

Crypto-governance *Blockchain Governance for Sustainable Development Goals 16 and 17*

Reshma Kamath

Blockchain Research Institute

Cryptogovernance, governance on the blockchain, has real, long-lasting potential to impact the United Nations Sustainable Development Goals 16 and 17. The idea of Cryptogovernance embeds consensus protocols, rights-based mechanisms and a convergence ecosystem. Through institutional reform via proof of attestation and proof of corruption, blockchain protocols are transforming interactions between people and systems. Several blockchain projects, though nascent and evolving, have instituted such reform (voting, asset tracking, tokenization, ecosystem building), yet development and public sector is lagging behind. This paper helps connect the dots between technology and governance, via a cryptogovernance framework.

Keywords: Blockchain, Sustainable Development Goals 16 and 17, Cryptogovernance, Proof, Rights, Tokens

Received October 2, 2018
Revised December 24, 2018
Accepted December 26, 2018

Corresponding Author

Reshma Kamath
Blockchain Research Institute
E-mail: reshmakamath2017@gmail.com

INTRODUCTION

For the United Nations Sustainable Development Goals (SDG) 16 and 17, Blockchains strengthen SDG “Means of Implementation” and revitalize Global Partnerships for Sustainable Development. (Sustainable Development Knowledge Platform, 2018). At the launch of the U.N. Blockchain Commission, Fernandez de Cordova Chairman of PVBLIC Foundation, touted values of inclusion and responsibility to industry experts: “Blockchain Commission invites visionary industry stakeholders — representing the full breadth of the blockchain ecosystem — into a robust, future-based, multitrack global conversation about social innovation, fair and consistent public policy and responsible guidelines for industry governance.” Christine Lagarde, Managing Director and Chairwoman International Monetary Fund (2018), established the importance of governance and partnerships in her speech on SDGs. Lastly, lessons from Millennium Development Goals (MDG) implementation point out the criticality of “good governance, rule of law, transparency and accountability” at all levels. (Maendolo Policy Forum, 1997).

Under SDG 16, blockchain technology bolsters SDG value chains through shared responsibility (Roby, 2018) and inclusive stakeholdership. The resulting convergence ecosystem (Lundy-Bryan, 2018) is strengthened by peer linkages and synergies amongst a wide range of actors and constituencies. For SDG 17, blockchain falls neatly under its finance and technology indicators. As a distributed ledger technology, blockchain builds traceability, monitoring and data auditing frameworks of SDG 17’s indicators and targets. With potential for cross-chain interoperability and proliferation, blockchains will bring data monitoring and accountability benefits to

SDGs as a whole.

In this paper, I introduce the term, ***Crypto-Governance*** -governance on the blockchain. Throughout this paper, I showcase the potential effect of blockchain governance on achieving certain targets and indicators under Sustainable Development Goals 16 and 17. No scholarly paper has even attempted to discuss blockchain's governance capacities in international development and cooperation. The United Nations has merely begun creating workshops and commissions to explore this innovative technology. This paper, thus, helps development experts and policy specialists connect the dots between a burgeoning technology and achieving sustainable development goals through a new form of blockchain governance, *crypto-governance*; creating new forms of decentralized institutions in government, law and civil society at large through token rights and distributed networks to resolve desiloed Goals, targets and indicators.

On the whole, this paper sets up novel and effective best practices in achieving targets and indicators of SDG 16 and 17. The following section discusses why blockchains, and what the technology is. Through inclusive e-stakeholdership and reimagining governance discourse, the paper focuses on applying blockchain's governance implications to the interdependent Sustainable Development Goals 16 and 17.

BLOCKCHAINS & SUSTAINABLE DEVELOPMENT GOALS 16 & 17

Why Blockchains?

The European Parliament Resolution (2016/2007 INI) has emphasized the potential of Distributed Ledger Technology "to contribute positively to citizens' welfare and economic development" (Art. 1). In line with SDG 16 and 17, Latin America's largest economy, Brazil has adopted blockchain technology to reduce corruption, legitimize legal decisions, and even track votes. The Dutch Government has issued blockchain's relevance in legal decisions with UNOPS. India has built land title and birth record registry on the blockchain. The U.N. has a multi-agency platform, UN Blockchain.

The United Nation's Blockchain Commission for Sustainable Development was formed at the SDG Media Zone during the 72nd Regular Session of the UN General. It launched Blockchain for Impact in 2017, a collaborative advocacy platform for multi-level and multi-zonal leadership from various sectors to convene and discuss.

The Commission's agenda is in alignment with SDG 16 - building global leaders in the blockchain community. It touches upon "application of blockchain to initiatives with profound social impact, transparency in the evolving marketplace, trust between multi-stakeholders, the development of an international policy agenda with a focus on accelerating progress in least developed countries, and the implementation of best practices towards nations' sustainable development targets." (2017). Its goal is to advance the 2030 Agenda for Sustainable Development.

While building public-private partnerships and multilateral agreements, the Commission is focusing on blockchains and its impact on civil society. In a tripartite system, it is fostering collaborations between and among governments, NGOs and the private sector. According to *The Economist*, nine in ten government organizations plan to invest in blockchain to manage financial transactions, assets, contracts and regulatory compliance by next year.

Michael Hsieh, Stanford's Center for International Security and Cooperation, states how blockchains create a threat for governments, only if they ignore the technology. He further goes on to state that those using it to institute "safe and honest systems for money exchange will appeal to business and investment interests."

According to IBM's Brigid McDermott, "the trust [blockchain] delivers enables more efficient and complete sharing of the critical data." In addition, it "has the capacity to reduce uncertainty, insecurity, and ambiguity in transactions by providing full transactional disclosure and producing a single truth for all network participants." (Beck et. al, 2017). Blockchain records span "audits, agricultural treatments, identification numbers, manufacturers, available device updates, known security issues, granted permissions, and safety-protocols, all logged in

real time and permanently stored as digital certificates.” (Kamath, 2017).

