Semih Severengiz (Ed.)

Blockchain & Decentralized Finance – Opportunities for Sustainable Development

Proceedings of the 2nd Symposium smart:sustainable

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Hochschule Bochum
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Foreword

Bochum University of Applied Sciences has identified the central transformation topics of sustainability and digitalisation as a key goal and anchored them in its strategy. In several study programmes, students are already being prepared and qualified as future experts for their tasks as agents of change in the transformation process. Numerous teaching and research projects deal with specific sustainability questions, which increasingly makes Bochum University of Applied Sciences a lighthouse for sustainability projects with an international orientation. The importance of digitalisation for solving future sustainability challenges is clearly becoming the dominant factor. In its report *Our Common Digital Future*, the *Advisory Council on Global Change (WBGU)* emphasises that digitalisation must be designed in such a way that it can serve as a lever and support for the Great Transformation towards sustainability and can be synchronised with it.

In this context, technological approaches and use cases from the areas of blockchain and decentralized finance are prominently discussed in the public debate and are still controversial with regard to their contribution to sustainable development. The researchers of the *Sustainable Technologies Laboratory (STL)*, a research institution of this university with a focus on the analysis and evaluation of technological solutions to questions of sustainability, have therefore organised the second international symposium *smart:sustainable: Blockchain & Decentralized Finance - Opportunities for Sustainable Development* with students in July 2021. Within this event, international experts from practice and research were invited to give parallel workshop sessions together with students to deepen their knowledge based on concrete questions. Also, the results of the seminar *Sustainability in Technology*, with student papers that were presented within the symposium, make it clear that blockchain and decentralized finance have great potential for realising sustainability effects, as long as they are consistently designed under sustainability criteria. The students' main topics were blockchain use cases on gender inequality, impact investment and local cryptocurrencies for communities in developing countries.

I would like to thank our external experts Wolfgang Pinegger, Will Ruddick, Niels Faber, Frank Voßnacker and Alex de Vries for their impulse presentations, the organisation of workshops and the exchange of ideas with the students. My thanks also go to the students Fabienne Peddinghaus, Emma Persson, Greta Janssen, Katrin Mertens, Mirjam Larissa Schaar and Maren Hormozi who prepared their technical presentations and publications as part of the seminar. I would also like to thank our researcher Sebastian Finke for providing the impetus and contribution to the event.

My special thanks to the organisers Maren Duprés, Denise Sperling, Christin Hömmeke and Martin Fortkort. Without your great commitment and motivation, this event would not have been possible.

Prof. Dr.-Ing. Semih Severengiz – Bochum, 17th March 2022

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Blockchain for Impact Investments: a Sustainability Assessment Framework on Six Use Cases

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Abstract – The 21st century is a century marked by excessive challenges regarding sustainability issues. Because currently technologies are being discussed as solutions for achieving and funding the Sustainable Development Goals (SDGs), this paper deals with the topic of blockchain technology for use in impact investments and aims to assess the implementation of the technology from a sustainability perspective. This paper identifies six use cases that involve blockchain technology as an impact investment strategy. To assess these use cases in an exemplary manner, we have developed a conceptual sustainability assessment framework. This framework allows us to evaluate blockchain technology implementation from a sustainability perspective in a holistic context. In doing so, our results not only show how the different blockchain technologies are already being used in the field of sustainability, but also how much progress has been made and what hurdles still need to be overcome. The statements that can be derived from this can make a major contribution to the public discourse on the sustainability of blockchains, which can be used not only for informing stakeholders, but also for optimizations and further progress on implementations of the technology.

Keywords – blockchain, impact investments, sustainability assessment, sustainable development goals

1. Introduction

The 21st century is a century in which global challenges have never before been more evident or perceptible. It is a century marked by climate change, irreversible interventions in ecosystems, loss of biodiversity, and ever-increasing social conflicts. Because of this, one of the greatest and most critical challenges societies are facing today, is how to transform themselves to achieve sustainable development. The change needed extends across the ecological, economic, and social dimensions of sustainability (Kropp, 2019). For instance, we need to emit less greenhouse gas emissions, achieve intra- and intergenerational equality, promote more sustainable lifestyles, take care of the planet, and ensure that all people live safe, healthy, and financially stable lives.

