# [UN]BLOCKED

PROGRAMMING A SUSTAINABLE [WORLD]

# BLOCKCHAIN, WEB3 & THE SDGS

## SUSTAINABLE DEVELOPMENT REPORT

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# Executive Summary

The report explores how blockchain networks as a backbone of the Web3 and the cryptoeconomic mechanisms that enable them can support achieving the SDGs defined by the United Nations. Cryptoeconomics and sustainability researchers of the Vienna University of Business and Economics have worked closely together examining blockchain networks and their applications, and researching relevant sustainability issues, analysing use-cases and identifying relevant stakeholders. Outputs of this applied research are provided in this report.

Analysing the potential of blockchain applications for the implementation of the SDGs in partner countries of the Austrian Development Agency, we came to the conclusion that the most promising cases for the successful application of blockchain are found in the context of SDG 7 (affordable and clean energy) and in the context of SDG 12 (responsible consumption and production).

Blockchain networks, smart contracts and tokens can drive radical innovations in decentralized, environmentally friendly energy supply systems while offering sound bridges to the community engagement aspects of energy networks. Blockchain networks can also provide quickly an effective and decentralised market structure between suppliers and consumers (or prosumers) which are of special importance in the development context, especially in regions, with a fundamental lack of infrastructure and efficient public institutions.

In the context of consumption and production blockchain networks and other distributed ledgers can refer to its already well explored and well documented advantages in supply chain management and to its strengths in the increasingly important field of impact assessment. Herein, supply chain management as well as for impact assessment provide promising links to recent initiatives in the context of fair trade or the integration of regional stakeholders for decentralized impact assessment along international supply chains.

By examining use-cases in a number of different fields and industries such as supply chain, energy, impact and entrepreneurship, the report outlines not only the possible benefits but also challenges, like the large energy consumption of the Proof-of-Work consensus mechanisms which is partly being tackled by tailoring alternative consensus mechanisms and planning the transitions to less energy demanding networks. Technological advancements like scalability and interoperability of blockchain networks and other distributed ledgers remain to be seen in the near future. The rigidity of current legal systems might slow down the process of overcoming legal challenges and jurisdictions' readiness to adapt to decentralised governance models.

Recording data on distributed ledgers like blockchain networks requires a comprehensive system design that examines the economic, legal, environmental and societal implications of such data models and events that derive from them. Grasping the wide range of implications and aligning them towards desirable outcomes demands collaboration across different institutions, juristictions and knowledge domains and strong and long lasting relationships between all stakeholders.

On the journey of achieving such collaborations, a lot more attention should be dedicated to interdisciplinary research than has been witnessed over the past 10 years. For future work, identifying the enablers of interdisciplinary collaborations and implementing them will play a crucial role for successful uses of blockchain technology. For example, clear communication across disciplines can be supported by agreeing on term definitions as in case with "cryptoeconomics", a term which has just recently been confirmed to be context dependent and been given different definitions in regard to micro, meso and macro perspectives (Voshmgir and Zarghan 2019).

# Introduction

Emerging technological innovations in specific the Internet with all its applications and use cases are setting new trends that provoke radical cultural and socio-economic transformation. This ongoing trends, often referred to as "digital transformation", already affects our way of living and will affect it even more in the future. Among the most recent innovations blockchain networks as the backbone for the next generation Internet, what some also refer as the Web3, is seen by many as a game changer which also could be a potential catalyst for achieving the Sustainable Development Goals of the United Nations (SDGs) - especially in the development context. Moreover, blockchain networks are a governance layer on top of the current Internet with the potential to create new social- and market dynamics.

However, there is also criticism about the negative social and ecological impacts blockchain applications might have. This also reflects the global debate on the impact of new digital technologies and the often associated, dangerous reduction of sustainable development to purely technological aspects. Against this background, this research report enters new transdisciplinary territory and dares to attempt to find a balance within a field of tension between belief in technology and technological fears.

The primary aim of this paper is a critical analysis of the opportunities and best practices of blockchain applications for achieving the SDGs. This joint publication will further provide key-criteria and recommendations for the implementation of specific Blockchain & SDGs pilot projects in the Austrian Development Agency (ADA) partner countries. Herein, companies and impact entrepreneurs will learn through the analysed use cases and guidelines, how the adoption of blockchain can support their SDGs related activities in the Global South.

Socio-ecological transformations lay in the root of the Agenda 2030 and call for a radical change from "doing things better" to "doing better things". In order for the socio-ecological transformations to take place, we need to provide an institutional and socio-economic environment that will enable innovations as well as new societal, economic, technological and political models that go far beyond just increasing efficiency and productivity. In this regard, blockchain technologies and blockchain networks have the potential to support the infrastructure layer of such models, contributing to transparency, eliminating power asymmetries, enhancing accountability and incentivising environmentally friendly behaviour.

This output paper will examine if and to which extent Web3 based use cases like blockchain networks and similar distributed ledgers can enable the 2030 Agenda to deliver on its transformative promise.

It might seem that with this focus, we address mainly the field of technological innovations and their contributions to the Agenda 2020 and the SDGs. But as Web3 networks and their applications also provide entirely new modes of decision-making and governance, our focus extends the boundary of technological systems.

The vision of Agenda 2030 stresses the need to go beyond existing approaches of improving unsustainable systems and to transform them instead. Additionally, transformative change addresses social and economic structures and relations that drive unsustainable practices and call for alternative socio-economic trajectories. This means that if blockchain networks want to become real game-changers and help us to implement the SDGs, they have to exhibit the characteristics of disruptive and transformative innovations. Contributing to more business as usual, and even providing a new wave of start-ups improving existing modes of production and consumption will be an essential first step, but it's not enough. This papers will explore whether Web3 applications can also be used to find new forms of value creation towards a more sustainable future.

# How to read this Paper

This paper can be read from three different perspectives: For researchers we provide an integrative and critical overview of the potential of blockchain networks for reaching the SDGs, highlighting the most promising applications in the context of development cooperation.

For companies and policy makers this paper offers a comprehensive analysis of the current state and shows existing best practice use cases. Herein, we provide concrete guidance and recommendations in the context of development collaborations and the SDGs.

For those who aim to implement their own SDGs-oriented-blockchain project, we will offer a basic roadmap for potential pilot projects. Herein, the list of key-criteria and recommendations can be found, and these will assist in evaluating potential blockchain applications in the general context of development cooperation as well as with the SDGs.

# Background of this Report

This report is an output paper of a research collaboration funded by the Austrian Development Agency (ADA). The research was conducted by the Research Institute for Cryptoeconomics together with Regional Centre of Expertise on Education for Sustainable Development Vienna (RCE Vienna) both institutions of the Vienna University of Economics and Business (WU).

During the first phase of the project, we explored and assessed the potential of blockchain networks to help address the SDGs. As a second step, pilot projects were defined in the context of development cooperation. We used an integrative and case-study-based approach to analyse the potential connections and contributions of blockchain to the SDGs. Considering the multidimensional facets of the SDGs the term *integrative* reflects a systemic setting in which our target groups, such as impact entrepreneurs, development agencies, CSOs, business networks, and international institutions interact and share knowledge with those holding expertise in blockchain and derived technologies. The aim was to:

- Map potential blockchain applications that can provide a significant contribution to the SDGs.
- Disseminate information about existing players in the market,possible applications and research areas.
- Consolidate the knowledge retrieved and identify future research and development needs for blockchain-based development projects.

In addition to the theoretical work, a conference - (UN)BLOCKED - was held in April 2019 at the Vienna University of Economics and Business. The aim was to bridge multifaceted gaps in knowledge between technological experts with those who work in sustainability, to find a common ground between policy makers and developers. 600 people attended the conference, from researchers to start-ups and policy makers, including representatives of local and international institutions.

# Agenda 2030 & the SDGs

The Agenda 2030 and its Sustainable Development Goals (SDGs) were born at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. The objective was to produce a set of universal goals that meet the urgent environmental, political and economic challenges facing our world.

The Sustainable Development Goals are often referred to as “a radical plan for humanity” and a new way of “doing development”. They are organised into 17 goals, which cover 169 more detailed targets. The goals are holistic – they cover social, environmental and economic aspects, and they are interlinked – meaning they influence each other and cannot be dealt with in isolation. Although there has been some success in reaching a number of the targets like e.g. poverty reduction or some of the health-related goals. However, our failure to achieve most of the others, e.g. preserving the natural fundament of our societies, will also render the successes useless in the future.

The UN General Assembly adopted the 17 SDGs in New York in 2015. They are binding for all signatory states, including Austria. The official title is "Transformation of our world: Agenda 2030 for sustainable development". Agenda 2030 is to be seen as a global plan for reconciling "dignity, peace and prosperity for man and nature now and in the future". In their third year of implementation, the countries are currently translating this common vision into national development plans and strategies (UN, 2018).

Although criticism in earlier draft versions of the SDGs was more or less ignored (Sachs 2012), asking for more incentives for business (Hajer et al. 2015), demanding inclusion of Safe Operating Space, Planetary Boundaries and the activation of societies suggesting priorities (Lu et al. 2015), the international reaction was overwhelmingly positive. One of the reasons for this positive echo from science and civil society was the fact that the SDGs can be seen as concrete guiding posts for both policymakers as well as for business. Positive assessments refer to individual targets and to the overall content, although some authors highlight that the expected thematic benefits arise only if the SDGs as a whole are taken into account (e.g. Orme et al. 2015; Waage et al. 2015).

Replacing the Millennium Development Goals (MDGs), the SDGs are not only highly relevant for developing countries - the SDGs are of enormous importance especially for industrialised countries such as Austria, as these countries are increasingly confronted with the task of acting as driving forces for a necessary socio-ecological transformation and of driving it forward rapidly. Addressing the SDGs also means that traditional boundaries for classifying countries as developing or developed have to be rethought: when a sustainability lens is applied, all countries are “developing” (…). The fight against global warming, the progressive loss of biodiversity, the increasing scarcity of natural resources, global inequalities, but also developments such as digitalisation, automation and changing demographics are just some of the many problems that make innovation and above all courageous action in economic, ecological and social areas indispensable – in all parts of the globe.

## Socio-ecological transformations & the SDGs

“Transforming our world”, as the 2030 Agenda is titled, is a far more challenging task than business as usual and it goes far beyond the narrow focus on efficiency gains and technological progress. Regarding the imperative of change emphasised by the climate and biodiversity crisis and our crossing of several other planetary boundaries, this task is very necessary, and it lies at the very heart of sustainable development itself. Transformation requires attacking the root causes that generate and reproduce economic, social, political and environmental problems, not merely their symptoms. It means nothing less

than a radical shift in the way we produce, consume, and make our decisions (Global Sustainable Development Report 2019).

Therefore, the new transformative 2030 Agenda is more than welcomed and highly needed. Instead of segregated policies in separate domains and economic sectors, it could lead to policy integration and push for an "eco-social" shift that helps us to embark on different socio-economic trajectories, both in terms of human well-being and inclusive development. Such a transformative agenda aims at doing better things and not at doing things better. This emphasises doing things differently to achieve radically different outcomes, rather than doing more of the same but in a more efficient way. Such a vision of radical change inspires hope for breaking the vicious circle of poverty, inequality and environmental destruction confronting people and the planet.

Against this imperative of change, we have to ask ourselves, what needs to happen to enable the 2030 Agenda to deliver on its transformative promise? What kind of new models, innovations and new approaches to socio-economic development do we need to enhance necessary transformations?

Referring to the implicit transformative fundament of the SDGs, the challenges of implementing the SDGs are challenges of initiating qualitative changes in different societal, technological, economic and political domains that are necessary to achieve the SDGs. Obviously, innovation is key to these challenges, but the term *innovation* goes far beyond improving the status quo through increased efficiency and productivity.

## Innovation and the SDGs

Researchers, as well as the UN, agree that to achieve the SDGs, transformational processes are necessary, and these go far beyond business as usual. It is required to attack the root causes that "generate and reproduce economic, social, political and environmental problems and inequities, not merely their symptoms… Indeed, it is the vision of doing things differently to achieve radically different outcomes, rather than doing more of the same, that inspires hope for breaking the vicious circle of poverty, inequality and environmental destruction confronting people and the planet." (UNDRISD 2016)

The UNDRISD Flagship Report 2016 (UNDRISD 2016) names three characteristics that mark desirable transformative change: (i) progressive (in a normative sense of social justice), (ii) systemic (addressing various factors simultaneously and in an interrelated way), and (iii) long term (cannot be easily reversed in the short term). This calls for innovation that supports transformation – leaving us with the question how such innovation could be characterised. In their paper on sustainability-oriented innovation (SOI) Broken et al (2015) present a model that can also be used to characterise the transformative potential of innovation (see figure below).

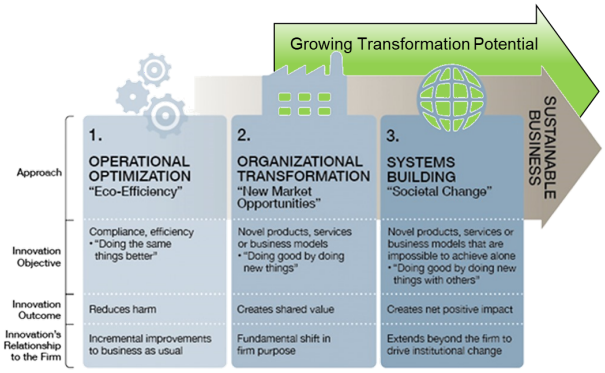


***Figure 1.*** *Model of SOI. Adapted from 'Sustainability-oriented Innovation: A Systematic Review, by Adam et al., 2015, International Journal of Management Reviews, 18, p.180 - 205*

Broken et al distinguish between three types of innovation which are differentiated along the axis of their objectives, outcomes and their relationship to the company. The first type "Operational optimisation" has an efficiency focus (doing the same things better) and represents an old fashioned view on innovation – often also characterised by a technology-centred focus on innovation. This kind of innovation might reduce harm but does

not contribute to a transformation as defined above. The two other types of innovation "Organisational transformation" and "System building" both focus on "doing good by doing new things" – the former approach also including a strong community or cooperation-centred approach. Both of them open the possibility to foster sustainable transformation. Both also apply a wider people-centred approach to innovation.

In this light, we ask the question how can blockchain as an emerging and novel technology contribute to the SDGs, e.g. by introducing new, transformative changes in relevant sectors. Keeping the SOI model in mind, the answer is that transformation potential depends more on the context of the innovation and the resulting application case then on the technology itself.

Blockchain Networks offer the potential to foster and enable new business models – and through the use case of the Bitcoin network, it has shown its transformational potential (although not in the sense of sustainable transformation) in the field of finances and banking. The increase in efficiency in transactions and the like that is often brought forward as the main contribution of the technology in the context of its transformative potential actually is the least impactful contribution to the needed sustainable transformations - although it might be the best selling point for blockchain projects towards companies locked in the first stage of SOI.

On the other hand, its ability to create self-organised and independent systems together with its focus on fostering behavioural change has a big potential for businesses interested in the second and third stage of SOI. Important for all blockchain projects striving to support sustainability transformation through innovation is to shift the focus from purely technological fixes to problems to a more holistic view on sustainability problems, conceptualising them as socio-technological challenges. The effects of a cluster of elements like, for example, regulations, user practice and markets cultural meaning, infrastructure and supply networks have to be considered leading to innovation beyond pure technical domains, i.e. adopting new business models.

Implementing transformative change requires innovative approaches: in conceptualising and defining problems and potential solutions, designing policy and institutional reforms, changing social structures and norms, and using new technologies that are affordable, socially acceptable and effective.

# Blockchain & the Web3

*If we assume that the WWW has revolutionized information and the Web2 revolutionizes interactions, the Web3 has the potential to revolutionize agreements and value exchange. It changes the data structures in the backend of the Internet, introducing a universal state layer, often by incentivizing network actors with a token.*[1]

The Internet we have today is broken. We do not control our data, nor do we have a native value settlement layer. Thirty years into mass adoption of the Internet, our data architectures are still based on the concept of stand-alone computers, where data is centrally stored and managed on a server, and sent or retrieved by a client. Every time we interact over the Internet, copies of our data get sent to the server of a service provider, and every time that happens, we lose control over our data. Even though we live in a connected world, with more and more devices getting connected to the Internet - including our watches, cars, TVs, and fridges - our data is still centrally stored: on our computers or other devices, on the USB stick, and even in the cloud. This raises issues of trust. Can I trust those people and institutions that store and manage my data against any form of corruption - internally or externally, on purpose or by accident?