In *Blockchain for Women Next Generation for Sustainable Development Goal 5*, Kamath (2018) highlights the potential of blockchain, a nascent technology, in revamping the role of Women, Children and Gender minorities through Identity, Ownership, and Access. It discusses the gender digital divide impacting SDG 5 and how blockchain technology is overcoming this problem to meet the targets and indicators. Yet with this growing emphasis on blockchain, governance implications of this technology for civil society and institutional reform is at its early stages; not fully explored and executed.

Harnessing blockchains in governance (Target 17.6-17.9) will transform interactions between civil society, its constituents, stakeholders, government, for-profit and corporate entities, and various other industries and sectors (Target 16.6-16.8). By leveraging existing ICT platforms, blockchains will help developing countries implement, and thus, leapfrog to Web 3.0. Further, blockchain’s peer-to-peer networks will facilitate and actuate transformational governance change. Blockchains, will thus, create a symbiotic e-governance ecosystem, both intra- and inter-country (Target 16.10, 16 (a) (b)), in the public and private sector.

The next section will briefly touch upon the technicalities of blockchain.

What Is a Blockchain?

Blockchain is not just bitcoin (Figure 1). Blockchain is the underlying technology in crypto tokens and virtual assets; a form of distributed ledger technology (DLT). Smart contracts (Blockgeeks) and triple accounting ledgers (Grigg, 2005) are manifestations of blockchain.

A blockchain (Nakamoto, 2008) is a sequential, time-stamped database of information, cryptographically secured through hashing proof (Tapscott and Tapscott, 2016). It is based on the Internet Protocol Suite, TCP-IP protocol. Within blockchains, merkle tree transactions (string of alphabetical and numerical values) (Rouse) are hashed (coded) and repeatedly paired, merged and rehashed until one hash is produced, the merkle root. Each block saves the merkle root of the previous block, creating a data chain; cryptographically secured and armored. Retroactively changing a block to affect a transaction requires rehashing the entire transactional block, as well as subsequent blocks; possible in theory, highly improbable in practice, with new blocks constantly added to the ever-expanding blockchain. Network users have a shared snapshot of the truth in real time, as well as ownership and control over their private information. Blockchains create a trusted ecosystem with cryptographic proofs as checks and balances.

For SDGs, public blockchains (decentralized networks) create multilateral agency platforms for both intra- and inter-country information. Private blockchains (permissioned private networks), on the other hand, maintain

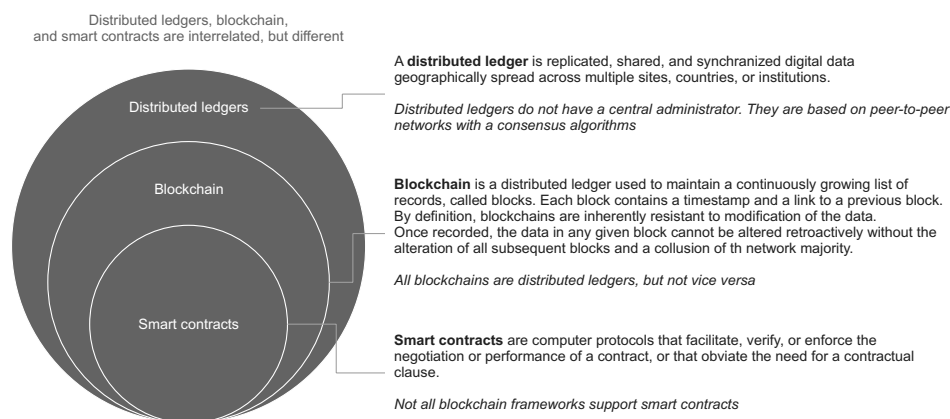


Fig. 1. What is blockchain? Visual relation to distributed ledger technology and smart contracts. <https://image.slidesharecdn.com/hfswebinar-the20mostpromisinguse-casesofenterpriseblockchainadoption-180119135830/95/hfs-webinar-the-20-most-promising-usecases-of-enterprise-blockchain-adoption-13-638.jpg?cb=1516370557>.

confidentiality and privacy of sensitive data to permissioned entities through special access regimes. The latter is mostly used by enterprises and institutions. This paper is not about what blockchain is. It is about *crypto-governance* -applying the technology's governance potential to SDGs. Applications of this will be discussed in Section 2.3 Methodology. The following Section 2.0 discusses *Crypto-governance*, by analyzing governance discourse with new, emerging forms of governance. Then, the definition of Crypto-governance, as applied in the paper is seen, followed by the Methodology used in the case studies and examples. The new terms I created, on-chain governance and off-chain governance, in the context of Crypto-governance are further examined throughout the paper.

CRYPTO-GOVERNANCE

Good governance and transparent government partnerships are essential elements of country-wide SDG frameworks. Lagarde calls "governance...the foundation upon which everything else is built. If institutions are weak, the odds of SDG success are severely handicapped. This is why the SDGs call for "effective, accountable and inclusive institutions at all levels." (2018).

Several countries reiterate this. The Government of Cambodia has "prioritized Good Governance in its NSDP" (UNDP, 2016). In its peace-related targets for Goal 16, about 70% addressed "fighting corruption; legal and judicial reforms; public administration reforms (including decentralization and deconcentration); and reform of the armed forces.

Even in governance, more and more countries are moving towards a digitized form of government and institution. E-governance between Republic of Moldova, Bucharest and Moldova is a live implementation of this. While using experience exchange, identifying common interests, and fostering cooperation and efficient digital transformation of the public sector, the Republic is keen on implementing the EU 2020 Digital Agenda Pan-European Targets. A second example is The Monitoring and Evaluation frameworks of African Nations for SDG 16 and 17. This system embellished development of simplified, local communication tools (European Center for Development Policy Management, 2015). The development world is witnessing more country-wide initiatives, human rights reports and global agendas to monitor and track progress on virtual platforms.