The need for change has also been recognized in the global arena. In 2015, the United Nations (UN) adopted 17 Sustainable Development Goals (SDGs), that can be understood as a universal call with the aim to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030 (United Nations Development Program, n.d.). To ensure that these goals are achieved, there is an urgent need to assess how to finance the necessary societal transformations. In this respect, the SDGs offer a kind of framework

for investors and corporations to follow for making investments and instigating other activities, and this has incited growth in impact investing: a type of investment that seeks both financial return as well as a positive social and ecological impact. However, there are many barriers that prevent these kinds of investments from being realized at a larger and necessary scale (Uzsoki and Guerdat, 2019).

In present-day discourse, technology shows great potential in contributing to the funding and achievement of the SDGs (Berawi, 2017; Imaz and Sheinbaum, 2017; Walsh et al., 2020). Specific to the topic of impact investments, blockchain technology enables new opportunities to scale up impact investing globally (Uzsoki and Guerdat, 2019). This technology has gotten a lot of attention in the last few years due to cryptocurrencies such as Bitcoin (Urquhart, 2018). In fact, many projects and organizations use blockchain technology for impact investing (Uzsoki and Guerdat, 2019). However, this technology, and especially Bitcoin, has been criticized for its high energy use (De Vries, 2018), which raises the question, whether the technology is suitable for the purpose of impact investing. For example, the annual carbon footprint of Bitcoin amounts for 66.43 Mt CO_2, which is comparable to the annual carbon footprint of Israel. Also, a single Bitcoin transaction amounts for 848.35 kg CO_2, which is equivalent to the carbon footprint of 1,880,230 VISA card transactions or 141,391 hours of watching YouTube (Digiconomist, 2021a).

When analyzing and evaluating sustainability aspects of blockchain technology, CO_2 emissions or energy consumption are usually mentioned as the only sustainability factors. However, sustainability is more than that, although it is doubtlessly an important factor to consider. From this point of view, the research field of blockchain and sustainability (and in this specific case: impact investments) is missing a framework that can assess the sustainability of the implementation of blockchain technology more comprehensively, instead of only focusing on emissions or energy use. Based on this, we developed a conceptual sustainability assessment framework, which contains indicators and sub-indicators that we found to be relevant for a sustainability assessment. These indicators are based on well-known concepts of sustainability, criteria from impact measurements, as well as our own knowledge regarding the topic. Within the background of this sustainability assessment framework, we aim to answer the following research question: *Where is blockchain technology used for impact investments so far, and how can this implementation be evaluated from a sustainability perspective?*

This research question will be answered based on six use cases, which are all projects that encourage sustainable and impact-oriented investments. We chose these use cases based on a literature review on the topic of blockchain and impact investments and implemented these within the framework to exemplify how it works. Moreover, we will describe how we developed and evaluated the framework. We also present our methodology and the results of the use cases. As an outcome, we discuss the possibilities and hurdles of our framework and provide an outlook for the future.

2. Theoretical Background

Due to the thematic focus on projects for sustainable and impact-oriented investments, these two terms need to be defined and explained in order to understand their relevance in the given context. As the need for financing the achievement of the SDGs was already mentioned in the introduction, the phrase “money makes the world go round” appears to be very accurate. The UN estimates that the total amount of investments needed to achieve the SDGs are between 5 trillion and 7 trillion USD per year (Uzsoki and Guerdat, 2019). Especially developing countries have estimated a financial gap of 2.5 billion USD per year for sustainable development. Fortunately, impact investments have received a great deal of attention in the past decades, and they have increased tenfold in five years (Uzsoki and Guerdat, 2019). Nevertheless, what exactly is meant by sustainable and impact-oriented investments? In general, these are terms used to describe investments with a social, ethical, and environmental focus to generate a positive, measurable, social and environmental impact alongside a financial return (Forum Nachhaltige Geldanlagen, n.d.). In the literature, there are countless other terms, which are often used as synonyms, and which make a comprehensive overview difficult. What they all have in common is their shared focus at the social, ethical and environmental levels to generate positive and measurable impacts in these areas. For this reason, the term impact investments will be used comprehensively for all terms relating to this theme in this paper. In addition to different terms, impact investments can also differ in their form, and thus, the strength of their impact.