In this context, blockchain seems to be a driving force of the next-generation Internet, what some refer to as the Web3. Blockchain networks reinvent the way data is stored and managed. They provide a unique set of data (a universal state layer) that is collectively managed. This unique state layer for the first time enables a value settlement layer for the Internet. It allows us to send files in a copy-protected way, enabling true P2P transactions without intermediaries, and it all started with the emergence of Bitcoin.

The Internet we use today doesn't have a native mechanism to transfer what computer science refers to as state - the status of who is who, who owns what, and who has the right to do what. State, however, is a key property for managing values. The ability to easily and efficiently transfer value P2P is at the heart of finance and efficient markets. If you can't hold state in the Internet, you can't transfer value without centralized institutions acting as clearing entities. Stateless protocols like the current Internet protocols only manage the transfer of information, where the sender or receiver of that information is unaware of the state of the other.

## Blockchain Networks

Blockchain networks are peer-to-peer (P2P) networks and provide a universal data set that every actor can trust, even though they might not know or trust each other. This data set is a list of who owns which tokens. Tokens can represent any asset or access right of the digital or physical work.

The concept of blockchain first came to fame in October 2008, as part of a proposal for Bitcoin (Nakamoto 2008), with the aim to create P2P money without banks. The underlying blockchain technology allows us to trust the outputs of a socio-technological system without trusting any human actors within it.

In the current Internet, because of its client-server architecture, digital information can be copied, and copies of that same digital file can be sent from one computer to multiple other computers at the same time. In a blockchain network all the computers in the network hold an identical copy of a ledger of transactions, which acts as a single point of reference. Since transactions are recorded across many computers, data on the blockchain cannot be altered retroactively without the consent of a majority of network actors and without the alteration of all subsequent blocks. This new form of distributed data storage and management also avoids the double-spending

[1] *This chapter is a summary of the book "Token Economy" (Voshmgir 2019b) written by one of the co-authors of this report.*

problem of existing value transfer over the Internet.

*The Ledger* is a file that maintains a continuously growing list of transaction data records, chained in blocks that are cryptographically secured from tampering and revision. Each block furthermore includes the cryptographic hash of the prior block in the blockchain, linking one block with another into a chain of blocks, which guarantees the integrity of the previous block all the way back to the first block, also referred to as the genesis block.

*Distributed Ledger:* A copy of the ledger is stored on multiple devices of a cryptographically secured P2P network controlled by an unknown set of people and institutions (network nodes) who do not know each other and where one has to assume that any of these network nodes could be potentially corrupt. In order to change the contents of that file on all copies of the network, network users need to reach a mutual agreement, also referred to as consensus. Blockchain can therefore be described as a shared, trusted, public ledger of transactions, that everyone can inspect, but which no single user controls. Each independent node has the latest version of the ledger, which contains all transactions that have ever been made, and can verify transactions. This is particularly useful in inter-organizational setups where no institution wants to trust another institution with the management of their data.

*Consensus:* The Consensus Rules of a Blockchain network govern how the participants in the network interact with each other. They define the rules of participation, feasible actions, and say when and by whom actions may be taken in the network. Every node involved "knows" the consensus rules defined in the protocol.

*Proof-of-Work* was the ground breaking consensus mechanism introduced by the Bitcoin blockchain that enables distributed control over the ledger. It is based on the combination of economic incentives (in case of the Bitcoin network the Bitcoin token) and cryptography. This reward mechanism is designed to make it economically infeasible to cheat the network; taking into account even extreme attack scenarios due to the immense amount of computing power that would be required to do so.

*Reward Mechanism*: The consensus rules are designed to collectively maintain a public infrastructure (in the case of Bitcoin and P2P payment networks) by rewarding node operators with native network tokens (ie. Bitcoin tokens), if and when they contribute to the security of the network. They make the network attack resistant, in spite of the lack of centralised parties to govern the truthfulness of network activities. This guarantees that each unit of value is transferred only once. In order to change the contents of a file, network users need to reach a mutual agreement, also referred to as consensus.

Tokens: The term "token" is simply a metaphor. Contrary to what the metaphor might suggest, a token does not represent a digital file that is sent from one device to the other. Instead, it manifests as an entry in the ledger that belongs to a blockchain address. Only the person who has the private key for that address can access the respective tokens.

To sum it up, blockchain protocols introduce a mechanism that makes it expensive to copy digital values and thus enables the rise of collectively managed digital values like the Bitcoin token, but also many other tokens that could represent any asset, currency or access right. People and institutions who do not know or trust each other, reside in different countries, are subject to different jurisdictions, and who have no legally binding agreements with each other, can now interact over the Internet without the need for trusted third parties like banks, online platforms, or other types of clearing institutions.

Blockchain can, therefore, be described as a shared, trusted, public ledger of transactions, as a distributed accounting machine, or supranational governance machine, that everyone can inspect, but which no single user controls. This system allows us to replace the role of many trusted intermediaries, securely managing and verifying information, bypassing many problems of the walled gardens of

client-server architecture, of the current Internet architecture.

Unlike distributed databases, where data is distributed but managed and controlled by one single entity, blockchains allow for distributed control and is ideal for collective governance across jurisdictional boundaries. Different parties that do not trust each other share information without requiring a central administrator. Each independent node has the latest version of the ledger, which contains all transactions that have ever been made, and can verify transactions. This is particularly useful in inter-organisational setups where no institution wants to trust another institution with the management of their data, from supply chains to international remittances.

The Bitcoin network and similar blockchain networks introduced a method for each participant in a network to hold and transfer value in a digitally native format, without the need for trusted intermediaries. The consensus protocol is designed in a way that the network can collectively remember preceding events or user interactions. Their underlying protocols resolve the problem of double-spending by providing a single source of reference for who received what and when. They can, therefore, be seen as a game changer, paving the way to a more decentralized Web. Before the emergence of Bitcoin, there has never been a practical implementation of a P2P network that managed to avoid the double-spending problem, without the need for trusted intermediaries guaranteeing value exchange.

## Other Distributed Ledgers

While *Proof-of-Work* is groundbreaking, as it resolved the problem of consensus in untrusted networks like the Internet, it comes at a cost. The mechanism guarantees security in an untrusted network, but it is slow, energy intense, and favors those who have more economic resources to spend. This is why many researchers and developers started to explore alternative consensus mechanisms.

The research questions that need to be resolved are: (i) How do we reach consensus on one version of history that the majority accepts as true? (ii) What is the economic incentive to collaborate? (iii) How can one align scarce natural resources (like electricity and CPU) with network resources to prevent malicious actors from spamming the system with bad behaviour? (iv) Where does security come from? (v) What are the security risks and attack vectors?

With the advent of derived technologies using modified governance rules to the original Bitcoin protocol, it seems necessary to classify different distributed ledger solutions. The main distinction is designed around the question of who is allowed to (I) validate transactions, (II) write transactions to the ledger, and (III) read transactions. Depending on the type of ledger, the answer will vary. To keep things simple, we can say that in public networks anyone can validate, write, and read transactions. Whereas in private networks, only invited members can validate, write, and read transactions. Hybrid variations are also possible. An example would be that validation and writing to the blockchain is invite only, but reading at least selected transactions is public.

Public and permissionless blockchain networks are designed on the assumption that everybody is potentially corrupt, and that the least common denominator is money. The consensus mechanisms allow for the creation of a new type of global governance tool, steered by economic incentives tied to the creation of the native token. The role of the native token is to encourage a disparate group of people who do not know or trust each other to organize themselves around the purpose of a specific blockchain network or similar public ledger, without the need of centralized institutions. The token is therefore an integral part of the incentive scheme.

While tokenized incentives make the untrusted networks safe, they also make them very slow. Public and permissionless networks can only handle a few transactions per second, which makes them unfeasible for large-scale applications with high transaction volumes. However, various technological solutions are currently being proposed to resolve these scalability issues.

## Public vs. Private Ledgers

Another question revolves around how trust in this network is generated: (I) algorithmic trust; or (I) trust though legal contracts. Public networks, for the lack of existing legal relationships, require algorithmic trust guaranteed by consensus mechanisms like "Proof-of-Work." All nodes participating in the consensus protocol are untrusted, as they are not known beforehand. The consensus mechanism for such a setup has to account for maliciousness. The token is an essential mechanism component to make this network of untrusted actors attack-resistant. Private and permissioned ledgers, on the other hand, have a federated setup with bilateral contractual agreements. It's an invite-only members club. Members trust each other because they have bilateral contractual agreements with each other, and if anything goes wrong, they know who to sue. Permissioned ledgers therefore do not need a token to incentivize coordinated action, whereas it is integral to permissionless networks.

The fact that the identities of all participating nodes are known beforehand provides a natural protection against "sybil attacks." Private and permissioned ledgers can therefore settle much more transactions per second, as they don't have to deal with an unknown amount of anonymous nodes. They also provide more privacy than current state of the art public blockchains. Permissioned ledgers are mostly used by industry consortia. Transaction verification is conducted by a pre-selected set of participants, for example sixty financial institutions, each of which operates a node, and where forty must sign every block in order for the block to be valid. Depending on the industry and use case, the right to read data of the ledger may be public, partially public, or restricted to the participants.

## Alternative Consensus Mechanisms

As for public networks, many different consensus algorithms are currently being experimented with. However, *Proof-of-Work* and *Proof-of-Stake* are currently the most widely spread consensus mechanisms.

*Proof-of-Stake (PoS)* is a consensus mechanism where only network actors who have a financial stake in the network could add the blocks in the blockchain. Instead of sacrificing energy to validate a block, users must prove they own a certain amount of the network tokens to generate a block. Holding tokens in a wallet represents one's stake. There are many variations of PoS implementations. Early PoS proposals assumed that those who have more stake in the system have natural incentive to act in a truthful manner when validating transactions and writing blocks. Token holders should have an interest in the success of that network; otherwise, their stake in the system would devalue if they contributed untruthfully.

It was assumed that the more of the token one owned, the more one had at stake if the network was attacked. Voting rights were therefore proportional to the amount of stake held in the network. However, there is a problem in the original "Proof-of-Stake" mechanism: as opposed to PoW, where mining is costly, and it is therefore not smart to waste your energy on a fork that won't earn you any money, PoS doesn't have such a provision. In a Proof-of-Stake network, one does not need computationally intensive work to create a block. It is assumed that the validator has nothing to lose but a lot to win.

The *Peercoin* network was the first project to introduce PoS. Other implementations that followed are found in *Tendermint* (*Cosmos Network*), *Ouroboros* (*Cardano Network),* and other networks like *Tezos*, *Dfinity*, *Nxt, BlackCoin, NuShares/NuBits, Qora*, each of which have different properties. Some like the *Decred network* combine elements of both PoW and PoS. The Ethereum project is planning to transition from PoW to PoS.

*Delegated Proof of Stake (DPoS),* as implemented by the *BitShares* network for the first time, is a more radical variation of PoS. Validators don't compete with each other to create a block of transactions. It is a kind of representative democracy where token holders (stakeholders) can vote for the validator. Token

holders do not vote on the validity of single blocks, they vote to elect delegates to do the validation on their behalf and who might be shuffled periodically or given an order to deliver their blocks in. Instead of competing on validating blocks, there are designated time slots for each delegate to publish their block. Token holders can withdraw their vote for a delegate, if delegates continually miss their blocks or publish invalid transactions. By partially centralizing the creation of blocks, DPoS is able to run orders of magnitude faster than most other consensus algorithms.

Different networks use their own variation of DPoS, examples of which are blockchain networks like *Steemit*, *EOS*, and *Lisk*. There are even more variations of PoS, most of which are only conceptual or have been implemented by one network only: *Leased-Proof-of-Stake*, *Proof-of-Importance*, *Proof-of-Capacity*, *Proof-of-Weight*, *Proof-of-Authority*, *Proof-of-Elapsed-Time*.

Another group of consensus mechanisms are variations of *Byzantine Fault Tolerance*, like *Federated Byzantine Agreements* (networks like *Stellar* or *Ripple*), *Practical Byzantine Fault Tolerance* (*Hyperledger Fabric*), and *Delegated Byzantine Fault Tolerance* as used in the *NEO* network.

Some more alternative protocols use a combination of mechanisms, such as *Hashgraph* (asynchronous Byzantine Fault Tolerance, Gossip Protocol, Virtual Voting). Furthermore, there is a whole series of protocols that use *Directed Acyclic Graphs (DAGs)*, like *IoT Chain*, *Byteball*, *Block Lattice (Nano)*, and *IOTA (Tangle)*.

The consensus mechanism of DAGs differ fundamentally from blockchain networks. Instead of bundling data together into blocks that are then confirmed one after another, Directed Acyclic Graphs require newly added data to reference and validate past data. Usually, each new transaction would have to reference and validate two transactions that came before. In doing so, the network comes to form a graph of converging and confirmed transactions. If one were to incorrectly validate a past transaction, one's own transaction would fail to be confirmed by other participants. DAGs are a complex data architecture where transactions are not sequentially ordered like in blockchain networks, but transactions flow in the same direction. In theory, this form of consensus not only solves the current problem of centralisation of bitcoin's mining, but also greatly improves the whole distributed networks throughput capacity – thereby lowering, or eliminating, the transaction costs.

Many DAGs utilise a structure that employs little or no transaction fees. However, they are susceptible to multiple points of failure due to having a lower threshold to gain an outstanding share of network power. Although widely scrutinised, and ripe with problems, there is great hope that DAGs will become the basic data structure for the next generation of blockchains.

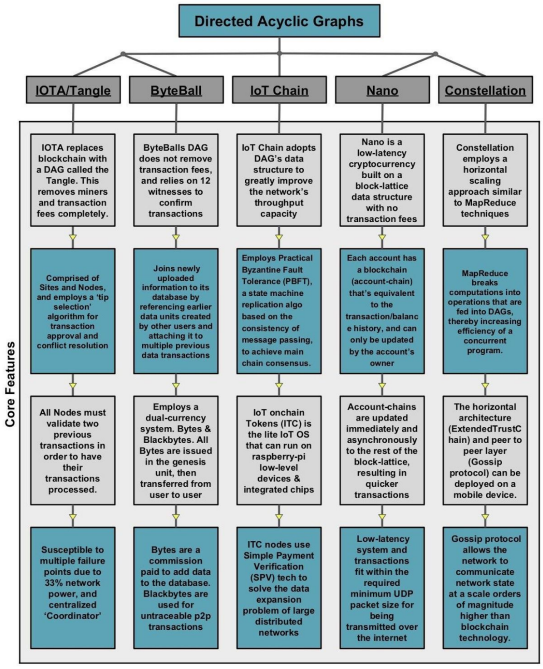


***Figure 2.*** *Directed Acyclic Graphs. Reprinted from 'Distributed Ledger Technologies Ecosystem Mapping' by M. Johnson, 2018.*

Explaining each of the consensus mechanisms listed above in detail is beyond the scope of this report and would require a dedicated book on comparing different consensus mechanisms.

## Smart Contracts

A smart contract is a self-enforcing piece of software that is managed by a P2P network of computers. Smart contracts are efficient rights management tools that provide a coordination and enforcement framework for agreements between network participants - without the need for traditional legal contracts. They can be used to formalise simple agreements between two parties, the bylaws of an organisation, or to create tokens. Every process, task and payment would have a digital record and signature that could be identified, validated, stored, and shared, and thus protecting them from deletion, tampering, and revision. Blockchain applications might replace many tasks of intermediaries like lawyers, brokers, bankers, and public administrators.

Individuals, organisations, machines, and algorithms can now interact with one another with little friction and at a fraction of current transaction costs. If implemented correctly, smart contracts could provide transaction security superior to traditional contract law, thereby reducing coordination costs of auditing and enforcement of such agreements. On the other hand, some of the costs would shift to the people responsible for formulation and coding of smart contracts. Trust issues would then shift to the correct functioning of the oracles, to the people coding the contracts or to the technology as such. A smart contract can be invoked from entities within (other smart contracts) and outside (external data sources) the blockchain. Among these entities, the so-called "oracles" inject data that is relevant to the smart contract from the off-chain world into the smart contract information store.

Smart contracts can track the performance of an agreement in real-time and can, therefore, save costs as compliance and controlling happens on the fly. Smart contracts reduce the transaction costs of agreement by orders of magnitude, in specific they reduce the costs of (i) reaching an agreement, (ii) formalisation, (iii) enforcement. Furthermore, smart contracts bypass the so called principal-agent dilemma[2] of organisations, providing more transparency and accountability and less bureaucracy. The term smart contract itself is a bit unfortunate since smart contracts are neither particularly smart nor are they to be confused with a legal contract. (i) A smart contract can only be as smart as the people coding it, taking into account all available information at the time of coding. (ii) While smart contracts might have the potential to enforce legal contracts if certain conditions are met, we first need to resolve many techno-legal questions, which will require time and interdisciplinary discourse between lawyers and software developers.

