

HARNESSING THE DISRUPTIVE POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR THE SUSTAINABLE DEVELOPMENT GOALS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF BUSINESS
OF
İSTANBUL ŞEHİR UNIVERSITY



BY

MOHAMED FOUAD BERGIGUI

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER
OF
BUSINESS ADMINISTRATION

JUNE 2020

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Mohamed Fouad, Bergigui

Signature

A handwritten signature in blue ink, consisting of stylized cursive letters that appear to read 'M. Fouad'.

ABSTRACT

HARNESSING THE DISRUPTIVE POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR THE SUSTAINABLE DEVELOPMENT GOALS

Mohamed Fouad Bergigui

Master of Business Administration

Thesis Advisor: Prof. Dr. Ahmet Faruk Aysan

June 2020, 143 pages

This paper explores the use of blockchain-enabled solutions to achieve the Sustainable Development Goals (SDGs). Blockchain can be visualized as this cryptographic book of truth upon which robust foundations of trust can be built. While virtually there is so much one can do with the blockchain technology, there is also little evidence to truly assess the contribution of blockchain-backed applications to sustainable development.

We argue that more research is required to assess the true extent to which development workers are able or not to transform the promising potential of blockchain-enabled solutions into tangible development results. Individuals and organizations need to look beyond the hype behind the rise of what we refer to as the “let’s blockchain it” movement in international development which suggests that blockchain-based applications are superior compared to other alternatives in terms of their ability to deliver development outcomes. Data from blockchain experiments remains critical to building a body of knowledge to extract good practices and lessons learned towards paving the way for functional blockchain-based ecosystems that are capable of producing nationwide solutions instead of experimentation silos with little impact at scale.

The three chapters of this research converge together to form a living Toolkit. By proposing an SDG Acceleration Scorecard and an Integrated Approach to use

blockchain-powered solutions as SDG accelerators, we have made our modest contribution in an attempt to co-create actionable tools to guide innovation and development practitioners as they strive to transform the disruptive potential of blockchain into sustainable development dividends beyond the hype. While we recognize the limitations in developing such tools, which are rather simplistic and not a replacement of academically proven methodologies, they can surely ignite further discussions and trigger future academic investigations. This will in return provide the much-needed food-for-thought during a period of transition as the blockchain technology is getting mature.

Keywords: Blockchain, Sustainable Development Goals (SDGs), Accelerator, Innovation

ÖZ

BLOKCHAIN'İN YARATICI OLMA POTANSİYELİNİ TESPİT ETMEK SÜRDÜRÜLEBİLİR KALKINMA AMAÇLARI TEKNOLOJİSİ

Mohamed Fouad Bergigui

İşletme Yüksek Lisans

Tez Danışmanı: Prof. Dr. Ahmet Faruk Aysan

Haziran 2020, 143 sayfa

Bu makale blok zinciri özellikli çözümlerin Sürdürülebilir Kalkınma Hedeflerine (SDG) ulaşmak amacıyla kullanımını araştırmaktadır. Blok zinciri, sağlam temelli bir güven üzerine inşa edilebilen, gerçeğin kripto-kitabı olarak canlandırılabilir. Blok zinciri teknolojisi ile gerçekleştirilmesi mümkün olan sayısız proje olsa da, blok zinciri destekli uygulamaların sürdürülebilir kalkınmaya katkısını değerlendiren çalışmaların sayısı çok sınırlıdır.

Blok zinciri özellikli çözümlerin gelecek vaadeden potansiyelinin, kalkınma personeli tarafından somut kalkınma sonuçlarına dönüştürülüp dönüştürülemediğini değerlendirmek için daha fazla araştırma yapılması gerektiğini savunuyoruz. Bireyler ve kuruluşlar, uluslararası kalkınma alanında yükselen, ve kalkınmada sonuç odaklılık bakımından blok zinciri tabanlı uygulamaların alternatiflerine oranla daha başarılı olduğunu ileri süren “let’s blok zinciri it” hareketinin popülaritesinin ötesine bakmalı.

Blok zinciri deneylerinden elde edilen veriler, sınırlı etkiye sahip deney ambarlarına kıyasla, ulusal kalkınma çözümleri üretebilmeye muktedir blok zinciri tabanlı ekosistemlere ulaşılabilmesini sağlayacak bilginin edinilmesi konusunda büyük önem taşımaktadır.

Bu araştırmanın üç bölümü bir bütün olarak alındığında canlı bir Araç Seti meydana getirmektedir. Blok zinciri destekli çözümleri SDG hızlandırıcıları olarak kullanmak

amacıyla bir SDG Hızlandırma Puan Kartı ve Entegre Bir Yaklaşım önererek, blok zincirinin sahip olduğu yıkıcı potansiyeli, sürdürülebilir kalkınma temettülerine dönüştürmeyi hedefleyen inovasyon ve geliştirme uygulayıcılarına rehberlik etmek için eyleme dönüştürülebilir araçlar oluşturma girişiminde mütevazı bir katkı yaptık. Akademik olarak kanıtlanmış metodolojilerin yerini alamayacak olan bu gibi basit araçların geliştirilmesindeki sınırlamaları kabul etsek de, kesinlikle daha fazla tartışmayı ve gelecekteki akademik araştırmaları tutuşturabileceklerine inanıyoruz. Bu gibi tartışmaların da henüz oldgunlaşmata olan blok zinciri teknolojisinin günümüzde çokça ihtiyaç duyduğu desteği vereceğini düşünüyoruz.

Anahtar Kelimeler: Blok zinciri, Sürdürülebilir Kalkınma Amaçları (SKA), Hızlandırıcı, Yenilikçilik

To the amazing souls with whom we crossed paths in our lives

To the good winds that brought me here

To my beautiful Turkey



Acknowledgments

I would like to express my very special thanks and appreciation to Prof. Dr. Ahmet Faruk Aysan for his inspirational leadership throughout a truly memorable educational journey at the Business School of the Istanbul Şehir University. I owe a great debt of gratitude to everyone who contributed by near or by far to this work.



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List of Symbols and Abbreviations

- 3D: Three-Dimensional
- 5G: Fifth Generation wireless
- ADB: Asian Development Bank
- ADKAR: Awareness, Desire, Knowledge, Ability, Reinforcement
- AI: Artificial Intelligence
- BUD: Blockchain Use case Development
- C++: Programming language
- CBECI: Cambridge Bitcoin Electricity Consumption Index
- CLI: Climate Ledger Initiative
- COVID-19: Coronavirus Disease of 2019
- CWI: Cartier Women's Initiative
- DAC: Development Assistance Committee
- DHL: Dalsey Hillblom Lynn (logistic company)
- DI: Development Initiatives
- DNA: Deoxyribonucleic Acid
- DTU: Technical University of Denmark
- FAO: Food and Agriculture Organization of the United Nations
- GHG: Greenhouse Gas
- GitHub: A global software development platform
- GO: Programming language
- GPS: Global Positioning System
- IBM: International Business Machines Corporation
- ICD: Islamic Corporation for the Development of the Private Sector
- ICOs: Initial Coin Offering (a type of funding using cryptocurrencies)
- ICT: Information and Communications Technology
- IEOs: A variant on Initial Coin Offerings or ICOs
- IoT: Internet of Things
- IRENA: International Renewable Energy Agency

- ISO TC 307: International Organization for Standardization's norm applicable to the standardization of blockchain technologies and distributed ledger technologies.
- M&EL Monitoring and Evaluation
- MDGs: Millennium Development Goals
- MIT: Massachusetts Institute of Technology
- MRV: Monitoring, Reporting, and Verification
- NDC: Nationally Determined Contributions
- NGO: Non-Governmental Organization
- OCHA: United Nations Office for the Coordination of Humanitarian Affairs
- OECD: Organization for Economic Co-operation and Development
- OPSI: Observatory of Public Sector Innovation
- PwC: PricewaterhouseCoopers
- QR Code: Quick Response code (a machine-readable optical label)
- R&D: Research and Development
- SDGs: Sustainable Development Goals
- SWB: Startups Without Borders
- UN DESA: United Nations Department of Economic and Social Affairs
- UN Women: United Nations Entity for Gender Equality and the Empowerment of Women
- UNCLOS: United Nations Convention on the Law of the Sea
- UNCTAD: United Nations Conference on Trade and Development
- UNDP: United Nations Development Program
- UNEP: United Nations Environment Programme
- UNFCCC: United Nations Framework Convention on Climate Change
- UoM: University of Melbourne
- WEF: World Economic Forum
- WWF: World Wildlife Fund

INTRODUCTION

This research is a contribution to the ongoing reflections within the international development community regarding the use of blockchain-enabled solutions, to solve specific development challenges and accelerate the achievement of the Sustainable Development Goals (SDGs). Through this work, we aim to add our modest contribution to supporting development practitioners and those working at the frontlines of innovation and sustainable development, to move beyond the hype towards harnessing the disruptive potential of blockchain technology.

In an attempt to deconstruct the mainstream perception claiming the superiority of blockchain-backed solutions compared to other alternatives that can be applied in the development space, we have conducted a literature review, shared our observations and experience working on development practice, and approached development professionals to break the hype-cycle that seems to be driving blockchain experiments. We have also proposed experimental tools to stimulate the ongoing debate, such tools can support building sound rationales and act as actionable methods that could be tested and further improved to support blockchain experiments to deliver their promises in the form of development dividends.

In the first chapter, we provide an overview of blockchain technology, looking at its mechanics and dynamics, at how it evolved, the different types of blockchains, and what are the possibilities for using blockchain-powered solutions to solve some of the most pressing development challenges we are facing today. Similarly, we shed the light on the “Agenda 2030” for sustainable development, the implementation gaps, and the challenges ahead to meet the global goals by 2030. We have also looked at what could be the possible implications of the new normal in the aftermath of COVID-19 on the pace of adoption and utilization of blockchain technology, as well as the concerns around shifting priorities that may reverse the hardly won development gains achieved over the

last decades. As we provided a bird's eye view of the international development landscape in which blockchain-powered solutions can be deployed, we initiated the discussion as to whether or not blockchain-backed applications can offer superior solutions to achieve the SDGs.

We argue that despite the undeniable potential for blockchain use cases to accelerate the SDGs, blockchain experiments in the development sphere remain largely understudied hence the huge lack of data and evidence to truly assess the contribution of blockchain to sustainable development. We also emphasize that blockchain is not a risk-free technology and that there is a fundamental need for a better understanding of what can be done and what cannot be done with blockchain. We stress that answering this question in a given development context, should be the critical starting point before “jumping-the-gun” to start a “let’s-blockchain-it” journey which may be a costly and risky one, and may not necessarily offer the best value for money when using resources earmarked for development financing.

In an attempt to explore the ongoing trial-and-error experiments of blockchain technology in the development space, we performed a reality check despite data scarcity to fill in the information chasm. To do so, we have examined the blockchain projects listed in the Blockchain Impact Ledger based on the 71 entries available at the time of conducting this research. Findings suggest that blockchain-enabled applications were primarily deployed to address governance matters and tackle issues of transparency, fraud, and other unethical behaviors within society. Nevertheless, and giving the interlinked nature of the SDGs, we argue that well-designed blockchain-backed solutions can contribute to several SDGs at the same time. This could have a multiplying effect on development results by accelerating the SDGs while yielding greater development co-benefits that are widely spread across geographies as once see from the maps presented.

The transition to the second chapter is made by emphasizing that blockchain-backed solutions should not be used when there are no problems to be solved with blockchain technology, especially in the existence of other alternative solutions that could be less

costly and less technical. In the absence of widespread methodologies and analytical frameworks to build promising use cases and deploy blockchain-based solutions, we took the risky way to prototype minimal viable products that can serve as experimental tools. While we fully recognize that for such tools to be academically viable and reliable, they need to be tested using appropriate research methods, which could be indeed pursued in the framework of future researches, we believe that such tools can be extremely useful today for the practitioners on the frontlines. Development practitioners are already experimenting blockchain-enabled solutions, by the time a critical body of knowledge will be widely available and accessible, to replicate good practices and establish well-researched standards for the use of blockchain technology to achieve development gains, experimental tools like the ones we propose in this work can provide much-needed guidance to fill-in today's gaps and narrow the error margin.

Similarly, we have adopted a cross-cutting approach to bring the necessary pieces together and bridge the gaps that we have identified in the literature review. We believe that these gaps should be addressed for blockchain experiments to deliver their development promise. While building a use case for blockchain-backed solutions, we have assumed that the solution should not come before the problem. We looked at what can be solved and what cannot be solved by blockchain? Which structured approaches are needed to understand the potential of blockchain in a given context? and how to design specific and promising use cases?

Monitoring and Evaluation (M&E) came-out as a key area where investments are required to generate the much-needed knowledge about blockchain experiments in the development space. Which structured approaches and tools to monitor and assess blockchain experiments? Looking beyond the pilots, can blockchain solutions deliver impact at scale? How can we measure such impact? We have assumed that while blockchain applications are contributing to solve some of the challenges around the implementation of the SDGs, it was mostly demonstrated and reported in the available literature through pilot applications that were not replicated at a larger scale. To better

assess blockchain's impact on the SDGs, to examine whether or not a given result could be fully attributed to the blockchain, or if blockchain rather partially contributed to such a result, we have assumed that there is a need to develop adequate tools to support monitoring and evaluation of different blockchain experiments. Such tools should not only track progress but also provide a standardized platform to ensure comparability and assess criteria of relevance, effectiveness, efficiency, sustainability, and impact, in addition to gender equality.

Another major gap we have identified was related to risk assessment and the ability of blockchain experiments to manage risks and ethical considerations. Are blockchain applications in sustainable development risk-free? What are the potential risks associated with the utilization of this technology and which ethical reflections should be taken into consideration? We assumed that there is a need to explore ethical considerations around the use of blockchain to determine potential risks for development professionals, make informed decisions, and come up with appropriate mitigation measures.

An often-overlooked dimension is change management within organizations and teams embracing blockchain technology for development. How does embracing innovation, in the case of blockchain applications, affect the way development and humanitarian organizations do business? We assumed that change management is a dynamic process that needs to be understood, to enable organizations to develop an evolutionary adaptation approach to navigate the transition, address resistance to change, and nurture a culture of innovation.

Inspired by the use of scorecards in the development practice, one of the experimental tools we have proposed in this work is the SDG Acceleration Scorecard. We argue that scorecards have several comparative advantages and can be extremely useful for development practitioners. They can be rapidly prototyped and deployed, they are flexible and can be adapted to different contexts, scorecards are also low-cost solutions

compared to fully-fledged monitoring systems or in-depth assessments. Yet, we also recognize the limitations of such scorecards giving their low analytical capacity.

To bridge these gaps and use blockchain-enabled solutions as SDG accelerators, we have also proposed an Integrated Approach that brings all these elements together to form a sort of a roadmap or guidelines, to help development practitioners navigate the sinuous roads of experimentation. We argue that the two experimental tools presented in this work, the SDG Acceleration Scorecard and the Integrated Approach, are rather simplistic and not a replacement of academically proven methodologies. Nevertheless, they can surely provoke further discussions and academic investigations. This will in return provide the much-needed food-for-thought during a period of transition as the blockchain technology is getting mature.

The third chapter was structured around experimental zones and acceleration areas. In the experimental zones, we provide an overview of different blockchain-backed solutions by exploring real-life case-studies of blockchain experiments contributing to each one of the 17 SDGs. This work highlights the tremendous potential of blockchain-powered solutions in the SDG space, while at the same time noticing that we are yet to achieve impact at a large scale beyond the promising pilots. In the acceleration areas, we propose our modest contributions to highlight some of the areas where blockchain-enabled solutions may drive disruption, in ways that could yield huge development dividends and accelerate the SDGs from impact investing, to remittances, Islamic finance, humanitarian aid, crowdfunding and startups' financing.

In our conclusion, we look at the three chapters of this work as functional pieces that can blend into an actionable "Toolkit for harnessing the disruptive potential of blockchain technology for the Sustainable Development Goals", which can be used by development practitioners working at the crossroads of innovation and sustainable development. Blockchain can be this cryptographic book of truth, upon which foundations of trust can be built, in this work we have only scratched the tip of the blockchain iceberg and added our modest contribution to walking the disruptive talk of

blockchain enabled-solutions, and shape the future of the Sustainable Development Agenda under a new normal in the uncharted territories of post-COVID-19.



CHAPTER 1

BLOCKCHAIN AND THE SDGS

Introduction

In this chapter, we provide an overview of the blockchain technology, navigating the jargon soup of its acronyms in the most simplified way we could to demystify what appears as a complex technological nature at first glance. We have then briefly introduced the Sustainable Development Goals (SDGs) and shed the light on the whys and hows of incorporating blockchain-enabled solutions into the sustainable development landscape. We have also provided some insights on the push given to blockchain-powered solutions during the coronavirus crisis, and expectedly the rise in its adoption in the aftermath of the pandemic as the technology is getting mature and as the divide between the physical and digital worlds is shrinking at an unprecedented pace as we are heading towards a new normal. We believe this chapter will come in handy for individuals and organizations to perform a “quick-dive” and visualize the bricks and dynamics of blockchain technology, then have a bird’s eye view of the international development landscape in which blockchain-backed solutions can be deployed.

Understanding Blockchain

Since ancient times, one of the key principles underpinning human relations and business transactions is trust, which happens to be in short supply for instance at times of financial crises or along opaque globalized supply chains. We can argue that the strong interest exhibited by the early adopters of blockchain technology resides in its ability to recreate trust by recording transactions that are secure, permanent, and disintermediated among parties (DHL, 2018). Its decentralized data architecture disrupts the siloed approach to safeguard data in the pre blockchain era. Now, in the digital age of blockchain, the spotlight has been on cryptocurrencies, such as Bitcoin. By doing so, the technology was

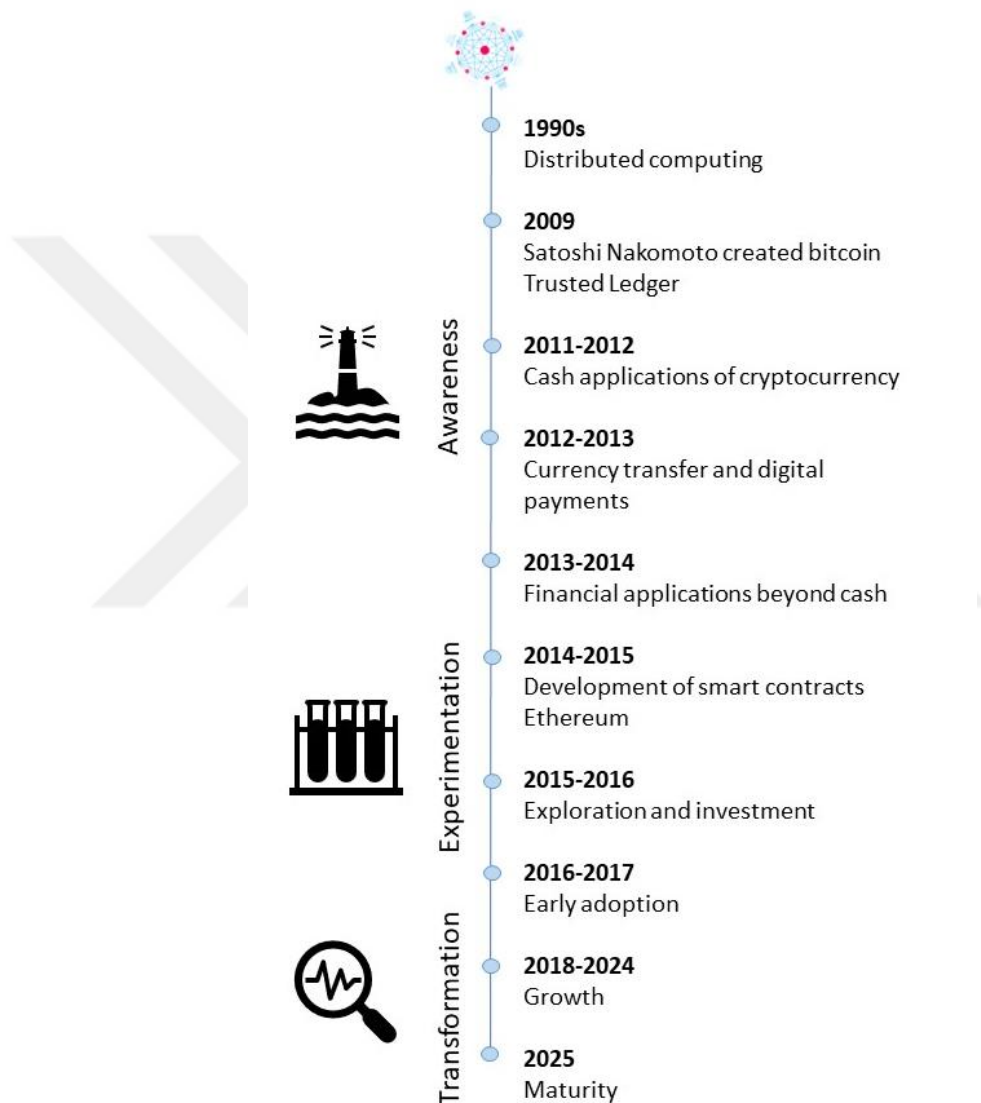
pushed to stay in the background. One can say that blockchain is not the main attraction, it's what you can do with it, that is what matters most. While financial transactions appear to be the first use case of blockchain, there are many other types of blockchain applications reported in the literature where such applications are already changing the way we address some of the most pressing global challenges. Many startups, companies, and governments joined the hype to experiment a wide array of use cases whether to tackle cybersecurity issues to store online data, manage health records to ensure authentication and confidentiality, track financial transactions, boost impact investing, enhance transparency within supply chains, reduce voter frauds, synchronize empty seats for ride-sharing, or to track intellectual property rights. These are just a few examples of how blockchain waves are building and breaking on the shores of disruptive innovations to provide a new basis for rethinking solutions and pushing the envelope further towards a new order of business as unusual.

Blockchain in simplistic terms

To avoid using the crypto jargon behind blockchain, a simplified way of describing it is to present it as the technology that enables consumers and suppliers to connect without the need for a trusted middleman to conduct transactions, removing thus the need for having a third party factored into the equation (Hutt, 2016). Technically, a blockchain can be explained as some sort of a database that is shared across a network of computers. One key difference with blockchain is that a database is centralized, while blockchain removes the need for a database administrator as the single point of failure (Schlapkohl, 2019). It is similar to making thousands of copies of a spreadsheet and sharing it within a network including many computers, and that spreadsheet is regularly updated by the network (Rosic, 2016). Transactions are kept secure by using cryptography on a decentralized database that anyone in the network can see (Hutt, 2016). Records on a blockchain can be any type of information, blocks are formed by bundling records, and chains are made by linking blocks together. Records provide transaction details and include a digital signature of the parties involved in the transaction, these details are

then checked by the computers in the networks called nodes, following which the accepted records are added to a block (Murray, 2018).