The first area of investments is traditional investing, where a social and environmental impact is limited or not at all considered. The goal is financial profits without taking ESG (environment, social, governance) factors into account (Uzsoki and Guerdat, 2019). The second area is responsible investing. Here, exclusion criteria are determined to help identify projects, companies or products that are not complying with the requirements or even violate the defined and specified norms and standards. Furthermore, sustainable investments can be identified as investments that are mainly driven by sustainable factors or themes such as carbon footprint, gender equality, waste reduction or climate change, urbanization, and population growth. Another form of investment strategy is philanthropy, which is a way of making investments for a positive impact without the aim of a financial return discussion shows the complexity of the underlying topic, but also its relevance regarding sustainable development.

3. Methodology

This paper is based on the research question, *Where is blockchain technology used for impact investments so far, and how can this implementation be evaluated from a sustainability perspective?* To answer this, we used an extensive literature review to identify rel-

evant use cases where blockchain technology is being used for impact investments. Furthermore, we developed a sustainability assessment framework to assess these use cases under a sustainability perspective.

The literature review for the topic of the use of blockchain technology for impact investing was conducted using the keywords "blockchain and sustainability", "blockchain for impact investments", and "Distributed Ledger Technology (DLT) and impact investments" in an extensive internet research. The results provided us with various articles and blog posts about projects and organizations using blockchains for impact investments. We selected these projects based on the available data, information, and the specifics in the context of sustainability. This selection was in general very limited. Finally, we chose three projects with sustainable cryptocurrencies (Fishcoin, SolarCoin, and BitGreen), as well as three other projects that use blockchain technology for facilitating sustainable process or goal optimization in their work (Moeda, Plastic Bank, and Energi Mine) (LeafScore, 2021; Uzsoki and Guerdat, 2019). Short explanations of each of these projects are listed in Table 1.

Table 1: Descriptions of the use cases (LeafScore, 2021; Uzsoki and Guerdat, 2019). *Logo references:* (BitGreen, n.d.; businesswire, 2021; CoinMarketCap, n.d.; Fishcoin, n.d.; Pitchero, 2017; Solarcoin, n.d.).

Projects	Logo	Description
Fishcoin	Fishcoin PROJECT	Fishcoin aims to improve the sustainability of seafood supply chains by incentivizing data capture and sharing on a blockchain at every step.
SolarCoin		SolarCoin is a digital asset, which aims to incentivize solar energy production and accelerate the global energy transition by increasing returns on investment and decreasing payback time.
BitGreen	BitGreen	The cryptocurrency BitGreen focuses on rewarding people for decisions that reduce their carbon footprints, such as volunteering, recycling, composting, or using a local bike-sharing program.
Moeda		Moeda is a cooperative investment platform connecting underbanked community-owned enterprises with impact investors from around the world, who can directly invest with the flexibility of digital tokens and the possibility to track their impacts.
Plastic Bank	plasticbank	Plastic Bank is a plastic offset program that uses tokens and digital wallets to promote financial inclusion of the poorest while contributing to the circular economy by rewarding the collection of plastic waste.
Energi Mine	energimine	Energi Mine is a decentralized market for energy that uses advanced technologies such as AI and blockchain to sustainably manage energy and incentivize energy-saving behaviours through the EnergiToken.

To assess the sustainability of these use cases, we have developed our own conceptual sustainability assessment framework. This framework contains relevant indicators and sub-indicators based on well-known concepts of sustainability, criteria from impact measurements, and our own knowledge regarding this topic.