## Oracles

Blockchains and smart contracts cannot access data from outside of their network. In order to obtain information from the outside world that is relevant to, e.g. a smart contract, so-called oracles are used. These oracles feed the smart contract with external information that can trigger predefined actions of the smart contract. This external data stems either from software (Big Data application) or hardware (Sensors, Internet of Things) and could be any data like weather temperature, successful payment, or price fluctuations. There are different types of oracles: *Software Oracles, Hardware Oracles, Inbound Oracles, Outbound Oracles, Consensus-based Oracles.* The main challenge with oracles is that people need to trust these outside sources of information, whether they come from a website or a sensor. Oracles are often the most critical element in blockchain networks, as it is here where data from the outside world enters the blockchain. All manipulations to the data at this stage will be collectively stored by the network and will not be visible as wrong or manipulated hereafter. Different trusted computing techniques can be used as a way to solve such issues.

[2] *Principal-agent dilemma occurs when the agent of an organization has the power to make decisions on behalf of, or impacting another person or entity in the organisation, and fails to do so in their best interest. An example hereof could be managers that act on behalf of shareholders or politicians that act on behalf of citizens.*

# Tokens

Cryptographic tokens represent programmable assets or access rights, managed by a smart contract and an underlying blockchain network or similar distributed ledger. They might affect the financial world in the same way as email affected the postal system. They are accessible only by the person who has the private key for that address and can only be signed using this private key.

Tokens are not a new thing and have existed long before the emergence of blockchain networks. Traditionally, tokens can represent any form of economic value. Shells and beads were probably the earliest types of tokens used. Other types of tokens are, for example, casino chips, vouchers, gift cards, bonus points in a loyalty program, coat check tokens, stock certificates, bonds, concert or club entry tokens (represented by a stamp on your hand), dinner reservations, ID cards, club memberships, train or airline tickets. Paper money or coins are also tokens, and like them, most tokens have some inbuilt anti-counterfeiting measures, which may be more or less secure - in order to prevent people from cheating the system.

Tokens are furthermore used in computing, where they can represent a right to perform some operation or manage access rights. A web browser, for example, sends tokens to web sites when we surf the web, and our phone sends tokens to the phone system every time we use it. A more tangible form of computer tokens is tracking codes that you get to track your parcel with postal services or QR codes that give you access to a train or plane. In psychology, tokens have been used as a positive reinforcement method of incentivising desirable behaviour in patients, especially in a hospital setting.

Cognitive psychology also uses reward tokens as a positive reinforcement tool to change behaviour, by rewarding some action with a medium of exchange that can be exchanged for special privileges. Such reward tokens, or incentive tokens are used in the context of loyalty programs for example.

Cryptographic tokens, however, are often issued with just a few lines of code using a simple, smart contract collectively managed by a blockchain network. These special type of smart contracts, also referred to as token contracts, define a bundle of conditional rights assigned to the token holder. Token contracts are essentially rights management tools that can represent any existing digital or physical asset or access right to assets someone else owns. Tokens can represent anything from a store of value to a set of permissions in the physical, digital and legal world. Tokens can also incentivise an autonomous group of people to contribute to a collective goal individually. These tokens are created upon proof-of a certain behaviour.

Terms like *cryptocurrency*, *crypto asset* and *tokens* are very often used synonymously. The media mostly tends to refer to these new assets as *cryptocurrencies*, which is often used to describe a diverse range of *crypto assets* or *tokens* that could represent anything from a physical good, a digital product, a security, a collectable, a royalty, a reward or a ticket to a concert. The term *cryptocurrency* is not ideal since many of these new assets were never issued with the intention to represent money in the first place.

Cryptographic tokens have lower issuance and management costs than state of the art digital assets. They can be easily issued and securely traded over a blockchain network, without an intermediary or escrow service. In contrast, state-of-the-art digital assets are controlled by centralised entities; they can now be issued with a few lines of code managed by a public and verifiable infrastructure like blockchain. Blockchain tokens can:

- Provide more transparency in marketplaces than with existing financial systems. This could significantly reduce fraud, or corruption, e.g. along the supply chain of goods, services and financial transactions.
- Reduce transaction costs of developing, managing and trading of cryptographic assets along distributed ledgers, compared to managing assets along state-of-the-art systems. This could lower barriers to create

efficient marketplaces for products and services that are not currently tokenised, like art or real estate.

- Increase liquidity, lower costs of price discovery, and create less fragmented markets for such products and services.
- Result in completely new use cases, business models and asset types that were not economically feasible before and potentially enable completely new value creation models that could also be more inclusive.

## Interoperability

While the number of blockchain networks and similar systems, as well as their tokenised applications is growing at a rapid pace, these distributed ledgers remain isolated. Most blockchain networks and other distributed ledger systems work as a silo. This means that one network has no knowledge of what happens on other networks, therefore tokens are not interoperable across networks. Interoperability in this context refers to the ability to share information across blockchain systems freely. The future of the Web3 might very well depend on the ability of blockchain networks to interact with one another. Interoperability can also enable different blockchains to easily communicate with one another without the need for an intermediary, like for example, a centralised exchange. It is hard to predict when such interoperability will be feasible. Different solutions and standards are working on the question of interoperability like *Cosmos*, *Polkadot*, or *Wanchain*, as well as the emergence of atomic swaps (Voshmgir 2019b).

## Scalability

One of the greatest challenges of distributed consensus like Proof-of-Work is that it makes the network safe, but slow. This is due to the trade-off between all dominant attributes of blockchains: decentralisation, security and scalability. Scalability is a big issue when it comes to evaluating the feasibility of tokenised use cases and a future of a token economy (Voshmgir 2019b). The "scalability trilemma" refers to the trade-off between all dominant attributes of blockchains: (I) decentralisation; (II) security; (III) scalability. Security is the most important aspect in a distributed network of untrusted actors. Decentralisation is the premise of distributed networks. Scalability refers to the number of transactions a system can process per second. As a result of this trade-off, the attribute of scalability wasn't a core feature in the early years of blockchain development. The demand for the technology was still marginal. Balancing scalability, decentralisation and network security might be the holy grail of decentralisation. However, it might be resolved over time as the technology matures.

Many solutions have been proposed to make transactions faster and cheaper, paving the way for mass adoption of this new technology. There is ample debate whether this should be resolved on a protocol level, often making concessions to decentralisation. In order to allow for more transaction volume, it would require one to grant more power to certain participants, and thus to increase the level of centralisation. On the main protocol level, alternative consensus mechanisms try to resolve the scalability issue by introducing a sort of permission layer to guarantee trust. Sharding of the ledger, which refers to partitioning the ledger into several smaller parts, or alternative cryptographic algorithms, are other means to address the scalability problem on protocol level. As an alternative, various efforts have been made to move scalability solutions to a second layer, like side-chains or state channels. In these cases, user interaction is moved out of blockchain and onto a second layer, while still allowing risk-free P2P transactions between participants.

## Legal Challenges

Regulation is a complex topic, taking into account all 200+ jurisdictions in the world. Many aspects of this new technology, including its applications, need explicit regulation, or change in existing regulation. The situation differs from country to country and from

industry to industry. In order to provide regulatory certainty to entrepreneurs, some jurisdictions have started to offer governmental sandboxes to guarantee innovation – allowing for a process of regulatory learning.

## Energy Consumption of Blockchain Networks

The electricity used for the Bitcoin network has become a topic of heavy debate. Media coverage about mining aspects of Bitcoin and other blockchain networks very often focus on the energy inefficiency of this new Internet Infrastructure, usually providing comparisons of its energy usage to smaller countries such as Switzerland, Iceland or Denmark.

As outlined before, the Bitcoin payment network uses an energy-intense security mechanism Proof-of Work (PoW). The exact amount of energy consumed by the Bitcoin network is not quite clear and ranges significantly between the lowest estimate of 4.12 TWh/year (Brevand 2017) up to 73 TWh/year (Digiconomist 2019). An estimate from January 2018 concludes that the Bitcoin network consumed on average 2100 MW or 18,40 TWh/year (Brevand 2017). The latest data from May 2018 states at least 2.55 gigawatts of electricity consumption (De Vries 2018). In contrast, a real-time energy consumption index from Cambridge University assumes a range between 31Tw/h and 68 TW/h (CBECI 2019).

These numbers sound shocking compared to a country like Iceland, which uses as much as 18.1 TWh/year. As a comparison, the energy demand of all existing data centres is assumed to be as high as 200 TW/h (Andrae & Edler 2015). As outlined in the prior chapters, however, alternative distributed ledger systems using different consensus mechanisms that are more energy efficient than PoW are being researched and developed. The scalability of these PoW networks is also being improved with different approaches (state channels, side chains, alternative cryptographic methods that reduce the bloat of a block and allow more throughput, and other interoperability solutions that can allow more overall throughput per unit energy used). It is therefore a matter of time until the carbon footprint of a blockchain transaction will be reduced.

Furthermore, the carbon footprint of a Bitcoin transaction needs to be compared with the carbon footprint of current financial transactions like credit card payments or remittances, but this data is not available and can only be estimated. After all these companies and their operations also have a carbon footprint, but it is unclear how high the footprint of a financial transaction in the current global financial system is.

During the scope of our research Parrer (2019) did a comparative analysis of CO2 Footprint of Bitcoin transactions versus traditional financial transactions following the Life-Cycle-Assesment approach to set up a model quantifying all material flow inputs and outputs. In order to meaningfully compare CO2 footprints of Bitcoin transactions and the traditional means of payment, such as cash or credit card transfers, the functional unit was set as one Bitcoin transaction in the Bitcoin network regardless of its size. By following the Life-Cycle Inventory Analysis, which demands the compilation and quantification of all inputs and outputs for a product throughout its entire life-cycle, the identification of system boundaries resulted in a number of parameters such as energy consumption, e-waste (GPUs, FPGAs, ASICs etc.), equipment transport and hardware recycling ratio. A comparison to traditional payment methods is given by examining existing reports on debit and credit card, PayPal and cash transactions. The research concludes that none of the available reports on the established payment methods uses an approach that would allow comparison between them and between a Bitcoin transactions or other transaction in another blockchain network, due to different system boundaries or functional units used.

# “Good Governance” Applications

Improving “good governance” is a field in which blockchain and Web3 based applications can have a big impact. In the context of the SDGs and for sustainable development in general - good governance is an important enabling factor. The term good governance refers to “a set of qualitative characteristics relating to processes of rulemaking and their institutional foundations. It encapsulates values such as enhanced participation, transparency, accountability, and public access to information. It also helps to combat corruption and secure both basic human rights and the rule of law” (UNU-IAS, 2015).

The UN states that “good governance” should support local implementation actions of the Rio Resolutions and Agenda 21 for real progress towards sustainable development and assist societies developing an effective government within a democratic system and in implementing sustainable development principles through global partnerships by way of:

- *Empowering the public to enable them to participate in decision-making for public interest effectively and to undertake local initiatives;*
- *Developing and strengthening good governance at the local level;*
- *Developing the capacity of the public and the government at the local level to cooperate in increasing the welfare of the people. (Good Governance in Sustainable Development 2019)*

Good governance is especially reflected in Goal 16 which asks to “Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.”

Blockchain networks and derived applications are governance technologies that facilitate coordination over the Internet and have the potential to support “good governance” practices. They can reduce transaction costs of coordination and policy enforcement (aka bureaucracy) by increasing transparency and accountability, thereby also reducing corruption. Blockchain-based applications are also seen as a development vehicle, which can help to empower people directly and mitigate power and information asymmetries.

Existing examples of blockchain-based applications in the field of governance show that Web3 based applications can complement existing governance systems. The following areas are seen as the most promising contributions of the blockchain networks and the Web3 to the SDGs:

- *Transparency and accountability regarding individual and collective action, as well as reliable provenance, e.g. within global supply chains.*
- *Reduction of bureaucracy and power asymmetries trough disintermediation and more inclusive and transparent governance structures*
- *Incentivising collective action towards a common goal.*

Selected application fields of blockchain networks and similar distributed ledgers analyzed in this report are: (i) supply chain transparency, (ii) impact assessment, (iii) collective value creation with purpose-driven tokens, (iv) government transparency & accountability, (v) inclusion of the undocumented and underbanked (vi) impact entrepreneurship, (vii) potential new markets (example: renewable energy sector).

However, as Web3 networks and their applications are still emerging, it is necessary to distinguish between “potential use cases” and “implemented use cases”. Potential use cases are areas where blockchain networks are believed to have a great impact in the future, but the applications have not been brought close to market yet. Implemented use cases, on the other hand, are areas where

blockchain-based technology has already been used at least in one operational environment. For each use case, we frame our analysis around three questions:

- What is the problem that needs to be addressed?
- Is blockchain technology better at addressing this problem than existing approaches and technologies?
- What are the challenges of using blockchain technology in this space and what new risks might it create?

It seems unlikely that the technology, at least in its current state, can replace or work in the context of broken or very weak governance systems. In his review of the potential of blockchain to disrupt government corruption, Carlos Santiso states that *"early experiments suggest that blockchain-based solutions will not work in all institutional contexts […] there are a number of prerequisites that ought to be met. These include […] that the existing data must be accurate, registries must be digitized, and the digital identity system should be reliable. There also needs to exist sufficient connectivity, a tech-aware population, and existing tech support services."*

## Use Case 1: Supply Chains

As globalization has spread the production of goods around the world, the social and environmental impacts of consumption in rich and emerging economies have increasingly been displaced to distant locations via global supply chains. With 80% of global trade flowing through multinational corporations, one in five jobs is tied to global supply chains, and over 95% of environmental impacts of food and retail companies stem from supply chains. Supply chains therefore play an outsized role in many of the most pressing social and environmental challenges (Lambin 2018).

With increasing globalisation supply chains have become more and more complex. Depending on the sector, they can span over several continents or countries and involve a diverse set of actors and companies. A typical chocolate supply chain, for instance, will involve a large number of small scale farmers in western Africa, local in-between traders, state-run and private certification, quality control and labelling bodies. A few big multinational global trading companies like Cargill then handle the mass of globally traded cocoa beans. Additionally, some small companies, who usually operate in niche-markets are involved in trade as well – usually in the context of bean to bar production. The production of chocolate itself is again dominated by a handful of multinationals like Mars, Ferrero or Mondalez, with smaller highly specialised producers operating in niche-markets. For chocolate as for most other supply chains retailers constitute the link to the consumer base. This sector is also highly concentrated, with retailers taking on the role of gatekeepers between producers and end-consumers and inhibiting considerable power and control over up-stream supply chain members (see Wildenberg & Sommeregger 2016).

Most agricultural-based supply chains will feature a very similar structure. In contrast, supply chains for non-food products ranging from clothes to electronics can involve even more actors from diverse sectors and countries, adding additional complexity. Nevertheless, a common feature of many supply chains today is that at least at some point a concentration of market power has taken place with usually only a handful of players controlling a relevant part of the market share. These powerful players often influence the up- and downstream parts of their supply chains – for example, by either demanding or refusing certification schemas to be implemented (e.g. Wildenberg & Dusch 2015; Wildenberg 2016).

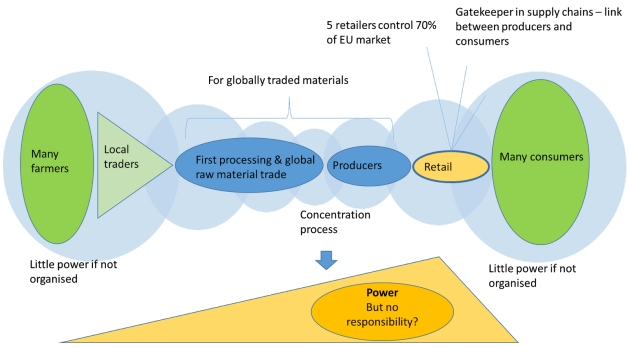


***Figure 3.*** *Schematic diagram of a typical global supply chain for agricultural products (source: Martin Wildenberg)*

## Supply Chains & SDGs

Supply chains represent a complex network of distant, separate entities that exchange goods, payments, and data across a dynamic, continuously evolving landscape. In the same way that supply chains connect a diverse set of producers, traders and consumers all over the world, they also connect to many of the SDGs. Almost every supply chain impacts several of the SDGs along its way – sometimes positive, e.g. by providing decent work, but often negative, e.g. through pollution, ecosystem degradation, workers right violation and alike.