Digitizing such participatory and transparent governance onto the blockchain platform is, therefore, a natural progression of international development. The question then becomes, what is this governance, what is its most effective form, and what is *crypto-governance*.

What Is Governance?

Public sector reform and changes in the 1980s and 90s coined a new term, "governance." (Armstrong, 2005). In development governance literature, governance is described as a pattern of rules arising when the state is dependent on others, or plays little or no role (Rhodes, 2007). In the corporate governance body of work, governance is a growing awareness of ways in which power and authority can secure order even in the absence of state activity.

Global governance takes a slightly different take on governance. United Nations isn't as strong to impose its will on a territorial entity. New governance raises issues of public policy and democracy. It also takes into consideration the growing role of non-state actors in public services delivery.

Governance without a government (Atzori et. al, 2015), the shift from public to private, and the major role of market in public affairs has emerged and evolved. Networks now have power to "self-organize, develop resilience and evade government control." (Box, 1995). Their emphasis lies in the "governments need to become more like business; markets can do better than the State." This network power "downplay[s] the role of State and dominate[s] public policy."

Alternative forms of public governance are ripe in the development world. These models are multi-stakeholder, decentralized, distributed and collaborative governance. These newer, innovative governance models are in line with crypto-governance. *The Crypto Anarchist Manifesto* and *Cypherpunk's Manifesto* stresses decentralization, laissez-faire, a hands-off government. It reinstates "freedom of speech, individual privacy in communication and

anonymous transaction systems.” (Atzori, 2015). In the developing world with weaker institutions and several cultural barriers preventing the public from speaking up, such a technology platform is a boon in disguise.

Blockchain experts such as Swan (2015) have stated the importance of blockchains to permeate “geography-based, nation-state jurisdiction to a truly global cloud.” Swan talks about transcending the notion of one government provider. Instead, she touts the importance of “one overall governance system rather than the host of inefficiencies in comply with multiple nation-state.”

Herein lies the central thesis of this paper, *crypto-governance*, creating a novel blockchain-based governance system, with inclusive stakeholdership - public and private actors, governments, civil society and the community at large.

Crypto-governance

This paper coins (*pun intended*) the term, *Crypto-Governance*, to describe governance on the blockchain. *Crypto-governance* is deploying blockchain’s cryptographic technology to revolutionize developmental governance. For purposes of this paper, blockchain is about de-siloing the legacy systems of bureaucratic development and government institutions. It is reinstating a transparent and accountable governance system, observable and reachable by entities and individuals alike, internal and external to the institutional system and process.

Blockchains, as a hyper-political tool, have the ability to manage “social interactions on large scale and dismiss traditional central authorities.” (Atzori, 2015). As an organizational theory, blockchains decentralize through “algorithm-based consensus.” In line with principles of the UN Blockchain Commission for Sustainable development, *crypto-governance* explores convergence ecosystems, value chains and shared responsibility amongst platform actors.

Crypto-governance for blockchain products and services is evolving and nascent. New projects are experimenting with automated governance in an attempt to avoid messy human decision-making. The U.N. SDG bond is a small step in economizing sustainable development goals and having marketplace attributes applied to development. In partnership, “the World Bank, BNP Paribas and Swiss private bank SYZ have renewed their partnership for an equity bond offering that will link investment returns to the performance of companies advancing priorities set out in the United Nations’ Sustainable Development Goals (SDGs).” (Holder, 2018).

Crypto-governance takes advantage of blockchain’s public-record keeping features; as a “universal, permanent, continuous, consensus-driven, publicly auditable,...record-keeping repository.” (Swan, 2015).

Critics may state applying blockchains, a forced governance scheme; a solution to a problem that doesn’t exist. Such naysayers come from the school of thought - “if it ain’t broken, don’t fix it” and “things have always been this way.” Most forward-thinkers and progressive reformers seek new ways to make existing models more efficacious, and/or replace old ways with innovative mechanisms.

As a standalone goal, development experts claim, “if Goal 16 failed, SDGs will fail.” Rightly so, because even though SDGs are inter-connected in a system of growth, an integration by synergy, where we cannot aim to achieve one goal without the others. Yet for SDG 16 and 17, this complicates matters. Some targets reinforce each other, others conflict as trade-offs; Sustainable Development Goals, as a whole, are “hard to follow and difficult to implement as Goal 16 has a number of agendas of various fields,” as stated by Conflict Management Expert, Dr. Deepak Prakash Bhatta. Therefore, it is crucial to have a systematic, traceable method, such as the blockchain, to trace progress touching upon different sustainable development goals, targets and indicators, and identify what actions further develop these goals.

The next section delves into blockchain’s governance attributes - convergence ecosystem, rights-based mechanisms and chain governance- to attaining SDG 16 and 17, as well as other Goals.

Methodology

Blockchain’s governance attributes play an important role in sustainable development, institutional reform, and data monitoring and accountability under Goals 16 and 17. *Crypto-governance* stems from an interdisciplinary school of thought combining mechanical and scientific methods to development governance. For instance, as proposed by economist Robin Hanson, futarchy is an engineering approach to public policies (Hanson, 1995),

widely discussed in development policy circles.

Two sets of rules govern blockchain: “the first is the classical set of rules provided by the legislative framework, the code of law and regulation. The second is the set of rules that determine the operation of the algorithms encoded by the software. This is the technical code, and there needs to be at least as much focus on ensuring the rigour of the technical code as on legislative code.” (UK Government Chief Scientific Adviser).

The following methodology, *convergence ecosystem*, *rights-based mechanisms*, and *on-chain and off-chain governance*, are visible in newer blockchain governance protocols, discussed in various projects throughout the paper.

Convergence Ecosystem

In line with an inclusive, multi-stakeholder governance model, blockchain’s “convergence ecosystem ... support[s] a diverse range of different governing models that support different communities. There is no optimal model of governance; only a perpetual tension to maintain alignment amongst stakeholders.” (Lawrence, 2018).

