blockchain/ DLT technologies can address?

A: All areas of climate action and SDG reporting are moving slowly, but inevitably, towards unified and consistent reporting norms. For example, the worlds of voluntary carbon markets and corporate inventory reporting have largely been separated in the past, but there are now overlaps, and double counting will increase going forward. This is a sign of progress because it shows more climate action, but it also introduces difficulties, especially where integrity is concerned and, more specifically, claims to carbon credits.

Solutions are needed in particular in the tracking and transparent disclosure of all aspects of corporate and national reporting, including their interplay with each other. Reporting must be aligned with science-based aspirations. Yet this complexity can only be managed with intelligently designed MRV approaches with compliance assurance and capture/tracking, all recorded in immutable and interoperable multi-layered registries.

Some of the most critical challenges concern the alignment of various approaches, including between standards criteria, data collection and reporting norms, baselines, boundaries, and scope definitions. Without this, reporting is not easily comparable.

Only once comparability has been achieved will it be possible to implement robust technological solutions to their fullest potential – although that is not to say there are not great leaps forward still ahead.

How would you summarise your planned digitalisation activities?

Gold Standard manages a standards and assurance scheme for high-quality climate mitigation, adaptation and sustainable development activities and finance. As we cover a wide range of activities, impacts and data usage, our standards documents are extensive and complex. This can make it challenging for proponents to know what is relevant to their activity, and how to reflect these requirements in design and implementation.

As with many standards, monitoring, reporting and verification (the process of collecting and reporting data against standards requirements), and assurance (the process of auditing and assessing conformity with requirements) are largely manual at present. This will be remedied in the new Gold Standard Impact Registry and data platform, which itself will be designed to be interoperable with whichever systems Gold Standard ultimately works. This combined programme is called 'GSIQ,' which stands for Gold Standard Impact Quantification.

What have you already learned from this initial process?

Having decided to invest in this effort, we quickly realised the scale and complexity of the endeavour. One major learning is the need for a distinct goal for what we want to achieve. That goal must also be based on solid scientific data and a clear vision of what we want to use that data for. We also discovered that, while we have a high degree of internal literacy about these topics, it is inevitable that we will need to bring in new talent and that the organisation will also look to build a group of experienced, independent experts to support our work.

With a clear vision, a detailed roadmap and the right resources supporting implementation, we are highly optimistic that we can get obtain impact data more efficiently, while increasing accessibility and interoperability.

Why are digitalised registries/standards not yet common practice?

The main reason that our solution has not yet become common practice is the complexity surrounding interoperability and the emerging alignment of different reference frameworks, which is only a recent phenomenon. If systems cannot yet work together, and the points of reference have not been settled, it can be difficult to determine the right time to get to work. This is particularly true of many organisations like ours, which are not necessarily able to reallocate internal expertise at short notice.

Where do you see the potential for upscaling your work?

It is in Gold Standard's DNA to share our work and our learnings, and so we hope that both our good ideas and our mistakes can inform and inspire quality and integrity in other organisations taking up the same challenge. For us, it is simply not possible to imagine continued growth and continued alignment between approaches without dealing with the inevitable complexity that follows. You can't manage what you can't measure, and you can't measure what you're not properly tracking and controlling. This requires a technology solution that itself has to be part of a comprehensive, integrated digitalisation effort.

> **"You can't manage what you can't measure, and you can't measure what you're not properly tracking and controlling."**
>
> **Owen Hewlett,** Gold Standard

3.2

A blockchain registry for Sweden's Article 6 pilot activities?

In contrast to earlier carbon market mechanisms under the Kyoto Protocol, the Paris Agreement's Article 6 paradigms move away from centralised accounting, unified comprehensive rules, and standardisation for the monitoring, issuance and transfer of international units. Instead, they allow less stringently defined decentralised, cooperative approaches. This more bottom-up approach requires states parties to "ensure environmental integrity and transparency" and to "apply robust accounting to ensure, inter alia, the avoidance of double counting." Any cooperative approach under Article 6 requires the establishment of strong institutional settings, regulatory frameworks, and reliable and trusted information systems in the form of a registry. These registry systems must track mitigation outcomes along the process cycle of ITMO transfers, including authorisation, MRV, issuance, transfer, the corresponding adjustments, and cancellation, etc.