From an industrialised countries perspective, global supply chains provide the possibility to relocate production processes in countries where they can be performed cheaper, which creates more return and a competitive advantage. Often cheaper production is connected to less strict regulations or weak enforcement regarding the environment, worker rights or land rights. Many negative impacts along supply chains are systemic in a sense that it is difficult or impossible for single companies to solve them alone, especially if they operate in a sector that is hypersensitive to costs (Mhlanga 2017). Implementing workers rights and having higher environmental standards always come with costs. They will, therefore, create a competitive disadvantage in cost-sensitive markets, which can only be tackled with collaborations across the supply chains or corresponding legal frameworks that level the playing field.

The lack of transparency along the global supply chains and in institutional settings is another main issue that creates many challenges like fraud, pollution, human rights abuses. Very often, when goods reach their final destinations, buyers and sellers do not know the true origins of the manufactured products and their ingredients.

The importance of correctly collecting, storing and managing data, i.e. having a transparent record of past events, is rising together with the customer awareness and pressure towards more sustainable production. The demand for supply chain transparency will continue to evolve, and consumer expectations regarding product origin will increase (Francisco and Swanson 2018). Even more powerful are legislations like the California Transparency in Supply Chains Act (see references and BHRRC 2017) that establish legal frameworks to hold companies accountable for human rights violations in their supply chains. Transparency in supply chains is a prerequisite – for consumers to vote via their buying decisions as well as for the enforcement of laws holding companies accountable for violations in their supply chains.

## Relevance of Blockchain Networks

The underlying architecture of supply chains has many similarities to how blockchains are set up. Blockchain technology has the potential to provide unprecedented levels of transparency with a shared, decentralised database where immutable and encrypted copies of the information stored on every computer (node) in the network (Crypto3conomics 2018). With an immutable ledger as infrastructure, blockchain-based tokens can be used as a digital representation of physical goods and especially for tracing the events associated with the item back to the point of origin. Therefore, one of the biggest use cases of distributed ledgers is seen in providing transparency and provenance along the supply chain of goods and services. Blockchain-based supply chain solutions can allow us to trace the provenance of goods and services along the supply chain, to unambiguously identify a

product's input materials, including the material's quantity, quality and origin. Achieving data security and exercising controlled transparency was, until the discovery of blockchain technology, best conducted with the help of a centralised system (Abeyratne and Monfared 2016). Accessing and verifying data is currently a slow process, for parties in a supply chain often do not share information, but instead employ a third party validator who is granted access to their activities and is obligated to update the common ledger (Dobrovnik et al 2018). Blockchain solutions can be used to collect, store and manage data in a supply chain, automate and more effectively facilitate the processes of product and information flows (Kouhizadeh et al 2018). Multiple supply chain actors can enjoy these various blockchain features, either for managing supplier contracts, recalling counterfeit products, proving sustainability of a production process or for retaining customers' loyalty. Such solutions, however, include a combination of a set of technologies, not only blockchain. The convergence of blockchain with machine learning, AI and IoT will be essential to provide full transparency over what happens along the global supply chain. Many of the envisioned transparency solutions will only be possible in combination with big data applications and the Internet of Things.

## Efficiency Increase

Inefficient document handling systems along the supply chain are a toll on company profits. Maintaining bureaucratic paper trails required to manage modern supply chains are costly and inefficient. Supply chain start-ups and established industry players are beginning to utilise blockchain to optimise their value chains, improve inefficiencies and free up working capital, and make goods and services more accessible. Cutting the costs in handling supply chain issues is often the main selling proposition of blockchain-based supply chain solutions. This is not per se a contribution to sustainability, but may lower the barriers of implementing such systems and is, therefore, potentially an enabling factor. Inefficient document handling systems along the supply chain cut into company profits. Maintaining bureaucratic paper trails required to manage modern supply chains are costly and inefficient (Voshmgir 2019a). Efficiency gains through technological solutions can drive supply chain actors towards faster document handling, more efficient resource allocation and a transparent presentation of the company's activities. What is more, current paper-heavy processes within supply chains are contributing to the motivation of changing the existing practices and integrating new technologies in their interest. For instance, international container shipment from East Africa to Europe is still a paper-heavy process. In order to complete the transport, 30 people and organisations must interact with one another on over 200 occasions (Hackius and Petersen 2017). The cost of processing such amounts of trade-related paperwork can make up from 15 to 50 per cent of the cost of the physical transport (Hackius and Petersen 2017). Digitally signed records of transactions can, in addition to automating the events, also facilitate faster dispute settlements and payment transactions, resulting in a more efficient resource and working capital allocation for the actors involved (Capgemini 2018).

## Transparency & Provenance

When goods reach their final destinations, most buyers and sellers do not know the true origin of products and the ingredients of the goods they have purchased. A lack of transparency, in prices and wages paid to farmers or workers, prevents many end-users from knowing if fair prices and wages are paid along the supply chain of the goods and services they consume. Transparent supply chain solutions have the potential to provide consumers and other downstream participants higher standards of transparency and foster sustainability in sourcing and production through a transparent record-keeping of environmental and social impact along the supply chain steps. Product safety and the associated product recall are not easy to

conduct if supply chains consist of a large number of actors, especially if all subcontractors are taken into consideration. The estimated costs of a typical beverage recall by a manufacturer is close to $8 million, for example (Capgemini 2018). Each transaction between supply chain actors additionally represent an opportunity for counterfeit or theft (Francisco and Swanson 2018). Companies are often not able to track a shipment through its internal system (Dobrovnik et al 2018), extending the product recall time and possibly endangering customers' health or safety. Optimising supply chain transparency and traceability is correlated, but the relationship between the two is not straightforward and linear (Francisco and Swanson 2018). That is, transparent record-keeping and having high information availability can lead to easier and faster traceability of goods. By contrast, increased traceability, may not lead to increased transparency, as some actors within a supply chain might have no interest in providing additional information such as temperature records or information on workers rights.

In this context, Blockchain-based solutions have the potential to enable greater accountability and responsibility regarding human rights, e.g. monitoring factory working conditions for modern-day slavery, child labour, employees being exposed to toxins, or revealing if farmers receive fair prices for the value they created. In addition, data on provenance, production type and ingredients of the food we eat can be stored through transparent processes immutable but accessible on a blockchain.

Creating decentralised monitoring systems accessible by smallholders, workers or other actors vulnerable to workers or human right violations could provide unprecedented transparency on these issues. In this case, the challenge would be less technical but rather in the design and implementation of the human interface like, for example, the processes organising and governing the access to the blockchain or the way data enters it.

## Certification & Labelling

Today certification and labelling are the most common ways to deal with transparency and trust issues in supply chains. SMEs and large manufacturers rely on multiple suppliers (Wu et al 2017), and have to assess suppliers' certifications regarding both sustainability and counterfeit regulations themselves. This can be a lengthy process, especially when choosing new or additional suppliers. The rules and governance models, such as actor certification, access and approvals, or data management, can be programmed into a smart contract (Kouhizadeh 2018), shifting the tasks of managing supplier contracts from employees almost entirely to the blockchain. Smart contracts can be programmed in such a way to trigger these actions as soon as the predefined conditions (e.g. price, certificates, quantity, date of delivery) are met, saving an organisation a lot in cost and time resources. Furthermore, using smart contracts in this process can prevent corruption or fraud.

Sustainability-related certificates are still being issued very centrally - by a small number of parties and are not universally regulated. These central entities who monitor actions and issue certificates, become a single point of failure vulnerable to corruption and attacks. In such a system, an end consumer cannot determine whether fair work practices were granted to the employees behind the product or if the company has abused any workers rights, for example.

Today, a range of certification labels that arose exactly for this reason are found alongside similar-looking logos. These often represent nothing more than a vague promise or are purely marketing stories, greenwashing the products they decorate. All consumer labels and certificates rely on consumers trust in the institutions offering and checking the certification; greenwashing undermines this trust and can create a downward spiral in terms of sustainable supply chains. Blockchain could offer ways to build certification systems in such a transparent and tamper-free way that they could prove their effectiveness of reaching the impact they promise in a trustworthy manner,

making them stand out from the want-to-be labels.

Although many blockchain projects have stood up to address these issues, it is by far not clear how they will do so. Involvement of stakeholders in the design, improvement and running of certification schemas is seen as a best practice by many independent NGOs and civil society organisations like unions or smallholder associations. The possibility to build decentralised, independent and community-managed certification systems – that also have a high level of security and an immutable record-keeping property – could be the application with the highest transformational potential for blockchain in supply chains. A Web3 based supply chain offers better assurance and transparent insight into the history of goods, potentially gaining back customers' loyalty for the companies involved and so strengthening their market share if they act sustainably. The *Diamond Time-Lapse Protocol (by Everledger)* or the *TRACR* project, for instance, has uses blockchain networks to store data on the provenance of diamonds. Each cut diamond is registered by using unique properties of its structure. In this way, the information of its origin is immutably tied to its physical properties. For other products, which do not possess unique characteristics that identify them like most food, clothes or technological items, other solutions have to be found that enable an immutable connection of the product with its supply chain information on the blockchain.

## Increased Automation: IoT & Sensors

Having an increasing number of devices connecting to the Internet means that a big part of supply chain interactions could soon become automated processes run by a network of devices, rather than relying on human input. Depending on the industry, these devices include, e.g. RFID chips for product's identity, tracers inserted into a product or sensors monitoring the environment around the product, measuring outside temperature, humidity, pressure, speed etc.

Many supply chain solutions will rely on the interaction of blockchain networks with sensors and other IoT devices. Some supply chain properties could be automatically monitored by using sensors, however privacy issues might come up when using 24/7 cameras when trying to monitor working conditions in a factory, combining IoT devices like cameras. Privacy issues could be resolved using machine learning algorithms that assess video data, obfuscating privacy related data. Such solutions are use cases dependent and require to resolve a series of techno-legal question. Furthermore, the data that is recorded on a blockchain network might be prone to manipulation before recording it on the ledger which will require security solutions that address the integrity of data feeds (oracles) into a blockchain network.

## Status Quo & Challenges

The challenges of integrating new technology into existing processes must be considered. Global supply chains represent a very complex environment with a large number of different stakeholders, who all need to comply with various laws and regulations, commercial codes, ownership and possession laws (Kshetri, 2017). Coordinating a large number of parties to integrate blockchain based solutions is a challenge in itself. Industries with a smaller number of supply chain actors might be better suited for implementing blockchain based supply chain solutions (Kshetri, 2017). Standardised data models are one of the biggest problems in supply chains, and something blockchain applications don't resolve. Blockchain networks don't offer a unified data model for an end-to-end integration of supply chain systems. This is why blockchain process functionalities were not seen to support integration for transactions in a case study conducted from 2014 to 2016 (Kshetri, 2017). Furthermore, blockchain based supply chain applications require investment in new hardware and software solutions. In order to collect reliable data, various devices such as sensors, RFID chips, trackers and others should be installed throughout the production and

supplier routes which is a cost intense transition for all partners along a supply chain (Mougayar 2016).

Another challenge is the current lack of technical expertise and general know how (Saberi et al 2019). This is partly associated with technology's immaturity and lack of acceptance. In a survey conducted in 2017, around half of the participants stated to see this and regulatory uncertainty as a big challenge towards adopting blockchain (Hackius and Petersen 2017). Research also shows that there are data security concerns, unclear benefits and too much dependence on blockchain operators (Hackius and Petersen 2017). Even the majority of logistics service companies declared only to be watching the technology's development from a distance. However, participants who have experienced blockchain implementation give better ratings when asked about blockchain benefits than the participants only looking at the technology from afar (Hackius and Petersen 2017).

Many of the sustainability challenges of today's supply chains do not stem from a lack of technological solutions to problems like missing transparency but rather from a lack of incentives, legal frameworks or willingness on the side of the involved actors. Technological applications that aim to increase transparency without affecting vulnerable actors at the same time, will only have a considerable impact on supply chains when legal frameworks are in place that empower the weaker members of the supply chain – including consumers – to hold companies accountable for misconduct in their supply chains. Blockchain solutions should, therefore, focus on the empowerment of the smallholders and workers along supply chains, making use of the self-organisational capacities of the technology. This would require not only focusing on technological innovation, but it also needs a strong focus on social innovation. Examples of blockchain applications in supply chains are: *Provenance*, *Ambrosus*, *Modum*, *OriginTrail*, *Vechain*, *Wabi*, *Waltonchain*.

## Use Case 2: Impact Assessment

The immutable and transparent nature of distributed ledgers are also interesting in the context of impact assessments: (i) the measurement of impact in the context of projects or businesses that want to achieve a positive societal change of some kind; (ii) the assessment of individual impact, i.e. for tracking the personal carbon footprint. The latter relates to the topic of tokenisation, impact assessment of projects and businesses, and it has many similarities to the use of blockchain for certifications or other quality management-tools in supply chains.

Blockchain-based solutions could, for example, provide more transparency regarding the actions of governments (countries, cities or regions) to reduce overall carbon emissions. Collectively managing and recording such emission data by a blockchain network would allow better enforceability of international treaties, at much lower costs than today. Impact assessment could be easier tracked, resulting in quicker feedback loops. Impact data can be measured and assessed in an automated manner, since smart contracts offer compliance and enforcement on the fly, triggering payments to the projects as soon as a certain impact (e.g. the number of pupils attending school) is reached. These approaches address donors who want to be sure that their money actually creates the intended impact. However, as outlined in previous chapter, the main challenge is a "garbage in – garbage out" system: a tamper-free ledger will not be of any use if false information enters the ledger to begin with. At the time of writing, the best-known application in this field is the *IXO* protocol, but many other projects in this area follow very similar approaches. The underlying idea of IXO is that proven impact data is a valuable asset for all those interested in funding impact in one way or the other. The impact of a given project is ideally automatically measured by sensors (oracle) or where this is not possible verified by some intermediaries.

Blockchain-based solutions could also provide more transparency regarding the individual impact assessment. All our daily transactions leave a carbon footprint, driving, flying, the food we eat, the way we wash clothes, or using the internet. Nudging people towards more climate-friendly behaviour and consumption patterns have been on the agenda of many organisations for some time already. Blockchain-based approaches can support this endeavour in two ways: (i) they can provide a means to record data on individual impact behavior in a tamper-free and privacy preserving way with more control over one's data, (ii) incentivize individual action towards a collective goal with purpose-driven tokens. This can influence impact through behavioural change. Combining blockchain applications with AI and IoT will enable us to draw better data for impact assessment and evaluation and make collective sustainability behaviour across groups and geographic boundaries more transparent. In combination with AI (software oracles) and IoT (hardware oracles), the fulfilment monitoring of sustainable action could be verified in an objective and decentralised manner. In a world where carbon emissions and credits could be tracked transparently and reliably at low costs, at the point of sale, retailers will be able to sell a product and take into account the carbon impact it creates at the same time. Governments will be able to measure, track and trade emissions transparently, consumers will be able to understand the environmental impact of the products they are buying - both in a positive and negative sense. Furthermore, these consumers will be able to mitigate this in an instant, with millions of micro-transactions scaling up to make a huge collective impact. The key to building such systems lies in the use of purpose-driven tokens as is currently being experimented with by the City of Vienna, where citizenry are incentivized for reducing CO2 emissions with a token that can be exchanged for free or reduced cultural activities in the city (Digitales Wien 2019).