The blockchain economy has manifest itself in a new form of organizational design—**Decentralized Autonomous Organizations (DAO)**— virtually dispersed organizations with governance rules specified on the blockchain. Although the first iteration of DAO was hacked, the blockchain community is working to better it. DAICO - a combination of the DAO and ICO, has also been proposed in blockchain with contribution mechanisms for funding. Crypto-Governance has now evolved from the DAO (Decentralized Autonomous Organization) combining with the ICO (Initial Coin Offering). Unlike an ICO, where “developers have complete access to all the contributed funds,” in a DAICO, at the end of the token sale, “contributors can vote on resolutions (during the development phase) to either increase the tap or to return the remaining contributed funds (self-destructing the contract)” (Pauw, 2018).

Moreover, in an ICO, these developers “calculate in advance how much is necessary to produce a minimum viable product and once they reach this amount, called ‘the soft cap,’ they can start to work on the product and spend the money on whatever they deem necessary. If they don’t reach this initial soft cap, they have to refund the money. But if they do, there’s no further real obligation.” In a DAICO, “if developers hold a large chunk of the distributed tokens, they potentially only have to influence a small percentage of contributors to sway their vote and get more funds released from the Smart Contract.” (Victoria and Vlad, 2018).

Most importantly in a DAICO, contributors “need to understand why the price of a specific token is rising or falling to make the right decision when voting on increasing the tap amount, or returning the funds. The best decision is one based on the facts relating to the project itself, not on emotions connected to the price of a particular token.” (Victoria and Vlad, 2018). A consensus-based community approach on the blockchain network. Think Torrent on steroids with access to information, in addition to creating and posting new information, while changing misinformation and errors.

Lastly, “contributors can also completely disengage by putting all their trust in the DAICO concept itself and therefore feel it’s not necessary for them to actually partake in votes and resolutions, reducing the majority threshold and weakening the security of the mechanism.” (Victoria and Vlad, 2018). For example, the Abyss, for instance, a next generation digital distribution platform based on a crypto reward ecosystem, plans to do this with the following DAICO features:

- “A resolution to vote on tap increases can only be initiated by project developers.
- There’s a percentage limit by which the tap can be increased at a time (to prevent abuse).
- The frequency of potential tap increases is limited (no more than say once every two weeks).
- Only investor tokens can be used to vote, not those held by project developers.
- Contributors will be informed well in advance of a planned poll.
- When contributors decide to terminate the project, the Smart Contract will change to withdrawal and refund their money, while at the same time destroying tokens held by developers.” (Pauw, 2018).

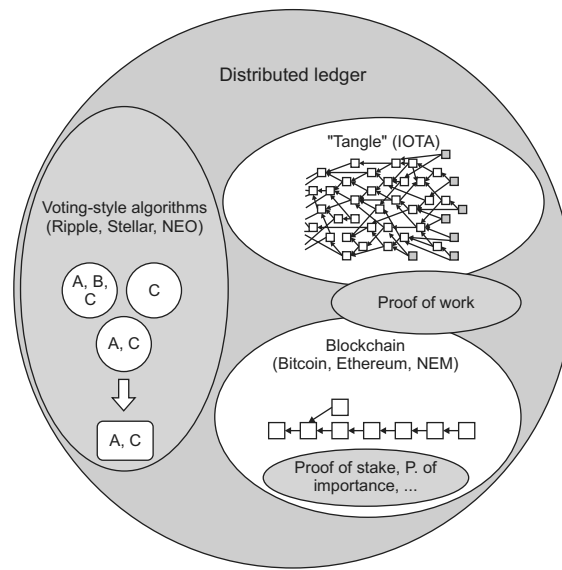


Fig. 2. Distributed Ledger Technology Chain of Custody: proof-of-work and proof-of-stake. https://www.die-gdi.de/uploads/media/DP_2.2018.pdf.

Rights Mechanisms

Crypto-governance focuses on rights embedded within blockchain tokens. These are (1) decision or control rights (ratification and concentration of decision-making power), (2) accountability rights, and (3) incentives or rewards. These broad rights include (a) distribution rights and (b) voting rights with verifiability, secrecy, robustness against false accusations, and usability within them. Crypto-governance rights are focusing on futarchy: “vote for values, but bet on belief.” (Boskanic, 2018; Beck et al, 2018; CarbonVote, 2018).

Governance tokens have rights embedded in them, so token holders can implement these rights in a network ecosystem. The principle of token proportionality underlies governance tokens. This means the amount of token a network user has determines the number of votes they have to use. For e.g., with voting rights on governance tokens, token holders get to make changes on the network to which they belong. Thus, “the network value of a governance token is bound by the net cost of forking [splitting from] or creating a new copy of the network.” (Yermack, 2017).

Non-Fungible Tokens (NFTs) are cryptographic tokens, unique and not interchangeable. Such non-fungible tokens certify each piece of property or service with a unique digital signature. They take the form of metadata, avatars, individual token ids and custody chains. Unlike currency tokens, whose nature is fungibility, these unique ids can represent people, things, property, events, and assets.

Other virtual tokens serve both as a transactional and governance utility. In combining these functions, the blockchain network can change the rules. “The two asset classes are designed for one to decrease its power over time (transactional) and the other to increase power (governance / control).” (Murck, 2017).

Chain Governance

Decentralized consensus is the single biggest value blockchains bring to institutional reform: in maintaining records and in decision making by providing incentives for nodes to guarantee blockchain integrity. *Consensus* mechanisms in blockchains encourage nodes to validate new transactions and discourage them from creating alternative histories of transactions. This consensus often employs economic incentives to keep the database consistent. *Proof of work* (PoW), used by Bitcoin and Ethereum, is the most common consensus mechanism. *Proof-of-stake* (PoS) is the other¹ (Figure 2).