Figure 1.1: How did blockchain evolve over time?



Source: author based on data from (Accenture, 2015), (PwC, 2017), (Capgemini, 2018)

Each block has a code called a hash, these are strings of letters and numbers generated by mathematical functions. A block also contains the hash of the previous block in the chain. Once a block is added to the chain, the hash codes connect the blocks in a specific order (Murray, 2018).

Another way to visualize this process is the following: one person has a spreadsheet on his computer, while two government accountants have the same spreadsheet on their computers as well. Now, every time you make a transaction you send an email to inform each one of them, they both rush to check, the first to get the job done hits a reply-all button attaching evidence showing that the transaction is valid to get paid a salary. If the other accountant agrees all spreadsheets are updated. In this illustrative example, the person with the spreadsheet is the node, the spreadsheet is the ledger, the accountants are the miners, the salary is a token or cryptocurrency, the attachment is the Proof of Work, and the whole process is powered by blockchain technology (Deloitte, 2019).

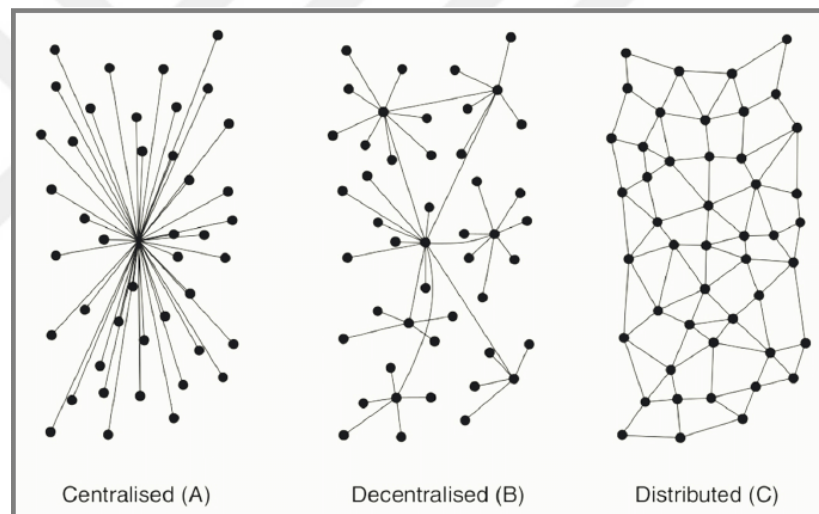
Unlike centralized networks, a blockchain is a database with no Master. Computers or nodes willing to join the network and add blocks to the chain will have to pass tests dubbed consensus models, during which new members are required to prove themselves (Murray, 2018). For instance, a proof of work is about nodes demonstrating that they have solved an increasingly complex computational puzzle, this process is called mining. Miners invest huge computing powers and rewarded in exchange for their work by tokens or cryptocurrency such as bitcoin. Now, any change to the original information recorded, will generate a new hash, that breaks the chain, and a potential hacker will have to recalculate the hash for the next block in the chain and so on which requires a huge computing power (Murray, 2018). With blockchain technology, no single entity controls the data, no one can override it and can be independently verified, making it virtually impossible to hack (SelfKey, 2020).

A quick dive into blockchain technology

Blockchain can be used for any transactions of values such as money, goods, and properties with its use cases seemingly having a limitless potential (Hutt, 2016). It is an open-source technology that excludes the traditional third parties to rely on collective verification, thus offering a great alternative in terms of costs, traceability, security, and speed. When two financial entities such as banks receive a request to transfer money from one account to another, they have to update the balances of their respective

customers. This costly and time-consuming coordination and synchronization exercise can be simplified on a blockchain by using a single ledger of transactions reflecting a single version of records instead of two different databases (Mougayar, 2016). But blockchain applications can be much broader than just finance, as the digital-physical gap is closing the technology is steadily growing to encompass a myriad of use cases (Deloitte, 2019). Blockchains can be designed either as private or public, while decentralization remains a common denominator to both forms, there is a key difference in the level of access granted to participants (SelfKey, 2020).

Figure 1.2: What is decentralization?



Source: (Baran, 1964)

In the case of a public blockchain, participants are typically encouraged to join the network through an incentivizing mechanism such as the case of Bitcoin (Jayachandran, 2017). Anyone can join the network, decentralization is pushed to the fullest extent (SelfKey, 2020). On the other hand, private or permissioned blockchain, are closed networks where participants face restrictions in terms of who can write data and who can read it. So, while public blockchains maximize the anonymity, permissioned blockchains know the identity of its participants and determine which information they should or should not have access to (Massessi, 2018).

While perceptions suggest that public and permissioned blockchains are competing with each other, they have different offerings and could be rather complementary in terms of the solutions they offer (Massessi, 2018). While public blockchains offer high security, an open environment, anonymity, and no restrictions, private blockchains on the other hand prioritize full privacy, high efficiency, and stability. We can argue that permissionless blockchains empower the user by pushing transparency and decentralization to their full extents, while permissioned blockchains empower enterprises instead of individual employees (Anwar, 2020). The convergence of public and private blockchains is expected to pave the way for virtual ecosystems where a wide range of players can collaborate in a secure and auditable way (Deloitte, 2019). So which blockchain is better for which applications? Indeed, public and private blockchains have distinct use cases.

Table 1.1: Public Vs Private Blockchains

Type of Blockchains	Pros	Cons
Public Blockchain Examples: Bitcoin, Ethereum	Trust Security Transparency	Slow Scalability Energy consumption
Private Blockchain Examples: Ripple, Hyperledger	Speed Scalability	Trust Security

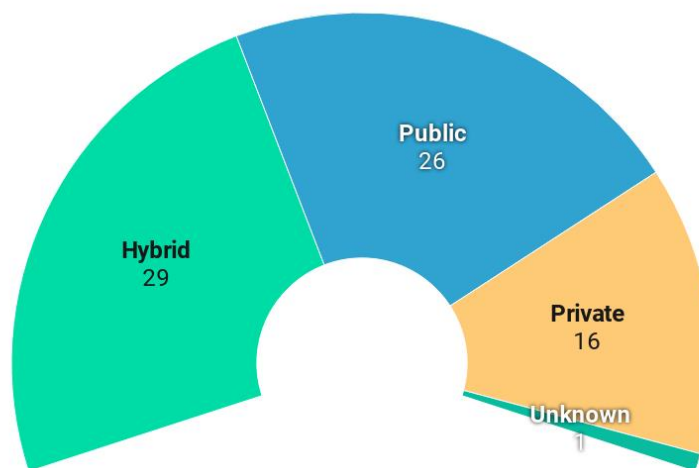
Source: author based on data from (SelfKey, 2020), (Massessi, 2018)

In general terms, public blockchains address business to consumer scenarios while private blockchains are more applicable to business to business relationships with some shared infrastructure between businesses (Massessi, 2018). The transparency and security features of public blockchains make it more suitable to develop blockchain-enabled solutions serving larger communities where trust is a key concern (SelfKey, 2020). It is a viable option in situations where all users should be treated equally and when the protection of users' anonymity brings an added value to the solution (Massessi, 2018). There are however some concerns whether confidential data should be recorded

on a public blockchain assuming the encryption could be hacked one day (SelfKey, 2020). For instance, anyone should be able to own cryptocurrency like bitcoin or Ethereum, having role-based access would defeat the purpose in this case (Massessi, 2018).

In the world of private blockchains, there are quite opposite concerns, since the players are reluctant to publicly share their business data. This is more appealing to financial institutions and corporates so they can know and predetermine who has access to what (SelfKey, 2020). The downside though is that trust comes down to the credibility of the authorized nodes, besides a relatively higher vulnerability to malicious attacks (SelfKey, 2020). As blockchain technology keeps evolving, hybrid solutions could perhaps offer the best of both options by bringing together trust and security alongside efficiency and speed (SelfKey, 2020). Giving the current momentum in adopting blockchain applications across a large spectrum of industries, blockchain technology can only gain in popularity as the world is facing a new normal in the post-COVID-19 era where technologies are poised to play an extremely important role in redefining business as usual. Figure 1.3 shows the types of platforms used by blockchain projects based on 71 entries listed in the Blockchain Impact Ledger which uses the SDGs to breakdown listed projects into impact areas (Goldstein & Tillemann, 2020).

Figure 1.3: Types of blockchains used by blockchain projects for social impact



Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

There is a myriad of platforms to develop blockchain applications, project managers need to do their due diligence by navigating variables from the type of blockchain needed, popularity of the platform, scalability requirements to smart contracts (Toshendra, 2020). These platforms use different types of networks, consensus algorithms, and programming languages. Ethereum and Hyperledger remain one of the most popular platforms (Malhotra, 2020). In terms of programming languages, C++ and Go are among the top used by programmers for blockchain-related projects (Deloitte, 2017). Ethereum backed projects on GitHub for instance rose from just 3 in 2013 to 9970 by mid-2017 covering a wide range of applications such as identity management, crowdfunding platforms, remittances, and new cryptocurrencies (Deloitte, 2017).

Smart Contracts

A key feature of blockchain technology is undeniably its ability to accommodate smart contracts. Smart contracts are agreements between two parties recorded as computer code on the blockchain, which is automatically activated when the conditions agreed upon in the agreements are met (BitDegree, 2020). In other words, assets or currencies are transferred into a program, which runs a code that automatically validates the conditions to decide on asset allocation. What smart contracts do is that they take intermediaries out of the equation, as they are stored on the blockchain and transactions are automatically executed, there are no trust-related issues (CoinTelegrap, 2016). In simplified terms, it works like a vending machine. By inserting the right amount of cryptocurrency into the smart contract, the asset be it a house ownership right or a driver's license drops into the designated account (CoinTelegrap, 2016).

There are virtually endless possibilities to use smart contracts for financial services, trade, healthcare, insurance, fundraising to virtually everything. For instance, by using smart contracts in the healthcare industry one can securely transfer data without the need for transiting via a third party. Patients can have control over their medical data,

they can get paid for it or simply choose not to sell it (EncrypGen, 2018). When smart contracts are used to write voting transactions on a blockchain, a token will be sent to the address representing the winner once the vote is over (FollowMyVote, 2012).

While smart contracts can be a miraculous solution to save costs, gain speed and disintermediate transactions, there are also questions about the future in terms of their impact on jobs that will be replaced and not needed anymore in the digital age of blockchain.

Understanding Trust

Between blockchain enthusiasts who believe that blockchain-powered solutions can be used to solve virtually anything, and crypto-skeptics who argue that the bubble driven by the overhype may fail to deliver its promises and burst, we believe that one of the key elements worth examining is the notion of trust.

Looking at the multidisciplinary definitions of trust, the rising complexity of networks in modern societies drives a composite trust that results from the interplay of features specific to a complex network (Cho, Chan, & Adalı, 2015). In the digital age, blockchain may shift the trust from analog to digital. Nevertheless, blockchain may not replace trust but rather become the future of trust, depending on how fast the transition can be from trusting legacy trust intermediaries to digital trust in the form of blockchain-backed crypto-trust (Blasingame, 2019). What blockchain does, is to shift from trusting people and institutions to trust technology from the cryptography to the software, the network, the computers, and the people making the system work (Shein, 2019).

In one research, a blockchain-backed model of trust was proposed in the field of higher education, to enable training institutions to adapt curricula to match the specific needs as endorsed by employers (Lizcano, Lara, White, & Aljawarneh, 2020). In another research, a trust model was proposed for blockchain-backed identity management, it is based on a numerical trust metric as an independent basis to characterize assurance levels (Grüner, Mühle, Gayvoro, & Meinel, 2018). In the case of tourism crowdsourcing

platforms, false data can distort realities hence the rising interest in trust and reputation modeling to assess the quality of the information outsourced from the crowds and its trustworthiness. Blockchain can associate contributions to contributors and make transactions reliable, which makes the case for blockchain-backed built-in trust and reputation modeling within crowdsourcing platforms to enhance trust between consumers and service providers (Veloso, Leal, Malheiro, & Moreira, 2019).

A recent book on blockchain and the new architecture of trust examined blockchain as a new form of trust by looking into its blend of social, technical, and legal features upon which the architecture of trust is built. Trusting a blockchain-enabled solution goes beyond the integrity of transaction ledgers and audit logs, and entail effective governance mechanisms which operate in decentralized environments (Werbach, 2019). Indeed, there are several tension points between law and blockchain, the latter may remove mechanisms for legal enforcement, create barriers to prosecute criminal activity, and can be less accurate in dealing with human variables when compared to courts and lawyers (Werbach, 2019). Yet, blockchain can also offer new opportunities to lawyers by removing the traditional frictions in transactions that are algorithmically executed using smart contracts (Werbach, 2019).

Critics argue that verification cannot replace trust, that institutional trust is still needed as well as governance outside the system to override the rules and introduce changes when there are required. Furthermore, several questions persist as to whether the trust intermediaries of the novel crypto architecture are better than their predecessors, the possibilities of abusing trust under in such a new system, and whether the benefits of public blockchains outweigh the issues they bring (Shein, 2019). As there are still more questions than answers, we argue that the future of blockchain technology may well depend on the viability of its new architecture of trust. Whether or not it will become the future of trust to replace or co-exist with traditional trust intermediaries, academic discussions and experimentations will continue exploring trust models in the crypto-space to bring-in some of the critical answers.

The Sustainable Developments Goals (SDGs)

The Sustainable Developments Goals (SDGs) replaced the Millennium Development Goals (MDGs) as the leading global development framework since their inception in 2015 to 2030. In contrast with the siloed approach of the MDGs which were not achieved overall by 2015 despite the tremendous progress made, the 17 goals and 169 targets are universal and represent an ambitious agenda for sustainable development spanning social, economic and environmental considerations all over the world uniting both developed and developing countries to raise a historical challenge of delivering on their ambitions by 2030 while leaving no one behind.

Overall and while recognizing the great efforts made and the significant progress achieved worldwide as reported by countries in their national voluntary reviews (UN DESA, 2020), there is no country in the world on track to achieve all the SDGs by 2030 (Sachs, Schmidt-Traub, Kroll, Lafortune, & Fuller, 2019). We can argue that the international community so far failed to create the conditions needed to achieve such an ambitious agenda. The multilateralism canopy which used to lay the foundations for the international community is shrinking driven by rampant unilateralism and trade wars (Ghosh, 2019). In an increasingly multipolar world, this could be explained by the worrying trends in the global economic architecture and patterns in trade and capital flows that are fueling inequalities. From intellectual property rights, the privatization of natural and social assets, market monopolies to corporate tax avoidance, regressive indirect taxations to fiscal austerity measures (Ghosh, 2019).

Before the new Coronavirus disease, the funding gap to meet the SDG targets by 2030 was estimated at US\$ 2.5 trillion annually (Burgess & Turner, 2019). To bridge the gap in development finance needed for the SDGs, there is a need to attract private capital flows and consider innovative and scalable approaches (Runde, Metzger, & F. Abdullah, 2020). This is a key area where blockchain-enabled applications can play a vital role in areas such as remittances, impact investing, crowdfunding, and Islamic finance.

Figure 1.4: The Sustainable Development Goals (SDGs)



Source: (United Nations, 2020)

Now in the age of COVID-19, how do we finance the SDGs under a new normal? How do we calibrate responses to face looming socio-economic crises? Which innovations to stay on track for the SDGs? Uncertainties under a new normal may indeed derail current efforts to meet national global targets. Initial assessments are already showing that the Coronavirus pandemic is affecting all the SDGs from loss of income drowning entire segments of societies below poverty lines, increased levels of violence against women, reduced commitment for climate action, to backlashes against globalization (UN DESA, 2020). The Preliminary findings from a recent survey of the public opinion on the impact of the pandemic on achieving the SDGs by 2030, suggest that the majority of participants with 43.6% believe that the crisis will both accelerate and slow down the SDGs in the same proportions, while another 36% see a negative impact and are of the view that on the long run it will only slow down the SDGs (Lafortune, 2020). In order not to derail the current momentum for meeting the SDG targets by 2030, countries will need to implement coordinated packages that support financial stimulus, concessional finance, debt relief, market liquidity, resilient infrastructures, crisis prevention, social protection systems, trade and supply chains (Subhanij & Hasannudin, 2020).

Can blockchain offer superior solutions to achieve the SDGs?

An overview of initiatives using Distributed Ledger Technologies (DLTs) suggests that blockchain could transform the ambition for good into tangible results (Kewell, Adams, & Parry, 2017). Blockchain can be an enabling technology to develop sustainable and secure solutions, this can be explained by its ability to enhance operational efficiency in global partnerships, but also to deliver the key functions of transparency, traceability, accountability, cyber-resilience to fulfill the SDGs (Fraga-Lamas & M. Fernández-Cara, 2020). While there is a growing interest in blockchain technology, there are not many examples in the literature explaining how is blockchain operationalized in concrete terms (Nikolakis, John, & Harish, 2018). There are also technological barriers facing the adoption of blockchain such as in the field of sustainable supply management that can be technical, inter-organizational, intra-organizational, or external (Saber, Kouhizadeh, Sarkis, & Shen, 2018).

The notion of blockchain for good in reference to the SDGs can be questioned through the lenses of the existing cautionary literature. It is still unclear whether DLTs can deliver a better society that is more democratic, inclusive and sustainable, or rather becomes another tool deployed by organizations and authorities for control and surveillance purposes (Kewell, Adams, & Parry, 2017). Some of the most promising use cases for a successful implementation of blockchain-enabled solutions were found in the areas of affordable and clean energy under SDG 7, and in the areas of responsible consumption and production under SDG 12 (Shermin, Tatjana, Wildenberg, & Rammel, 2019).

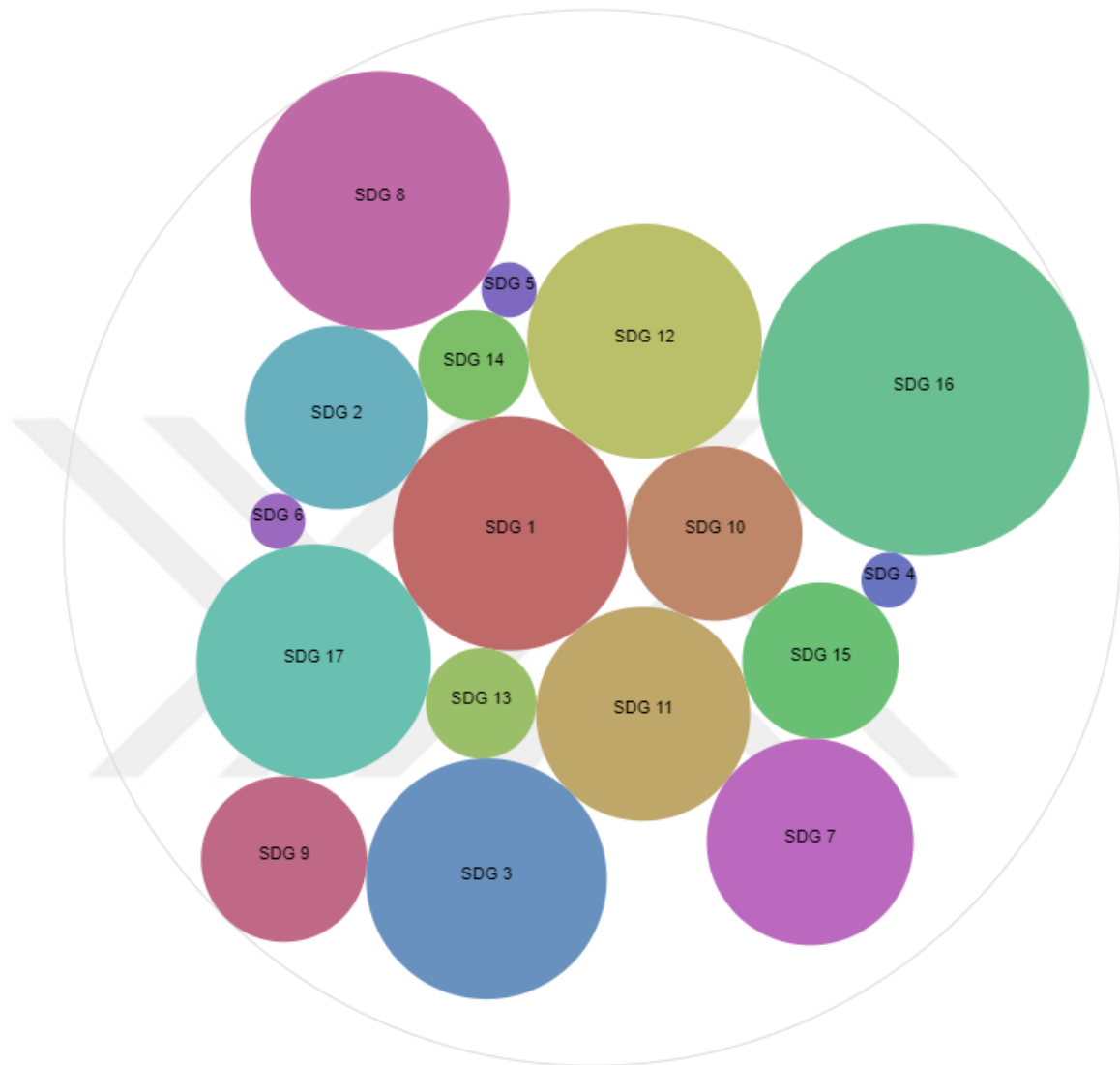
Despite a noticeable increase in blockchain-related research, little attention was given to the issues of sustainability and open innovation while developing academic and commercial solutions, most of which are still at their early stages (Fraga-Lamas & M. Fernández-Cara, 2020). The usefulness of blockchain-powered solutions for instance to increase financial inclusion can be negatively affected by the absence of protocols and definitions, which hinders its ability to make a significant difference (Danho & Habte, 2019). Similarly, for blockchain to fulfill its promise for instance to enhance sustainability

within global value chains, there is a need to establish proper safeguards (Nikolakis, John, & Harish, 2018). More research is needed for a better understanding of the extent to which DLTs can be deployed and their ability to deliver the SDGs purposes (Kewell, Adams, & Parry, 2017).

While virtually there is an undeniable potential for blockchain use cases to accelerate achieving each one of the SDGs, there is also a huge lack of data to truly assess the contribution of blockchain to sustainable development. Unlike its financial and commercial applications, blockchain-enabled solutions for social impact remain relatively understudied (Goldstein & Tillemann, 2020). In the absence of aggregate data to build the body of knowledge about blockchain use cases for the SDGs, organizations, and individuals implementing blockchain projects for social impact may not be able to learn from it. We argue that such knowledge is indeed critical to extract good practices, lessons learned, share experiences, and catalyze joint efforts towards reaching economies of scale and perhaps pave the way to functional blockchain ecosystems.