Insights from
JUERG FUESSLER
Managing Partner
INFRAS

The Swedish Energy Agency (SEA) planned to pilot Article 6 activities in a very specific way even before the details of the Article 6 rulebook were defined at COP26 in Glasgow. It had therefore already started to think about piloting a digital registry. The SEA is considering how to digitalise the necessary electronic infrastructure, and related processes in the cycle described above. Juerg Fuessler from INFRAS and CLI led the advisory consortium for the Article 6 blockchain infrastructure study, consisting of INFRAS, Carbon Limits, the Stockholm Environment Institute (US), Cosmos and CLI.

Q: Why is Sweden looking into implementing a blockchain-based registry?

A: The benefits of using a decentralised blockchain, or more generally distributed ledger technology, as well as other digital innovations for electronic registry systems and MRV, include increased security.

Blockchain entries are immutable and therefore provide for an extra degree of trust compared with a conventional centralised database. Also, digital technologies provide for additional levels of automation – such as those in smart contracts – which not only increase confidence in the functioning of the system but also lead to efficiency gains in the project transaction cycle. Blockchain/digital ledger systems may also be better suited to connecting different registry systems, and thus allow multiple heterogeneous carbon markets to be linked.

This sounds very promising; do you see any obstacles?

Of course. Depending on the technology used, blockchain technologies may also have limitations compared with conventional databases. These include lower transaction speeds and capacity, and much higher power consumption and transaction costs. Ways of overcoming these shortcomings include, for instance, hybrid approaches, which combine conventional databases with an immutable blockchain/DLT layer.

In your opinion, how should Sweden proceed with its e-registry infrastructure?

If the SEA wants to implement a registry system focusing purely on its domestic needs, then a conventional database may be a better solution. Such a system may be more performant and, in a domestic system for Sweden, public trust in government and public databases is high enough that there is no need for an extra technological trust layer from blockchain/DLT. However, I think it is important for Sweden to cooperate with other partners from the Article 6 community, as collaboration is the very essence of the new market mechanisms. As an internationally well respected and neutral country, Sweden may join together with like-minded countries to form the nucleus of an international Article 6 registry and transaction infrastructure. Based on its usefulness, trusted technology and high environmental integrity, it could attract many other host and acquiring countries with similar mindsets.

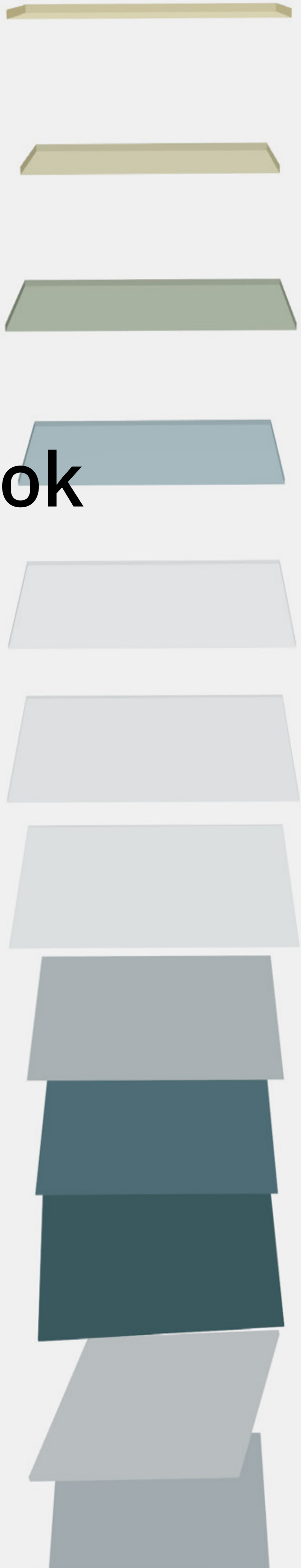
From a technical point of view, what recommendations do you have for the SEA?