¹Bitcoin Developer Guide, bitcoin, <https://bitcoin.org/en/developer-guide#block-chain>.

Proof-of-work requires solving a computationally expensive cryptographic puzzle. The node (participants on the blockchain) finding the solution to the puzzle first validates the next block, and is remunerated with cryptocurrency. In *proof-of-stake*, nodes (participants on the blockchain) with more cryptocurrency (larger stakes) have higher probabilities of being chosen to validate the next block. The stake may be destroyed if the node behaves maliciously, which thus discourages such behavior. (Pearson, 2018). Through forking², disagreements are resolved in a decentralized manner. Network participants resolve decisions in a decentralized manner by copying existing code and developing it further based on their goals (Beck et al, 2016).

In the same line of thinking, this paper discusses *proof of corruption* and *proof of attestation* with examples of blockchain protocols. These mechanisms institute risk-reward reinforcements recorded on the blockchain through voting and consensus, viewable and accessible for participants via each blockchain network (SDG 16.10).

Following are newly-devised governance concepts, *on-chain governance* and *off-chain governance*, deploying on-chain and off-chain engineering to development and public policy.

- On-Chain Governance: Opting-in is the key difference between off- and on-chain. *On-chain governance* employs smart contracts to automatically self-execute a code change after a voting period. Forking (splitting) is possible, as in off-chain, i.e. the minority disagrees with the majority vote by replicating the entire network and then forging a new development path. In on-chain, a majority votes triggers a protocol change. In off-chain, network participants download a protocol change.

Decred is a hybrid PoW/PoS cryptocurrency embracing autonomous on-chain governance models. Network users develop their constitutions, and on-chain models and stakeholders make protocol upgrades as well as invalidate blocks on consensus. This enables greater participation when the stake required to govern the network grows with the network size.

- Off-chain governance: In *off-chain governance*, network participants (nodes) communicate external to the blockchain governance network. External participants can be given informal rights such as informal voting signal to change a protocol. Carbonvote is a prime example, where informal voting rights are attached to tokens, and thus, transferred to token holders. Such off-chain rights don't automatically trigger a change. Minority participants can choose not to download and accept the updated code. This creates a fork, resulting in two separate networks. "In this way, off-chain voting serves as a coordination tool." (Bonello, 2018). It also respects the privacy and anonymity of the individual in not creating immutable data sets.

The next Section discusses crypto-governance and SDG 17 for data monitoring and accountability. Showcasing the intertwined nature of the two goals, this Section demonstrates how digitization through blockchain can be a potential solution for SDG 16's corruption and institutional reform.

CRYPTO-GOVERNANCE & SUSTAINABLE DEVELOPMENT SDG 17 FINANCE, TECHNOLOGY, CAPACITY-BUILDING & SYSTEMIC ISSUES

Institutional Reform: Chain Attestation and Corruption (SDG 16 & 17).

Fraud and corruption investigations take an average of 15 months. Illicit financial flows, and as a result, growing tax revenues, cost African (and developing) nations close to \$50 billion per year. Of this, 83% is due to mis-invoicing. With blockchains, they could be performed at the touch of a button and at a fraction of the cost. This financial tracking would be a deterrent for bribes in the public sector, amounting between \$1.5 trillion and \$2 trillion annually, roughly 2 percent of global GDP.

In relation to SDG 16.5 indicator of corruption, *Substantially reduce corruption and bribery in all their forms*, and 16.6, *Develop effective, accountable and transparent institutions at all levels*, blockchain's benefits of Anti-Money Laundering (AML) and Know Your Customer (KYC) are instrumental in building SDG 17.7 transparent,

²Fork, accidental fork, bitcoin, <https://bitcoin.org/en/glossary/fork>.

networked public services, and SDG 16.9 and 17 identity-based financial aid technology. Issuance of *non-fungible unique digital identifiers* in a *convergence ecosystem* enable low friction value transfers via the blockchain. Such a seamless and decentralized blockchain-as-a-service delivery can span from “access to aid, welfare, education, and healthcare as well as enabling donations to be delivered digitally.” (Cheng et al., 2017).

Triple accounting ledgers on the blockchain answer in real time the question of how, what and to whom deliveries are made, and whether distributed resources are going to intended beneficiaries (Simoyama et. al, 2017). For SDG targets and indicators, stakeholders and the public can thus “identify wastage, inefficiencies, and cases of fraud and error,” (Distributed Ledgers for the Prevention of Accounting Fraud Blockchains Between Expectations and Reality, 2017) live with real-time updates. Fraud and corruption tracking and enforcement is achieved via the nature of stored information on the blocks. Blocks store the expense, as well as the project and activity linked to the funds. Block verification through additional data is achieved through smart contracts. Such automated, self-executing functionality via conditional if/then statements, allows the blockchain to “release funds, dates from which they can be made available,” (Localethereum’s officialblog, 2017) and thus, prevents improper expenses. Smart contracts ensure interactions go as planned, and generate marketplace specific reputation for successful deals (Symbiont, 2017). This is a huge achievement in public procurement for products and services tracking. Following are proof of corruption and proof of attestation, blockchain-based consensus mechanisms in alignment with SDG 16 and 17.

Proof of corruption as a consensus mechanism and as a token design right will reduce administrative and human errors. Like proof of stake or proof of work, proof of corruption is easily detectable in an online digital format, and is tamper-evident years from the origin. For instance, 0xcert protocol translates one-of-a-kind digital or real-world assets into non-fungible tokens (NFTs). Its native token, ZRX drives protocol (rule) governance and allows stakeholders to securely vote on protocol upgrades. With a phased-transition to community governance and rights-based mechanisms (Bonello, 2018), such unique tracing and monitoring on the blockchain has implications in development governance, for public procurement, asset tracing, fraud and corruption tracking, as well as data accountability. Through reward mechanisms, as in the Ouroboros Cardano protocol, network users can be incentivized to find errors before validating new blocks (Kiayias et. al), under 16.7, by *Ensuring responsive, inclusive, participatory and representative decision-making at all levels*.