Several initiatives are working to fill in the information chasm within the arena of blockchain for sustainable development by building online databases of blockchain projects such as the Positive Blockchain database reportedly the largest with more than 850 impact blockchain projects (PositiveBlockchain, 2020), the Blockchain Impact Ledger (Goldstein & Tillemann, 2020), and the Canonical Blockchain List (Brand, 2018).

Figure 1.5: Blockchain projects addressing each SDG



Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

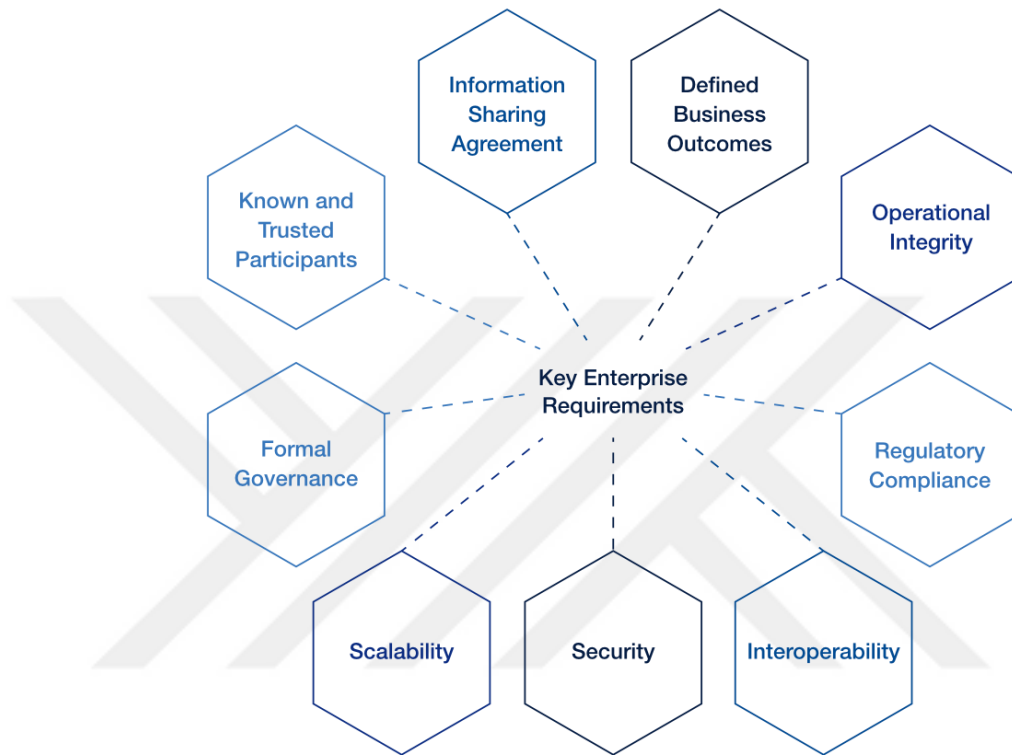
The Blockchain Impact Ledger uses the SDGs to breakdown listed projects into impact areas. As shown in figure 1.5 above, SDG 16 (Peace, justice, and strong institutions) topped the list of the SDGs addressed by blockchain projects based on 71 entries listed in the Blockchain Impact Ledger (Goldstein & Tillemann, 2020). It comes as no surprise to see blockchain-enabled applications primarily deployed to address governance matters to tackle issues of transparency, fraud, and other unethical behaviors within a wide array of sectors within society. Earlier findings suggest that the scape for blockchain

projects for social impact is still in its infancy as most projects are less than 2 years old, Ethereum is reportedly the most popular blockchain platform, and deploying the technology itself happens to be a multi-stakeholder process with projects consulting with 3-5 partners on average during product design and deployment (Gregori, 2019).

While many agree on the promising potential of blockchain technology, critics highlight its early stage of development and the need for a better understanding of what can be done and what cannot be done with blockchain, when to implement it, which underlying ethics to consider, and how to monitor and evaluate its system-wide improvement and measure its impact on the international humanitarian and development practice (Joost & Andrej, 2018). Other critics emphasize the absence of appropriate data and evidence to support claims throughout the chain of results from outputs, outcomes to the impact of blockchain-backed solutions. The same applies to lessons learned and practical insights which remain understudied compared to other emerging technologies (Vota, 2018).

At the core of the relationship with donors and partners funding the SDGs are the imperatives of trust and accountability. While both can be achieved to some extent via traditional reporting mechanisms, such practice can surely benefit from appropriate technological innovations. Against this backdrop, the adoption of blockchain technology within the international development community should not be solely approached through the lenses of testing new technological gadgets. The ongoing trial and error experiments of blockchain technology should also consider blockchain standards such as those being developed by ISO TC 307 (Ryan & Horner, 2019). A more transparent and efficient international development is critical to sustaining healthy levels of trust between donors, governments, businesses, multilateral organizations, and civil society organizations. It is also necessary to maintain the reputation of blockchain technology (Ryan & Horner, 2019). Blockchain is not a risk-free technology and has its own set of transparency and cybersecurity risks, regulatory challenges, and interoperability problems resulting from fragmented digitalization (ADB, 2019).

Figure 1.6: Essential considerations typical for enterprise technology solutions



Source: (WEF, 2020)

Deploying blockchain-backed solutions comes with its own set of challenges from talent shortages, to scalability concerns, regulatory issues, governance, and change management concerns (Ranjan, Hung, Mohindroo, & Vignesh, 2019). The blockchain deployment toolkit released by the World Economic Forum on April 2020 for instance, may provide some of the very much needed tools needed in the blockchain space to guide organizations and individuals in their journey to galvanize more responsible deployment, de-risk adoption by the early movers in their industries, while also carefully considering unintended consequences (WEF, 2020).

Blockchain and the SDGs in the age of COVID-19

The year 2020 is a symbolic landmark within the international development community marking 10 years to achieve the ambitious sustainable development Agenda by 2030. As the world declared war to the invisible enemy, the uncertainties and volatilities that followed are posing serious risks to sustain the momentum in meeting the SDG targets by 2030 as the world priorities may shift towards managing the pandemic. At the very time where financial markets were tumbling, borders shutting down, people panic buying and millions losing their jobs, development financing may be repurposed to solve pressing domestic issues at home first, as countries inject stimulus packages to revive their economies. During unusual times, unusual solutions may be required, disruptive technologies may be needed more than ever before.

As the world is walking into the uncharted territories of the post-COVID-19, and as disruption waves are building and breaking on the shores of the international development practice as we once knew it, business-as-unusual will undeniably become the new normal. With that in mind, there is a need to rethink the architecture of international development as the current practice might become obsolete before we know it in the race to the unknowns. So how do we adapt to a new normal? With initial estimates indicating that the Coronavirus disease will cost the global economy around US\$ 1 trillion (UNCTAD, 2020), disruptive solutions are needed in the face of a looming socio-economic crisis to avoid reversing the hardly achieved development gains during the recent decades. Luckily, the new normal is not only a matter of uncertainties and volatilities driven by skepticism, fear, and fragility, it is also an era-defining moment of opportunities.

In the aftermath of the Coronavirus disease, we are witnessing a historical opportunity to reboot our systems and rebuild our economies based on the triple bottom line of social, economic, and natural capitals. As we are rebuilding our economic systems, many questions remain however as to how we address inequalities, reverse the loss of biodiversity, or tackle the climate crisis. While there are no easy one-size-fits-all answers,

we argue that we cannot solve an issue with the same thinking that created the issue. For instance, to embrace a true sharing economy we don't have to redistribute wealth once it's created but instead pre-distribute productive assets to the crowds upfront through a decentralized system.

Tech trends during the pandemic provided a pre-taste of what would a new normal look like. Online shopping, contactless payment, remote working, e-learning, digital health, e-entertainment, data-based supply chains, 3D printing, 5G, robotics, and drones are all part of the rich landscape of digital readiness (Xiao & Fan, 2020). Similarly, some technologies are expected to boom in the aftermath of the pandemic, this is the case for example of data-enabled health care, digital supply chains, e-commerce, digital collaboration, and entertainment (Ruokonen, 2020).

The current economic and development landscapes suggest that disruptive technologies such as blockchain will play a leading role in defining and adapting to the new normal in the post-COVID-19 era (Banafa, 2020). As a consequence, we can safely assume that the blockchain technology will only gain further attention which will in return boost its adoption and growth making it perhaps the new internet of tomorrow, the internet of value.

Discussion and conclusions

Undeniably, blockchain, and distributed ledger technologies are disrupting traditional business models in so many ways, including within the international development space. Driven by the hype to embrace what appears to be a must-have a powerful tool to join the early movers, blockchain-powered pilots, and experiments to design minimum viable products and test proofs of concepts are burgeoning across spectrums all over the world. Against this backdrop, to produce sustainable development impact and accelerate the ongoing efforts to meet the SDGs by 2030, many are willing to prototype promising use cases in an attempt to harness the potential of blockchain-enabled solutions.

Now, while virtually there is so much one can do with a blockchain-backed application, there is also a huge lack of evidence to truly assess the contribution of the blockchain technology to sustainable development. Even more, thought-provoking is the chronic lack of data along with the blockchain industry. Ironically, in contrast with its promising potential to foster trust and accountability, the overall blockchain industry may appear relatively opaque because of the overall scarcity of data from pilots and experiments which remain largely under-studied especially with regards to blockchain-based applications for social impact and sustainable development.

In the absence of aggregate data to build the body of knowledge about blockchain use cases for the SDGs, organizations, and individuals implementing blockchain projects for sustainable development may not be able to learn from it and consequently improve their practices. Such knowledge is critical to extract good practices, lessons learned, share experiences and catalyze joint efforts towards reaching economies of scale and perhaps pave the way to functional blockchain ecosystems to produce nationwide solutions instead of experimentation silos with little or no proven impact at scale.

Admittedly, this could be explained by the fact that we are still in the early days of the blockchain technology as it is getting mature and the wave of its adoption is building and breaking across the shorelines of the international development practice. While we can learn from the trials and errors experimentations conducted by the early movers at the early days of a nascent technology, no one can accurately predict the trajectory and impact that blockchain-enabled applications can have on development practice in terms of enabling development workers and organizations to overcome new challenges or even achieve better development results.

Now, if we can't predict its outcomes till the technology become more mature, we argue that we can still make sure that blockchain use cases experimented by the development community are properly designed and implemented to live up to their promises. To do so, we argue that more research is needed to go beyond the hype-driven by the mainstream awareness behind the rapid rise of what we refer to here as the "let's

blockchain it” movement which suggests that blockchain applications are superior compared to other alternatives in terms of their ability to deliver development outcomes.

Researchers, experts, and resource persons at the frontlines of innovation for development are called upon to develop actionable toolkits and toolboxes. Providing individuals and organizations with tools and approaches to guide their efforts step-by-step can not only yield sound use cases of blockchain enables solutions for sustainable development, but also break the hype-cycle for blockchain to maintain its reputation and live up to its promises. In the second chapter of this work, we made our modest contribution in an attempt to co-create such tools by proposing an Integrated Approach to use blockchain-enabled solutions as SDG accelerators in the international development space, as well as an SDG Acceleration Scorecard.

CHAPTER 2

TOWARDS AN INTEGRATED APPROACH TO USE BLOCKCHAIN-ENABLED SOLUTIONS AS SDG ACCELERATORS IN THE INTERNATIONAL DEVELOPMENT SPACE

Introduction

In this chapter, we examine the blockchain hype and the gaps in data and tools to build promising use cases for blockchain technology to achieve the Sustainable Development Goals (SDGs). By doing so, we attempted to break the hype-cycle portraying blockchain's superiority by navigating a rational blockchain use case development pathway. Individuals and organizations designing and experimenting blockchain-based solutions for sustainable development may find the tools we have prototyped useful namely the SDG Acceleration Scorecard and the Integrated Approach to use blockchain-enabled solutions as SDG accelerators. Acknowledging the limitations in prototyping these tools, we believe these are minimally viable products and should be considered living tools that can further evolve as the blockchain technology is getting mature, its pace of adoption increasing, and its lessons learned, good practices and standards widely shared and internalized by teams and organizations working on innovation for development.

We will examine how various blockchain solutions were ideated, designed and applied and how their related implementation choices were made in an attempt to define a structured approach to develop effective use cases for blockchain applications in the fields of international and sustainable development. We will then identify potential gaps in terms of monitoring and evaluation, risks, and ethical considerations to propose tools to assess the impact of blockchain-powered applications and manage the associated potential risks and ethical considerations. We will also explore to what extent does the use of blockchain influences business processes and identify structured ways to manage transformational change within organizations deploying blockchain solutions. By doing

so, we aim to provide useful insights towards developing an integrated approach that is fit-for-purpose to guide organizations and practitioners in their quest to make informed decisions to design and implement blockchain solutions as SDG accelerators.

Moving beyond the hype

Through this chapter, we aim to add our modest contribution to effectively harness the disruptive potential of blockchain as an SDG accelerator. This work will support development workers and organizations experimenting or willing to experiment blockchain-enabled applications to address various challenges facing the achievement of the sustainable development goals by providing a practical toolbox to facilitate the deployment of structured approaches and meaningful tools to build promising use cases for blockchain applications, monitor and evaluate the results of blockchain-enabled development interventions, assess and mitigate the risks associated with the blockchain technology, manage organizational change and nurture a culture of change fostering an early and rational adoption of disruptive innovations.

Five years after the adoption of the SDGs in 2015 and 10 years ahead of the 2030 finish line, too many people's lives are reportedly changing for the worse (Ghosh, 2019). Now, if new technologies are going to contribute to solving the puzzle, there have to be adequate tools, methodologies, and standards to navigate the blockchain hype-cycle and move from a generalized "let's blockchain it" approach towards a rational narrative that is evidence-based.

Despite blockchain's promising potential, the reality can be challenging, there are not enough data, blockchain-backed applications for social impact are under-studied, and claims that blockchain-backed solutions can yield superior results when compared to other alternatives are yet to be supported by evidence. While we can agree that blockchain has a promising potential to trigger disruptive innovations, we can also agree that the technology is not mature yet and that there is still a gap in terms of approaches and tools to develop blockchain use cases, evaluate blockchain applications, monitor

experiments, mitigate associated risks and manage organizational changes to galvanize innovation-readiness within organizations considering to adopt blockchain technology and run use cases' experiments. It is only by filling the existing gaps that we can make a stronger case for using blockchain as an SDG accelerator.

We can argue that the comparative advantage of blockchain can be explained by its ability to address the issue of trust within the world financial system in the aftermath of the 2008 global financial crisis (Jiang, 2018). Looking into the current practice among the key players in both worlds of public and permissioned blockchains, there is a costly race among early adopters towards becoming the standard and prototyping blockchain applications to do things other technologies simply cannot. Against this background, we can look at the blockchain as a package of technologies and approaches to open up new opportunities for users to manage transactions, exchange values, and maintain digital trust (Gartner, 2018). Blockchain applications designed in areas where trust is a must, yet hard to secure are predicted to prevail (Jiang, 2018).

In one forecast the business value of blockchain was predicted to climb up reaching \$176 billion by 2025 before skyrocketing to \$3.1 trillion by 2030 (Gartner, 2018). Nevertheless, blockchain is yet to deliver its promise to match the hype despite its potential. The maturity of blockchain technology is expected to facilitate its wider adoption, widen the scope for its utilization, and consequently foster blockchain's ability to stimulate successful disruptions. This goes in line with the need to stimulate business processes, enable regulatory frameworks, and trigger the necessary cultural shift and the underlying organizational structures.

Methodology

To prototype an integrated approach for this research, we will go through several stages. First, we will define the minimum viable product for the integrated approach by examining the available literature using four thematic clusters: building blockchain use cases, monitoring and evaluation of blockchain-based applications, risks, and ethical

consideration associated with blockchain-powered experiments, and change management in organizations deploying blockchain-based solutions. Second, the integrated approach built based on the initial findings from the literature review will be further improved based on our observations and the inputs shared by resource persons approached to conduct this research.

During the last stage, we will finally propose an Integrated Approach together with an SDG Acceleration Scorecard to assess the potential for SDG acceleration. While we recognize the limitations of this work and the need to conduct further field investigations to explore the proof of concept by reaching out to a larger number of respondents to gather and analyze critical data, we believe that the proposed package composed of the Integrated Approach and the SDG Acceleration Scorecard is a necessary first step. Such tools should be considered as “living tools” that can be further improved as blockchain technology is getting mature, based on the feedback from end-users as they domesticate and internalize these tools to develop meaningful blockchain solutions.

Thematic Clusters

To do so, we consider four thematic clusters according to which we will test the following research questions and assumptions in an attempt to verify their validity as follows:

1. Building a use case
2. Monitoring and Evaluation
3. Risks and ethical consideration
4. Change management

Table 2.1: The thematic clusters proposed to prototype the integrated approach

Thematic Cluster	Research questions & Assumptions
Building a use case	What can be solved and what cannot be solved by blockchain? Which structured approach to understand the business potential of blockchain in a given context and design specific and promising use cases? We assume that the solution should not come before the problem. To make a meaningful use case for blockchain there are many boxes to tick-in.
Monitoring and Evaluation	Which structured approach and tools to M&E blockchain applications? Looking beyond pilots, can blockchain solutions deliver impacts at scale? How can we measure such impacts? We assume that while blockchain applications are contributing to solve some of the challenges around the implementation of the SDGs, it was mostly demonstrated and reported in the available literature through pilot applications that were not replicated at a larger scale. To better assess blockchain's impact on the SDGs, to examine whether or not a given result could be fully attributed to the blockchain, or if blockchain rather partially contributed to such a result, we assume that there is a need to develop adequate tools to support monitoring and evaluation of different blockchain experiments. Such tools should not only track progress but also provide a standardized platform to ensure comparability and assess criteria of relevance, effectiveness, efficiency, sustainability, and impact, in addition to gender equality.
Risks and ethical consideration	Are blockchain applications in sustainable development risk-free? What are the potential risks associated with the utilization of this technology and which ethical reflections should be taken into consideration? We assume that there is a need to explore ethical considerations around the use of blockchain to determine potential risks for development professionals to make informed decisions and come up with appropriate mitigation measures.
Change management	What about change management in organizations adopting blockchain? How does embracing innovation, in the case of blockchain applications, affects the way development and humanitarian organizations do business? We assume that change management is a dynamic process that needs to be understood, to enable organizations to develop an evolutionary adaptation approach to navigate the transition, address resistance to change, and nurture innovation.

Building a Use Case

Low experimentation costs of blockchain solutions driven by platforms made available via service providers known as Blockchain as a Service (BaaS) offerings (DeCleene, 2018), combined with the increasingly complex nature of delivering development and humanitarian interventions in a time where both developing and developed countries are pursuing their sustainable development targets, stimulated many investments to build use cases for blockchain solutions in a wide array of contexts. Here, we are looking beyond the hype at the fundamental question of what can be, and what cannot be solved by blockchain? We can also agree that given the scarcity of development finance, the increasing demand, and challenges faced by organizations and practitioners in today's world to deliver effective yet lasting results, the return on investment of innovation experiments including blockchain should not be limited to the proof of concept but also consider impact at scale.

While blockchain can be the appropriate choice in some cases, other conventional technologies might be more appropriate in other cases (Sin Kuang, Xiwei, Yin Kia, & Qinghua, 2017). Giving the blockchain hype, we consider that the critical starting point to make a use case for a given blockchain application is to avoid at all cost developing a blockchain solution when there is no problem to be solved with it. The specific problems that need to be fixed and the feasibility of the blockchain solution should be rigorously examined while building a promising use case for blockchain (Mckinsey, 2018). Other criteria to consider could include the realities on the ground in line with the specific development or humanitarian contexts for which a blockchain solution is sought, the capabilities of the staff involved in the blockchain experiment, the flexibility of the applicable business processes and the underlying managerial structures.

Another vital factor is coordination among stakeholders involved in the design and implementation of a given blockchain solution. To design viable blockchain solutions, due consideration should be also given to the ability to manage technology constraints

through trade-offs, to convince various stakeholders of the relevance of the blockchain use case, to cooperate with other players, and to comply with the applicable regulations and standards on a case-by-case basis.

For this research, we have adapted the stages defined in the blockchain use case development method (BUD) proposed by (Fridgen, Lockl, Radszuwill, Schweizer, & Urbach, 2018) using a design thinking process (Dam & Siang, 2019). We argue that these stages will evolve to reflect the latest developments in blockchain as the technology is getting mature and reaching a stage of producing impact at scale.

Step 1 - Understand blockchain

We assume that the focus here should not be on understating the technology itself, but on what can be done with it. This also means taking into consideration the capabilities organizations should have to design and implement blockchain solutions.

Step 2 - Define the problem you are trying to solve with blockchain

Here we need to clearly define the challenge that we are trying to overcome with blockchain. Individuals and organizations need to consider the feasibility aspects, as well as various organizational implications including with regards to business processes and change management, should be also taken into consideration. Guiding questions can be provided as:

- What is the exact problem you are trying to solve?
- How does it affect your sustainable development context?
- Which capabilities do you need to develop a blockchain solution to address this problem?

Step 3 - Pitch your ideas

We assume that while teams can consider existing blockchain use cases in their fields of interest, they should only use such cases for inspiration and come up with their innovative ideas by brainstorming and working together in cross-functional teams. Guiding questions can be provided such as (Wachal, 2019):

- Are transparency and traceability important in your context?
- Do you need a centralized or decentralized solution?
- Which transactions require trusted partners or processes?
- Which intermediaries can be eliminated?
- Will you reduce transaction time for end-to-end processes with blockchain?
- Which costs can be reduced?
- Which data is most sensitive and which data will be stored?
- How much control do you need for stored data?
- Who are your potential end-users?
- Which transformational change can result from using blockchain in your organization?

Step 4 – Build Consensus

We assume that while consensus protocols make blockchain platforms immutable, achieving such consensus may require huge computational power and large amounts of energy, while design choices can have implications on how much time is needed for consensus and the degree of decentralization.

- To what extent are timing and decentralization critical factors in your context?
- How much computational power is needed to achieve consensus? Can it be reduced?
- Which consensus protocols can be used?