# Use Case 3: Collective Value Creation with Purpose-Driven Tokens

Purpose-driven tokens incentivise individual behaviour to contribute to a collective goal. This goal might be a public good[3] or the reduction of negative externalities to a global common good[4]. They introduce a new form of collective value creation without traditional intermediaries. Purpose-driven tokens provide an alternative to the conventional economic system, which predominantly incentivises individual value creation in the form of private goods. Purpose in this context refers to a "higher purpose" in addition to maximising one's personal profit. Purpose-driven tokens allow you to contribute to the creation of a public good – or the reduction of externalities to a common good – while at the same time incentivising private profit (Voshmgir 2019a). The Bitcoin network showed us how it is possible to create a public infrastructure by rewarding people with native network tokens, if and when they contribute to the security of the network. It could be seen as a new form of tech-driven public good, albeit an impure one. Upkeep and maintenance of the network are collective and permissionless. Usage of the network is permissionless and non-rivalrous, but only as long as capacity limits are not reached. In their current form, public blockchains don't scale well and can be considered as rivalrous when the network becomes clogged. This inspired many projects ever since to build on this principle of incentivising behaviour with "purpose-driven tokens". Incentivising contributions to a social network with a native social-network token are

[3] *The term public good refers to goods that any individual can use without paying for it (non-excludable, or permissionless), and where use by one individual does not reduce availability to others (non-rivalrous, or unlimited).*

[4] *Common goods are similar to public goods as they are non-excludable (permissionless). Still, they are rivalrous, which means that the consumption of a good by one person excludes others from consuming it. Examples of common goods are water, air, forests, and natural resources in general. They are public but scarce, often to varying extents. If natural resources are exploited or polluted beyond their sustainable capacity, it affects others from consuming them.*

another example for tokens that incentivise a public infrastructure, or a public good, as are TCRs (Voshmgir 2019b). A purpose-driven token can furthermore set an incentive for individual action, with the goal of maintaining a common good and could resolve many tragedy of the commons[5] problems society faces today. CO2 tokens are examples for tokens that could reduce such tragedy of the commons problems. CO2 tokens provide a mechanism of "nudging" individuals to collectively contribute to the reduction of negative externalities of a common good. This can be done by incentivising people to plant trees instead of cutting and rewarding them with "tree tokens". Another example would be to incentivising people to reduce CO2 emissions by using a bike instead of a car or use solar energy instead of carbon-intensive energy forms. Cryptographic tokens issued by a smart contract incentivise individuals and corporations to act in a sustainable manner. In such a setup, individuals and organisations who can prove that they reduced CO2 emission can be rewarded with a token. Depending on the design of the token, it could be exchanged for some other services provided by the organisation issuing these tokens. Depending on how this reward token is designed, they might be tied to the identity of a user (non-fungible), or they might be designed to be tradable (fungible). They might be designed to expire after a while, or have unlimited durability. The design of the reward function can differ greatly from project to project. Examples of such projects incentivising CO2 emission reductions are Walking Coin or Changers who incentivise riding a bike, walking or using public transportation instead of using a car. Other projects incentivise producing or consuming renewable energies. Examples of such tokens include Solar Coin, Electric Chain, Sun Exchange. Users could be incentivised with a token every time they prove that they have used less energy by using energy-efficient devices, turning the lights off, etc. Users basically earn money for reducing their carbon footprint: Energi Mine, Electron. Alternatively, one could be incentivised for undertaking actions to help natural resources like for example planting trees, cleaning beaches, reduction of food waste, recycling of goods like proof-of-tree-planted or proof-of-bottles recycled: Plastic Bank, Earth Dollar, Bit Seeds, Eco Coin, Earth Token, Recycle To Coi.

Purpose-driven tokens therefore provide an alternative to conventional economic systems, that predominantly incentivised individual value creation: private actors extracting rent from nature or from the workforce, transform these into products, often externalising costs to society, while internalising (and maximising) private profits. However, this new and collective value creation phenomena that the Bitcoin network introduced will likely need a lot of research & development and a long phase of trial and error in the market until we can better understand the potential of incentivising contributions to a public good. Operational use cases are still limited. The study of economics, public choice theory, theory of public goods and behavioural sciences will be essential for a better understanding, and as a result, also better economic engineering of future purpose-driven tokens (Voshmgir 2019b).

## Use Case 4: Corruption Prevention

Blockchain networks can provide near real-time transparency of what happens to taxpayers' money and international loans, and how funds are reallocated and therefore help to prevent corruption and tackle public mismanagement (Santiso 2018). Blockchain-based applications can eliminate opportunities for falsification and the risks associated with having a single point of failure in the management of data and funds. It can also help overcome data silos in traditional bureaucracies in which public entities are reluctant to share information among themselves. Blockchain is particularly suited to fight corruption in the registry of assets and the tracking of transactions such as

[5] *"Tragedy of the commons" occurs when individuals withdraw resources to secure short-term gains without regard for the long-term consequences. This might be avoided with regulation to limit the extraction of the goods beyond a sustainable level. While the world's fish stocks can be seen as a non-excludable resource, it is finite and diminishing because of continuous fishing by different private actors worldwide.*

procurement processes. It eliminates the need for intermediaries, cutting red-tape, reducing discretionality and strengthening public integrity. Blockchain could also be especially useful for cross-jurisdictional governance where cost-effective, transparent auditing measures can be implemented into the protocol; for example, making the monitoring of sustainability goals easier. There are many use cases regarding donations and for the work of development organisations, especially when remittances to third parties are involved. Blockchain provides near real-time transparency of what happened to one's donations, supporting civil society accountability by tracking funds and ensuring they support the cause of the donation without the need of sophisticated banking infrastructure. Examples: Giveth, Alice, Aidcoin

## Use Case 5: Inclusion of Undocumented & Underbanked

Depending on the type of estimation, more than one to two billion people worldwide are unable to prove their identity — often excluding them from property ownership, free movement, and social protection, as a result. Additionally, a lack of identity prevents credits, loans and thus prevents entrepreneurship. Millions of refugees trying to relocate around the world can't be identified, a disproportionate amount of them being women and girls, who struggle to obtain IDs, often because of barriers related to freedom of travel, distance, financial costs, time constraints, illiteracy, lack of information and awareness and lack of support from family members. Blockchain-based applications could allow for complementary decentralised and self-sovereign identity solutions. Linked to the problem of personal identification is the access to bank accounts and other financial services like credits, state or relief funds. While the number of unbanked individuals is decreasing, there are still an estimated two billion people worldwide without access to traditional banking services, who have to rely on alternative financial services like payday loans, pawnbrokers, and loan sharks, that are often highly unregulated and can be exploitative and even downright criminal. Web3 based identification systems introduces complementary verification systems to cater to such cases. The World Food Programm (WFP) is currently trialling blockchain based solutions as a means of making cash transfers to the underbanked more efficient, transparent and secure, through vouchers or prepaid debit cards, allow people to purchase their food locally. Such a system is an effective way to empower refugees to make their own purchasing decisions and relieve hunger. Cash transfers are an increasingly important means of providing assistance, for example, to refugee camps. The WFP, therefore, aims to reduce payment costs associated with cash transfers, better protect beneficiary data, control financial risks, and set up assistance operations more rapidly in the wake of emergencies. To date, the WFP is inviting other UN agencies and humanitarian actors to collaborate on a neutral blockchain network to improve cooperation, reduce fragmentation, bolster efficiency to "ultimately further empower the people we serve."

## Use Case 6: Impact Entrepreneurship & Impact Investment

Businesses have received growing attention in the discourse around the SDGs – they are seen as an important agent for positive change. At the same time, the UN keeps emphasising that tackling the SDGs is also a business opportunity. This has given rise to so-called "Impact-Start-Ups & Impact-Businesses", entrepreneurial ventures whose primary objective is to maximise their social or environmental impact while creating profits. They address socio-economic challenges with innovative products and services, often embracing new types of business models and a transformative approach throughout their whole business endeavour.

But impact businesses still face many challenges. Although the private impact investment sector is steadily growing, many start-ups face the challenge of finding funding that fully support impact-driven business development or has the necessary know-how and infrastructure needed to support the development of such applications. Many impact-based projects do not fit into the available funding schemes of institutional investors like state development agencies. Blockchain based solutions can leverage impact-innovation offering using smart contracts based governance ecosystems steered by impact-entrepreneurs (Martin and Osberg 2007). However, communicating the proposed value is not an easy task as the target (the SDGs), the motivation (creating impact) and the technology (blockchain) are already highly complex on an individual base.

Envisioned cost reductions of applying blockchain-based platforms, are argued to origin from disintermediation within incumbent processes involving a set of independent stakeholders. Blockchain networks are governance technologies that can provide platform as a service in return for a fee. From the perspective of an entrepreneur, the key motivation for considering blockchain may be that the main value creation is not occurring at a single point on the platform itself, but rather on the ecosystem level that they built upon it and are part of. Thus, it requires less capital to develop and provide individual products & services, while one may benefit from a continuous & collective development of the governance platform at the same time. In this sense, blockchain-based platforms have the potential to provide the building blocks to a new type of economy where innovation can be collectively enhanced as a common good that provides just access to returns to all that contribute to its development. Examples of collective impact initiatives are: WePower, Powerledger, Exergy, Sunchain, Bitlumens, Inuk, Gruenstromjeton, Energy Blockchain Network, Astrn Energy (assetron), Dao Ipci, Ecochain, SolarDAO, Waves, Suttonstone, Pylon Network. From an investors perspective, enhanced accountability through traceability of capital flows is the main advantage of blockchain. In terms of impact investing this especially relates to the facilitation of earmarked and results-based financing through which assets are shared or being donated towards the secure, shared allocation of ownership of assets. Blockchain based solutions could furthermore help facilitate global crowdsourcing as it could provide a technological solution to transparency and accountability issues in this area. The provenance of funds could be traceable and smart contracts could automate compliance and enforcement once a crowd-sourced funded project delivers. In terms of development applications, an aspect that is often mentioned as an interesting application field is enabling automated micro-payments to reduce micro-payments for loan repayment with reduced management and transaction costs.

## Use Case 7: Energy Markets

SDG 7 aims at increasing access to affordable, reliable energy, while at the same time reducing anthropogenic carbon emissions. Global energy systems are still largely dominated by carbon-intense energy technologies. To realise such a complex transition, a new mindset is necessary (REN21 Report 2018). In the broader sense of promoting SDG 7, Web3 applications can be beneficiary for impact assessment and transparency. Many use cases can be beneficial for the goal of ensuring universal access to affordable, reliable and modern energy services, increasing the share of renewables and lowering the energy intensity.

For developing countries, in particular, the main issues have been high demand growth coupled with inefficient system management and irrational tariff policies. This has affected the availability of financial resources to support investments in improving generation and transmission capacities. In such circumstances, many utilities were forced to restructure their power sectors under pressure from international funding agencies (Choice 2019).

One of the main strategies is deregulation, which aims to enhance market competition to increase consumer rents by lowering market entrance barriers. The integration of renewable energy is not a simple task. The main reason is that renewables share few characteristics with conventional thermal power plants. Renewables are connected to the grid in a decentralized manner, are non-dispatchable and can provide electricity at nearly zero marginal costs. This stands in fundamental conflict with the prevailing market design and grid architectures. The main consequence of a greater share of renewable power is a growing need for decentralized short-term electricity exchange capabilities to compensate for the volatile feed-in. For now, the prevailing strategies to maintain grid stability is curtailment, in case overproduction is reached. In contrast, underproduction is handled by fairly flexible thermal power plants. The latter results in increased CO2 emissions, larger stress on components, reduces their life-time and thus increases the costs of electricity. Electricity always follows the path of least resistance. The logical conclusion is to balance such volatilities at the very location where they occur, from the bottom-up.

One example is roof-top photovoltaic installations which first covers self-consumption of the building while surplus electricity is stored in batteries before feeding it into the grid. These type of hybrid solutions are especially relevant in rural regions where microgrid solutions are required, and no common point of coupling to larger grids is available. The dominant solution for providing the necessary flexibility in microgrids are still internal combustion engines. Besides technical challenges, the integration of renewables requires a thorough design of electricity pricing mechanism, as the costs of the produced electricity cannot be covered by calculations based on operational expenses alone. The problem is non-trivial due to the homogenous nature of electricity, which makes it difficult to distinguish low carbon from carbon-intense electricity sources.

Without cost-reflective grid tariffs, revenues will not be sufficient to cover grid expansion and operation costs, nor does it incentivise investments in energy generation or consumption capacities.

## Renewable Energy Certification

Intransparency regarding the provenance of electricity sources makes it difficult for the consumer make an educated consumption choice, hence often hinders companies adding value to electricity provided by low carbon-intense energy technologies. The compliance with political committed emission budgets complicates the administration of private and public actors. Voluntary participation in carbon markets is often not possible in current systems. EU Emissions Trading System (EU-ETS) and the UN's carbon offsetting scheme, Clean Development Mechanism (CDM) – are not yielding satisfactory results. Attaining impact measurements necessary for accessing international climate funds is cumbersome. Distributed ledgers could complement and substitute national registries for countries wishing to participate in Article 6 of the Paris Agreement. They could act as the settlement network for tracking trades and for reconciliation and avoidance of double counting, or could serve as a common language to communicate across countries. DLT-based systems could greatly enhance provenance capabilities and reduce erroneous or fraudulent double-spending of certificates.

Moreover, it can establish trust for participants that are consuming low-carbon intense electricity. For example, the project Blockchain for Climate is developing a draft specification for a new token type called “Unique Fungible Tokens” that should help support carbon trading. Other initiatives: Poseidon, EW Origin, Ecocoin, Veridium, Greeneum, Climate Chain Coalition, Climate Coin, Climate Ledger Initiative, Swytch, Power Ledger, Sunchain, Carbon Grid Protocol, Zero Carbon Project, DAO IPCI, Adaptation Ledger.

## Data Economies & Real-time Energy Monitoring

As opposed to conventional thermal power plants, renewables depend on accurate locational-specific data analysis from the very beginning, starting from advanced analytics for weather forecasts towards more granular predictions of consumption behaviour. This implies a paradigm shift of grid operation and planning that is increasingly driven by data on the supply of electricity instead of demand. To facilitate that shift, further deployment of intelligent grid-edge technologies (e.g. smart meters), enhancing grid connectivity is needed. This development towards smart grids can increase the speed and accuracy of communication between distributed energy resources, through which large operational efficiency gains can be achieved. For example, grid flexibility can be provided to a larger extent by an aggregation of small-scale distributed energy resources (e.g. virtual power plants). Today, data collection regarding energy production and use at the household level is scattered, measure intervals are insufficient or delayed, often owned by the metering operator and not publicly accessible. In general, a high level of information asymmetries is present, which hampers grid operation and planning. Smart metering, at least in Austria, faces strong mistrust on the consumer side, especially in terms of data privacy (Energy Blockchain Network 2018).

Using blockchain networks or other distributed ledgers, a "Smart Meter" would measure the usage of energy and store the data in local memory. The data is then uploaded to the blockchain and a "history" of the users' consumption is recorded. The Smart Meter connects to the internet through whatever means are available — GSM, WiFi or a mesh network creating a local ISP. This allows real-time traceability from generation and consumption assets at kWh level. Building applications on top of blockchain networks could give consumers full control over their data, permitting companies only to see the minimum of information necessary for their operation. ElectriCChain, for example, is an open solar energy generation data project with the aim to verify and publish data from currently estimated seven million solar energy generators globally on an open blockchain. Other similar initiatives are: Gridx, Electron, Freelio, Future-grid, Verv.

## Power Purchase Agreements

Power Purchase Agreements (PPA) for the developing world are negotiated, for example, through NGOs like the World Bank, USAID's PowerAfrica project, African Development Bank and others working through existing government-owned infrastructures. Evaluation of projects by these bureaucratic clearing houses proceeds slowly, and even when a project is approved, and loans are secured, co-investors must be found before the project can be initiated (Impact PPA 2018). The ImpactPPA is a blockchain based solution that ensures that the PPA execution and settlement process is implemented before the PPA is signed. Counterparties will see the same invoice, marketing for PPA and other contracts between market participants can be done through transparent data facilitating B2B relationship management. It also alows for legislative changes to be automatically updated. Other similar initiatives are: Clearwatts or DNV GL.

## Challenges of SDG 7

Greater effort will be required from end-uses, regarding heating, cooling or mobility, where renewable penetration remains low. Adoption of district energy systems based on biomass, geothermal or solar thermal energy could be one solution. Sustaining the growth of renewable electricity will further require additional attention to grid integration, including the incorporation of battery storage and smart grid technology to support the management of variable generation resources. Currently, the majority of blockchain projects work on local energy markets (Koirala et al 2016). Most suggested solutions focus on the creation of novel market ecosystems that allow large scale integration of micro-market

participants (e.g. distributed energy resources). Their aim is to enable local individuals to be better integrated into the global energy transition and offers grid flexibility, which is needed for further deployment of renewables. However, the market mechanisms are often unclear or not well defined. This might be due to the fact that many suggested models attempt to solve multiple problems instead of one at a time.

# Potential Pilot Projects

This section describes potential pilot projects for using blockchain applications for the implementation of selected SDGs in partner countries of the Austrian Development Agency (ADA).

Most blockchain use cases in the development context have to tackle complex socio-technical questions across jurisdictions and national institutions that require different levels of expertise. In order to reduce complexities and be resource efficient, we suggest to collaborate with existing startups in the blockchain field who are relevant to development challenges in ADA partner countries rather than developing solutions from scratch.

SDG 7 (affordable and clean energy) and SDG 12 (responsible consumption and production) were selected as the two most appropriate SDGs for future Blockchain pilots which will be outlined below. The annex of this paper furthermore contains a list of blockchain activities in relevant ADA partner countries.