In theory, information from birth records to business transactions, can be baked into a blockchain, creating permanent and secure records which cannot be tampered with, for instance by corrupt officials. All changes are encrypted in such a way that they cannot be altered or deleted without leaving a record of the data’s earlier state.

Additionally, inter-governmental bodies, NGOs or civil society stakeholders “could use an existing non-anonymous cryptocurrency or develop its own and give it a name. Cryptocurrency value can be market-determined, or pegged to a physical currency or asset to reduce volatility.

Examples of blockchain protocols, Ethereum and Dfinity, provide further color to these words. Ethereum has created a global set of principles for peer-to-peer decentralized networks, in the form of an EOS Constitution. In payments, “a developer can attach an invoice for a network protocol upgrade, payable to their address, after the upgrade is approved and included.” (Bonello, 2018). In other Ethereum protocols, it is possible to “check whether a token possesses concrete features in order to perform or decline the operation, making the smart contract even smarter. [In addition], the new ERC-777 standard will fix the problem of a recipient’s tokens being lost when sent to a contract that doesn’t support the receiving or managing such assets.” (A New Advanced Token Standard #777. Ethereum Improvement Proposals).

Dfinity allows changes onto the ledger itself given there is a consensus among the coin holders. It can smoothly remove any illegal content engraved into the ledger by bad actors. Since its launch, critiques such as, “What content should be categorized as illegal given there are several jurisdictions?” and “What about hate speech and who draws the line?” have arisen.

In development circles, blockchain technology can be used to trace and track transactions and exchanges of ownership at every step of the value chain. For the public sector, transparency is of prime importance. The smart

contract feature of blockchain provides advantages such as: “Identity of bidders and the bidding entity is proven; Ensure that all participants have the same information; Automate the process (closing, bid analysis based on defined criteria); Auditing, review, and communication of decisions; Correct authorizations / signature; Logs of progress/milestones; Automated payments when certain conditions are met.” (Maltaverne, 2017).

Proof of attestation with cryptographic hashes is useful in asset verification. At a point in time, the blockchain hash proves the existence and contents of a document or digital asset. A new asset class of information technology is formed through attestation functionality of hashing plus time-stamping. In public procurement, assets verifiable through a public general ledger signify a tremendous tracking function. Examples of this are Virtual Notary, Bitnotar, Chronobit, Pavilion.io.

Additionally, micro-payment schemes, time-stamping, fair secure computation, secure messaging and PKI applications revolve on the concept of blockchain. A multitude of financial firms are piloting blockchains to “lower transaction costs, remove geopolitical barriers to transferring assets, and reconcile differences between systems.” (Dafflon et. al). This falls under SDG 17.7 *Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed.*

Swarm City is a blockchain-based marketplace, where different types of platforms compete with each other and get rewarded to earn immutable reputation. Here, developers customize the design of disintermediated sharing economy platforms by choosing application areas (e.g., ride sharing) or by defining governance rules (e.g., whether or not transaction fees are charged). Swarm City has built-in reputational attributes to allow people to communicate and transact value, and earn contextual reputation.

Under 16B, *Promote and enforce non-discriminatory laws and policies for sustainable development*, the blockchain acts as a trusted platform of transparency, so users safely interact with people they don’t know, while keeping their private information to themselves. Network users establish identity through a public/private keypair, through a unique digital identifier, a.k.a wallet. As they create their identity and exchange SWT tokens for others. Swarm City marketplaces are “hashtags, and its communities are *hives*.” (Swarm City Terminal, 2017). Network users may also form decentralized communities to benefit from economies of scale, and earn reputation together through marketplace transactions, as per 16.6 and 16.7.

Applying the Swarm City Token to institutional reform will bring transparency and accountability to auditing trails and public records, under SDG 17.18 *By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts.*

For example, in 2013, South Africa’s hidden textbook crisis came into the spotlight. Funding allotted for school materials and textbooks never materialized. Department officials verbally stated that provinces received the percentage of books stated. Such concealed problems will come to light faster on a blockchain network, funds will be disbursed accordingly, and bad actors punished.

By bringing in blockchain to track such school funding records, a resident could key and track each transaction for the school’s finances. Instead of having a central authority auditing and verifying funding transactions, a concerned citizen could check on the school’s transactions - donations, funds, and their uses. In South Africa, “the auditor-general is the only institution that, by law, has to audit and report on how the government is spending the South African taxpayers’ money.” (Auditor General). Bolstering legislative and regulatory acceptance of blockchain technology will allow the South African government and people to save on a costly and expensive auditing department. Millions of residents can ask questions, validate blocks (information and metadata), and/or fork the chain if they have disagreements, earning reputational attributes on their governance tokens.

Even with non-fungible governance tokens, multiple parties can assign rights, like setting up governance rules, voting and approving transactions in the form of digital signatures. Alternately, they can set up several levels of rules to process and permit each transaction.

Similarly, India has a land-pooling process. Thousands of farmers and property owners are yet to receive compensation for their bartered assets. Even worse, farmers are forced to give up their lands to the government, or not been given the promised property. To rectify this, “the Andhra Pradesh Capital Region Development Authority is pushing to implement blockchain technology to help fix the country’s disorganized land-record system, as well as to help avoid the tampering and falsifying of documents.” (Bhattacharya, 2018). Decentralizing digital information will lessen data manipulation, according to the Zebi blockchain startup.

Before blockchains, “an audit trail log [could be] erased by a hacker or an insider.” With blockchains, such erasure or tampering will be evident by others on the blockchain network, thus, *Substantially reduc[ing] corruption and bribery in all their forms* under SDG 16.5. Digix’ Proof of Asset protocol is embedded on Ethereum in the form of DGx token. At each step, the Digix blockchain “proves the existence of an asset as well as its ownership within the distributed ledger. Proof records are published permanently with [coding rules or protocols such as] IPFS [Inter Planetary File System] and Ethereum.” This makes client ownership the priority, instead of the company as a whole. Whether title to land, gold, or some other asset, Digix gives network users rewards and incentives within the ecosystem.