In the context of sustainability concepts, we have focused on the Three Dimensions Model, in which sustainability is reflected in the three dimensions: ecological, economic, and social. A move toward a possible valuation and weighting is based on the globally recognized model of strong sustainability, whereby the ecological dimension is seen as the basis for the development of the other dimensions. In this model, natural capital cannot be replaced by other forms of capital from other dimensions (Landesarbeitergemeinschaft Agenda 21 NRW e.V., n.d.). The dimension of ecology addresses environmental issues, including the long-term conservation of natural resources, and it is often exemplified by an emphasis on environmental protection. The social dimension involves people and society, with a particular emphasis on aspects of fairness, equality, and well-being. The economic dimension focuses on the long-term preservation of economic power, yet this kind of economic return entails a separation from steady economic growth, since steady economic growth is also accompanied by an overexploitation of resources (Landesarbeitergemeinschaft Agenda 21 NRW e.V., n.d.).

Furthermore, already existing concepts and frameworks regarding impact measurements in the management approach were helpful for identifying relevant indicators. However, it should be added that non-financial indicators in particular are also oriented here towards the three dimensions of sustainability, the ESG criteria (environment, social, governance) or, alternatively, the SDGs (Youmatter, 2020).

Another tool for the development of this framework was a preliminary literature review for the use cases, from which we were able to identify other relevant indicators for the sustainability assessment. In particular, the individual features mentioned in each project were identified as possible further indicators. We categorized the indicators that emerged according to the three dimensions of sustainability (ecological, economic, and social) (Kropp, 2019) and added a further category called "Further indicators". This additional category includes further measures that could not be allocated to the other categories. Nonetheless, these are also very important for a scientific and meaningful sustainability assessment. The indicators that were used are shown in Figure 1.

Categories	Indicators	Sub-Indicators
Ecological		
	Environmental impact	Electricity mix
		Energy consumption / year
		Energy consumption / transaction
		CO2 Footprint / year
		CO2 Footprint / transaction
	Contains actions for climate protection	
	Includes actions to protect ecosystems	
	Facilitates sustainable actions	
Social		
	Promotes awareness of sustainability	
	Focuses behavioral changes for more sustainability	
	Promotes gender equality	
	Promotes equity	
	Promotes independence and autonomy of stakeholders	
	Enables participatory processes	
	Employment	
Economic		
	Fair return on investments	
	Profits for operators and stakeholders	
	Considers given infrastructure and resources as well as general possibilities	
Further Indicators		
	Characteristics	Blockchain technology
		Consensus mechanism
		Transactions per second (TPS)
	Enables further process-oriented actions for the promotion of sustainability	
	Availability of scientific research	
	Promotes transparency	
	Relevance of addressed topic	
	Measurement of the impact	
	Good solution for a relevant problem	
	Addressing the topics of SDGs	Total of 17

Figure 1: Criteria of our sustainability assessment framework.

The indicators in the field of ecology aim at environmental protection or a reduction of the degree of environmental degradation. One relevant aspect in the context of ecological impact is therefore the energy consumption of the technology (Sedlmeir et al., 2020). This in turn is based on the energy mix used, which accordingly represents a relevant sub-indicator in the environmental context. It is also a special case because we are talking about a decentralized system where computers and servers can be located anywhere. To show the difference and relevance of the indicator we looked up three examples of energy mixes. Table 2 shows the different energy mixes in the countries of Germany (Strom-Report, 2021), Kazakhstan (Schlumbohm et al., 2021), and China (China Energy Portal, 2020) regarding their composition of fossil fuels, renewable energies and even nuclear energy in percent. It becomes clear that the energy composition varies from country to country, which leads to the conclusion that the sustainability impact varies greatly, depending on the location of the computers and servers. Therefore, ecological influences cannot be generalized, but rather they must be determined individually for each location.

Other sub-indicators are the electricity consumption as well as the transaction and the resulting CO_2 emissions per year, which give an overview over the total amounts this technology is using. The other indicators in the ecological dimension aim to reveal what direct and positive impacts the use cases have in the context of sustainable actions, or to what extent they facilitate these.