Step 5 - Prototype the solution

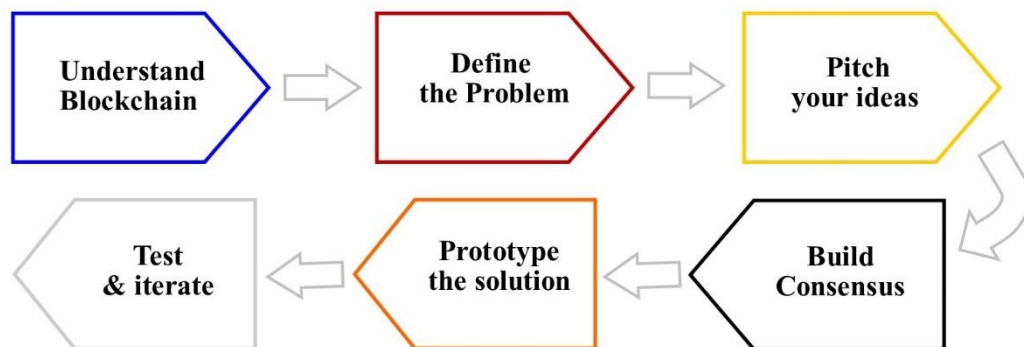
We assume that issues of efficiency, scalability, performance, and impact should be factored-in while defining the parameters for any given blockchain prototype. Guiding questions may include:

- What is the cost of developing this blockchain solution?
- What would be the return on investment?
- Which blockchain platform should be used in your case (Public, Private, Hybrid)?

Step 6 - Test & Iterate

We assume that blockchain solutions should be tested with potential end-users to identify residual issues which will be taken back to the prototyping phase through an iterative process.

Figure 2.1: Presentation of the blockchain use case development method



Source: author based on (Fridgen, Lockl, Radszuwill, Schweizer, & Urbach, 2018)

Risks and ethical considerations

Are blockchain applications in sustainable development risk-free? What are the potential risks associated with the utilization of this technology and which ethical reflections should be taken into consideration? We assume that there is a need to explore ethical considerations around the use of blockchain to determine potential risks for development professionals to make informed decisions and come up with appropriate mitigation measures.

We can praise blockchain for its disruptive potential and all the benefits it can bring into a given use case. Nevertheless, we can also agree that there is no return on investment without risks. Organizations and practitioners must avoid at all costs creating more problems than the ones a blockchain application is designed to solve. Given the complex nature of blockchain technology, it is not an easy task to assess the underlying risks especially in the absence of standards and regulations (Panetta, 2016). For this research, we have adapted the frameworks for risk analysis and management proposed by (S. Kaplan & Mikes, 2012), (Tasca, 2017) and (Thivaivos, 2018).

1. Analyze (identify core risks and assess their potential impact and likelihood)
2. Manage (develop proper management responses to mitigate risks)
3. Anticipate (detect new risks that are arising from various ethical considerations)

Risk Analysis

At the design stage, there are no blockchain standards as the technology is not mature yet. Lessons learned and good practices should be coded into standards to minimize risks and pave the way towards enhanced cooperation. We assume that the inter-operability between blockchain platforms will remain a key issue and thus represents a key risk. Other technical risks may potentially stem-out from design-related choices for instance

whether forking another version of the ledger is allowed or whether automated actions are built-in on a blockchain infrastructure.

Implementation comes with its own set of risks. Consensus building algorithms can cause serious delays giving the nature of participatory processes. High maintenance costs can cause projects to fail and scalability might not be done through economies of scale. Cybersecurity risks and frauds are a key challenge for shared technological infrastructures that can originate from the outside or from within. While the likelihood of outside attacks appears to be minimalistic, risks stem-out from the irreversible nature of internally produced mistakes such as sharing an erroneous code across the network or building consensus on a false entry. Updates and maintenance managed by third parties may qualify as potential risks as well, especially if the skills required and the availability of service providers are in low supply.

Other risks in general terms are linked to the constantly evolving blockchain regulations in various jurisdictions, the cost of technology updates, competition from other disruptive innovations, and the ecological footprint of blockchain giving its energy consumption. In general terms, the more we understand blockchain, and the more we understand the problem we are trying to solve with blockchain, the highest is our chance to come up with the most appropriate risk mitigation measures.

Risk management

We consider three risk categories that can be analyzed at different stages before, during, and after the implementation of the blockchain-backed solution.

- Preventable risks

Here we are looking at internal and avoidable risks arising from within organizations and teams. With blockchain, the need for human interventions can be reduced when using automated processes and smart contracts, which in return can decrease the likelihood

of alteration of records or corruption of people involved. However, risks may stem-out from the irreversible nature of internally produced mistakes such as sharing an erroneous code across the network or building consensus on a false entry. We assume that active prevention through a rules-based control model is the most suitable risk management response to risks listed under this category, it could be achieved by monitoring business processes and by guiding human-made decisions related to blockchain applications.

- Strategic risks

These are risks organizations and teams are willing to take to achieve high targets. Here the managerial response is rather towards reducing the likelihood for risks to occur and containing such risks in the case they materialize. While blockchain can minimize risks related to compliance and litigations, early investors driven by an appetite for innovation to pioneer their field of practice can see their projects seriously delayed by consensus building algorithms giving the nature of the participatory processes, or even fail due to poor buy-in from their stakeholders, high maintenance and scalability costs which might not be done through economies of scale.

- External risks

These are consequences of events happening in the outside world that cannot be accurately forecasted, and over which organizations and individuals have no control whatsoever. Proper mechanisms should be set in place to track such risks and mitigate their impacts to the extent possible using appropriate managerial responses. Although the likelihood of outside attacks appears to be minimalistic, cybersecurity risks are a key challenge for shared technological infrastructures. Updates and maintenance managed by third parties may qualify as potential risks as well, especially if the skills required and the availability of service providers are in low supply. Other risks in general terms are linked to the legal-technology mismatch due to the constantly evolving blockchain

regulations in various jurisdictions, in addition to the cost of technology updates and competition from other disruptive innovations.

Ethical considerations

We can argue that ethics made a late appearance in the blockchain sphere because it is seemingly complicated to understand how the technology works. Several ethical considerations need to be addressed. Due to massive energy consumption, public blockchains based on mining can potentially have significant impacts on the environment. The annualized total electricity consumption of bitcoin assuming constant power usage over one year is estimated at 77.38 TWH (CBECI, 2019). This number should be understood as an educated guess to have an idea giving that it is not possible to accurately calculate the electricity consumption of bitcoin.

The hyper-efficiency which is indeed a valuable comparative advantage of blockchain applications can disrupt the jobs of many people involved for example in data maintenance (Houlding, 2019). Also, blockchain can over-promise and fail to meet the expectations, or inadvertently facilitate crime-related transactions and oppressive conduct (Longstaff, 2019). Blockchain can be used for money-laundering, in illicit business activities such as weapons and drugs or other related transactions (Smith, 2019).

Equally important is the way we design blockchain applications based on trade-offs which can have far-reaching consequences (Aponte & Fishbane, 2018). It can codify biases and exacerbate social dynamics within a given community, the transparent nature of blockchain information can put persons at risk because of their ethnicity, religious background, or sexual orientations (Aponte & Fishbane, 2018). The same applies to the immutability of digital identity records in case a person is threatened and would need anonymity or a new identity, or if erroneous data is recorded. If there are no ways of retrieving a lost private key it might simply mean that a person lost control over his digitally recorded assets. When the encryption algorithms used are outdated, sensitive

information might be exposed, and transactions can be forged (Apoinde & Fishbane, 2018).

Monitoring and Evaluation (M&E)

Monitoring

We argue that the core ingredients to successfully monitor blockchain interventions would be for organizations to have clear monitoring policies in place, for individuals to have clearly defined roles and responsibilities in the monitoring process, and to have a first-hand understanding of the operational context in which a given blockchain-powered application is being deployed. Appropriate M&E frameworks should be developed to track specific project outputs especially the annual targets that blockchain projects expect to achieve in line with their results' matrices. Monitoring actions should capture and analyze data to report on the progress towards outcomes, impeding factors, partners' contributions to achieving the expected results, and lessons learned to develop and disseminate knowledge products. While blockchain experiments for social good remain largely understudied, such knowledge products are very much needed by the global community working on blockchain-based applications giving the scarcity of data to identify good practices and share lessons learned in the blockchain for social impact space. Additionally, monitoring data and reports are key resources for evaluation professionals, they should be accessible and shared to conduct successful evaluations to inform decision making and future experiments.

For this research, we propose a basic 3-step approach for monitoring blockchain projects being data gathering, analysis, and reporting.

- Collecting data using available tools. Data can be collected based on field investigations and through different reporting mechanisms, then triangulated for validation and discussed via participatory processes such as during coordination meetings with partners.

- Analyzing the data gathered to extract useful information, identify patterns, and detect bottlenecks. Data interpretation in terms of what needs to be done may be used to generate useful and user-friendly insights to guide decision-makers.
- Reporting to inform future decisions. Stakeholders and partners involved in blockchain projects can be guided to make informed decisions to ensure the project is on track to deliver their expected results.

Evaluation

Since their adoption in 1991 (OECD, 1991), the five OECD DAC criteria are the most referenced and used standard to evaluate international development interventions. For many years, evaluation professionals considered relevance, effectiveness, efficiency, impact, and sustainability as the standard to assess development interventions. The main issue here seems to be how these criteria should be used, as one mainstream mistake is to start using such criteria in a mostly mechanical way by ticking-in-the-box instead of using them to support a non-linear critical analysis (Pasanen, 2018). As one of the key reforms being approached in the SDG era, there are ongoing discussions as to what extent the DAC criteria should be revised to capture the new paradigms of sustainable development. We can argue that not every evaluation should cover all the 5 criteria, and even if it's the case, not all the criteria are analyzed in the same depth, and most importantly, there might be something missing today 28 years after the DAC criteria were adopted (Pasanen, 2018). We are looking here into disruptive innovations and specifically blockchain-enabled applications for sustainable development to extract key guiding criteria, which evaluation professionals could consider when evaluating blockchain-backed projects.

One common critic of blockchain applications is the lack of evidence to support claims for disruptive results. This can be partially explained by the fact that the technology is

not mature yet, or that lessons learned from blockchain experiments are poorly documented. As a result, we can argue that the hype was driven to some extent by a fear-of-missing-out bubble based on proof-of-concepts experiments to get the headlines (Jiang, 2018). This being said, there is a promising potential for blockchain use cases to have a transformative business impact by improving productivity and quality, increasing transparency, and reinventing products and processes (WEF, 2019). Hence the need to fill in the gap by developing proper M&E evaluation frameworks for blockchain applications in international development.

After developing a promising use case for blockchain, securing the support of various partners, and unlocking the necessary funding, and before kicking-off the implementation of a given blockchain-powered solution there is a need to set up robust M&E frameworks. Organizations might consider hiring full-time M&E practitioners or investing in diffuse M&E skills throughout their workforce assigned to design and implement blockchain-based applications. Now, various considerations make it difficult to perform M&E functions for sustainable development interventions driven by innovative processes. For instance, the uncertainty associated with innovation-based solutions, the speculative nature of the results one should expect down the road, and the hard-to-measure nature of innovation-driven benefits such as stimulating an appetite for a diffuse business-as-unusual culture, are all vital aspects to consider while monitoring and evaluating blockchain-centered experiments.

Before implementation starts and while choosing a platform for a given blockchain solution certain criteria need to be considered for blockchain practitioners to come up with the right decisions (Vangala, 2018). In terms of governance, for instance, it is vital to identify who controls access to the blockchain application, who makes decisions and who enforces such decisions to alter the blockchain solution as the needs evolve in a given development or humanitarian context. One of the main preoccupations for developers of blockchain applications in sustainable development contexts is to

minimize their power consumption and reduce their ecological footprint (Vangala, 2018). That's why choosing the right consensus scheme and offering the right incentives, can enhance the acceptability and thus the success of blockchain-enabled solutions. To decide on the right type of blockchain platform to deploy, organizations need to take into consideration whether the data is meant to be accessible publicly, in a restricted circle, or a combination of both.

For this research, we have adapted the evaluation framework which was developed by (Fridgen, et al., 2018) to evaluate the applicability of blockchain technology along with the public sector. We argue that the framework can be used for the evaluation of blockchain use cases, it does also provide a set of evaluation criteria to consider while conducting mid-term or final evaluations of blockchain projects for sustainable development. Here we consider 3 sets of criteria namely technical, functional, and legal criteria.

1. Technical Criteria: in this set, we have included 4 criteria namely performance, scalability, security, and usability.
 - Performance: due consideration should be given to how fast transactions can be operated within a blockchain network, duration and latency need to be verified using available metrics such as the number of blocks and the size of transactions.
 - Scalability: This is a key element giving that blockchain experiments are usually designed to be tested in small pilot cases. Once the candidate blockchain applications deliver the proof of concept and graduate from the experimentation phase, they are expected to be applicable on a larger scale to address international development needs that are global. It is thus critical to factor-in scalability parameters such as the network size, number of possible nodes, and transactions needed down the road on a larger scale.

- Security: we can assume that a fair number of development solutions were designed as blockchain applications given the enhanced security features of blockchain technology. This is to point out the need to carefully consider the security features provided by a given blockchain application and assess whether it answers specific contextual requirements related to the security of data and transactions.
 - Usability: user-friendly applications tend to be more accepted. The ease of use is a critical parameter to consider which comes down to ensuring that everyone can benefit from the blockchain solution and that no one is left behind. Important details to factor-in can range from internet traffic to the ability to fork new features, the available tools, and languages, the number of possible users, etc.
2. Functional criteria: this set includes criteria related to the costs of R&D to build a blockchain-backed solution, implement it, ensure its operationalization and maintenance, besides other criteria related to the flexibility and transparency of the process.
- Costs: Some applications of blockchain may require heavy transactions and storage of data which implies high costs. This should be duly considered while budgeting to include not only the prototyping and deployment of the blockchain application but also its operational and maintenance costs.
 - Flexibility: Another important feature in international development set-ups, is the adaptability of blockchain-powered pilots to be replicated or altered in a way to serve new needs or address new challenges. If a blockchain platform for instance is only meant to be deployed in a restricted area, such limitations are to be considered before any investments upfront.
 - Transparency: It is important to find out the right trade-offs between transparency and other outputs. Confidentiality can be increased by storing encrypted data but it

will reduce transparency and performance. Transparency can be in tension with commercial confidentiality such as in cases where competitors exist (Sin Kuang, Xiwei, Yin Kia, & Qinghua, 2017).

3. Legal criteria: this set includes criteria related to data privacy, legal procurement frameworks, employee protection rights, and other legal regulations.
- Here we highlight various legal considerations applicable in the jurisdictions and to the entities involved in blockchain experiments. These include requirements for data privacy, contractual modalities specified in procurement laws, employment protection rights, and any other legal instruments that are potentially applicable to blockchain within a specific jurisdiction.

Change Management

What about change management in organizations adopting blockchain? How does embracing innovation, in the case of the blockchain technology, affects business-as-usual in the international development space? We can argue that blockchain technology stimulated a progressive evolution in the ways business is conducted. Development organizations and practitioners running various innovation experiments and aspiring to harness the disruptive potential of blockchain are facing the challenge of managing the change towards a new normal. New avenues and meaningful ways are being explored to nurture a culture of innovation, keep risks at acceptable levels and address pockets of resistance for both organizations and individuals within to be able to follow a trajectory of evolutionary adaptation and achieve a transformational change in doing business (Gartner, 2018). To do so, blockchain should not be considered as a technology option but understood in terms of its capabilities to address specific issues and deliver precise solutions. Organizations and individuals should also consider experiments where they can explore decentralized business processes and allocate staff having both technological but also technical capabilities (Gartner, 2018).

We argue that organizations and individuals embracing the disruption wave brought by the blockchain technology need to be change-adept. When an organization invests in a blockchain application, it has already identified a problem and came up with a use case for blockchain as a solution. Now, managers will need to set-up innovation-prone environments to ensure effectiveness and efficiency, reinforce collaboration, address siloed-behaviors, provide leadership and coaching, and avail resources needed for the blockchain-enabled solution to deliver its promises. Here, the focus is on the capability of the organizations to implement a blockchain-backed solution. In fact, without a structured approach for implementation, an innovative solution is likely to fail. We assume that change management is a dynamic process that needs to be understood, to enable organizations to develop an evolutionary adaptation approach to navigate the transition, address resistance to change, and nurture innovation.

For this research, we will focus on change at the individual level as the cornerstone for change to happen at the organizational level. The following change management approach was inspired by the ADKAR (Prosci, 2019) and Kurt Lewin's (Talib Hussain, et al., 2016) change management models.

- Unfreeze: At this initial stage the focus should be on raising awareness beyond the hype to visualize potential opportunities of adopting blockchain-based solutions and seize the most promising ones.
- Change: This is an intermediary stage where the spotlight is on motivating individuals and teams to design blockchain-powered solutions. This includes coaching, managing resistance, fostering readiness to become a change agent, as well as investing in core capabilities through learning and practice for individuals and teams to acquire a wide spectrum of skills deemed necessary to implement blockchain projects.

- Refreeze the change: this is the final stage where the focus is on re-calibration through corrective actions whenever applicable, but also on measuring achievements and celebrating success.

SDG Acceleration Scorecard

Giving the current hype, one can argue that in general terms development practitioners and organizations tend to “jump the gun” to address a given problem without necessarily being aware of the alternatives and without running proper assessments that would or wouldn’t prioritize “let’s blockchain it!” as the best way forward. Now, even after an assessment indicates that a blockchain solution is the number one option, one can still do more to harness not only the direct benefits to address the initial problem for which a blockchain solution is needed, but equally important are the wider sustainable development co-benefits to which such blockchain solutions can contribute. Giving the interlinked nature of the SDGs, one blockchain-backed solution can contribute to more than just one SDG at a time. In other terms, one should think beyond the simple issue to be solved by a blockchain application. While such an application can solve a specific problem, it can also contribute to achieving other development targets if properly designed and implemented, hence the SDG acceleration effect. That’s why we truly believe that for blockchain-powered applications to deliver wider development co-benefits, it is critical to assess their SDG acceleration potential by taking into consideration an initial set of criteria and indicators related to use case development, monitoring and evaluation, risks and ethical considerations and the change management.

Our attempt here is to provide a simplified scorecard that will help development practitioners and organizations running blockchain experiments understand the bigger picture, pilot their interventions in a way to accelerate the achievement of the SDGs, and fulfill the sustainable development aspirations of individuals, communities, cities, regions, and governments worldwide.

Table 2.2: SDG acceleration matrix

Acceleration area	Multiplier effect (# of SDG targets)	Balance across the 3 dimensions			Score
		Social	Economic	Environmental	
Ex: women empowerment	15	Yes	Yes	Yes	15 3
Ex: impact investing	10	Yes	Yes	Yes	10 3
Ex: Health records	8	Yes	Yes	No	8 2

Source: adapted from the SDG Accelerator and Bottleneck Assessment Tool (UNDP, 2017), the acceleration areas, multipliers, balances, and scores are examples for illustration and will depend on the specific context applicable to a given development intervention

Inspired by the use of scorecards in the development practice, one of the experimental tools we have proposed in this work is the SDG Acceleration Scorecard (SAS). We argue that scorecards can be extremely useful in helping development practitioners monitor progress and measure results. To monitor capacity development, scorecards can be used as tools to quantify qualitative processes and measure the change in capacities using a set of relevant indicators to which specific ratings are assigned, this was the case for instance of the Capacity Development Scorecard developed to monitor the progress made towards achieving global environmental benefits for projects funded by the Global Environment Facility (Bellamy & Hill, 2010). This scorecard was adapted to measure increases incapacity in the case of the implementation of the Access and Benefit Sharing (ABS) mechanism of the Nagoya Protocol which governs the utilization of genetic resources and their associated traditional knowledge (CBD, 2018). Simplified scorecard systems were also used to gather general information and conduct assessments. The WWF-World Bank MPA Scorecard for instance was designed for marine protected areas, it mainly relies on the available literature in addition to the opinions of sites' managers and independent assessors (Leverington, Hockings, Lemos, Courrau, & Pavese, 2008). Such a scorecard can be rapidly deployed, is not costly, and broadly covers the issues.

Nevertheless, the depth of analysis provided by such tools remains low (Staub & Hatzios, 2004).

In our attempt to develop a scorecard to assess the SDG acceleration potential of blockchain-enabled solutions, we have applied the core criteria defined in the thematic clusters to propose acceleration areas, and we tried to identify possible drivers of acceleration by asking specific questions to generate useful information that can be used for two main objectives. Under the first scenario, the scorecard can be used to assess the multiplier effect of a given blockchain-enabled solution in terms of how many SDGs are expected to benefit from such an intervention. The information generated by the scorecard can also be used to run a quick assessment to check whether or not the gaps in design and implementation were or are being properly addressed. In the second scenario, gathering data using the scorecard can enable the comparison between different blockchain-backed candidate solutions, in terms of their rational, risk category, the existence of proper mechanisms to generate data, track the progress, assess outcomes, manage the change, and their overall ability to deliver tangible and holistic development outcomes.

The proposed SDG Acceleration Scorecard is made-out of acceleration areas, drivers, and a scoring system. To characterize the acceleration effect of a given blockchain-enabled solution, the scorecard provides descriptive sentences for each driver in the acceleration areas, each corresponding to a numerical rating from zero (0) to three (3) based on a 33-point scoring system. In the following paragraphs, we provide practical explanations related to the acceleration areas, the drivers within each area, and how are the scores assigned using descriptive sentences to describe each driver.

A. Acceleration area 1: Use Case Development

When use cases of blockchain-enabled solutions are properly designed by taking into consideration the interlinked nature of the SDGs, they can have a multiplier effect on the

development dividends expected down the road. This in return will boost the ongoing efforts to achieving the SDGs hence the acceleration effect.

- Driver A1: It generates useful information to explain whether or not there is a strong justification for the design choice of a blockchain-backed solution. We propose asking the following or other alternative questions: why would you consider blockchain as a solution to the problem encountered in your case?
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
 - 0--No Response/ Not sure
 - 1--Blockchain is an emerging innovation in international development
 - 2--Blockchain has the potential to solve some development challenges we face today
 - 3--Blockchain is the best alternative to address the specific challenges we are facing
- Driver A2: It generates useful information to explain whether or not a given blockchain-backed solution was compared to other alternatives. We propose asking the following or other alternative questions: did you compare blockchain to other alternative solutions in terms of efficiency, scalability, performance, impact, and cost-effectiveness?
- Scorecard rating: we have assigned a score of 0 to 1 to the responses provided
 - 0—No/ Not sure
 - 1—Yes
- Driver A3: It generates useful information to understand whether or not end-users were involved to test and iterate a given blockchain-backed solution during the design which is crucial to strengthen ownership and for consensus building. We propose asking the following or other alternative questions: How many end-users were/will be approached during the design of your blockchain experiment?

- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
 0 – None/Not sure
 1 – Less than 2
 2 – 2 to 5
 3 – More than 5
- Driver A4: It generates useful information to assess the multiplier effect of a given blockchain-powered solution in terms of its ability to generate wider development co-benefits by contributing to multiple SDGs. We propose asking the following or other alternative questions: How many SDGs do you expect your blockchain project to contribute to?
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
 0 – None/Not sure
 1 – Only 1 SDG
 2 – From 2 to 3 SDGs
 3 – Multiplier effect across more than 3 SDGs

B. Acceleration area 2: Risks & Ethical Considerations

This part of the scorecard can generate risk-related information to reveal whether risks and ethical considerations related to blockchain technology are well understood and to ensure that a given blockchain experiment does not create more problems than the ones it was designed to solve.

- Driver B1: It generates useful information to assess whether or not a risk analysis was undertaken for a given blockchain-powered solution. We propose asking the following or other alternative questions: Have you conducted a risk analysis to identify and assess the core risks associated with your blockchain experiment?

- Scorecard rating: we have assigned a score of 0 to 1 to the responses provided
0—No/ Not sure
1—Yes
- Driver B2: It generates useful information to assess the ability to identify and categorize risks in a structured way to enable a proper risk management response. As a follow-up to the question under B1, we propose asking the following or other alternative questions: what were the risks you have identified?
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
0--None/ Not sure
1--Mostly external risks (High risk)
2--Mostly strategic risks (Moderate risk)
3--Mostly preventable risks (Low risk)
- Driver B3: It generates useful information about whether or not there is a risk management mechanism for a given blockchain-powered solution to mitigate different types of risks. We propose asking the following or other alternative questions: Did you come up with a proper management response to mitigate the risks identified?
- Scorecard rating: we have assigned a score of 0 to 1 to the responses provided
0—No/ Not sure
1—Yes
- Driver B4: It generates useful information whether or not there is a mechanism in place to update risk-logs and detect emerging risks as blockchain-backed solutions are being prototyped and deployed in a rapidly evolving legal, institutional and technological landscape. We propose asking the following or other alternative

questions: Did you set up a mechanism in place to detect and anticipate new emerging risks and address ethical considerations?

- Scorecard rating: we have assigned a score of 0 to 1 to the responses provided
0—No/ Not sure
1—Yes

C. Acceleration area 3: Monitoring & Evaluation

This part of the scorecard can generate M&E-related information to explain how activities will be monitored, how progress will be tracked, and which criteria will be used to evaluate the applicability but also the outcomes of blockchain experiments.

- Driver C1: It generates useful information to assess the extent to which data is being collected for a given blockchain-powered solution. We propose asking the following or other alternative questions: Do you collect any type of data on your blockchain experiment?
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
0 -- There is essentially no data collection
1 -- There is some sort of data collection
2 – Data is collected and analyzed
3 – Data is systematically collected, analyzed and publicly shared to inform peers and decision making
- Driver C2: It generates useful information to assess whether or not an M&E mechanism is in place for a given blockchain-powered solution. We propose asking the following or other alternative questions: Do you have an M&E mechanism in place to ensure proper monitoring of your blockchain experiment?

- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
0 -- There is essentially no mechanism
1 -- There is some sort of mechanism
2 -- There is a relatively good mechanism
3 -- There is a well-functioning mechanism
- Driver C3: It generates useful information to explain the set of criteria used in assessing the applicability of blockchain experiments and evaluate their outcomes. We propose asking the following or other alternative questions: Which of the following criteria would you consider in evaluating your blockchain project? Performance, Scalability, Usability, Security, Cost, Flexibility, Transparency, Legal regulations, Environmental footprint, Social impact, and SDG acceleration.
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
0--None/ Not sure
1--At least 1 criterion
2--At least 3 criteria
3--At least 5 criteria including the one on SDG acceleration

4 Acceleration area 4: Innovation Management

The last part of the scorecard can be used to generate information to better understand the change dynamics in a given development setup and trigger adequate change management responses towards nurturing a culture of innovation and addressing pockets of resistance.

- Driver D1: It generates useful information to assess whether or not there is some sort of awareness about change management. We propose asking the following or other alternative questions: Would you conduct any awareness-raising activities within

your organization or team to visualize the potential of blockchain-enabled applications and co-create promising ones?

- Scorecard rating: we have assigned a score of 0 to 1 to the responses provided
0—No/ Not sure
1—Yes
- Driver D2: It generates useful information to assess the willingness of managers to understand the root causes of resistance to change, and more specifically to blockchain-driven innovations. We propose asking the following or other alternative questions: Are you planning to explore the reasons behind any resistance that blockchain-backed solutions may face within your organization or team?
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
0—No/ Not sure
1--Yes
- Driver D3: It generates useful information to assess whether or not there are proper mechanisms in place to enable an innovation-centered environment. We propose asking the following or other alternative questions: Would you consider motivating your staff, partners, and end-users involved in your blockchain experiment?
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
0—No/ Not sure
1— Yes, by allocating appropriate time and resources for the team members to innovate and prototype promising solutions
2—Yes, by investing in core capabilities and skills to implement blockchain projects through learning and practice
3— Yes, through coaching for readiness to become a change agent

- Driver D4: It generates useful information to assess whether or not there is some sort of policy or strategy to maintain an innovation-prone set up in a given context. We propose asking the following or other alternative questions: Do you have a strategy to maintain an innovation-friendly environment within your organization?
- Scorecard rating: we have assigned a score of 0 to 3 to the responses provided
 - 0—No/ Not sure
 - 1— Yes, by recommending corrective actions for improvement
 - 2— Yes, by measuring achievements
 - 3— Yes, by celebrating successes

We emphasize that the scoring system proposed here is not exclusive and that the scores assigned to each descriptive sentence can be revised and weighted accordingly on a case-by-case basis to better reflect the context within which a blockchain-backed solution is deployed. The scorecard can be used at the beginning of the design phase, but also to generate useful insights as the implementation of blockchain experiments is moving forward, and stay on track towards reaching the established targets. The SDG Acceleration Scorecard is a flexible tool and can be adapted and further improved to reflect the differentiated contexts underpinning blockchain experiments.

We fully recognize the limitations of using an SDG Acceleration Scorecard in the context of blockchain experiments. While it was designed as a low-cost and rapidly deployable tool, it should not be seen as a replacement of academically proven methodologies. The concept of scoring can entail risks of distortions, which leave ample room to improve accuracy by weighting the scores (Staub & Hatziolos, 2004). In this case, we assume that the weights assigned to each question in the SDG Acceleration Scorecard reflect some sort of rational which might not be necessarily the case. We have considered a simple scoring system while recognizing its limitations.

Again, while recognizing the limitation of the proposed acceleration scorecard as a minimum viable product, which should not replace academically tested methodologies, the scorecard can help individuals and organizations to generate useful insights to guide their efforts throughout the journey of co-creating blockchain-powered solutions in the field of international development, and more specifically to meet the 2030 deadline for achieving the SDGs.



Table 2.3: SDG Acceleration Scorecard

Acceleration areas	Drivers	Scorecard	Score
Use Case Development	Why would you consider blockchain as a solution to the problem encountered in your case?	0--No Response/ Not sure 1--Blockchain is an emerging innovation in international development 2--Blockchain has the potential to solve some development challenges we face today 3--Blockchain is the best alternative to address the specific challenges we are facing	
	Did you compare blockchain to other alternative solutions in terms of efficiency, scalability, performance, impact, and cost-effectiveness?	0—No/ Not sure 1--Yes	
	How many end-users were/will be approached during the design of your blockchain experiment?	0 – None/Not sure 1 – Less than 2 2 – 2 to 5 3 – More than 5	
	How many SDGs do you expect your blockchain project to contribute to?	0 – None/Not sure 1 – Only 1 SDG 2 – From 2 to 3 SDGs 3 – Multiplier effect across more than 3 SDGs	
Risks & Ethical Considerations	Have you conducted a risk analysis to identify and assess the core risks associated with your blockchain experiment?	0—No/ Not sure 1--Yes	

	If yes, what were the risks you have identified?	0--None/ Not sure 1--Mostly external risks (High risk) 2--Mostly strategic risks (Moderate risk) 3--Mostly preventable risks (Low risk)	
	Did you come up with a proper management response to mitigate the risks identified?	0—No/ Not sure 1--Yes	
	Did you set up a mechanism in place to detect and anticipate new emerging risks and address ethical considerations?	0—No/ Not sure 1--Yes	
Monitoring & Evaluation	Do you collect any type of data on your blockchain experiment?	0 -- There is essentially no data collection 1 -- There is some sort of data collection 2 – Data is collected and analyzed 3 – Data is systematically collected, analyzed and publicly shared to inform peers and decision making	
	Do you have an M&E mechanism in place to ensure proper monitoring of your blockchain experiment?	0 -- There is essentially no mechanism 1 -- There is some sort of mechanism 2 -- There is a relatively good mechanism 3 -- There is a well-functioning mechanism	
	Which of the following criteria would you consider in evaluating your blockchain project? Performance, Scalability, Usability, Security, Cost, Flexibility, Transparency, Legal regulations, Environmental	0--None/ Not sure 1--At least 1 criterion 2--At least 3 criteria 3--At least 5 criteria including the one on SDG acceleration	

	footprint, Social impact and SDG acceleration		
Innovation Management	Would you conduct any awareness-raising activities within your organization or team to visualize the potential of blockchain-enabled applications and co-create promising ones?	0—No/ Not sure 1--Yes	
	Are you planning to explore the reasons behind any resistance that blockchain-backed solutions may face within your organization or team?	0—No/ Not sure 1--Yes	
	Would you consider motivating your staff, partners, and end-users involved in your blockchain experiment?	0—No/ Not sure 1— Yes, by allocating appropriate time and resources for the team members to innovate and prototype promising solutions 2—Yes, by investing in core capabilities and skills to implement blockchain projects through learning and practice 3— Yes, through coaching for readiness to become a change agent	
	Do you have a strategy to maintain an innovation-friendly environment within your organization?	0—No/ Not sure 1— Yes, by recommending corrective actions for improvement 2— Yes, by measuring achievements 3— Yes, by celebrating successes	

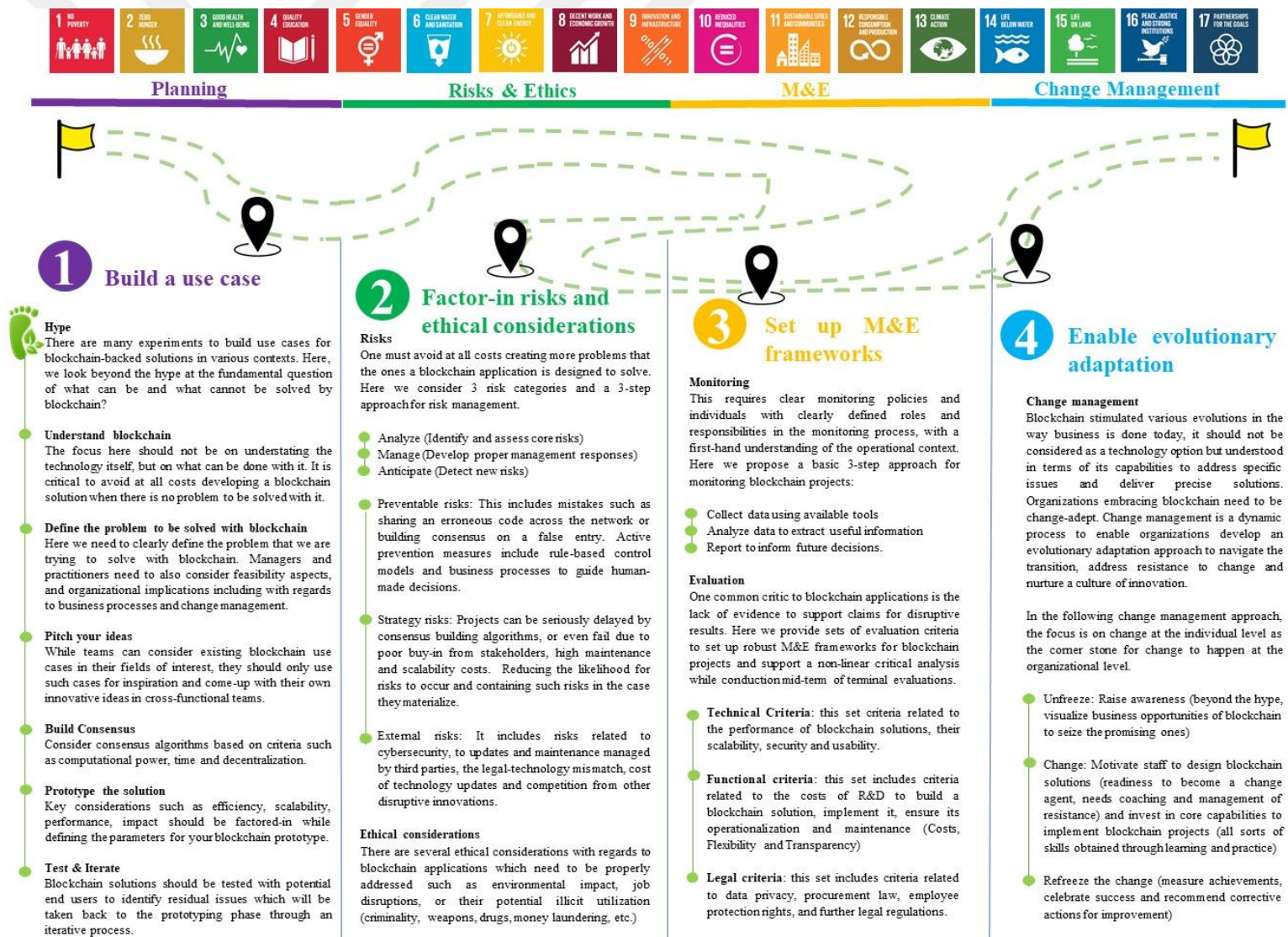
Source: Author

Integrated approach

Intentional design is the recipe to develop promising blockchain applications. Unlike other technologies, it is not simple to fix flows, alter records, or change contracts because of the immutable and distributed nature of data. By intentional design here we mean an integrated approach that goes beyond identifying the problem faced and implementing an intervention to achieve expected outcomes, it is the extra mile of understanding risks, ethical considerations, and technology choices that will usually make the difference.

The living prototype of the integrated approach proposed at this stage was slightly modified following additional inputs from resources persons approached for this research. This is a living tool that can be further improved as blockchain technology is getting mature over the years to come, based on feedback from end-users as they domesticate and internalize the tool in their quest to adopt the technology and run experiments of blockchain-backed solutions in the international development space.

Figure 2.2: Integrated Approach to use Blockchain-enabled solutions as SDG accelerators



Source: Author

Discussion and conclusions

Can blockchain be a game-changer as an SDG accelerator? Or is it a hype that is driven by high expectations for its applications? We argue that the power of blockchain can be effectively harnessed to deliver significant progress towards achieving the SDGs. Nevertheless, we also argue that there are limitations to what can be done, hence the need to nuance that development professionals cannot solve all the issues around the SDGs with blockchain, and that implementation choices to design and implement blockchain-enabled solutions should be rigorously justified to demonstrate a tangible added-value compared to other alternative solutions which might be less costly and less technical.

While we recognize the limitations in developing the Blockchain SDG Acceleration Scorecard and the Integrated Approach to use blockchain enable solutions as SDG accelerators, these are meant to be minimally viable products and serve as living tools making room for further improvements and finetuning as the technology is getting mature and lessons learned from various experiments widely shared across the international development space.

“Don’t over-hype” and don’t over-promise”, remains indeed a key message for individuals and organizations experimenting blockchain-powered solutions in International development. The third chapter of this work provides an overview of blockchain-powered solutions for sustainable development, experimentation zones, and acceleration areas. We believe it offers good food for thought to further stimulate the discussions within the research community but also among innovation and development practitioners working at the frontlines to raise the double challenge of adapting to the new normal post-pandemic and meeting the SDG targets by 2030.

CHAPTER 3

USE CASES OF BLOCKCHAIN ENABLED SOLUTIONS ACROSS THE SDGs

Introduction

In this chapter, we navigate the disruptive waves brought by blockchain-powered solutions to exploring examples of experimental uses cases applicable to each of the 17 Sustainable Development Goals (SDGs). These experimentations zones are also complemented with an overview of specific acceleration areas, to have a closer look on areas where we believe blockchain-backed solutions can have a great impact as we are heading towards the uncharted territories of the post-pandemic era while eyeing the finish line in the race to meeting the SDGs by 2030. We hope that individuals and organizations working on blockchain-based solutions for sustainable development will find these insights and discussions useful to guide their efforts and inform their decisions to harness the disruptive potential of blockchain alone or in tandem with other emerging technologies in the new world of business as unusual.

Experimentation Zones

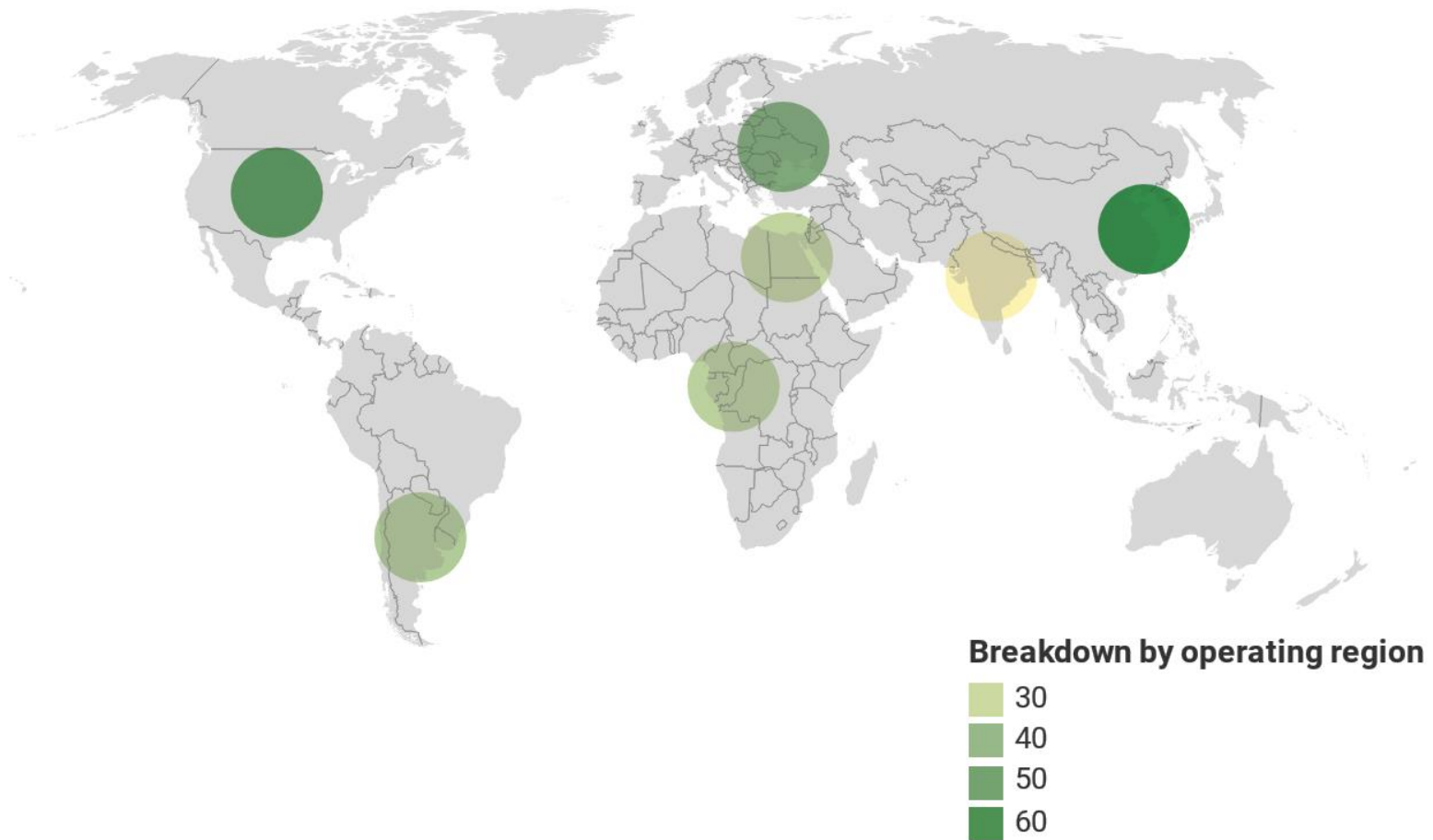
There are multiple experiments, where tests are being conducted to explore the proof of concept to develop blockchain-backed solutions and address some of the most pressing challenges in global development. The fundamental question that comes in mind, is how can distributed ledger technologies be useful to solve a given situation which implies changing the narrative to re-think innovative ways out of the problem. For instance, to address identity-related issues, blockchain solutions were designed to provide digital economic identities (BanQu, 2019) or open identity systems (Uport, 2019). To ensure traceability and equity along supply-chains, blockchain applications are experimented to document the Cocoa's journey from the Amazonian farms in Ecuador to the grocery stores in the UK (AltFinLab, 2019), for tracing tuna fish from catch to

consumers in Indonesia (Provenance, 2016), tracing the authenticity of diamonds (Everledger, 2018), or tracking minerals (Khatri, 2019).

In the field of energy, blockchain solutions are tailored to produce solar energy in Moldova using solar-coins (SolarCoin, 2019), or support the Cedar forest in Lebanon using Cedar-coins (AltFinLab, 2019). In the field of governance, blockchain applications are used in Estonia to run a digitalized e-government system on blockchain to ensure the security of government registers (Sihvart, 2017). In South Korea, blockchain solutions are tested to improve government services such as public safety, welfare, and transportation (Buck, 2017). Another experiment is looking into building peer-to-peer voting platforms to ensure transparency and accuracy (FollowMyVote, 2019). The list goes on and on to include various blockchain applications with relevance to global development such as copyright, social media, retail or real estate.