## SDG 7: 3Fsolar, Africa Green Tech & The Sun Protocol

Research shows that almost 1 billion people worldwide live without electricity (Alstone, Gershensone, & Kammen, 2015), which makes the SDG 7 especially relevant for the development context. Additionally, the share of renewables in final energy consumption of the electricity provided to the 88.86 per cent of the global population (World Bank, 2017) is still very low, it stood at 17.5 per cent in European Union in 2017 (European Environment Agency, 2019). The fact that the access to clean and affordable energy can be a boost for the quality of life and wellbeing implies a possibly great impact of deploying renewable and efficient energy production in rural areas. Although there has been some remarkable success regarding access to energy in the period from 2000 to 2016, the proportion of the global population with access to electricity increased from 78 per cent to 87 per cent. Still, almost 1 billion people live without electricity. Today, in the face of the climate crisis, also decarbonisation of energy production is of paramount importance if success towards any of the SDGs is to be sustained. The share of renewables in final energy consumption increased modestly, from 17.3 per cent in 2014 to 17.5 per cent in 2015. Yet only 55 per cent of the renewable share was derived from modern forms of renewable energy. In 2015, 29 per cent of the global population still lacked access to safely managed drinking water supplies, leading to the proliferation of waterborne disease affecting especially children, women and other vulnerable groups.

With today's advancements in PVCs it is possible to provide affordable off-grid solutions, which can supply whole villages with clean and green energy. Also, water purification and sanitation units can be built compactly.

Infrastructure needs maintenance. Through the use of a blockchain tokens – backed by the produced energy – it would be possible to create systems where the maintenance and other favourable behaviours like, e.g. energy or water-saving measures are rewarded with tokems. These tokens could be then used in the system like paying for the received energy, for example. Ideally, a self-sustaining system would emerge. Additionally, it is possible to link external funders via tokens to the project.

Blockchain networks and their application can be used to manage off-grid infrastructure for clean electricity. The pilot projects described below focus on making electricity accessible while fostering sustainable transformations at the same time.

The use cases of "3F Solar" and "The Sun Protocol" present similar approaches to tackle the issue of missing infrastructure, especially for clean electricity. In both cases, blockchain technology is suggested to be used as a way to create local management and an economy around the supplied electricity. Ideally, leading

to self-organised maintenance of the system, as well as fostering the development of a local economy. Both projects would focus on the use of blockchain tokens to create incentives for maintaining, training and economic development around the electricity provided. Whereas 3F Solar has just started to explore the possibility of blockchain use, The Sun Protocol was from the beginning designed around the idea of utilising blockchain. The larger vision of The Sun Protocol is to create a whole blockchain ecosystem stretching across the entire continent.

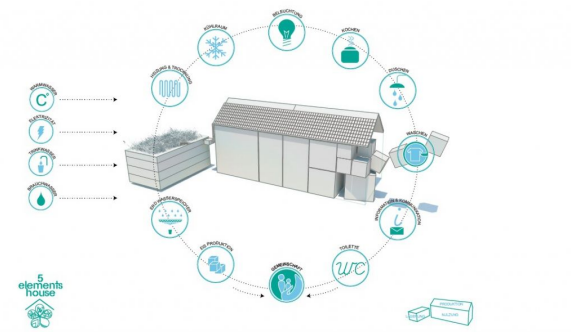

***Figure 5.*** *5-elements house with a set of different modules. Reprinted from '3F Solar 5 Element House', by 3F Solar, n.d., Retrieved from [http://www.3f-solar.at/en/5-element-house/](http://www.3f-solar.at/en/5-element-house/)*

## 3F Solar

3F Solar offers the 5-elements house, a community building that is energy and water self-sufficient. The 5-elements house is a modular, scalable, simple installable, regionally and culturally adaptable house that requires low maintenance and serves people with the basic infrastructural needs. The aim is to makes use of the four elements from mother earth and creates the fifth element, the community. The house comes with an "energy-roof" that produces electricity, heat and collects rainwater. An attached "earth-water tank" can store rainwater in high purity. With electricity, warm water, sanitary water and potable water, different applications can be supplied. These applications are heating, drying, cold room, illumination, cooking, showering, washing, information, communication, toilet and ice production. 3F Solar is planning to integrate blockchain solutions into the concept the 5-elements house. 3F Solar is currently active in Austria and has been exploring implementation possibilities in the Philippines - inter alia with an ADA feasibility study in the village Adams in 2014 (Friedrich, 2018).

## Africa Green Tec & The Sun Protocol

The aim of Africa Green Tec is to bring electricity to rural areas by deploying solar containers close to consumption sites with a project called The Sun Protocol. In doing so, centralized power plants and long-distance power distribution networks would be replaced by a decentralized power generating system. Electricity produced and consumed from the solar container is captured and represented with a blockchain-based token. The token is backed by the value of a kWh and acts as a reward for electricity spent on productive activities (The Sun Protocol 2019). For example, the number of tokens earned is higher if the electricity is used for productive house appliances, such as a sewing machine, than it would be for watching TV. The token can then be spent on various bills, e.g. rent, water purification, equipment. The varying reward distribution system hopes to incentivise people to use the electricity in order to create and produce and so contribute to local economies. Africa Green Tec has been conducting their pilot project in Mali, West Africa (Africa Green Tec 2019).

# SDG12: WWF & Tuna

SDG 12 depends to some extent on the management of supply chains and process design within them. For the reasons described in previous sections (provenance, traceability, efficiency, certification and labeling, product recall etc.), this project outlines the advantages of Web3 networks to supply chains. Illegal, unreported, and unregulated (IUU) fishing remains a persistent problem in the Pacific region. This does not only come with detrimental environmental damages and workers right violation but also causes considerable economic damage. A study from 2016 estimated the value of the black market catch at US$616 million, but said it could range anywhere from $US520 million to US$740 million (MRAG 2016). For some of the Small Pacific Island States the tuna fisheries are the most important export industry so the harm to their economics is significant. Additionally reports on human rights and workers rights abuses especially on large commercial fishing ships have become available over the last few years and have unsettled consumers (e.g. The Guardian 2019).

Today the buying and selling of Pacific tuna is either tracked by paper records or not at all. This has enabled tuna from IUU fishing to enter the supply chains of legally fished tuna. With an increasing pressure from consumers who want to be sure that the tuna they consume has been sourced ethically, wholesale and retail seafood buyers have started to ask for improvements in transparency and traceability to reduce the risks their brands face when being associated with illegal activities.

The WWF in Australia, New Zealand and Fiji have teamed up with Consensys (a global blockchain company), TraSeable (an ICT implementer) and Sea Quest Fiji (a tuna fishing and processing company) to launch a pilot project that uses blockchain technology to increase the transparency and traceability in the tuna supply chain n(WWF, 2018). The WWF describes its vision as follows: *"Through blockchain technology, soon a simple scan of tuna packaging using a smartphone app will tell the story of the tuna fish in question – where and when the fish was caught, by which vessel and fishing method. Consumers will have certainty that they're buying legally caught, sustainable tuna with no slave labour or oppressive conditions involved. […] This is about helping people understand exactly where their food comes from – telling the story about the fish, the fisherman, the families, the crew – the path from ocean to plate."* (WWF, 2018)

The project uses a combination of RFID sensors and QR codes to capture information throughout the supply chain. As soon as a fish is landed on board a RFID tag is fixed on it. This tag is automatically registered from various devices on the vessel, at the docks and in the processing facility leading to a digital trace that is logged onto the blockchain. Once in the processing facility the product is partitioned and receives QR codes that is used to continuously track the product. For the future it is planned to use near field communication (NFC) devices to cover this part of the supply chain. In a blogpost on the use of blockchain networks in the fishing industry Kenneth Katafono the founder of TraSeable states that the technology itself is still not understood by the fisheries industry whereas the technology providers do not understand the issues around food traceability, especially regarding the "fist mile" (TraSeable 2019). This divide in understanding technology on one side and practice on the other is probably still the major reason why blockchain (and also other high tech solutions) often do not live up to their full potential in the context of development projects.

This project can be seen as a best practice for blockchain in supply chains in the context of developing countries. With TraSeable a local company with ample experience in the local fishing industry, a tech-partner was found that understands the economic, social and cultural circumstances under which the technology needs to work. On the other side the WWF has a good understanding of the bigger picture regarding IUU and also importantly a good understanding of the downstream users (the wholesale and retail companies in the States) as well as a good outreach to the consumers who also need to accept the technology.

# Successful Project Implementation

Assessing potential pilot projects can be difficult. The Web3 networks and their applications are new socio-technical systems, with many legal and technological uncertainties and few best practices and proof of concepts. At such an early "trial and error stage" it is hard to judge the feasibility of many blockchain projects and their feasibility in a development context. Due diligence should be applied to the assessment of any blockchain project, especially given the intricacies of each use case based on the country and other circumstances of implementation. A checklist of questions can be helpful in the assessment of a project regarding the resilience of the team and the value proposition of the project. This checklist is an outcome of workshops around the (UN)BLOCKED conference conducted in April 2019 with potential stakeholders.

General Questions

- *Is there a good understanding of the sustainability problem that the application should solve?*
- *Does the team reflect the knowledge needed to address the problem?*
- *Have the different stakeholders' roles been considered?*
- *Have potential negative impacts of the project on stakeholders, beneficiaries and environment been considered?*
- *Is there a long-term vision of impact and scale?*
- *Does the project aim at systemic change or efficiency gains?*
- *Is the proposed model of change consistent?*
- *Is relevant information provided in a transparent manner?*

Token-Design Questions

- *Token design and flow*
- *Oracles – how data gets into the blockchain*
- *Role of different agents in the token design/ creation/flow*

*Infrastructure Questions*

- *Readiness of technology vs project pathways*
- *Technological environment (e.g. dependencies on other development projects)*
- *Energy requirements (related to blockchain)*

Governance Questions

- *Who writes and controls the rules of the system?*
- *Who has the power / capability to change or repair the system?*
- *Does the implementation of the system lead to new dependencies?*
- *Does the project need blockchain – or could the same results be reached by the use of established technology?*

Team: How trustworthy is the team and the partner institutions? Is there enough diversity in domain expertise of different relevant fields? If the project targets developing countries (or any other countries than the home country of the project) are there people in the team that can provide the necessary cultural background information? This is especially important in those projects which want to influence people's behaviour or build self-organised systems relying on the active participation of locals.

Stakeholder involvement**:** Blockchain networks and their applications are particularly useful in cross institutional setups, which is necessary that all key stakeholders are involved in the project and on the same page. One of blockchain's main strengths in terms of transformation potential lies in its capability to build self-organised systems or influencing people's behaviour. Both approaches rely on an understanding of the involved stakeholders. Showing how and which stakeholders have been involved in the development of the project is (or should be), therefore, an important quality criteria for blockchain projects.

White Paper: Is there a main information source on the implementation of the project with sufficient information regarding technical, legal and business/governance logic? Does it address why blockchain applications are relevant in the context of the project.

Problem Description**:** A problem description allows one to put the proposed solution into context. Understanding the problem in all its facets is a prerequisite for designing useful solutions. This part should also state why the problem was not solved until now – and why and how blockchain technology can provide a solution.

## Rethinking Development Funding

One of the major findings in the workshops conducted around the (UN)BLOCKED conference, which brought together blockchain-based impact businesses and start-ups with funding agencies like the ADA or GIZ (German Development Agency), was that the mode of entrepreneurial activity is not compatible with the traditional forms of funding that development institutions provide.

Especially in the context of innovative technologies or approaches where implementation involves experimentation, learning and adaptation along the way makes funding difficult. On the other hand, start-ups involved in the area of "Tech for Good" often also face problems finding traditional investors as their primary aim of creating positive impact is often emphasised before the financial return. Furthermore, if the goal goes well beyond increasing efficiency of existing systems to rather developing transformative innovations (see chapter Innovation and Transformation), it becomes difficult for them to find support (and hence seed money) from companies in the sector without diluting their approaches.

If the potential of the start-up and business sector contributing to the necessary sustainability transformation is to be fully utilised, funding agencies should find novel ways to support start-ups making full use of the innovation potential of these change-makers.

| KEY CRITERIA FOR USING BLOCKCHAIN APPLICATIONS IN THE CONTEXT OF DEVELOPMENT PROJECTS | | |
|---|---|---|
| **GUIDING QUESTIONS** | | |
| 1 | Is there a trust problem between the involved stakeholders & beneficiaries? | Ask yourself these questions - and be prepared to answer them to potential funders. If you can answer these questions with yes, a distributed ledger like a blockchain network could be a great benefit.<br><br>Give the problem you want to solve the priority about the technology you want to use. If you can answer at least one of the questions with YES -> Blockchain based solution could be a good choice. |
| 2 | Are intermediaries involved that are part of or contribute to the problem faced by the beneficiaries? | |
| 3 | Is potential fraud or corruption a major part of the problem setting? | |
| 4 | Are local institutions eroded and weak or missing any capacities to contribute to the solution? | |
| 5 | Is there an inherent mistrust between the involved stakeholder groups that cannot be overcome? | |
| 6 | Can Web3 based solutions provide stronger transparency and stakeholder inclusion in this use case? | |
| 7 | Compare the advantages and disadvantages of alternative distributed ledgers. | |
| 8 | Does the project require data exchange with different/legal entities & jurisdictions? | |
| 9 | Is it possible to involve local actors / companies & by doing so build up competencies in blockchain technology? | |
| **GOVERNANCE RELATED APPLICATIONS** | | If the answer of one of the questions is NO then a blockchain based governance solution might be too difficult to implement. |
| 10 | Is there a willingness to actively support the project? | |
| 11 | Do the involved institutions have the necessary capacity to support the project? | |
| **SYSTEMS ADOPTION** | | |
| 12 | Is the proposed solution compatible with the available local infrastructure and funding of involved stakeholders? Does the lifetime of any build infrastructure and application match with the estimated lifetime of any software necessary to run it? | You should be able to answer all questions with YES. Otherwise rethink the design of your approach. |
| 13 | Are local users involved in any governance processes relating to changes in the proposed infrastructures and decentralized applications? | |
| 14 | If the blockchain system breaks down - will it still be possible to use and maintain the projects infrastructure? | |
| **EMPOWERMENT OR DISTORTION OF LOCAL STRUCTURES** | | |
| 15 | How far are locals in control of any rules implemented in the web3 infrastructures and their applications? | Use these guiding questions as a self-reflection tool about the role of local stakeholders. |
| 16 | Who can change the rules of the protocols? How far are power structures changed / respected? | |
| 17 | Would proposed solution replace established (social) structure, if yes, with what consequences? | |
| 18 | How would the system change from the different stakeholders point of view when a blockchain based solution is implemented? Will this erode or strengthen existing institutions? | |

# Outlook

While blockchains networks and their applications show potential to facilitate more sustainability, the technology used is just a tool, not a silver bullet. It will not magically protect forests, reduce CO2 emission or restore ocean health. Applied correctly, it can facilitate smart choices by producers and consumers, governments and corporations. However, the technology is still in its early stages, with many technological, legal and network effect challenges ahead.

Furthermore, token engineering, which refers to the design of token governance rules, is a new field of applied research development. Most tokens today do not incentivise behaviour but represent assets. There is still little experience, expertise and tools for token design or "purpose-driven-tokens" and we are in a state of trial and error, with very few best practices we can learn from. Tokenised initiatives need to be translated into everyday applicability for the improvement of local livelihoods. Incentive-structures need to take a range of different agents into account. Blockchain-based solutions also need to take ground-truths into account, including existing physical and social infrastructure.

Furthermore, it is important to understand that most blockchain or token application, also in the development context, need more than just blockchain networks. Many use cases that are attributed to blockchain, for example, transparency along the supply chain of goods and services, will only be possible in interaction with big data applications, AI, and the Internet of Things. The convergence of these emergent technologies that often interdependent will be more powerful than any single technology alone. Most of these emerging technologies have not yet reached their inflexion point, but when they do, network effects and exponential development will kick in.

When talking about blockchain and derived technologies, most people seem to focus on the positive potentials. Too little focus seems to lie on the negative implications of this new technology and its applications. But any technology is always just a tool. How we use that tool is almost never a technological question, but a governance question. The question of how we design these new protocols and smart contracts like tokens is much more of a socio-political-economic issue than a technological one.

How we design the governance structures of this system, the question of who gets to decide how this systems are designed and the trade off between transparency and privacy are socio-economic decisions, not technological decision. Discussing potential negative aspects at such an early stage is, therefore, crucial. One of the most important aspects of will revolve around developing and deploying privacy-preserving cryptography in blockchain networks and resource allocation as well as incentive structures in these systems. If we do not face these important questions at an early stage of designing the systems, what was designed to be a free P2P value exchange, can soon become an effective control machine and a perfect tool for totalitarian regimes.