The system essentially consists on prediction market speculating and betting through cryptocurrencies and tokens. It based on two processes: “Individuals first vote on generally specified outcomes (like ‘increase GDP’), and second, vote on specific proposals for achieving these outcomes...If the proposal is accepted, then all trades on the rejection market would be reverted, but on the acceptance market after some time everyone would be paid some amount per token based on the futarchy’s chosen success metric, and vice versa if the proposal is rejected.” (Buterin, 2014).

DigiX has created a voucher system with checks and balances governance protocol. This is similar to the Blockstack sale, which lets non-accredited users, without a net worth of \$1M+ or made \$200K/year for the last two years, get a free voucher for a potential future payment instead of paying in the upcoming sale. This is in a non-security, utility sale.

Over time, blockchains will help digitize records and make them smart. IT departments in government agencies will create rules and algorithms for data in a blockchain to be automatically shared with third parties once predefined conditions are met. For networked public services, this will create strategic buy-in over the long term.

The next Section discusses blockchain’s application SDG 16.3, *Promote the rule of law at the national and international levels and ensure equal access to justice for all*. Using chain-of-custody and evidence-based governance protocols, blockchains can transform the nature of judicial transparency and legislative accountability.

Judicial and Legislative Blockchain Reform: Access to Justice and Rights.

Internationally as well as with African regional and national levels, crime-prevention is now being explored in “a cooperative, developmental, rights-based,...evidence-based framework...[and within a] broader developmental framework.” (Hale et. al, 2018). Rather than relying on a strict law enforcement approach, “an evidence-based approach that draws on what has worked in preventing crime and violence, particularly in a development context.” (Edwards and Tait, 2016). Under 16.3 *Promote the rule of law at the national and international levels and ensure equal access to justice for all*, *haka* and *Juris* are examples of judicial reform on the blockchain, followed by Dash and Tezos for voting and consensus-based governance mechanisms. In these examples, minimizing reliance on human intermediaries via neutral blockchain platforms will help disseminate justice to the underprivileged and under-represented.

*haka*³ is legal access generation for low-income litigants, who face the harsh reality of court inefficiencies; court bonds and fees, shoddy services, and a slew of other institutional shortcomings. *haka* creates a bridge between such litigants and justice. Pre-trial, *haka*, built on blockchain technology, provides finances to transmit the person’s bail funds. On arrest, the person (*haka* Citizen) notifies her family and friends network (FFn), which

³*haka*, property of Reshma Kamath (2018).

then connects to the trust-based *haka* platform. *haka* verifies the person's identity along with FFN as co-signors or guarantors. *haka* income verifies the *haka* Citizen's FFN and creates smart legal contracts between the litigant + FFN and the contributors. By weighing the network's total income-to-bail ratio through pretrial analytics, *haka* allows transacting bail to courts, in entirety or as the court's fee. *haka* provides litigant with finances in a cryptographically-secured wallet at tailored interest rate payments starting with 0%. The FFN then pays *haka* back in case-based installments. *haka*'s finances come from- corporations, law firms, and individuals. The public make contributions in a publicly-displayed token pool. *haka* is built on values of transparency.

Even as the *haka* citizen moves beyond bail into trial, her progress is continually traced. *haka* work with the person's network to help with court fines and fees. *haka* offers services, like transportation, child care, messaging, and clothing by partnering with local organizations.

Throughout this process, family and friends create *haka* Citizen IDs by humanizing the person's life from birth until arrest and into trial. For the content, *haka* employs smart contracts to send tokens to *haka* citizen's digital wallet. *haka* also incentivizes positive behavior with tokens. These include attending court dates on time, meeting with lawyers and support staff, and complying with other court-mandated processes.

Juris is a human-powered dispute resolution for blockchain smart contracts, built on the Ethereum protocol. With such contract disputes and mediation, "users can in fact escalate to a Juris PANEL which provides a decentralized, United Nations-compliant arbitration tribunal judicially enforceable in 157 countries." (Kerpelman, 2016). Blockchains are designed to execute objective and deterministic contracts. Arbitrators are designed to be oracles for subjective evaluation of non-deterministic contracts.

Consensus-building: For SDGs, applying blockchain's convergence ecosystem model will build anonymous or pseudo-anonymous voting mechanisms on the network. Dash was the "foremost crypto in popularizing blockchain governance." Here, master nodes and network users vote on budget proposals. Other forms of embedded crypto-governance are "tacking voting rights onto the token, vesting rights with different time periods, and proof (s) of stake, ownership, experience, research, value to name a few." (Sedgwick, 2018). The Ethereum EOS constitution experimented as "the first contracting platform focusing on formalizing, automating, and clarifying agreements" (Town, 2018) with consent and intention of parties.

By establishing a "formal process and basis of authority by consent," (Town, 2018) those with a difference in opinion take the open source code and generate their own community with own rules. This laissez faire approach to SDG governance instills notions of free market competition and corporate governance in civil society legal reform. While running a global, border free contracting and judicial system, blockchains are fundamental in transforming.

Tezos is upgrading governance through community voting. Augur and Gnosis are testing futarchy, a type of voting model in which the community defines a set of values and then prediction markets are used to decide which decisions will maximize those values. For SDG 16 and 17, as well as their indicators and sub-indicators, such blockchain voting projects demonstrate how anonymous or pseudo-anonymous voting on civil society reform can be effective. For instance, network users are broadly divided into groups or communities they belong to (e.g. NGO 1, Gov't Dep't A, Person Y). These groups are hashed onto the blockchain network. Then, individuals within the groups are given voting or decision-making powers through internal rules like seniority or ranking. Depending on the votes, the blocks are defined and move on to the next set of blocks. Lastly, blockchain promises neutral jurisdictions and open border. Aragon is a platform for the entire governance service for other token projects. It also has a token, ANT, that grants voting rights to make decisions about future development. The end result: to be a fully decentralized autonomous organization and Dapp (decentralized application) with a neutral jurisdiction for its adopters to create an organization on the blockchain.