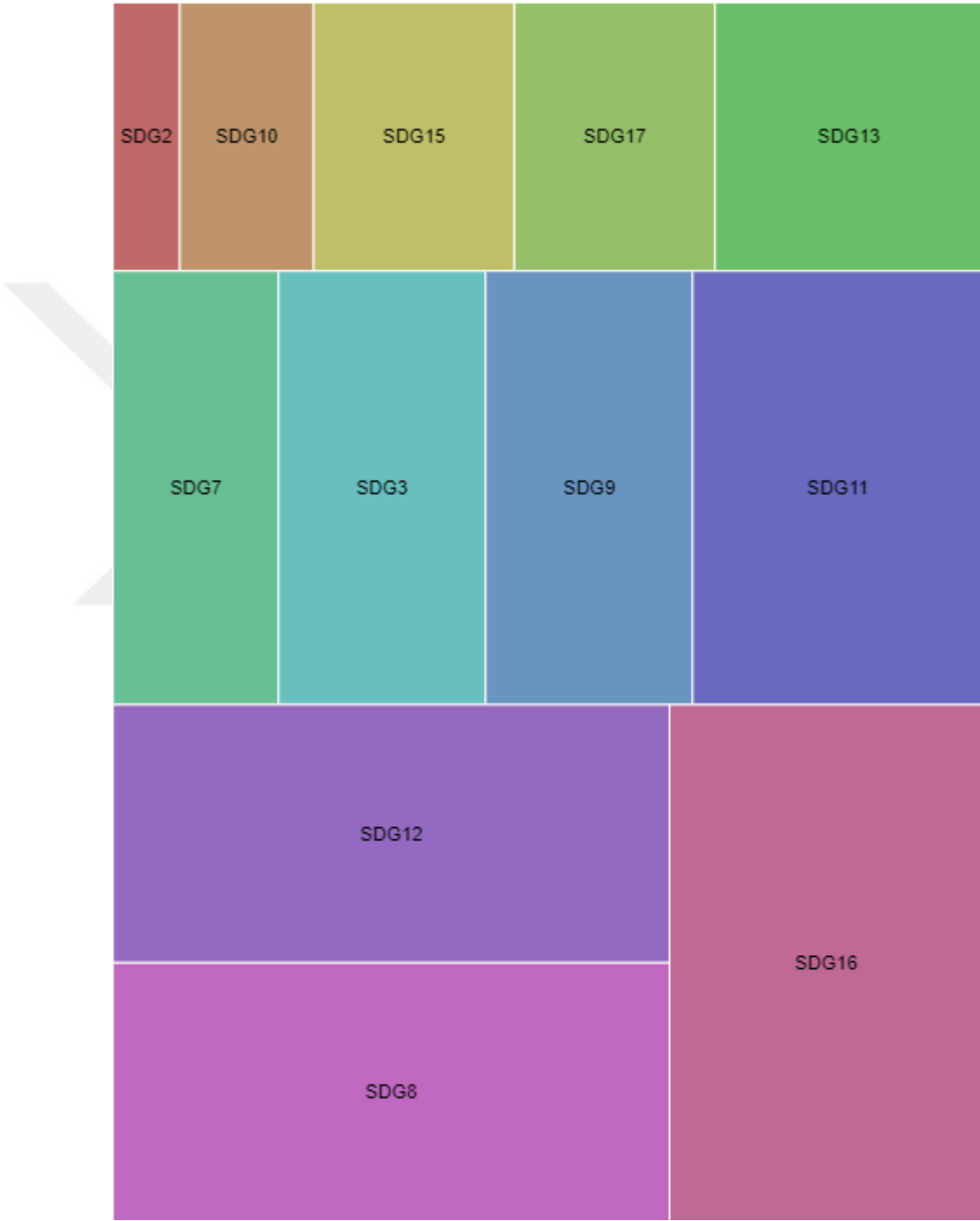
The map in figure 3.1 shows a breakdown by region of the cumulative numbers of the SDGs to which blockchain projects for social impact contribute based on 71 entries listed in the Blockchain Ledger Impact database. This visualization suggests that East Asia and Pacific comes first as the region where blockchain projects contribute to the largest number of SDGs (Goldstein & Tillemann, 2020). It's followed by North America, Europe, and Central Asia, Latin America and the Caribbean, Sub Saharan Africa, the Middle East and South Africa, and South Asia. While the map itself offers much-needed insights into the dynamics of the contribution made by blockchain-enabled solutions to the SDGs, it is only based on a limited number of blockchain projects for social impact (n=71) and naturally falls short of providing the full picture. This shows that blockchain-powered solutions remain largely understudied, which stresses the need for reliable sources of data to study how blockchain projects deliver or not, social impact on the ground (Goldstein & Tillemann, 2020). Such insights are critical learning tools for organizations and individuals alike in an exciting but demanding journey to develop blockchain-backed solutions for social good.

Figure 3.1: Map showing the contribution of blockchain projects to the SDGs per region



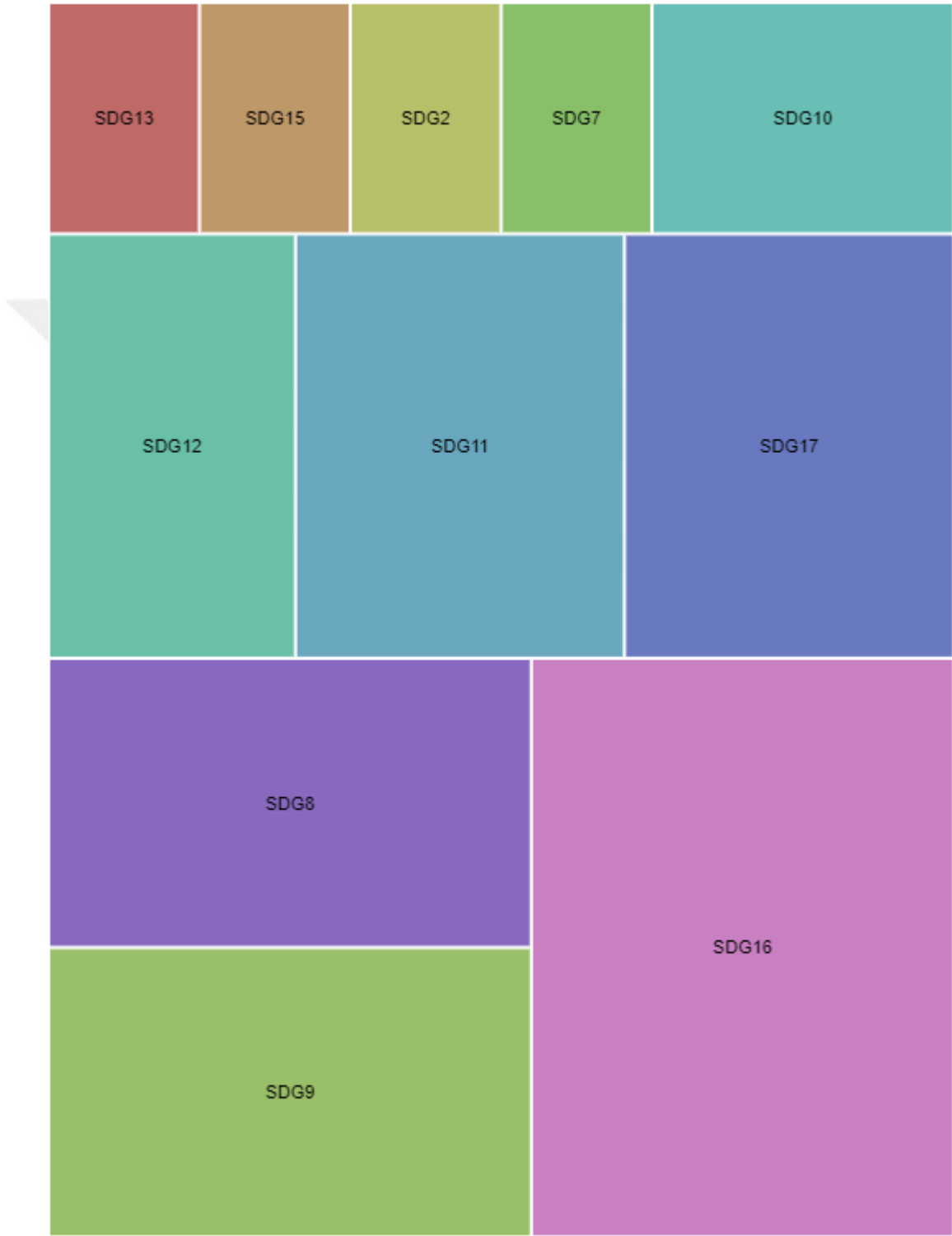
Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

Figure 3.2: Treemap visualizing the contribution of blockchain-enabled applications to the SDGs in North America



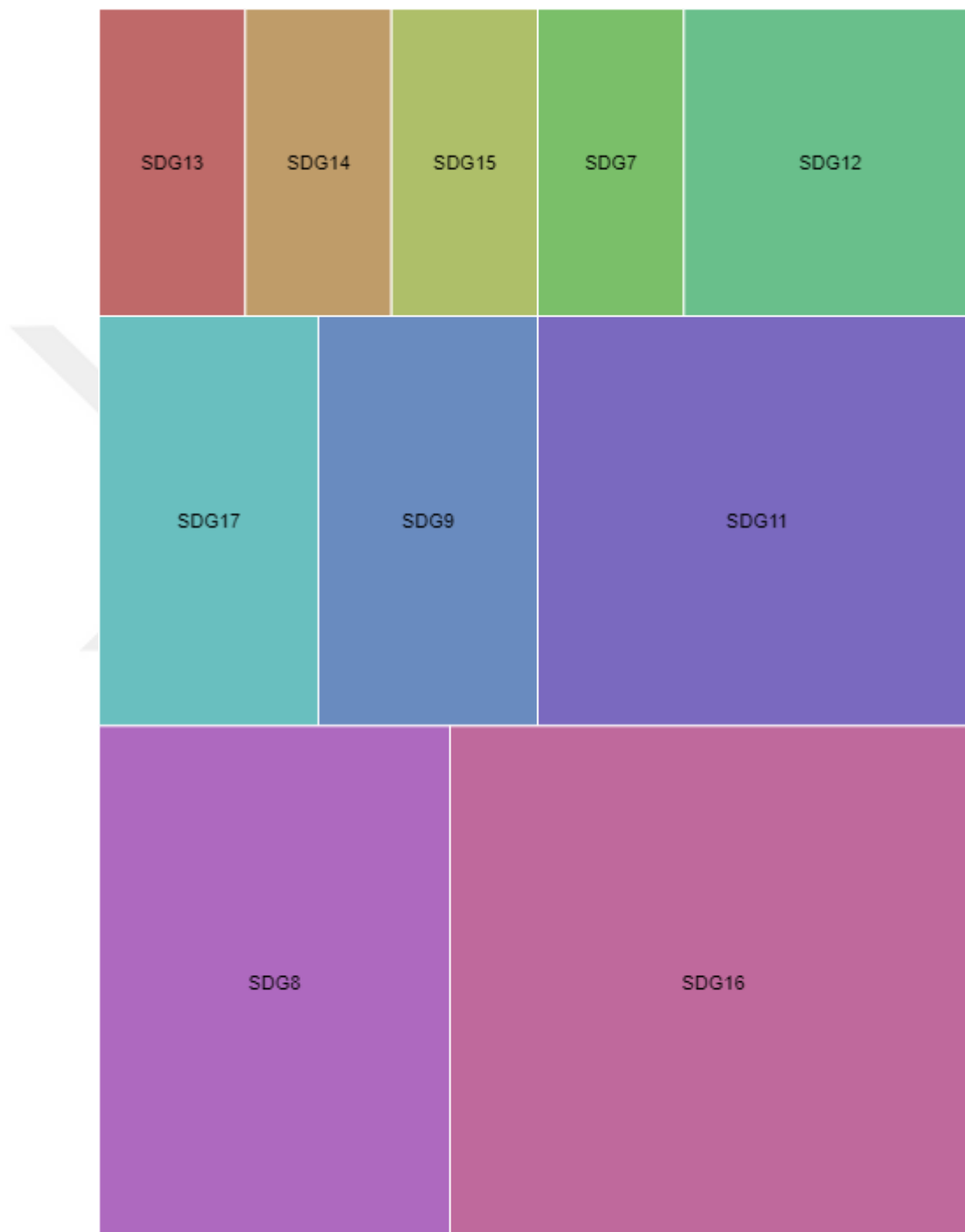
Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

Figure 3.3: Treemap visualizing the contribution of blockchain-enabled applications to the SDGs in Sub Saharan Africa



Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

Figure 3.4: Treemap visualizing the contribution of blockchain-enabled applications to the SDGs in South Asia



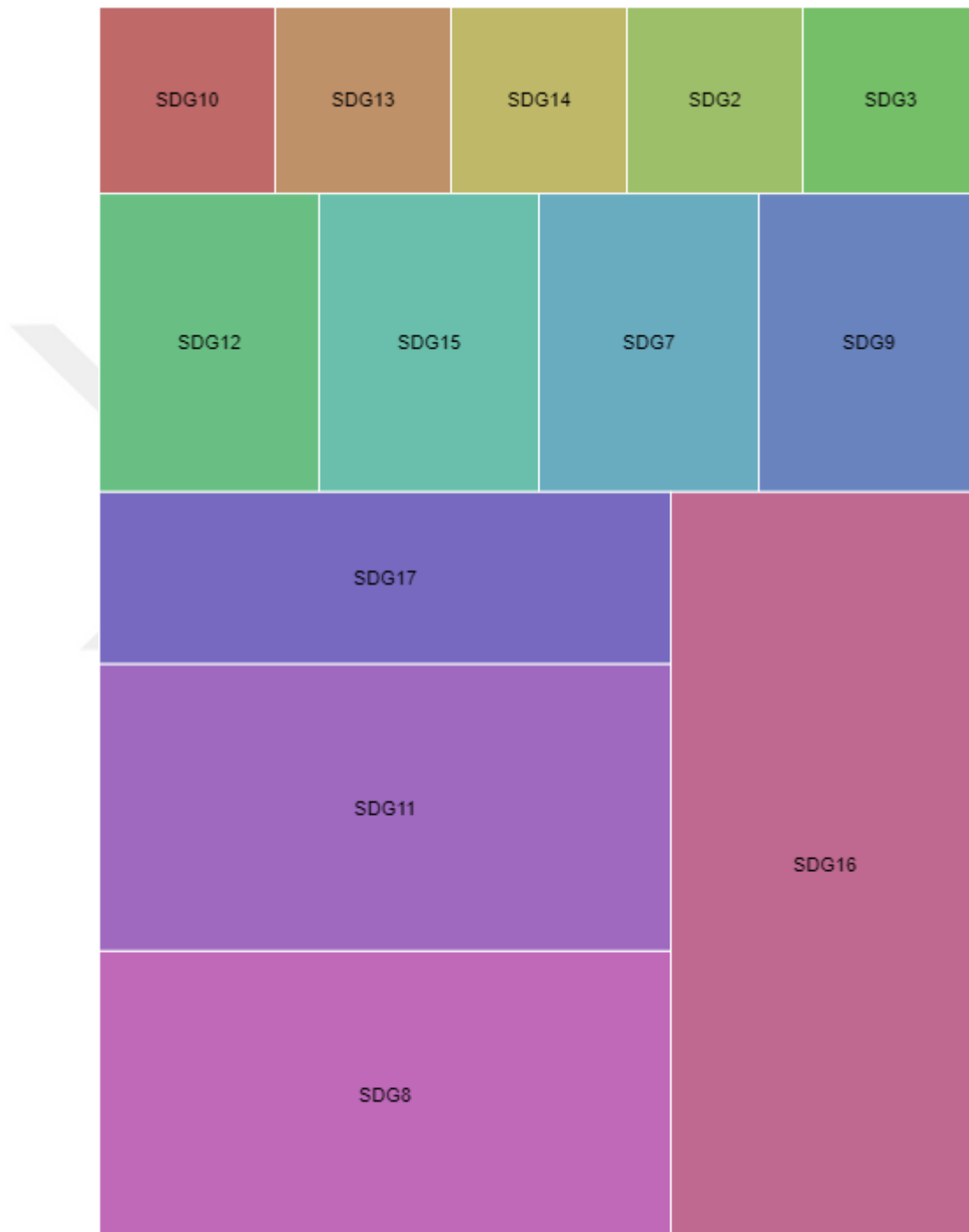
Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

Figure 3.5: Treemap visualizing the contribution of blockchain-enabled applications to the SDGs in the Middle East and North Africa



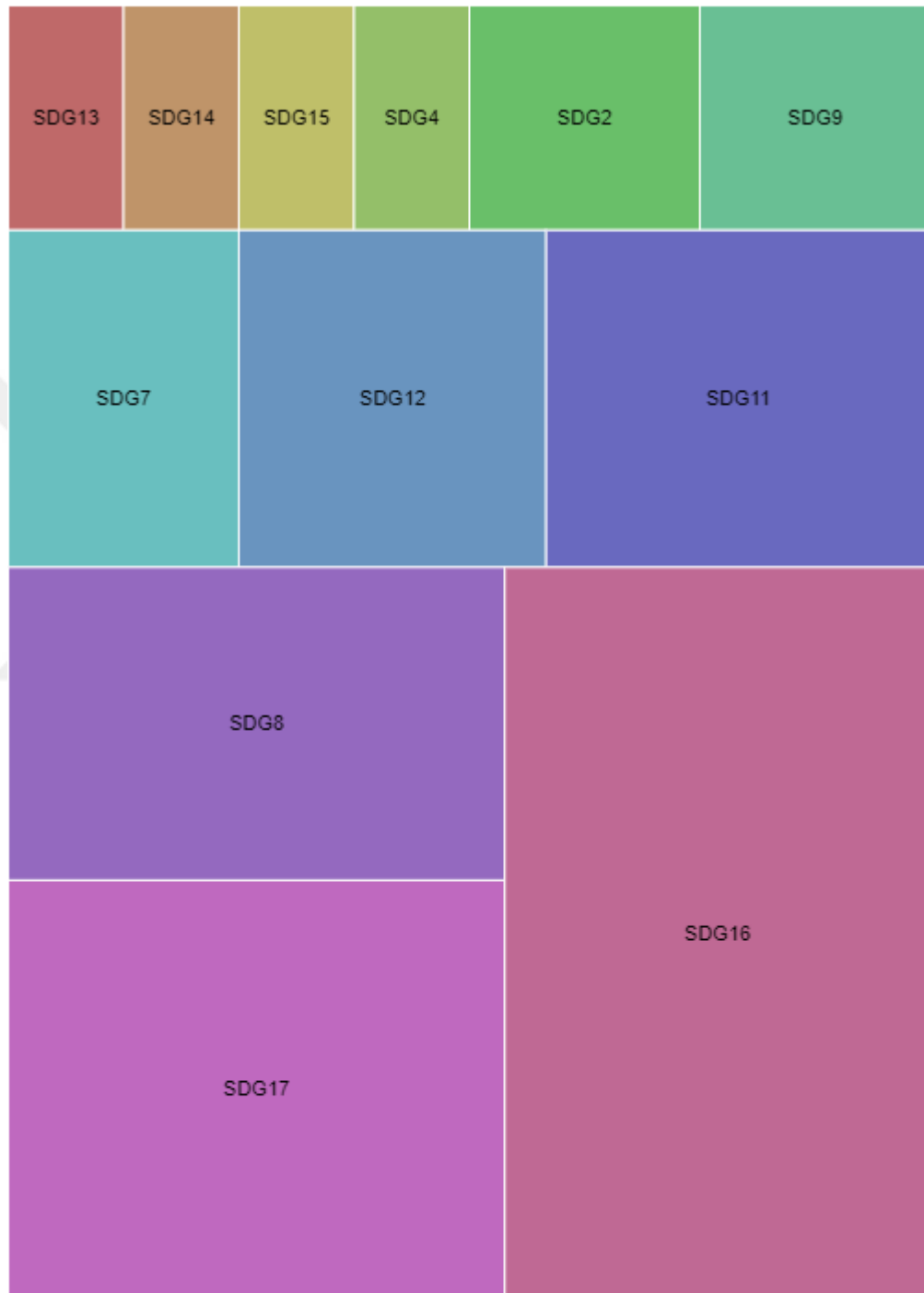
Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

Figure 3.6: Treemap visualizing the contribution of blockchain-enabled applications to the SDGs in Latin America and the Caribbean



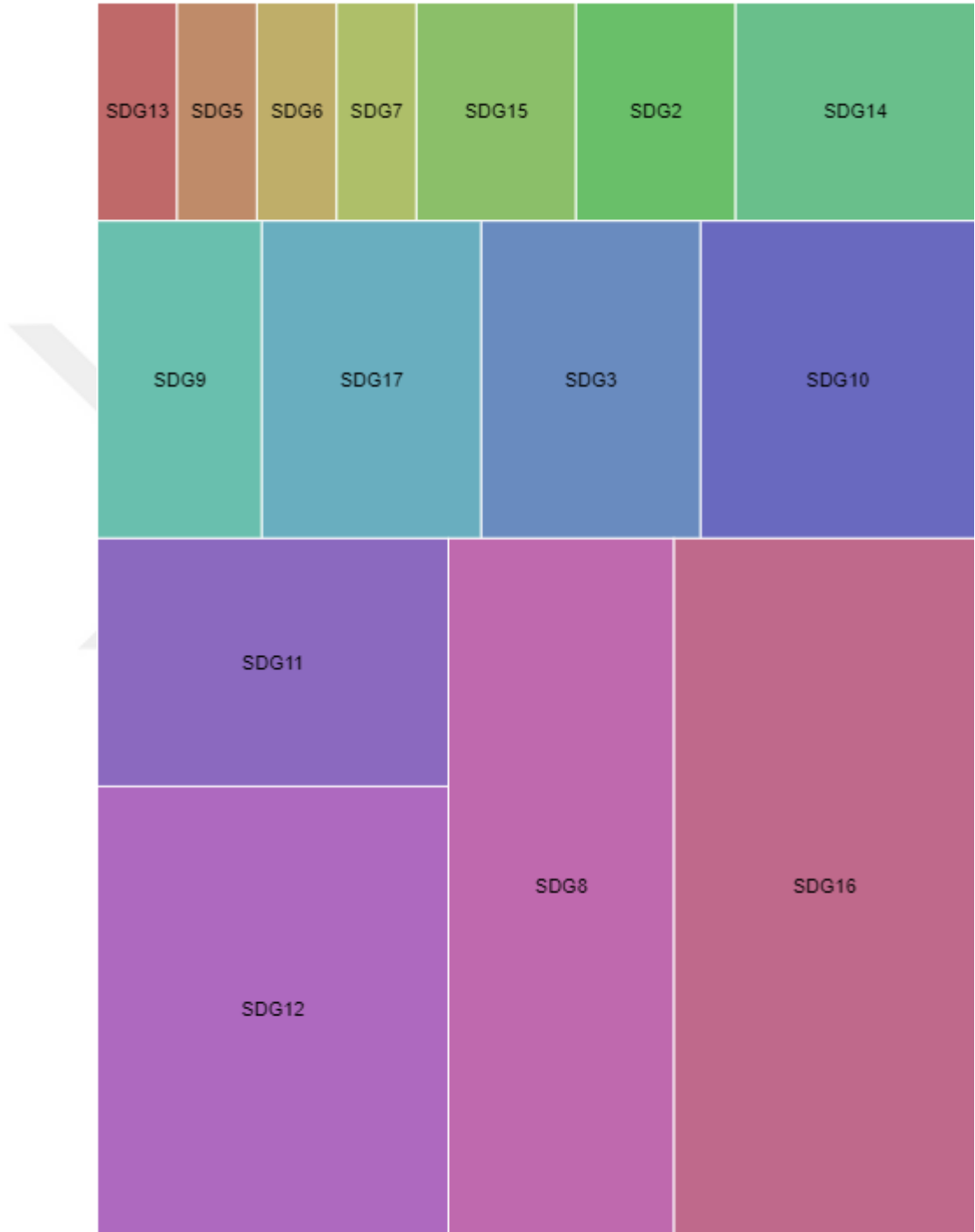
Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

Figure 3.7: Treemap visualizing the contribution of blockchain-enabled applications to the SDGs in Europe and Central Asia



Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

Figure 3.8: Treemap visualizing the contribution of blockchain-enabled applications to the SDGs in East Asia and the Pacific



Source: Created by the author based on data from (Goldstein & Tillemann, 2020)

The above figures show treemap visualizations of the contribution of blockchain-enabled solutions to each one of the 17 SDGs, these findings are based on data related to 71 entries listed in the Blockchain Impact Ledger. For instance, figure 3.3 shows a treemap visualization of the contribution of blockchain-enabled solutions to the SDGs in Sub Saharan Africa. Agora, for example, a blockchain-backed voting ecosystem allows people worldwide to vote online using a digital device while ensuring the security of elections and making it convenient for voters (Agora, 2019). It is reportedly contributing to two SDGs namely SDG 10 on reducing inequality within and among countries and SDG 16 on promoting peaceful and inclusive societies, providing access to justice and building effective, accountable, and inclusive institutions. Such contribution spans across three regions namely East Asia and Pacific, North America, and Sub-Saharan Africa (Goldstein & Tillemann, 2020).