# Annex:
# Overview of Blockchain Projects in ADA Partner Countries

Our project team guided the research of Alberto Medina, Mirna Smoljan and Sofya Parfenova, students at the Regional Academy on the United Nations (RAUN) who were writing papers on the topic "Innovations for Development: Towards Sustainable, Inclusive and Peaceful Societies". It was concluded that the implementation and adoption of the blockchain network and other Web3 applications is usually preceded by introducing the topic at public and private events, followed by schools and universities, establishing blockchain communities and organising large-scale events. Such activities can, therefore, serve as very important indicators for further blockchain development in a country. For this reason, nearly all activities around the technology have been considered in this overview, e.g. meet-up events, conferences, associations, partnerships, collaborations, pilot projects. The list is very extensive, and for the purpose of an easy-to-read overview, the three RAUN members mentioned above have constructed a table grouping the activities by regions.

| ***Executing Entities*** | ***Project Type*** | ***Description & Status*** | ***SDGs*** |
|---|---|---|---|
| ***Ethiopia*** | | | |
| Ethiopian Ministry of Science and Technology together with IOHK | Supply chain of coffee beans | *Using cardano platform, the company aims to track the supply chain of coffee by implementing genetic sampling to identify species, origin, pesticide and exposure to any chemicals to authenticate the coffee. Status: Ministry of Science and Technology (MoST) signed a Memorandum of Understanding (MoU) with cardano. Cardano has had Haskell (programming language) training in Barbados and Greece. Coffee is the countries' largest export. Ethiopia is also one of the world's largest producers.* | *12, 8* |
| Bext360<br><br>other source | Supply chain of coffee beans | *The project aims to track coffee beans produced in Ethiopia and consumed in the US throughout the entire supply chain. Test with coffee beans produced in Ethiopia and a coffee shop in the Netherlands. Daniel Jones, founder of the company and ex-employee of the US Defense Intelligence Agency, proposes to deploy robots which could analyse the quality and weight of the coffee beans produced and directly pay the farmers on the field. Status: Potential adoption by coffee cooperatives or larger organisations like the Coffee Farmers Coalition (CFC). In November 2017, the company conducted a pilot between Great Lakes Coffee in Eastern Uganda and exporting the product to Coda Coffee in Denver. The second pilot program was between Moyee Coffee brand based in Ethiopia and Amsterdam, was only announced, but there is currently no information about the status or the results of the first pilot.* | *12, 8* |
| United Nations Economic Commission for Africa (UNECA)<br><br>Other Source | Event & capacity building | *Conference "Exploring opportunities for blockchain technology in Africa" Bitcoin and other cryptocurrencies were at the main topic of discussion. Consequently, financial services, remittances, and financial inclusion were at the top of the agenda. Security concerns and implementation challenges such as the lack of a common structure in the existing systems (common data structure) were identified as the main hindering factor. Finally, laws and regulations were mentioned as essential. Status: n/a* | *8, 4* |

| **Uganda** | | | |
|---|---|---|---|
| CleanPath Emerging Markets Uganda (CPEM) & Wala in cooperation with the Ugandan Ministry of Energy and Mineral Development | Production & distribution of solar energy | *Wala is a start-up based in South Africa that offers remittance services, value-added services, savings and credit services on its platform. It currently has operations in South-Africa, Zimbabwe and Uganda. Wala uses Ether for the wallet and Stellar for transactions. Status: The $1.5 billion project will create an ecosystem around the DALA token. The project owners expect to pay energy grid workers with the same token. Users will be able to access solar power by means of the existing Wala platform. The program aims to double the current electricity generation capacity in Uganda, serve approx. to 25 percent of the population and create around 200,000 new jobs. The Energy Progress Report (WB), indicates that the electricity access rates in Eastern Africa remain very low. Kenya, with 56 percent has the highest access rates. The approach followed by the project can cope with the large infrastructure limitations in the region while contributing to build up an alternative ecosystem. The sources consulted were published in Oct 2018. There is still very limited information. Further research required.* | *7, 11, 8, 9* |
| *Block Commodities & Pure Grow Africa* | *Agricultural commodities project* | *The project aim is to increase production and scale up from a subsistence to a commercial level. The project will provide loans to farmers at lower interest rates using the Dala token. Important to note that the project has a vertical approach. That is to say, it seeks to facilitate the supply of agricultural products like fertilisers to the farmers. It is possible that the farmers could enjoy a lower interest rate and greater access to commodities that were previously difficult to attain. However, it would be highly advisable to thoroughly analyse the projects' trade-offs and the implications of using different tokens simultaneously. Status: The first pilot test, including 1,000 farmers linked to Pure Grow is planned. However, no information on a specific date could be found. Upon the completion of the pilot project, the project is planning to integrate the 50,000 farmers already linked to Pure Grow and occasionally expand to another sub-Saharan African countries.* | *8, 2* |
| *Blockchain Association of Uganda (BAU) and the Africa Blockchain Alliance (ABA)* | *Association / Capacity building* | *BAU is a membership organisation that consists of individuals and organisations that are interested in promoting blockchain related technologies and capabilities in Uganda. It has recently joined the ABA which aims to grow, teach and empower African people about blockchain technology. Status: The African Blockchain Alliance, consists of Cryptography Development Institute of Nigeria (CDIN), Blockchain Association of Kenya (BAK) and Ghana Blockchain Society. The ABA has already a presence in Ghana, Kenya and Nigeria and now in Uganda.* | *8, 4* |
| *Binance in cooperation with Crypto Savannah* | *Association* | *In an official statement, it was announced that Binance Foundation in partnership with Crypto Savannah (a blockchain innovation centre in Kampala), is planning to conduct a "train the trainers" blockchain programme involving around 1,000 participants. Additionally, Mr Changpeng posted on Twitter that by means of the above-mentioned partnership, Binance will "support Uganda's economic transformation and youth employment through blockchain, embracing the fourth industrial revolution". It is considered that Binance cooperation agreements will bring economic development to the country. Binance also announced partnerships with the Made in Africa initiative and Msingi, an organisation supporting East African industries. Both cases are usually used to illustrate the above-mentioned view. However, the information found falls short in explaining the ways in which such an objective could be attained. Status: Very limited data are available to estimate it accurately. There is, for example, no reference to the specific nature of the training. No more information could be found that confirmed the scope of the initiative. Similarly, no agreed-upon dates or the actual status of implementation can be found in the sources analysed. (2018)* | *8* |
| *The Africa Blockchain Conference 2018* | *Event & capacity building* | *The largest blockchain event on the continent. Uganda hosted the 2018 conference. Uganda's President, Yoweri Museveni, opened the two-day Africa Blockchain Conference, held at the Serena Hotel Conference Center in Kampala. Status: Frank Tumwebaze, the Minister of ICT and National Guidance commented: "I have agreed with the Blockchain Association of Uganda, that in the coming weeks, the Ministry will appoint an advisory task force of eminent people on blockchain to further assess the opportunities of the technology and challenges, and advise the government on how to harness the technology."* | *n/a* |
| *Binance* | *Fiat-Cryptocurrency Exchange* | *Binance is starting fiat-crypto trading pair with the Uganda Shilling. The project itself has little or no significance for the SDGs. Nevertheless, the possibility of trading cryptocurrencies with the Ugandan Shilling opens up opportunities for another blockchain-based project. For instance, global payments (remittances) or* | *n/a* |

| | | | |
|---|---|---|---|
| | | *financial services. Status: It was officially launched at the end of July 2018. The company plans to expand first to other East African Countries* | |
| ***Burkina Faso*** | | | |
| *International Association for Maternal and Neonatal Health (IAMANEH)* | *Token of Gratitude / Donations* | *Fundraise to support a three-year project (2016-2019) in Burkina Faso, which IAMANEH have implemented in collaboration with their local partner AMMIE (Association pour l'Appui Moral, Matériel et Intellectuel de l'Enfant). Donations are made in Ether via a smart contract, which after receiving a donation issues a non-transferable token to the contributor's wallet, serving as a "donation certificate".*<br><br>*Status: Potential similar fundraisings* | *3* |
| *ModulTrade* | *Payments and trade* | *ModulTrade is based on blockchain and smart contracts and is promising to open up global markets for African SMEs through its platform. It allows for cross-border trade for emerging markets and micro, small and medium enterprises. Status: SIMAT, which is a leading logistics company in both Cote d'Ivoire and Burkina Faso, is among the first companies to benefit from both ModulTrade's products. Another company that is set to benefit from the products is SERFIN. The company is a major player in financial services. It is also based in both Burkina Faso and Cote d'Ivoire.* | *8* |
| ***Albania*** | | | |
| *Meet Up Series* | *Event & Capacity building* | *Created for blockchain entrepreneurs, engineers, investors and anyone interested in the world of Distributed Ledger Technology (DLT) to discuss blockchain fundamentals featuring presentation of innovative DLT-related products and technologies, followed by Q&A sessions.* | *8, 4* |
| *A simple Blockchain Implementation* | *Event & Capacity building* | *Q&A and food for thought* | *8, 4* |
| *Startup Albania* | *Event & Capacity building* | *Ten carefully curated summits to shape much deeper connections and conversations between tech community leaders and all industries both old and new to better understand how technologies such as blockchain and AI will directly affect all industries, professions and the way we innovate.* | *8, 4* |
| ***Kosovo*** | | | |
| *KosICT´17* | *Event & Capacity building* | *aKosICT started six years ago as a regional conference with the aim to bring the global IT trending topic to the Balkan region. It is about the future with IoT, AR/VR, Blockchain, SaaS, FinTech etc.* | *8, 4* |
| *BarCamp Prishtina 48 - The World of Cryptocurrencies* | *Event & Capacity building* | *Discussion about the importance and the legal issues related to the blockchain technology.* | *n/a* |
| *Unichrone (Blockchain Training Course in Pristina)* | *Event & Capacity building* | *Mastering the various aspects of blockchain like building a peer-to-peer network, ethereum language Solidity, digital smart contracts, hyperledger, understanding the strengths of bitcoin and ethereum while working on industry designed projects in both classroom and live online classroom modes.* | *8, 4* |
| *Secure Ethereum Engineering Training* | *Event & Capacity building* | *This training aims to provide with all the knowledge one needs to begin developing smart contracts for Ethereum blockchain while adding security. Starting from lab setup and Linux Operating System and diving deeper into smart contract development is the journey that participants are going to take in order to master all the skills they need to program and deploy smart contracts. The Ethereum tech ecosystem is in constant change but the experience that participants will gain are going to guide them to adapt to any circumstances regardless of difficulties that they may face.* | *8, 4* |

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|---|---|---|---|
| *BlackStone eIT* | *Blockchain Company* | *Designed to dramatically reduce operating costs, increase competitiveness, mitigate risk, boost internal productivity, improve the customer and employee experience, and to make the previously impossible, possible.This digital transformation platform can be deployed in the cloud or on premise and includes: AI solutions, IoT tracking and logistics, blockchain, etc.* | *n/a* |
| ***Bhutan*** | | | |
| *BHUTAN BLOCKCHAIN BUDDAH* | *Agriculture market* | *Bhutan's agricultural market is struggling. Since 1970, agricultural price inflation in Bhutan has far outstripped the rest of the SAARC countries. The idea of a small self-sufficient place of your own is, for many, a distant dream. Bhutan has not built enough liquidity (cash) to avail resources that are necessary for change development. It has a vast possibility of raising zero-carbon tokens and reselling them to high carbon emitters and thus use funds to sustain its vision. The white paper introduces increased transparency around land ownership, so everyone knows if someone is unfairly sitting on a site that could be better used. It introduces as well improvement of the coordination of public investment in infrastructure and support timely connections to utilities, and tackling unnecessary delays caused by everything from planning conditions to great crested national emblems.* | *2, 9* |
| *Blockchain Training Course Bhutan* | *Event & Capacity building* | *For startups and corporations to understand how they can start implementing and using blockchain to their benefit, with different use cases that are specific to developers, fiscal entities or simply entrepreneurs and product managers looking to get started implementing blockchain solutions.* | *8, 4* |
| *Thimphu TechPark: "Understanding Blockchain and Cryptocurrencies for Managers"* | *Event & Capacity building* | *The course is designed to induce a competent level of understanding of key developments surrounding blockchain and cryptocurrencies. It will cover all the major aspects and components that dictate the current market dynamics of the rapidly evolving crypto-financial economy, and enable individuals as well as organisations to transition from a passive or reactive stance to having the ability for critical decision-making in a proactive manner.* | *8, 4* |
| ***Mozambique*** | | | |
| *Fura Gems* | *Gem Supply Chain (Mozambican ruby)* | *Fura Gems is a company with headquarters in Dubai.<br>Their blockchain-based solution to track gems will also be used in Mozambique in the context of ruby trade. The way this is used for supply chain management, in the mining industry, is that right from the point of mining a stone, right through to the consumer's pocket, the stone can be tracked.* | *9, 16* |
| *BenBen* | *Land Registry* | *Start-up BenBen's blockchain-enabled land registry allows people to search, manage, and verify property and land documents such as site plans, indentures, and mortgages. BenBen has two programs running in Accra, Ghana, and plans to expand to Nigeria, Mozambique, and Colombia. Bitland hopes to create a digital land registry that is universal, transparent, immutable, and bridges the gap between the government and undocumented areas. The company currently runs pilots in 28 communities in Kumasi, Ghana, and aims to expand across Africa to train people about blockchain technology, land rights, and corruption reduction in the land sector.* | *8, 9, 16* |
| *Global Blockchain Technologies Corp. - Coinstream Mining Corp.* | *Energy Supply* | *Blockchain can be used to track renewable energy consumption. Energy companies such as Powerpeers in the Netherlands and Exergy in Brooklyn, New York have used this. In related industry news, Global Blockchain Technologies Corp. (CSE: BLOC) recently acquired Coinstream Mining Corp., which will give authority to the former to manage the assets under the latter. Included in the assets are the Manitoba joint venture facilities, the Mozambique facility and a 25 per cent interest in blockchain software company Distributed Mining Inc. The wholly-owned Mozambique facility totaling 25 MW of capacity, with 10 MW of capacity available immediately. The Mozambique facility will host BLOC machines and/or seek joint ventures for the rapid procurement of cryptocurrency miners. These facilities have an average power cost of USD$.03 per KwH.* | *7* |

| **Armenia** | | | |
|---|---|---|---|
| Blockchain Technologies Corporation | Governance & Regulation | The Armenian government is considering the possibility of incorporating blockchain technology. Status: In discussion | n/a |
| PUBLIQ | Media | The blockchain network serves as the foundation on which PUBLIQ is building the distributed media ecosystem.PUBLIQ is a nonprofit foundation that places authors at the centre of the publishing and digital media industry by offering them an efficient and reliable ecosystem in which to interact and thrive. Authors have access to a free, secure, and censorship-resistant platform where they can upload their pieces of writing, protect them adequately within the latest blockchain architecture, and distribute them safely. Intermediaries or traditional publishing houses, which used to dominate the author in his or her work, are removed from the chain of creation and distribution. PUBLIQ's instant rewarding process encourages and incentivises authors to share their talents with the world. Rewards are assigned daily to authors depending on their PUBLIQ Score – a reputation-scoring system exclusively shaped from the readers' views and feedback. This unique evaluation system allows authors to be fairly rewarded as well as celebrated for their good work. | 4 |
| Center of Strategic Initiatives | Blockchain-based registries | Blockchain-based registries. Transaction costs will reduce. Cryptocurrencies may serve as an efficient tool if state structures find solutions for at least dealing with MLTF (Money Laundering and Terrorism Financing) issues; they should understand where the money comes from. Status: October, 2017, discussion | 8, 16 |
| UNDP's Alternative Finance Lab, AID:Tech and Neocapita | R&D | A working group was created which will be conducting a field visit in Armenia during 3-7 July. The group, comprised of representatives from UNDP's Alternative Finance Lab, AID: Tech and Neocapita will hold consultations with policy-making institutions in various areas and perform initial assessment, identifying and prioritising the areas where blockchain technology can be introduced and successfully executed for better, more transparent and more engaged governance. Status: CSI, in partnership with UNDP, started a project, which aims at mapping the opportunities of using blockchain technologies in public services sector in Armenia. | n/a |
| ECOS | Governance & Regulations | An innovative ecosystem based upon transparency, security, and synergy created with support from the Armenian government. It aims to deploy and scale up the innovative technologies, ECOS has set up the Free Economic Zone for blockchain and AI projects development with further launch to the global markets. Status: ECOS is the organiser of the Free Economic Zone in Hrazdan, Armenia. Further Steps: 1. Innovation Hub: R&D Centre and Hackathon Platform, PreAccelerator, Accelerator, Apps<br>Marketplace, ICO Marketplace; 2. IT: Data Center, AI Platform, Shared Mining, Parking; 3. Financial Tools, Capital Management, Lending, Acquiring, CryptoExchange, MultiCurrency Wallet, Fund & Algo Trading Platform; 4. Expertise: Laboratories with Universities, Certification Center, Online & Offline Education, Excellence Centers | 8, 4 |
| SCIENCE AND TECHNOLOGY CONVERGENCE FORUM | R&D | Science and Technology Convergence Forum (STC) aims to encourage science and industry cooperation in IT sector. | 8, 4 |
| American University of Armenia | Event & Capacity building | Through the joint efforts of AUA and Blockchain R&D Hub, an effective course on blockchain programming was created. Hajian stated that AUA and Blockchain R&D Hub will continue to cooperate in future endeavours and encourage other technology companies, within Armenia and abroad, to join their efforts. Status: October, 2017, discussion | 8, 4 |
| Armenian Blockchain Forum | Event & Capacity building | Armenian Blockchain Forum is a part of ECOS project and the backbone of its educational initiative ECOS. Status: First Forum was in April, 2018, the next one is in planning for next year. Also, in 2018 three blockchain meet-ups with local specialists were organised. | 8, 4 |