To start developing concepts for this kind of joint approach, it is important for the SEA to learn more about the specific needs and expectations of host and acquiring countries, and other partners. This should explore technological functionality and standards, for example, as well as governance and readiness to share sovereignty with partners. If the SEA is aiming to work with other nations, then blockchain-based technologies have numerous benefits and can be implemented in a way that largely overcomes potential limitations such as capacity, power consumption, and transaction costs.

Based on a limited analysis of this study, a private permissioned blockchain operated by a defined consortium might be the best solution to back a registry system. This resolves issues with government oversight, and can be more closely aligned with existing national and international regulations than a public blockchain. In addition, it does not require energy-intensive consensus mechanisms, and does not need to rely on a major third party blockchain operator.

4

Findings and outlook



4.1

Findings from the use cases

This year's edition of the CLI Navigating Report puts our thriving use cases into the spotlight. A series of interviews (chapters 2 and 3) highlight experience and remaining challenges while testing and implementing blockchain and other pilot digital applications for climate action. We draw the following conclusions from these use case interviews:

ENGAGEMENT WITH POLICYMAKERS, GOVERNMENTS, AND DIFFERENT STAKEHOLDERS

As an innovative technology, blockchain needs to attract the attention of policymakers, potential users and other stakeholders. Blockchain applications need to be user-friendly, providing participating entities with ample time to become familiar with the technology and to develop internal structures. Furthermore, government-assisted training on the benefits of blockchain applications help to disseminate the technologies. Back-up from national authorities is seen as very important to influence legislative processes in the long term. The use cases show that it is crucial to collaborate with the relevant authorities, to understand how those cases can support the efforts of the government and to design a tool that complements its work.

LIMITED MOBILE PHONE USE AND INTERNET CONNECTIVITY ARE KEY CHALLENGES

Many pilot projects rely on mobile phones or internet access. Over the past decade, networks have expanded rapidly, providing access to digital services to an increasing proportion of the population, including in Africa. However, connectivity is still often poor, especially in more remote regions.

For instance, in areas of Peru where the logging industry is concentrated, there is neither internet nor mobile phone connectivity, which makes it hard to work on technological solutions. It may be assumed that connectivity will improve over time, in particular through recent projects for lower-cost satellite connections. In other cases, solutions such as LORA low-power, wide area networks may be the key to digitalisation in remote areas.

> "Disruption rarely comes from the established players. Sometimes they even slow down the process of developing innovative solutions to urgent problems"
>
> **Jan Stockhausen,** Etherisc

LACK OF INTEROPERABILITY IS AN EMERGING PROBLEM

Interoperability between different digital systems is key to the success of the climate applications of digital technology. It extends beyond the technical aspect to non-technical interoperability at the human, organisational, and institutional levels. The lack of interoperability and homogenous standards emerges as a major obstacle to the seamless implementation of different technologies in different sectors. For instance, the corporate action conversation is increasingly turning to accounting for value chain decarbonisation. This is complex, because value chain accountability is 'crowded in', in the sense that many companies become responsible for the same emission (or benefit, where that emission is reduced). Interoperable accounting norms will have to be put in place, and effective tracking implemented to attribute liabilities and benefits properly. The risk of not doing so is financial flows that are inefficient, inaccurate, double-claimed and not attributed to those who are actually accountable. In short, a failure here may mean the difference between thinking that our actions will avert the climate emergency, and actually doing so.

DIGITALISATION HELPS TO COLLECT EMPIRICAL DATA AND INFLUENCE POLICIES

There is often a lack of reliable empirical data as a sound basis for policymaking, for instance in the case of indoor air pollution. However, this data is vital for an accurate analysis that then influences national and international policies. For example, indoor air quality data from low-income households using different cookstove technologies underpins the government's promotion of sustainable cooking technologies.