In this work, we choose to classify blockchain experiments into different experimentation zones in line with the 17 SDGs to map-out their potential in solving specific issues by looking into their ability to disrupt the existing business models and share new ways of delivering tangible impact at scale in line with the 2030 sustainable development agenda.

SDG1: End poverty in all its forms everywhere

With regards to eradicating poverty for instance, in 2015 during the transition from the MDGs to the SDGs, there were still about 736 million people surviving on less than USD 1.90 per day with more than 25% of the world's populations living on USD 3.20 and almost 50% living below USD 5.50 daily (World Bank, 2018). In 2017, there were some 1.7 billion adults worldwide with no banking account, however, two-thirds of unbanked adults did have a mobile phone (World Bank Group, 2017). Although wealthier adults are more likely to own a phone and have access to the internet in contrast with their poorer counterparts, financial inclusion can be improved to lift the world's poorest and most vulnerable out of poverty by leveraging the new generation of financial services including

blockchain-based solutions that could be accessed through mobile phones and internet. While it might not be profitable for the traditional banking system to offer services below a certain threshold, by processing micro-transactions via the blockchain the technology can connect smallholders and enable those usually overlooked to engage for instance in micro-trade or micro-lending. The tokenization of assets is disrupting the financial industry by making it more accessible, faster, cheaper, and easier (Laurent, Chollet, Burke, & Seers, 2019).

In the Asia Pacific, the Asian Development Bank engaged Everest, a blockchain-based decentralized platform (Everest, 2020), to enable money transfer operators from Australia, New Zealand, and Samoa process cross border payments through the blockchain (Rheeney, 2019). By installing the Everest platform in the Samoan Central Bank, such a platform will support identify verification through biometrics, e-wallets, and compliance reporting including “Know Your Customer” and “Anti-Money Laundering” (Vilar, 2019). A similar project is taking place in Indonesia to facilitate cross-border remittance transactions along the Indonesia-Europe corridor in partnership with Bank Rakyat Indonesia (Ledger Insights, 2020).

Another example comes from East Africa, where Kenya’s famous and largely imitated mobile money system M-Pesa has reportedly lifted 194.000 households out of poverty, about 2% of the total households in Kenya (Suri & Jack, 2016), despite its siloed nature which limits its impact. This is where blockchain technology can come into play to allow systems like M-Pesa seamlessly to interact with digital wallets, traditional bank accounts, and remittance services (Morris D. Z., 2020). This is the case of Mojaloop, the Swahili word for “One loop” (Mojaloop, 2020), an open-source global platform which can support real-time and interoperable digital payment systems in developing countries to increase financial inclusion (Hunter, 2020), and consequently uplift the world’s poor out of poverty (ModusBox, 2017). The platform enables an ‘internet of payments’ through secure, low-cost, and interoperable payments using different components to bring bank

accounts together with mobile money wallets and merchants in one loop, identify transaction accounts, ensure instant and irrevocable payment as well as protection against fraud (Cable, 2018).

SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Following a steady decline over the last decades, hunger is on the rise with more than 820 million people suffering from hunger in 2019, with Africa being the most hit continent showing the highest prevalence of undernourishment (FAO, 2019). In contrast, about 14% of the food produced globally is lost during production or along the supply chain between harvest and retail (FAO, 2019) and about a third of the food produced for human consumption is lost or wasted, representing an estimated global volume of food wastage of about 1.6 gigatons (FAO, 2013) and putting its economic cost at about \$1 trillion every year (FAO, 2014).

Blockchain-based solutions can disrupt the global food value chain by tackling some of its inefficiencies. One way to optimize the supply-chain and tackle the opacity of the global food industry is by increasing transparency to sustainably mitigate food loss and wastage. Given the interlinked nature of the SDGs, by addressing the supply chain in the food industry it will also contribute to reducing the carbon footprint of agriculture (SDG13), preserve biodiversity and ecosystems by reducing water consumption and soil contamination through the use of fertilizers and other chemicals (SDGs 14 & 15), and control the spread of food-borne diseases (SDG3).

Blockchain can be the platform to apply algorithms to match offer and demand while using valuable insights from behavioral sciences to predict consumption patterns, agriculture data, and remote sensing. This can enable the right amount of fresh harvest to make an optimal journey from the field, through processing to retail, by tracking every

step of the value chain including the production and harvesting techniques, storage protocols, transportation, processing, and distribution. The same thinking can be applied to humanitarian food aid, for instance, to ensure the transparency of cash transfers and enable refugees to purchase food.

AgriLedger, created under 48h in a hackathon then tweaked to become part of the Agtech landscape (AgriLedger, 2017), is a seed-to-customer blockchain-enabled platform offering end-to-end traceability along agricultural value chains (Leveille, 2019) which aims to democratize agricultural data using blockchain (Aspioneer, 2018). A pilot project with the World Bank along the fruits value chain in Haiti, allows buyers to scan a QR code to tell the story of the fresh mango produce by revealing the tree it came from, where it was packaged and how it was transported and the costs incurred at each milestone. The immutable data related to registration, certification, and sale documents are made easily accessible on the web and via smartphone (Leveille, 2019).

In Ethiopia's Limu region, Token, a new consumer brand of coffee or rather a blockchain coffee, is a blockchain-powered solution that aims to connect coffee growers and consumers (Bryman, 2018). While such an application contributes to transparency and traceability, it may also strengthen ownership. Token coffee bags come with a token that is worth 50 cents of a Euro which represents its marketing cost. Coffee consumers can then use the CrypCore platform (KrypC, 2019) to invest their tokens whether by discounting the price of the coffee they bought, by supporting coffee producers or the brand itself. The proof of concept was based on an initial experiment covering 60,000 Kg of coffee produced by smallholder communities, and the tokenization was initially tested with about 100 individuals (FoodIngredientsFirst, 2018).

Again, this shows how the SDGs are interlinked. By paying a more just and equitable price to smallholder farmers, they can afford the cost of production while preserving their social and environmental capitals in the long run.

SDG3: Ensure healthy lives and promote well-being for all at all ages

In the healthcare industry, blockchain use cases range from record management to surveillance systems, streamlining communication, tracking outbreaks, managing crises, tracking medical supply chains, preventing zoonotic diseases, and providing genomic services. Mutual health plans and insurance firms can offer accessible insurance products to low-income groups and expedite payments to participants by eliminating paperwork and easing verification of claims.

Alipay's Xiang Hu Bao, an online blockchain-backed mutual aid platform that complements premium health insurance plans. The online system publicly discloses claims on the blockchain and facilitates the digital authentication of official documents (Ant Financial, 2019). Its coverage includes 100 critical illnesses, there are no premiums to be paid, participants share the cost of claims made and contribute to payouts, and the approved claims may entitle participants to a one-time payout of up to roughly US\$ 44,000 (Ledger Insights, 2019). In Hong Kong, Blue Cross Asia-Pacific Insurance was able to handle over 1000 simultaneous transactions in one second through its blockchain-based platform with no human interaction, by shortening the time spent on paperwork, blockchain can ease the pressure on health care systems (Tran, 2020).

In Estonia, a blockchain-backed solution by Guardtime will enable an audit trail through the lifecycle of patients' records making data virtually impossible to manipulate (Estonia, 2016). Patientory is a platform to store, manage, and transfer private health information including through the execution of smart contracts on the Ethereum blockchain (Patientory, 2020). In the field of genomics, Nebula Genomics provides a blockchain platform to conduct free DNA sequencing in exchange for consent for the data to be used in research (Morris N. , 2018).

During the global pandemic of COVID-19, as the world struggled to cope with a health crisis with far-reaching consequences on the economy and long-lasting impacts on different aspects of human life, different blockchain-based solutions emerged. Panic buying and inflation for instance could be interpreted as signs of poor trust in institutions in charge of keeping people safe. In supply chains, for instance, blockchain was used to trace and confirm the source of products and information to fight counterfeit production and misinformation. It can also play a role in minimizing price inflation by ensuring a transparent cost distribution.

Acoer created the HashLog data visualization engine, a blockchain-enabled dashboard to track and map out vital health information and enable professionals in the healthcare and life science space track and visualize the outbreak (Nasr, 2020). Shanzong launched a blockchain-based platform to ensure the efficiency and transparency of donations, it tracked which donations were made from money to medical equipment, how they were matched, and delivered during the Coronavirus pandemic (Zhang, 2020). Other blockchain-powered solutions during COVID-19 include e-learning platforms (Humayun, 2020) and decentralized learning certificates (Hayward, 2020).

SDG4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

In the areas of education and lifelong learning, blockchain can be used to store records, secure students' identities and credentials, transfer credits, increase the efficiency of existing business-processes, process students' payments and grants, protect and track the use of the intellectual property for educational content. This will reduce costs and fraud by skipping manual verification of degrees and transcripts while increasing efficiencies through automated smart contracts (Cognizant, 2019).

ODEM, a blockchain-powered education platform, offers a decentralized education scheme within which students, educators, and schools operate autonomously while enjoying full control over their educational data and employment records (ODEM, 2020). It provides a secure solution for integrated enrollment, learning management, in addition to blockchain-backed digital learning certificates which can be used to track progress and achievements (ODEM.IO, 2020). Such a blockchain-based solution empowers students to take full ownership of their educational records. Not only can they select courses according to employer demand, but they also will not have to wait for hard diplomas to be delivered to apply for jobs or need to replace originals if they get lost or damaged (Maaghul, 2019).

Digital Academic Credentials, an MIT incubated project (MIT Media Lab, 2016), allowed students to receive tamper-proof and verifiable digital diplomas on their smartphones using the Blockcerts Wallet app on the bitcoin blockchain (Trachy & Durant, 2017). Using the same open-source code in the Asia Pacific, the University of Melbourne issued recipient-owned digital credentials on the blockchain in an attempt to tackle the challenges raised by increasingly itinerant students and workforce (UoM, 2017).

SDG5: Achieve gender equality and empower all women and girls

Gender equality is not just about SDG5, it is central to the achievement of all the SDGs. Empowering women and men will not only contribute to the global economy, lift entire families and rural communities out of poverty but also accelerate national efforts on different frontlines by promoting all sorts of gender-smart, gender-responsive and gender-sensitive interventions in the economy, climate change, biodiversity conservation, education, innovation, and other areas pertaining to the wider spectrum of the Sustainable Development Agenda. Blockchain can disrupt the way financial services are provided to the most vulnerable groups which remain underbanked and largely excluded from the traditional financial markets. More specifically, women in

developing countries are most likely to earn their income from the informal sector and suffer from financial illiteracy, mobility constraints, insufficient collaterals, or even the lack of identification. Blockchain can bridge the gender gap in cross-border payments and empower women and men to fulfill their financial independence.

UN Women is exploring blockchain-enabled solutions to support the humanitarian response targeting women and girls in emergencies such as refugees to secure their identity, medical, and asset ownership records (UN Women, 2018). Among the innovations showcased is SPENN (Blockbonds, 2019), a digital wallet that enables users to interact with each other using their smartphones to receive, save, transfer and spend money (Young & Hammond, 2018). In refugee camps, such solutions can remove the need for women to carry physical cash and empower them to have greater control over their financial resources. In Vietnam, the World Bank is testing a blockchain-backed pilot to support women entrepreneurs prove asset ownership, verify production values, and establish digital identities (Young & Hammond, 2018).

From Norway, a blockchain application called VipiCash was developed not only to securely transfer money and reduce transfer costs but also to enable women in the refugee camps to decide on how it will be spent independently from men in their families. By locking the money for a specific use, for instance, to buy groceries or pay for school fees, a Congo born winner of the Nordic Startup Awards wanted to help refugees in Malawi to avoid frictions between men and women and ensure that remittances are used for what they are intended for (UN Women, 2018). This blockchain solution faced challenges to overcome biases and get access to resource persons who can help grew up the idea (SWB, 2018).

Hiveonline, a company using blockchain-backed solutions to support underserved micro-businesses access credit and markets by creating a trusted history for formal reputation, has launched its community finance platform eARZIKI in Niger, targeting village savings

and loans groups to enable women to grow their businesses through formal reputation and access to finance (Blakstad, 2019). It digitizes money and identities, boosting thus the trustworthiness of micro-entrepreneurs seeking to borrow funds. Activities such as attending meetings and payments made are recorded to prove the borrowers reliable to the lenders and vice versa, meaning that lenders are also rated based on their reliability and how they treat customers (CWI, 2020).

It is true however that the gender divide extends its branches over the digital walls to the crypto space, with the management of crypto-firms being mostly men-dominated and few women trading in crypto-assets. The transformational change will also need to start from within the crypto industry itself. There is a need to invest in the skills sets women and other social groups from all walks of life need to enter the crypto space as coders, developers, data scientists, mentors, or managers. Diversity in Blockchain, an NGO working to empower individuals to equally engage with the blockchain technology, highlighted the lack of inclusion in its State of Diversity and Inclusion in Blockchain report (Tinianow, 2019). The report recommended in its call for action to implement best practices such as training on unconscious biases, measuring and reporting diversity and inclusion, and creating policies of openness and trust (Joseph, 2019). Ironically, while blockchain can foster trust, it also needs to bolster policies of trust, and while it can empower women and men to challenge gender inequalities, it also needs to become gender-responsive.

SDG6: Ensure availability and sustainable management of water and sanitation for all

Blockchain-based schemes can transform the future of water management and trade by recording transactions between parties to boost transparency in times of water scarcity, crises, and mistrust towards governments and corporations. Blockchain platforms can also fund water treatment projects, while waste management systems powered by blockchain can increase efficiency and transparency. The technology can also enable

water trading, smart meters, monitoring of rainfall and water quality in catchment areas, and automated crop insurance during droughts (WEF, 2018)

Bundling blockchain-based solutions with other digital water technologies such as IoT, AI, and big data can bolster smart water management systems using sensors to collect valuable data about water quality, pressure, leaks and pipe bursts and trigger adequate management responses. Such innovations do not only have the potential to optimize the use of water resources, but also nudge rational behavioral changes among consumers. Nevertheless, early movers will have to overcome the high start-up cost, secure the expertise needed, and comply with health standards and regulations.

Waterig, an off-grid network powered by blockchain and IoT aiming to facilitate the exchange of surplus water and food, proposes a water production solution through its installations by capturing atmospheric water, purifying grid water, collecting rainwater and also by treating free water for irrigation purposes. It also harvests renewable energy from solar, eolian, underground, and waste sources which can be fed into water production and processing or used to power nearby vertical food farms. The system broadcasts water and food data on the blockchain to track and monitor water usage and quality (Suen, 2020). This innovation targets participants such as hub micro-owner, water token traders, vertical farms operators, mainly benefiting people with limited mobility to acquire water and food such as the elderly. The pilots can be financed by crypto-tokens from local micro-investors, the token signifies micro-ownership and can be freely traded on a dedicated platform (Suen, 2020).

Civic Ledger, specialized in data-driven solutions for the public sector, was tasked to examine the reluctance of some irrigators to trade water in the Australian water markets. A blockchain-backed solution dubbed Water Ledger was proposed in the feasibility study offering a digital peer-to-peer water entitlement registry and trading platform. While it simplifies and automates water trading, it also improves transparency

related to water prices and volumes while enables non-traders to offer unused water allocations (Civic Ledger, 2020). WaterChain, a blockchain-backed water funding platform, aims to open up investments in clean water projects, investors can buy WaterChain tokens to hold a stake in specific water projects and get dividends. It is also exploring ways to process payments and blend blockchain with IoT to track the usage and quality of water (WaterChain, 2018).

SDG7: Ensure access to affordable, reliable, sustainable and modern energy for all

Giving its complexity the energy sector needs a great deal of intelligence and transparency which provided a fertile ground for new business models to evolve and emerge driven by blockchain technology, including through power trading and financing for renewables (IRENA, 2019). Blockchain can be a true disruptor for the energy industry which remains despite its technology-rich landscape a complex and costly transactional ecosystem (Deloitte, 2018). Its use in the energy market is predicted to reach record high driven by a surge in interconnection and digitalization raising security concerns of grids and networks. Most of the blockchain energy projects are building peer to peer energy markets, with many countries reaching energy parity, individuals producing their energy will be able to trade it with their neighbors and peers.

Other blockchain applications are used to redesign the wholesale electricity distribution by supplementing retailers and allowing users to connect directly to the grid, to securely manage energy data, support commodity trading, share information and data among utility providers, facilitate and track the trade of gas and oil, allow regulators access transparent data for reporting and compliance, reduce and track carbon emission and to reward the adoption of renewable energy.

In Australia, the City of Fremantle is using blockchain-backed solutions to power renewable solar energy systems through the RENeW Nexus project. In its trial the

platform enabled neighbors from about 40 households to trade the excess in rooftop produced solar energy, providing real-time tracking of energy transactions among the participants (Power Ledger, 2020). In Estonia, WePower tokenized national energy production and consumption data in the blockchain. A total of 26.000 hours and 24TWh of energy data was uploaded to a blockchain-backed platform creating 39 billion smart energy Tokens. By linking smart contracts with power grid data, the tokens represent self-settling power purchase contracts of 1KWh which can be traded and liquidated in the local energy wholesale market (Invest In Estonia, 2018).

SDG8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Economic growth and employment can also benefit from disruptive technologies such as Blockchain, which is seen by some as the new infrastructure for building efficient ecosystems to spark innovation across various economic sectors and achieve growth, enable countries to tap into their demographic dividends, create qualified jobs in the crypto sphere and facilitate recruitment processes.

In the Background Check industry, the current business model is relatively slow, involving multiple personnel and does neither guarantee successful screenings nor the security of sensitive data. CVerification, a blockchain-based platform, offers a new way for corporations and recruitment agents to headhunt the most promising candidates through a blockchain-backed and direct exchange of employment records and academic references. The platform also supports the verification of various educational records while providing useful analytical tools to track important insights related to the employment markets (CVerification, 2017).

SDG9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Blockchain applications can spark innovation across a wide spectrum of industries from automotive to banking, health care, insurance, media and entertainment, retail and consumer goods, travel, and transportation to name just a few examples.

In the automotive industry, for instance, cars can become much more than vehicles in the rapidly evolving landscape of smart mobility and evolve into some sort of connected software on wheels. This is the case made by IBM and partners developing a blockchain-based eWallet to handle cashless payments from tolls to electric charging, but also between cars and the use of a vehicle's trunk to securely drop a package (IBM, 2018).

SDG10: Reduce inequality within and among countries

Blockchain can play a vital role as a core enabling technology for the sharing economy which has the potential to rebalance wealth distribution between and within countries based on pre-distribution of productive assets in contrast with wealth re-distribution once inequalities have already occurred (Berggruen, 2018). In other words, the ability of blockchain to transfer wealth over the internet makes a strong case for a contemporary solution to enable a true sharing economy that is secure, efficient, and transparent (Avendano, Pico, & Igunma, 2019).

By issuing Sharia-compliant Sukuk using blockchain, Blossom Finance and partners raised USD 50,000 using a profit-sharing structure and carrying a one-year maturity to expand financing to local entrepreneurs. Its impact investing platform is financing social impact projects using Ethereum smart contracts while ensuring an audit trail on transactions carried on at every step of the process (Blossom, 2019). Consumers can be also empowered to trace back the origin of their food supply. Food Trust is a blockchain platform that connects consumers with smallholder coffee farmers to trace coffee throughout the supply chain from the moment beans are picked (IBM, 2020). To tackle

a changing climate and boost the resilience of rice farmers in Sri Lanka, Oxfam and partners are developing a blockchain-enabled micro-insurance platform to lower costs and enable rice farmers to access affordable insurance options (Aon, 2018).

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

The next-generation infrastructure for smart cities can be built on blockchain layers to come up with disruptive solutions to tackle pressing issues such as waste management, protection of personal data, strategic urban planning, green energy, public participation, low carbon transportation, water management, health systems, traffic management and the security of IoT devices.

In Malta, the Government is developing a platform for transport and logistics to proactively predict growth, balance routes, and systems, and optimize services based on passenger' behavior by using blockchain-backed data flows such as GPS systems, and journey tracking (Omniitude, 2018). In Estonia, the Government created the concept of e-residency, invested in digital IDs and cybersecurity, and established data embassies abroad with blockchain-backed State registries including healthcare, property, succession, and business in addition to the digital court system and the state Gazette (PWC, 2019).

SDG12: Ensure sustainable consumption and production patterns

The current business model according to which goods and services are produced and consumed is facing unprecedented scrutiny driven by an increasingly aware consumer base, the pressure on planetary boundaries and the devastating consequences of over-production and over-consumption on natural equilibriums whether it is about climate change, loss of biodiversity and ecosystem services, besides damaging other assets of natural capital. A supply chain for a given commodity, for instance, may involve a dozen

middlemen and brokers between the smallholders and the consumers while adding no significant value to the products or services supplied. Not only the consumers will end up having no information if the price they are paying is fair, but the smallholders will be missing all the value addition downstream of the supply chain. This is indeed one of the scenarios where blockchain-based solutions can come into play. In fact, by recording data and keeping it safe in a decentralized manner, it can increase transparency, renew confidence, and restore trust within peer-to-peer transactions (University of Canterbury, 2019).