| | | | |
|---|---|---|---|
| NATIONAL COMPETITIVENESS REPORT OF ARMENIA 2017 | R&D | The report deals with possible extreme scenarios of blockchain development: 1. Blockchain will disrupt the global banking industry and banking operations will largely be replaced by blockchain technology 2. Cryptocurrencies will substitute current operating currencies for making payments 3. Central banks will lose monopoly as issuers of money 4. New asset classes will emerge. Short-term applications may be anti-money laundering (AML) compliance and payment systems. The technology may also provide cost savings to the clearing and settlement of securities and a secure base for smart contracts, which may transform the nature of financial relationships. | n/a |
| **Georgia** | | | |
| Association Blockchain Georgia | Event & Capacity building, R&D | Association Blockchain Georgia is a nonprofit organisation whose goal is to unite the blockchain society in Georgia. The goal is to increase the awareness of blockchain technology; support its adoption in Georgia; develop the research process; support Georgia in participating in international partnerships and associations; and to support the popularisation, search, research and discussion of blockchain technology. | 8, 4 |
| Bitfury, Georgian Co-Investment Fund | Mining farm | One of the biggest Data Centres for mining in Georgia. Status: First data centre was built in Gori in July 2014, second centre was built in Gldani in 2015.<br>A few months later, the government declared this territory a free industrial zone, which provides for favorable and simplified conditions for doing business. The companies operating in the free industrial zone are exempt from value-added tax (VAT) as well as from corporate income and property taxes. In addition, they are exempt from paying VAT when purchasing electrical power, which makes it 18% cheaper for them. | n/a |
| National Bank of Georgia | Governance & Regulations | A special statement was released, warning the citizens against the risks associated with the use of cryptocurrencies. The NBG stressed that 'cryptocurrency isn't a legal means of payment in Georgia. Its circulation isn't governed by law and there is no agency that can assist citizens regarding problems related to a cryptocurrency or protect them against the risks thereof'. | n/a |
| Smile-Expo | Event & capacity building | The first international conference in Georgia dedicated to earning on blockchain tech, cryptocurrencies and ICO. The conference aims to provide every participant with a comprehensive understanding of the economic and legal subtleties of the crypto industry in the country.<br><br>Status: Blockchain & Bitcoin Conference Georgia is part of the event network held by Smile-Expo in various countries around the world. June, 2018 — first conference in Georgia | 8, 4 |
| The government of Georgia, Bitfury | Land Titles & property | Blockchain technology to register land titles and validate property-related government transactions. A custom-designed blockchain system has been integrated into the digital records system of the National Agency of Public Registry. It is anchored to bitcoin blockchain through a distributed digital timestamping service.<br><br>Status: It was officially launched in 2016. February, 2017, pilot project. Since that time all land and real property titling transactions in Georgia have been hashed and stored on blockchains. The Georgian Justice Ministry keeps introducing new technologies as part of the project. It plans to introduce blockchain-based business registrations as well as 'smart contracts' – digitally authenticated and safeguarded agreements. | 1 |
| **Moldova** | | | |
| UNOPS, the government of Moldova, the Moldova's Ministry of Internal Affairs, the World Identity Network (WIN), ConsenSys | End child trafficking | The digital tool behind the cryptocurrency bitcoin, to stamp out child trafficking with help from United Nations experts. Status: November, 2017 start of pilot project. Further reference | 5, 16 |

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|---|---|---|---|
| *Digital & Distributed Technology Moldova Association (DTMA)* | *Event & capacity building* | *Promotion of Moldovan tokens: ZoZo Coin and Drachmae's own DTMI token. The conference speakers will address various blockchain and crypto-related topics, including the influence of digital currencies, applications of blockchain technology, blockchain programs in universities, and use cases of the technology. The organisers also plan a panel discussion titled "Legislation: country positions, opinions, perspectives."Status: It was launched in May, 2018. DTMA is currently preparing the creation of ZoZo Lab to be hosted within academia and will be recruiting students to take on internships to work on projects such as marketing and public relations (PR), information technology (IT), and real estate projects.* | *n/a* |
| *Moldova Blockchain Center* | *Governance & Regulations* | *The Moldova Blockchain Centre is currently undergoing major structural and governance-related change. All activities of the centre are suspended until the next announcement.* | *n/a* |
| *Drachmae Market* | *Crypto exchange* | *Drachmae Market is the country's first crypto exchange. It is trading 10 digital tokens initially, including leading cryptocurrencies like Bitcoin Core (BTC), Bitcoin Cash (BCH), and Ethereum (ETH), as well as a couple of Moldovan tokens like ZoZo Coin and Drachmae's own DTMI token. The trading platform also supports transactions of eight fiat currencies, among which euros, dollars, rubles, Moldovan leu (MDL). Status: It was launched in May, 2018. Central Bank of Moldova accepts the potential development of blockchain technology in finance field and ready to implement the technology through local banks.* | *n/a* |
| *Blockchain platform Moldovacoin* | *Crypto currency* | *Moldovacoin is a non-profit operation. The main goal of this project is to create a nation-wide blockchain platform to instil innovation in the Republic of Moldova. The objectives of this project are to draw attention to blockchain technology, train interested people and promote the services implemented on Moldovacoin platform. Within the Moldovacoin project, new electronic currency Moldovacoin (MDC) was developed. You can earn MDC tokens in several ways by participating in free distributions of tokens (airdrops), buying them on exchanges and with the help of mining.* | *8, 4* |
| *International Decentralized Association of Cryptocurrency and Blockchain (IDACB)*<br><br>*Further reference* | *Event & capacity building* | *World Blockchain and Cryptocurrency Summit - One of the largest blockchain- and cryptocurrency-focused conferences in the world. The purpose of the summit is to create the most accessible, politically-oriented forum in which business and government leaders can learn how blockchain can influence the efficiency of their work. As blockchain makes significant innovations in financial services, pioneers are beginning to recognise its opportunities in areas like energy, transport, healthcare and even the arts.* | *4* |
| ***Palestine*** | | | |
| *The Palestine Monetary Authority (PMA)* | *Digital national currency* | *Palestine Pound - the proposed digital currency can help Palestinians skirt around Israeli curbs that have been imposed and the need for obtaining clearance from them. A Palestinian currency thus would not be the first or unique in this respect. Still, it does bring to the fore an interesting use case: countries that have trouble printing their own currencies due to one reason or another can explore a digital currency alternative. Status: It was announced in May, 2017. Cryptocurrencies legal framework: Planned within the next 5 years.* | *8* |
| *Techno Park Palestine Birziet University* | *Event & capacity building* | *This workshop aims to address this new disruptive technology's basics in an easy, non-technical, heart-to-heart talk in order to build a surface level of understanding about the technology's possibilities and its wide applications. It will be interactive and more of a discussion to bring the most basic questions and to correct numerous misconceptions and wrong beliefs about this technology, we also want to show its real world uses and how far it went worldwide, and to brainstorm with the audience its use cases in the Palestinian context. Status: May, 2018, completed. Second lecture was held on August 29, 2018* | *4* |

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## Blockchain Projects Mentioned

- *3F Solar: https://www.3f-solar.at/en/*
- *Akasha: https://akasha.world/*
- *Ambrosus: https://ambrosus.com*
- *Astrn Energy: https://astrn.com*
- *Bitcoin Cash: https://www.bitcoincash.org/*
- *Bitlumens: https://bitlumens.com*
- *Bit Seeds: http://bitseeds.org/*
- *BitShares: https://bitshares.org/*
- *BlackCoin: http://blackcoin.co/*
- *Blockchain for Climate: https://www.blockchainforclimate.org*
- *Block Lattice: https://docs.nano.org/integration-guides/the-basics/#block-lattice-design*
- *Byteball: https://byteball.org/*
- *Cardano: https://www.cardano.org/en/home/*
- *Changers: http://changers.com*
- *Clearwatts: https://www.clearwatts.com*
- *Climate Chain Coalition: https://www.climatechaincoalition.io*
- *Climate Coin: https://climatetrade.com*
- *Climate Ledger Initiative: https://www.climateledger.org*
- *Colored Coins: http://coloredcoins.org/*
- *Cosmos: https://www.cosmos.com/*
- *DAO IPCI: https://ipci.io*
- *Decred: https://www.decred.org/*
- *Dfinity: https://dfinity.org/*
- *Diamond Lapse Protocol, Everledger: https://diamonds.everledger.io/*
- *DNV GL: https://www.dnvgl.com/index.html*
- *Earth Dollar: https://earthdollar.org/home/*
- *Earth Token: https://earth-token.com/*
- *E-chat: https://echat.io*
- *Eco Coin: https://www.ecocoin.com/*
- *Electric Chain: http://www.electricchain.org/*
- *ElectriCChain: https://www.electricchain.org*
- *Electron: http://www.electron.org.uk/*
- *Energi Mine: https://energimine.com/*
- *Energy Blockchain Network: http://www.energyblockchain.network*
- *EOS: https://eos.io/*
- *Ethereum Classic: https://ethereumclassic.org/*
- *EW Origin: https://www.energyweb.org/technology/ew-origin/*
- *Exergy: https://exergy.energy*
- *Fairfood: http://fairfood.nl/*
- *Freeelio: https://www.freeel.io*
- *Future Grid: http://www.future-grid.com.au*
- *Golos: https://golos.io/*
- *Greeneum: https://www.greeneum.net*
- *GridX: https://gridx.de*
- *Gruenstromjeton: http://jetons.stromstunde.de*
- *Hyperledger Fabric: https://www.hyperledger.org/projects/fabric*

- *Inuk: https://www.inuk.co/home*
- *IOTA: https://www.iota.org/*
- *IoT Chain: https://iotchain.io/*
- *IXO: http://ixo.foundation*
- *Lisk: https://lisk.io/*
- *Litecoin: https://litecoin.org/*
- *Mastercoin: https://en.wikipedia.org/wiki/Mastercoin*
- *Minds: https://www.minds.com/*
- *Modum: https://modum.io/*
- *Nano: https://nano.org/*
- *Neo: https://neo.org/*
- *NuShares/NuBits: https://www.nubits.com/nushares*
- *Nxt: https://nxt.org/*
- *Ocean: https://oceanprotocol.com/*
- *OriginTrail: https://origintrail.io/*
- *Plastic Bank: https://www.plasticbank.org/*
- *Poseidon: https://poseidon.eco*
- *Power Ledger: https://www.powerledger.io*
- *Provenance: https://www.provenance.org/*
- *Pylon Network: https://pylon-network.org*
- *Qora: http://www.qora.org/*
- *Recycle To Coin: https://iywto.com/things/recycle-cans/recycle-to-coin*
- *Ripple: https://ripple.com/*
- *Solar Coin: https://solarcoin.org/*
- *Solar DAO: https://solardao.me*
- *Steemit: https://steemit.com/*
- *Stellar: https://www.stellar.org*
- *Sunchain: https://www.sunchain.fr/en*
- *Sun Exchange: http://www.thesunexchange.com/*
- *Suttonstone: https://suttonstone.com*
- *Sweatcoin: https://sweatco.in/*
- *Swytch: https://swytch.io*
- *Tezos: https://tezos.com/*
- *The Sun Protocol: https://thesunprotocol.io*
- *TRACR: https://www.tracr.com/*
- *Traseable: https://www.traseable.com*
- *Vechain: https://www.vechain.org/*
- *Veridium: https://www.veridium.io*
- *Verv: https://verv.energy*
- *Wabi: https://wacoin.io/*
- *Waltonchain: https://www.waltonchain.org/*
- *Waves: https://wavesplatform.com*
- *WePower: https://www.wepower.network*
- *Zero Carbon Project: https://www.zerocarbonproject.com*

## Project Mentioned in Annex

- *Ethiopian Ministry of Science and Technology together with IOHK: https://www.coindesk.com/ethiopia-explores-blockchain-role-in-tracking-coffee-exports*
- *Bext360: https://www.bext360.com, https://www.globenewswire.com/news-release/2017/11/03/1174728/0/en/bext360-Announces-Partnerships-in-Africa-Europe-and-North-America-to-Produce-the-World-s-First-Fully-Blockchain-Traceable-Coffee.html*
- *United Nations Economic Commission for Africa (UNECA): https://www.uneca.org/egm-upbta-2017, https://www.uneca.org/sites/default/files/images/e1701284_concept_note_egm_22_november_2017.pdf*
- *CPEM & Wala in cooperation with the Ugandan Ministry of Energy and Mineral Development: https://disrupt-africa.com/2018/09/sas-wala-to-finance-ugandan-solar-programme-with-digital-currency/*
- *Block Commodities & Pure Grow Africa: https://www.enterprisetimes.co.uk/2018/09/18/block-commodities-launches-ugandan-blockchain-ecosystem-pilot/*
- *Blockchain Association of Uganda (BAU) and the Africa Blockchain Alliance (ABA): https://www.itnewsafrica.com/2018/05/africa-blockchain-alliance-launches-in-east-africa/*
- *Binance in cooperation with Crypto Savannah: https://www.newsbtc.com/2018/04/26/binance-meets-with-ugandan-president-plans-to-support-economic-development-with-the-blockchain/*
- *The Africa Blockchain Conference 2018: https://bitcoinafrica.io/2018/05/28/uganda-blockchain-taskforce/*
- *Binance: https://cointelegraph.com/news/exclusive-binance-set-to-launch-its-first-crypto-fiat-exchange-in-uganda*
- *International Association for Maternal and Neonatal Health (IAMANEH): https://procivis.ch/2018/06/20/successful-women-in-blockchain-launch-event/*

- *ModulTrade: https://www.domradio.de/themen/soziales/2018-03-06/welternaehrungsprogramm-spart-mit-blockchain-konten-tausende-euro*
- *MeetUp Series: https://www.facebook.com/BlockchainWB/*
- *A simple Blockchain Implementation: https://icoholder.com/en/events/a-simple-blockchain-implementation-2367*
- *Startup Albania: http://startupalbania.tilda.ws/#summits*
- *KosICT´17: http://www.beinkosovo.com/event/kosict17/*
- *BarCamp Prishtina 48 - The World of Cryptocurrencies: http://ipkofoundation.org/activities/barcamp-prishtina-48-the-world-of-cryptocurrencies/*
- *Unichrone (Blockchain Training Course in Pristina): https://unichrone.com/xk/courses/it-software/block-chain-training/pristina*
- *Secure Ethereum Engineering Training: https://ickosovo.com/training/courses/secure-ethereum-engineering-training*
- *BlackStone eIT: http://www.blackstoneeit.com*
- *BHUTAN BLOCKCHAIN BUDDAH: https://www.linkedin.com/pulse/bhutan-millenium-goals-tying-agro-cyber-mustapha-saha-ali-niwaz/*
- *Blockchain Training Course Bhutan: https://unichrone.com/bt/courses/it-software/block-chain-training*
- *Thimphu TechPark: "Understanding Blockchain and Cryptocurrencies for Managers": http://thimphutechpark.com/training-on-understanding-blockchain-and-cryptocurrencies/*
- *Fura Gems: https://www.forbes.com/sites/bernardmarr/2018/03/14/how-blockchain-could-end-the-trade-in-blood-diamonds-an-incredible-use-case-everyone-should-read/#2baeae51387d*
- *BenBen: http://www.benben.com.gh*
- *Global Blockchain Technologies Corp. - Coinstream Mining Corp.: http://markets.financialcontent.com/prnews/quote?Symbol=BLKCF*
- *Blockchain Technologies Corporation: https://itel.am/en/news/10076*
- *PUBLIQ: https://publiq.network*
- *Center of Strategic Initiatives: https://banks.am/en/news/fintech/14607*
- *UNDP's Alternative Finance Lab, AID:Tech and Neocapita: http://new.reforms.am/use-of-blockchain-technologies-in-public-services-sector-in-armenia/*
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