LOW-COST OPTIONS ARE A KEY ASPECT OF UPSCALING

When it comes to monitoring, bringing down the costs of remote data capture is key, but these low-cost technologies still need to be sufficiently accurate to generate reproducible results. High sensor costs are an obstacle to upscaling data monitoring. The CLI-supported use case demonstrates that low-cost indoor air pollution measurement devices have a role to play in assessing pollution and therefore impacts on health – if done correctly in terms of calibration and data capture, and the processing protocol.

> “Without trust, environmental monitoring, reporting and verification may be useless, or left with very little room to generate the value that it is meant to deliver, and most of the opportunities that it may create will be erased”
>
> **Cristián Mosella,** Green Tracker

DIGITAL SOLUTIONS CAN RESTORE TRUST

The immutable nature of blockchain applications can generate increased transparency and trust for its users. This has been observed in the Etherisc crop insurance use case in Kenya, where blockchain technologies automate the lifecycle of the insurance product and thus reduce costs and increase confidence in the database. Digitalisation and the use of mobile phones increases transaction speed, allowing payments to farmers in near real time, in contrast to the weeks or months of delay with conventional systems.

WORK WITH NEW ACTORS BUT EXPERIENCED TECHNOLOGY PARTNERS, TOO

Working with new actors from outside the sector may involve risks, but at the same time it can harness technological skills that may otherwise be missing. Digital disruption rarely comes from the established players. Sometimes they actually slow down the process of developing innovative solutions to urgent problems. That said, potential projects with partners who are still unfamiliar with your technology are a very long shot.

4.2

Assessment and outlook

EXPERIENCE FROM USE CASES PAVES THE WAY FOR DIGITAL DISRUPTION

The initial hype about blockchain has settled down. While CLI always took a very sober approach to identifying potential for the technology in climate action, the focus of our key questions is evolving from 'what is it and how does it work?' to 'where is the potential for real-life implementation, and how can we do that successfully?' The latter includes a systematic evaluation of technological and related business-models, policy considerations and developing governance paradigms as rules and standards are formulated. This is why selecting, supporting, and empowering use cases has become a rapidly growing pillar of CLI activities. In such a challenging field as the application of innovative digital technologies for climate action and sustainable development in a developing country context, the importance of putting actual use cases to work in the field can hardly be overstated.

The experience of some of our partners in recent years shows that too many ideas and technical concepts that look good on paper fail when applied in real life, particularly in developing countries.

ROBUST AND ACCURATE CLIMATE DATA WILL BE THE BE-ALL AND END-ALL

One big theme from the recent COP26 international climate conference in Glasgow is the need to move *from pledge to plan to performance*. As the international community shifts the conversation further towards the implementation of climate pledges, it will be increasingly important to have climate data correctly and robustly attributed to its sources and responsible entities. In turn, this can help to ensure that funding is deployed efficiently and that those who are accountable exercise their responsibility transparently. While it is possible to do this without blockchain and the other technologies covered by this report, their application does address the complexity of such interdependent attribution. Finally, given that the capacity of global citizens to observe such a system will inevitably be low, it is important at least initially that credible and transparent governance systems are in place.

CLI BEYOND 2022

In addition to sluggish progress towards the Agenda 2030 SDGs, the latest IPCC report highlights the urgent need for accelerated action on climate and sustainable development. The past work of CLI and others demonstrates that innovative digitalisation can be one of several important factors that help efficiently to scale up and leverage the necessary climate action on a global scale. Meanwhile, governments, policymakers, multilateral development banks, and development agencies do not yet seem to have fully embraced the potential of digital technologies. Some appear rather hesitant to take their first steps in this direction, and they may also lack the capacity to apply the technologies successfully. To respond to these needs, CLI is currently working on a new programme of activities for 2022 onwards.

This new programme builds on the existing network of actors, governments, and multilateral development banks, as well as the established process for open calls, shortlisting, and selecting the most promising use cases. It places even greater emphasis on the development, scaling and market launch of those specific use cases that tap digital innovation for climate action and sustainable development in developing countries. We will otherwise be kept busy with our systematic support for development cooperation projects, the MRV of carbon offset systems, and identifying, implementing and mainstreaming digital innovations.