A growing body of research conducted on sustainable production and consumption points towards the need to increase efficiency at the production stage while reconsidering consumption patterns. This entails considering technological improvements, generating reliable data for consumers to make informed decisions, which can influence consumption, distribution and pave the way for institutional changes (Bengtsson, Alfredsson, Cohen, Lorek, & Schroeder, 2018).

Swachhcoin, is a blockchain-based platform working to reinvent waste management through an integrated ecosystem of blockchain, Big Data, IoT, and AI. By using smart bins capable of recognizing and recording the type of waste the latter is turned into 20 different types of useful products such as electricity, precious metals, and timber (Gopalakrishnan & Radhakrishnan, 2019).

SDG 13: Take urgent action to combat climate change and its impacts

To solve a disruptive climate crisis, one should consider disruptive solutions. In the climate change arena, numerous blockchain use cases are emerging to give an impetus to the much-needed climate action. The technology can be used to improve carbon emission trading, enable peer-to-peer renewable energy trading platforms, facilitate all sorts of financial transactions, and most importantly provide more transparency in the

reporting of GHG emissions and the progress made in implementing the NDCs (UNFCCC, 2017). However, to truly unleash the potential of blockchain for climate action, more research is needed to design meaningful approaches according to which blockchain-enabled solutions can become part of the climate action landscape, experimentations at the crossroads of blockchain and climate change are expected to shed some light on good practices and lessons learned. The most promising use cases for blockchain in climate action were reported to be those related to registries and tracking, MRV systems, and access to clean energy and finance (CLI, 2019).

A blockchain-backed carbon trading platform created by IBM and Energy Blockchain Labs allows high carbon emitters to buy carbon credits from low emitters to comply with the applicable Government quotas (IBM, 2018). CarbonX, a peer-to-peer voluntary personal trading platform, operates by sourcing carbon credits and recasting offsets as tokens on the Ethereum blockchain, which are then distributed through a loyalty rewards program to offset the carbon footprint of products and services and allow its customers achieve carbon neutrality in their consumption behaviors (CarbonX, 2018). ClimateTrade, another blockchain-enabled platform is offering services from acquiring carbon credits to offset emissions, impact investing, and blended finance by allowing customers to invest in equity and generate revenues by funding climate change mitigation and adaptation projects (ClimateTrade, 2020).

Carbon market applications of the blockchain technology offer advantages ranging from high speed to immutable audit trails, lower transaction, and management costs and the traceability of emissions reduction (UNEP DTU, 2019). In a comparative study of 4 blockchain platforms, Ethereum blockchain stood out as the best benchmark for climate policy instruments which was attributed to its architecture and key features such as self-made cryptocurrencies, limited operational costs, flexibility for programming and ease of use (Braden, 2019).

SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

For the ocean's conservation and the sustainable use of our marine resources, it is necessary to ensure full traceability of the seafood supply chain by tracking the resource from ship to supermarket. This can be facilitated through the use of promising technologies such as radio frequency identification tags, DNA barcoding, or blockchain (WEF, 2017). By enabling transparency and traceability along the seafood supply chain, blockchain-backed platforms can empower markets and consumers to reward sustainable producers while flagging unethical practices (Cook, 2018). In the maritime shipping and logistics industry, disruptive solutions are pursued by maritime transport operators to reduce costs and ensure efficiencies (OECD, 2019). While global ocean governance instruments such as the UN Convention on the Law of the Sea (UNCLOS) are vital for the sustainable management of oceans and marine resources, they fall short in terms of policing and reinforcing the regulations they entail. Disruptive technologies can be the key to transparency and traceability (Scruggs, 2018).

Fishcoin, a blockchain-enabled data ecosystem approach to transform the seafood industry, offers an incentive for seafood harvesters to capture and communicate data in exchange for rewards such as top-ups for mobile data plans. As a consequence, the economic burden of data collection is shifted downstream to the supply chain by using tokens while ensuring traceability and transparency (Chase, 2018). WWF and partners initiated a blockchain-based project to tell the story of Fijian tuna fish. By assigning QR codes or sensor devices to assets, consumers can view the journey of the product they are buying using a smartphone application, and get to know the actors behind it from the fishermen to the plate (Cook, 2018). To trace Indonesian skipjack and yellowfin tuna from vessel to factory, fishermen send text messages to register the catch which results in an asset being issued on a blockchain and transferred as the fish moves along the supply chain (Leber, 2018).

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

How do we confirm corporate claims that a company's impact on the environment does not threaten ecosystem services? How can citizens verify if their Governments respect their entitlements to live in healthy environments? How can countries providing genetic resources track the utilization of their resources after they leave their countries of origin to claim a fair and equitable share of benefits arising from their utilization as per the Nagoya Protocol? The key feature to foster environmental sustainability relies on the ability of the blockchain technology to guarantee immutable and verifiable records of how biodiversity, natural resources, and ecosystem services were managed as a reliable alternative in the absence of trust and poor confidence in the existing environmental governance schemes.

The Earth Bank of Codes, a digital platform to map out the genetic sequences of biological diversity in key terrestrial and maritime biomes, works on registering assets on blockchain recording the origin of the resource as well as the rights and obligations associated with its utilization. Once the value is created through products and services derived from bio-inspired innovations, benefits can be shared via smart contracts with the resource providers which will contribute to the conservation and the sustainable use of biodiversity (Earth Bank of Codes, 2018). To fight deforestation in the Amazon, GainForest empowers donors and caretakers to protect the rainforest through smart contracts. The way it works is that volunteer caretakers commit to ensuring that a forest patch is protected from deforestation and stake a voluntary amount which they can claim back in addition to a reward after the conservation period is over (Murtaza, 2019).

SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

It comes as no surprise to see blockchain-enabled applications primarily deployed to address governance matters and to tackle issues of transparency, fraud, and other unethical behaviors within a wide array of sectors within society. These are the very foundations to ensure peaceful and inclusive societies, accountability, and justice. Giving the secure and immutable nature of the blockchain technology, SDG 16 topped the list of the SDGs addressed by blockchain projects based on 71 entries listed in the Blockchain Impact Ledger (Goldstein & Tillemann, 2020).

Civil, a blockchain-backed network for journalists, news organizations, and investors, offers a combination of tokens and voting rights to its shareholders. Participants hold a blockchain-based token to govern the network, they can vote and propose rules. The platform also features a micropayment enabling journalists to receive donations from readers in the form of tokens which forms a substantial part of their salaries and makes reporters also shareholders of Civil (Ivancsics, 2019). Blockchain use cases in journalism can be targeted solutions to store data or hybrids introducing cryptocurrency which may disrupt the way newsrooms and reports work (Ivancsics, 2019). Some argue however that blockchain will not save journalism and that the hype around the technology is driving incomprehensible applications (Jonah, 2018).

SDG 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development

One key issue to achieve the Sustainable Development Goals (SDGs) is indeed financing for development which remains way below expectations especially in developing countries. While public finance and Official Development Assistance will not be enough to fill in the financing gap, achieving the SDGs cannot be done without securing business financial flows.

Blockchain backed solutions can improve the financial infrastructure for international development and humanitarian aid. Trócaire Ireland, a development agency, simultaneously transferred €10,000, via Trócaire Rwanda, to Caritas Rwanda using the Disberse platform, and €10,000 via their regular banking channel. The transfer via Disberse incurred no additional charges; the parallel transfer through the banking system incurred at least one additional charge of EUR35. In this pilot, Disberse did not charge transaction fees, but a small fee will be considered in the future. There was clear tracking of the Disberse financial transfers. The transactions were transparent and accountable to each stakeholder in the transaction chain. Transactions were timestamped and created a viewable trail. There were challenges in comparing time savings measured by the number of working days it took funds to move from Trócaire Ireland to Caritas Rwanda, the banking system took 6 days, while Disberse took 5 days (Start Network, 2018).

Acceleration Areas

Here we discuss specific acceleration areas for the SDGs worldwide which complement the 360 degrees overview provided in the experimentation zones. The spotlight here is made on areas where we believe blockchain-backed solutions can have a great impact on the SDGs as we are heading towards the new normal in the post-COVID-19 pandemic.

Humanitarian Aid

Aid agencies work with millions of people caught in crisis all over the world. While vulnerabilities are increasing, funding volumes are shrinking. In 2017, about 201 million people located in 134 countries needed international humanitarian assistance (DI, 2018). In 2019, with an expected increase in the average length of humanitarian crises, some US\$21.9 billion are needed (OCHA, 2018). This translates into slow responses in crises and a weak coverage of the existing needs, hence the necessity to re-invent a way out of the funding gap (WEF, 2019). Anticipatory financing, market-based funding, aid effectiveness, but also blockchain applications could be among the solutions.

We assume that we can provide better aid by enhancing the effectiveness and efficiency of the financial flows channeled through humanitarian systems. A proof of concept was tested using a dedicated blockchain platform, by enabling a cross-border transfer of funds from the Netherlands to Albania, the sender was able to trace the financial flow using an immutable record of transactions. Transferring an amount as little as €5000 was reported to generate a cost saving of 1.15% in addition to making the funds traceable and ensuring the immutability of record transactions (James, 2018). The margin for savings is expected to be larger in a situation of crisis when greater funds are channeled through humanitarian systems. Users' highlighted the ease of use and applicability of the blockchain solution to humanitarian aid. A previous test using the same platform enabled a charity to save 2.5% on transfer costs (James, 2018).

In 2018, the World Food Program distributed cash transfers of \$1.6 billion to refugees (WFP, 2019). To speed up aid delivery in the wake of crises, enhance accountability, and reduce third party fees, a proof of concept was initiated in Pakistan enabling direct, secure, and fast transactions with no intermediaries involved. This solution was adopted later in refugee camps in Jordan, where some 100,000 people can buy groceries by scanning their iris. The solution was built using permissioned blockchain enhancing also security and data privacy (WFP, 2019).

Remittances

We can argue that remittance transfer from migrants to their countries of origin is one of the strongest linkages between migration and development. In terms of market size, the volume of remittances significantly surpasses flows of Official Development Assistance (ODA), and in most countries except China, exceeds Direct Foreign Investments. Annual remittance flows to low and middle-income countries are predicted to grow up to \$550 billion in 2019 compared to \$529 billion in 2018 (World Bank, 2019). These "dollars wrapped with love" (Schiller, 2017) are vital for developing countries to

alleviate poverty, create economic opportunities, and overall support the realization of the SDGs. Nevertheless, various fees applied to migrant remittance by banks and money transfer operators implies that a significant share of this vital source of development financing is often lost in transaction fees and unforeseen charges. This seems to be mainly driven by various processing fees and currency conversion rates applied by third parties and intermediaries involved in cross-border financial transactions (World Bank, 2006). Moreover, the cost of setting and maintaining networks of money transfer operators also seem to be passed on to their customers. The average cost for sending remittances globally is roughly 7%, this figure climbs to 9.3% for money transfers to sub-Saharan Africa (World Bank, 2019). This is a lost opportunity in terms of the development potential of the remittance share that disappears along the value chain of money transfer transactions to developing countries. Hence the recent wave of initiatives using distributed ledger technologies to provide migrants with alternatives that are low-cost, more transparent, and timely.

Blockchain applications to remittances sent by migrants can thus contribute to mobilizing additional financial resources for developing countries (SDG17), reduce the transaction costs to less than 3% of migrant remittances, and eliminate corridors with costs higher than 5% (SDG10), and empower women (SDG5). It will also fulfill the Global Compact on Migration (objective 20) as an innovative technological solution that is low-cost, fast, and more secure. It can be also gender-responsive to benefit all the social groups who receive remittances including women, men youth, elderly, underserved populations in rural areas, minorities, persons with disabilities, and other vulnerable social groups.

In Serbia, a pilot project was launched in 2018 aiming to set up a quicker and safer remittance transfer mechanism where any Diaspora sender from abroad can send money with a lower commission to a recipient in the city of Nis. Complex legal and regulatory systems, timeframe expectations from multiple stakeholders, the lack of first-hand data and assumptions that usability and costs are the main influencing factors

driving user behaviors, were some of the challenges faced to develop the blockchain application. In practice, diaspora members can log-in to a secure blockchain platform, and transfer funds in \$100 or €100 (UNDP, 2018). Recipients get a QR code on mobile or via email, the codes can be used by electronic readout to purchase goods in selected grocery stores or pay for public utility bills, the commission is reduced from up to 10% to up to 3% (UNDP, 2018). This solution is seen as replicable giving its underlying technology, its success could be conditioned by securing the buy-in from decision-makers and funding outside of revenue-generation, the growth rate in terms of active users will be measured periodically to assess its impact (OPSI, 2019).

Crowdfunding

Put into simple words, crowdfunding is about raising small amounts of money or investments from a large number of people (Aitken, 2019), that we can call “crowd-investors”. We argue that such an innovative financing mechanism could help secure additional funding by enabling a larger base of “backers” to contribute to the SDGs.

Traditional crowdfunding platforms like venture capital funds can influence, based on pre-defined sets of criteria, which projects are worthy of the “crowds” support (Wade, 2018). Furthermore, the rate of successfully funded projects on Kickstarter, a US-based crowdfunding platform that received more than 4.7 billion in pledges since its creation in 2009 (Kickstarter, 2020), was about 37% (Szmigiera, 2019). One way to improve such figures would be by harnessing the disruptive effect of blockchain.

Currently, no specific regulations are governing Initial Coin Offerings or ICOs (Legalink, 2019). Moreover, similar to traditional crowdfunding platforms ICOs are not immune to scams and frauds (Aitken, 2019). Nevertheless, the crypto-sphere is continuously evolving with the emergence of counter-party platforms or crypto-exchanges (Wade, 2018). This can strengthen confidence among crowd-investors and allow legitimate projects into the market. Initial Exchange Offerings (IEOs) unlike ICOs are administered

by a crypto-exchange and not the startup issuing tokens to raise funding. The start-up pays a listing fee and a percentage of the token sold to the crypto exchange (Wade, 2018).

Impact Investing

In their quest to achieving the SDGs, governments and development partners are continuously exploring new ways of attracting responsible business investments that are capable of generating a wide range of development co-benefits. One promising way of doing so is by scaling-up impact investing using blockchain. When properly used, blockchain-powered platforms can enable impact investing ventures to enhance trust, transparency, and accountability while lowering costs and broadening the participation base for impact capital investors through effective disintermediation and decentralization (Heuberger & Puhl, 2018).

Impact tokens have the potential not only to accelerate financial flows for impact investments but also to capture multiple values. Tokens can be used to attribute impact and derive financial value from it, as quantified units of impacts for one or several SDGs, and to bolster trust and transparency (Heuberger & Puhl, 2018). Nevertheless, the technology is not mature yet and it might be too early for impact investing communities to use impact tokens at the scale needed to unlock critical financing for the SDGs.

Startups' Financing

Considering their economic footprint as an engine of growth and their social impact in developing countries, startups can boost developing economies and accelerate the achievement of the SDGs. Blockchain technology can be a game-changer in terms of how startups access funding and operate business processes and transactions (De Meijer, 2016). Blockchain-backed startup financing can be a form of democratization of capital for startup companies, by allowing the participation of the “crowds” into what used to be an inaccessible niche reserved for business angels and venture capitalists (Syndicate

Room, 2015). Blockchain-powered peer-to-peer platforms can enable startups to raise equity funding, while other blockchain applications can reduce excessive overheads such as commissions and brokerage fees and simplify trade financing by connecting all the stakeholders involved. Similarly, accurate and immutable information supplied by blockchain platforms can result in faster transactions along supply chains, improving cashflows, and easing access to loans and invoice financing (De Meijer, 2016).

In developing countries, there is a need for catalytic financing to experiment new use cases for blockchain in traditional economic sectors, and layout the missing foundations for integrated blockchain ecosystems to catalyze the matchmaking of non-tech startups with technology providers providing thus the necessary infrastructure to design and deploy blockchain-based solutions at scale (De Meijer, 2016). This is an opportunity for public aid and impact investors not only to catalyze economic growth but also to channel its impact to accelerate the Sustainable Development Goals.

Islamic Finance

The digital wave of disruption is having a far-reaching scope with many blockchain applications currently testing the waters of Islamic finance. With its assets reaching \$2.5 trillion in 2018, a 3% increase compared to 2017 (ICD, 2019), the Islamic finance industry is being shaped by Financial-technology or Fintech. Scholars and regulators alike are exploring the potential of crypto-assets and blockchain-powered digital platforms. Giving its multiple applications designed for Islamic social finance, blockchain has the potential to lay out the foundations for a booming industry while accelerating the achievement of the SDGs (ICD, 2019).

Blockchain can be harnessed in Islamic finance in different ways such as smart contracts which can be used for managing profit-sharing agreements and partnerships, the verification of Islamic financial transactions for banks and customers to avoid conflicts and increase transparency, and the integration with mobile technology in countries lacking banking infrastructure (OConnell, 2019). While Islamic fintech faces the challenge

of blockchain-related “sharia” compliance, Islamic financial institutions can increase efficiency, transparency, and customer satisfaction by adopting fintech (Rabbani, Khan, & Thalassinou, 2020).

For instance, the Zakat ecosystem is facing several challenges that are related to reporting, transparency, and traceability. From Zakat (Blossom, 2018), to charitable donations (KryptoPal, 2018), halal certification (Mirchandani, 2018), and Sukuk transactions in the financial markets (Al Hilal Bank, 2018), the winds of blockchain-based technological innovation are blowing and driving substantial change in the Islamic finance industry, in particular with millennials (ICD, 2019). The snowball is getting bigger and bigger.

The Practitioners at the frontlines

To better understand how multilateral development actors are embracing innovative solutions for international development, several development professionals at the frontiers of innovation for development were approached to gather valuable insights for this work. Unfortunately, access to information and data related to blockchain experiments in the development space remains a key obstacle that confirms the difficulties encountered in similar investigations.

In a call interview with Marc LePage from the Asian Development Bank, he explained that innovation practitioners are aware of the blockchain hype and are getting beyond advocacy to experiment relevant use cases. By running various experiments, innovation practitioners can move beyond the hype to confirm whether or not a blockchain-enabled application is superior compared to other technologies and alternatives to design effective use cases. ADB’s Digital Sandboxes are specific tracks of experimentation focusing on four major emerging technologies namely AI, robotics, and big data in addition to a blockchain space where many applications are being experimented (ADB, 2018).

Several initiatives are being implemented from blockchain-backed management of land records in Fiji (Roño, 2018), to blockchain-based trade finance transactions in the Asia Pacific (ADB, 2019), and a blockchain-operated single window for trade in the Maldives (ADB, 2020). Other interventions are being explored in the areas of scripless bonds (Supadulya, Tansanguan, Sethaput, Wattanasiriwiroj, & Areechitranusorn, 2019) and central bank digital currency initiatives towards cashless societies (Shirai, 2019). While AI took the lead in terms of its use cases and applications in the immediate response to COVID-19, and with ICT's posed to be at the core of a new normal defined by an increased digitalization, other emerging technologies including blockchain are also expected to play an important role in rethinking the new normal for instance through data-enabled health care and insurance schemes.

Discussion and conclusions

Blockchain can be visualized as this cryptographic book of truth upon which robust foundations of trust can be built. Coping with relentless technological advances is not an easy task, riding the wave of disruptive innovations such as the blockchain technology can be illustrated with climbing a mudslide raging down the mountain. More research is required to assess the true extent to which development workers are able or not to transform the promising potential of blockchain-backed solutions into tangible development results beyond the hype.

With blockchain experiments demonstrating disruptive solutions, the surge in recent years looking into an increasingly diversified pool of use cases to rethink a wide array of applications across the SDGs, combined with the progressive removal of some of the key barriers slowing its adoption at scale, are all encouraging signs of its maturation. Despite all the existing challenges and those yet to come, we can argue that the blockchain technology made it to the much-cherished pool of game-changers that have the power to disrupt our ways of thinking, those have undeniably become the tools for today's and tomorrow's business as unusual. Nevertheless, it is very important to distinguish

between those cases where blockchain can deliver tangible value and stay away from unnecessary investments amounting to “blockchain washing”.

The blockchain technology has a tremendous potential to disrupt traditional ways in which we used to do development towards achieving the Sustainable Development Goals by 2030 but there are caveats. When use cases are properly chosen, adequately designed, and implemented, blockchain can deliver its promises beyond the hype mainly by restoring trust and enabling efficiencies. As blockchain is peaking, project managers and development practitioners down the road should anticipate the slow but steady emergence of disruptive new business models, to deliver sustainable development results by moving from log frames to acceleration labs, and from siloed expertise to disruptive co-creation.

Within the development community, there is a clear need to reboot our expectations in terms of what can be done with and without blockchain technology. The tendency to ride the wave of the blockchain hype under all circumstances without prior due diligence is not the right path forward and can be even detrimental to the very concept of aid effectiveness. The critical starting point for development practitioners would be to build rational use cases for blockchain to solve specific development challenges taking into consideration the variety of contexts in which such solutions are needed.

By weighing the tangible benefits expected from a blockchain-backed solution against the extra cost attributed to the additional complexity inherent to the blockchain technology, development workers can seek meaningful tradeoffs and create promising use cases to unlock the truly transformational potential of blockchain as an SDG accelerator that can truly disrupt the way we do development.

As we are heading towards the uncharted territories of the new normal in the aftermath of COVID-19, whatever this will entail for the global order in an increasingly multipolar

world, trust is in rare supply more than ever before. The alternative to a system prone to failure could be to replace blind trust by a trustless ecosystem where transactions are fast, secure, verifiable through an audit trail, and cost-efficient, where trust is not needed anymore.

Certainly, this work only scratched the tip of the blockchain iceberg. Its hidden part will only emerge over time, as the technology is getting mature and lessons learned are being shared based on the trial and error experiments being conducted within various geographies and across a wide range of economic, social, and environmental spectrums.

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Appendices

Below are the questions addressed to the resource persons approached for this research.

1. Blockchain backed solutions in development became very popular over the last years, yet, the technology is still getting mature and many initiatives are pilots that are not implemented at a larger scale. Over the last decade since the creation of Bitcoin in 2009, what would be the main successes and limitations so far from blockchain-enabled applications in sustainable development?
2. While there are many examples of a “let’s blockchain it” approach to developing new use cases for blockchain technology, there is little data on whether or not development practitioners conduct cost-benefits assessments. How do blockchain projects’ managers move beyond the hype to confirm the superiority of blockchain compared to other technologies and design sound use cases for blockchain-backed solutions?
3. As we are heading towards the uncharted post-pandemic territories, ICT’s are posed to be at the core of a new normal of increased digitalization and where the adoption of new technologies is expected to be on the rise. How do you see the opportunities for Blockchain use cases along with other disruptive technologies such as AI and IoT in the Post-COVID019 era?