The category of social dimensions contains indicators regarding the social requirements of the use cases. These indicators are used to examine to what extent projects meet general social requirements, such as gender equality or equity. Also, they examine to what extent relevant stakeholders are involved and whether future independence, thus autonomy, of the people is promoted. Another indicator is “Employment”, which reflects on people’s working conditions and their financial opportunities to create a better life. Furthermore, we also took the indicator, “Promotes sustainability awareness”, into account. This is important in order to achieve sustainable development, because the required long-term behavioral changes go hand in hand with an understanding of the fundamental issues and challenges (Milke and Rostock, 2013). The related measure, explicit education, is called “Education for Sustainable Development” (ESD), which not only imparts sustainable knowledge, but also connects different disciplines regarding the aim of a sustainable future (Bundesministerium für Bildung und Forschung, n.d.). We therefore checked to see whether the use cases gave detailed information and explanations with the goal of understanding their actions within a sustainability context.

Table 2: Electricity consumption in Germany (2020) (Strom-Report, 2021), Kazakhstan (2018) (Schlumbohm et al., 2021) and China (2019) (China Energy Portal, 2020).

Country	Composition	Percentage
Germany (2020)	Fossil fuels	49%
	Renewable energy	51%
Kazakhstan (2018)	Fossil fuels	97%
	Renewable energy	3%
China (2019)	Fossil fuels (coal, gas, oil, biomass)	69%
	Nuclear energy	5%
	Renewable energy	26%

The category of economic dimensions contains indicators such as “Fair return on investments” and “Profits for operators and stakeholders” to look at the financial realities from both sides: the funders and the actors. Although we placed a strong focus on the environmental influences within the framework of the evaluation, economic indicators also need to be included as well. The reason for this is the underlying economic growth and social system, which cannot function without monetary means. The UN attributes a much higher relevance to the financial aspects of sustainable development, which was already discussed in the introduction (Uzsoki and Guerdat, 2019). In the area of use cases, this relevance is also given. Investment returns determine the attractiveness of investments for investors, that is, if and how much they want to invest. This is particularly relevant for the fundamental existence of a use case. Also, the financial return for actors who perform certain actions is relevant in the context of the engagement of the project, the success, and the actual impact on sustainability.

The last category, “Further indicators”, starts with the technological characteristics of the use cases, where the general blockchain technology, the consensus mechanism, and the transactions per second (TPS) are addressed. We considered these aspects in our framework because the technological conditions have a major influence on the environmental impact of the use cases. Technology and consensus mechanisms are particularly decisive for energy consumption. In our case, we assumed that a higher TPS is a lot more energy efficient, because more transactions can be done in a shorter time compared to other consensus mechanisms with a lower TPS. To exemplify this, for 100 transactions, an Ethereum blockchain needs four seconds for these transactions to be made, whereas an IBM blockchain can be done it in less than a second (Krisha, 2021; Raczyński, 2021; Sedlmeir et al., 2020). This reduces the overall energy required, which is why our assumption is that it is more energy efficient, because the amount of work can be done in less time.

Further indicators, which aim at additional characteristics of the use cases, are for example transparency, whether further process-oriented actions are possible, and if a measurement of influence was implemented in the use cases.

Likewise, our framework has the claim to derive an objective evaluation. However, this creates an issue for the indicators “Relevance of addressed topic” and “Good solution for a relevant problem”, because the assessment of these indicators can be highly subjective. For example, someone may consider reduction of plastic waste as an important sustainability issue, whereas someone else sees gender equality as the most important tool in achieving sustainable development. We solved this problem by always evaluating the use cases from the point of view that every topic is equally important. However, some of the use cases focus on direct actions for sustainable development, financial support and raising sustainability awareness, which we consider as especially urgent for achieving the SDGs, and thus, somewhat more important.

Additionally, the availability of scientific research as well as the number of addressed SDGs was evaluated within the framework. In the end, the scientific nature of the information analyzed is crucial for the quality of a sustainability assessment. Likewise, the SDGs deliver solid indicators on the evaluation on to the extent to which the use cases contribute to sustainable development.

With the help of an extensive literature review and analysis regarding the use cases, we were able to fill in and evaluate these indicators. For a clear and structured presentation of our results, we have created a table in which the assessment and evaluation of the individual indicators is shown in color (see Figure 3).