If you are interested in CLI and its activities, please register for our newsletter.

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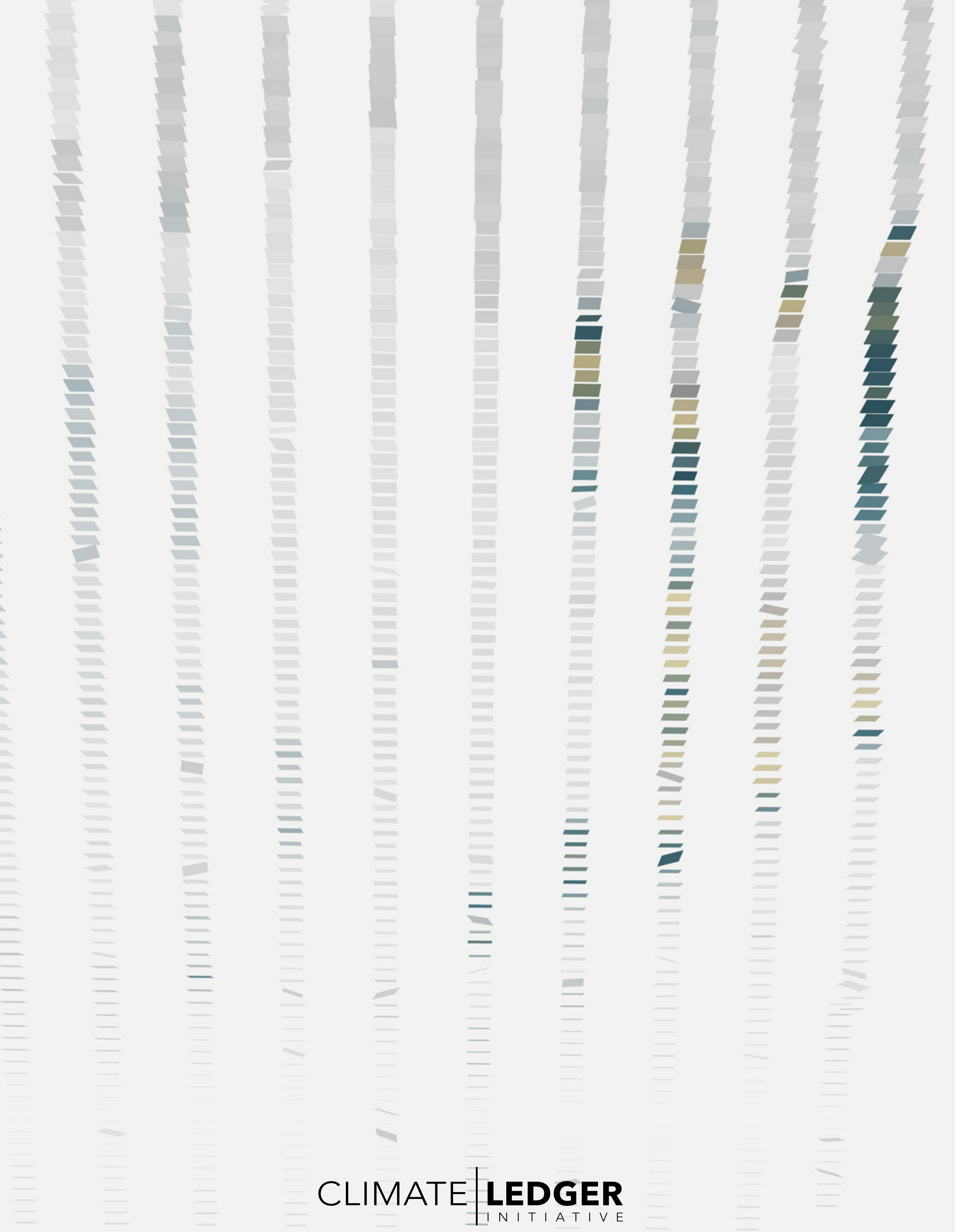

CLIMATE LEDGER INITIATIVE