Eximchain use Quadratic voting on its blockchain network. It "enables a group of users to jointly choose a collective good for themselves." (Posner, 2014). Network user can purchase votes for or against a proposal by paying into a fund the square of the number of votes that he or she buys. The money is then returned to voters on a per capita basis. Quadratic voting is useful in political elections, creating public policy, and securing decentralized

systems for finite periods of time.

Self-Sovereign Identities, CryptoDemocracy: ID2020 is “an alliance committed to improving lives through digital identity.” This approach is holistic and market-based. Interoperability between blockchains, as well as “across geographic and institutional borders, and a mechanism for coordination on non-technical topics, is crucial. To meet the needs of governments, international organizations, businesses and individuals alike, the ID2020 digital identity must be “personal, persistent, portable and private.” Malawi, Jordan, and Pakistan are three jurisdictions where ID2020 is being implemented and tested.

Internet of sovereignty: Bitnation is the “world’s first Decentralised Borderless Voluntary Nation (DBVN).” It hosted the world’s first blockchain marriage, birth certificate, refugee emergency ID, World Citizenship, DBVN Constitution.” Article 6 of the Bitnation Constitution envisions “a global free market for governance services; a post-Nation State world of Voluntary Nations, City States and Autonomous Communities which compete for Citizens by providing a range of opt-in governance services. Sovereignty shifting from the Nation-State to the citizen reclaims the latter’s freedom of choice in accessing freedom of choice.” (ID 2020).

On the Panagea, “every citizen is sovereign and has the right to self-determination and is at liberty to choose any form of expression or way to be human or posthuman and with whom to associate and cooperate.” (Tarkowski, et al, 2018).

The Bitnation created the Pangea Jurisdiction and Pangea Arbitration Token (PAT). The Pangea Arbitration Token (PAT) is an ERC20 compatible in-app token for the Pangea Jurisdiction. PAT is an algorithmic reputation token, an arbitration currency based on performance rather than purchasing power, popularity or attention. It incentivizes good reputation through “accumulated non-tradable reputation tokens” via creation of a “contract, successfully completing a contract or resolving a dispute attached to a contract.” Under 16.9, *By 2030, provide legal identity for all*, Bitnation’s PoC has a blockchain ID and Public Notary through blockchain’s proof of attestation. It can be used by Bitnation Citizens and Embassies around the world.

Upholding notions of democracy under 16.8.1 *Proportion of members and voting rights of developing countries in international organizations*, Civil media is an online platform for participative governance amongst individuals. It helps in building spontaneous civil constitutions, instead of the status quo which lacks in innovation and benefits the few. Liquid democracy and feedback to ensure the political will of participants and delegate voting rights is central to Civil Media. It allows diverse groups of people self-organize to make democratic decisions online. Through open feedback, the Liquid Feedback program provides “participation without the need for physical assemblies or in-person voting.” (Bolier, 2014).

Instead of leaders misrepresenting the political will of masses, LiquidFeedback “empowers any accredited member of a group to propose a new initiative; make suggestions about it; create alternatives to the proposed initiative; and vote on a final proposal. Discussion generally takes place on other platforms, however, outside of LiquidFeedback.” (Atzori, 2015).

17.17 *Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.* Combining “non-moderated, self-organized discussion process (quantified, constructive feedback) [with] liquid democracy (delegated or proxy voting),...interactive democracy through LiquidFeedback introduces a new communication channel between voters and representatives (in this case members and board members), delivers reliable results about what the members want and can be used for information, suggestion, or directive depending on the organizational needs and the national legislation.” (Mendoza, 2017).

CONCLUSION

Crypto-governing frameworks will revolutionize SDGs and their implementations. They will “evolve, throughout sectors and industries with multi-types of governance, each co-evolving with blockchains.” (Lundy-Bryan et al., 2018). Blockchains and tokens will be issued, distributed, governed and owned in diverse ways, both in

public and private sector. The latter has taken off, the former yet to emerge as development has traditionally not been privy to technology, and generally, lags behind in instituting reform. UNICEF has funded six blockchain projects worldwide.

Even with blockchain's tremendous technological potential, SDGs will have to move forward with caution. Scalability and accessibility are the next challenges with governance on the blockchains. How do we get the blockchain decentralized applications (Dapps) to the masses who most need it? How do we overcome the barriers to entry: "digital divide and cognitive entry barriers to digital communities and hackathons, strong asymmetries of information between developers and users, moral hazard and the prevalence of economic individualism over common good." Data governance and privacy issues can lead to a distorted market structure (Kim and Kang, 2017), if designers are not careful.

Interoperability between and across different blockchains is the next hurdle. Due to majority rule and consensus, decentralized networks established by developers can be hard to break through. There has been a lot of legal and regulatory uncertainty with the crypto side of blockchain. Even with the technology itself, standards are slowly being set, and patents are being given for the technology, not the governance design or model (think Steve Jobs Apple design patents, much later in the schema).

Lastly, the crypto-governance model itself can become weak and fragmented. On-chain governance has flaws, with costs outweighing the benefits, states Vlad Zamfir, a principal architect of Ethereum's proof of stake. For example, unevenness seen in the real world can be projected onto the blockchain. To make it one token = one vote is a design issue on the blockchain ecosystem. Then, the costs of dividing network costs creep up. Moreover, if unstable and shaky governments and stakeholders exist in real life, online platforms can produce negative externalities.

With these hurdles in mind, specialists and stakeholders working on Sustainable Development Goals 16 and 17 can cautiously implement an equitable and just society through crypto-governance, both on chain and off chain, bringing positive externalities in the physical world.

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