The legend to these colors can be viewed in Figure 2. The colors range from dark green as very positive to dark red as very negative. In some cases, we did not find the information needed to assess a specific indicator. We solved this by using a dark grey color where no information was available. In some cases, we were able to estimate the possible

answer, which we marked with a light grey color and the letter “A” for assumption. Furthermore, it must be mentioned that the results of the framework are made based on estimations and assumptions that we made using the literature available about each project. However, estimations and assumptions like these are always based on the subjective perceptions of the author. After all, the aim of our paper is not to assess these specific projects, but to identify projects that use blockchain technology for impact investments and use these projects to exemplify how a sustainability assessment framework like ours can work.

	Very high/Very good/Very much
	Rather high/ Rather good/ Rather much
	Moderate
	Rather poor/ Rather little/ Rather low
	Very low/ Very bad/ Very little
	No information
	Assumption
A	

Figure 2: Color legend for the results of the sustainability assessment framework.

4. Results

In this section, we explain the results of our methodology in more detail. During the application of the methodology and due to the underlying research question of this paper, we noticed that we obtained different types of results, which we would like to explain separately. First, under “Results: Methodology”, the results related to the methodology and its application is provided. Here, we elaborate the general results around the framework and the hurdles in its use. Second, under “Results: Use cases”, we focus more on the substantive results of our methodology, because our aim was not only to develop a sustainability assessment framework, but to identify projects that could be applied in it in an exemplary manner at the same time. Together, this section provides the results of the sustainability assessment of six different use cases in the context of blockchain implementation for impact investments.

4.1 Results: Methodology

The results of our sustainability assessment regarding the six chosen use cases can be viewed in Figure 3. The framework presents a wide variety of evaluations, whereby the results differ greatly in some categories. In comparison to the other categories, negative evaluations are clearly more frequent in the social dimension, while strongly positive evaluations are more frequent in the areas of the "Further indicators". The positive evaluations around the relevance of the topic are particularly noteworthy, because it clarifies the reason for the selection of these projects within the framework of sustainable development. It was difficult to determine the energy consumption of the technologies in the use cases, as there was almost no data available. If there was data available, it was only isolated data based on assumptions. For this reason, the data is very similar for almost all use cases

(four of them use Ethereum as blockchain technology) or not currently available, especially when it comes to smaller or newer blockchains.

It should be noted that even if there was no direct action on sustainability, each use case enabled or facilitated sustainable action. Direct sustainability awareness was only rarely addressed and must be further developed in all use cases. Social factors were only mentioned by the use cases if the projects showed a particularly positive effect in that area. Participation processes have been established for all use cases because they often depend on the help and active participation of the actors for a successful implementation. It is interesting that the fair returns on investments for investors are not discussed, especially because the projects focus on impact investments. In contrast, the profits are clearly emphasized as advantages and positive aspects. In addition, most of the projects consider local conditions and respond to them accordingly. Often, attempts are made to compensate for this lack of consideration for local settings. For example, Fishcoin addresses the current conditions considering that people in developing countries often do not have a bank account or ID, which makes traditional money transfer useless for them. Fishcoin's solution is to use the devices that almost everyone has in these countries: cell phones. Thus, in cooperation with various mobile phone providers, recharging data plans for collecting and uploading project-related data is offered (Uzsoki and Guerdat, 2019).

Moreover, a widespread basis for the projects mentioned is the Ethereum blockchain. This blockchain is frequently used by the projects we chose for our use cases, but in comparison to newer blockchains, it is not that efficient. This can particularly be seen in the transactions per second.

Certainly, there is much room for improvement, for example, around impact measurements. On the other hand, many challenges such as a lack of transparency are already being addressed in these projects. A big point of criticism, which is also a big challenge for the implementation of the methodology, is the lack of scientific literature, as it is indispensable for a good application and meaningful results. Finally, many evaluations and numbers are based on estimations, assumptions, and less on solid measurements. In summary, we have managed to evaluate use cases according to their sustainability within the framework of the three dimensions of sustainability and beyond.

Indicators			Fishcoin	SolarCoin	BitGreen	Moeda	Plastic Bank	Energi Mine
Ecological								
	Environmental impact	Electricity mix			Aim: 100 % RE			
		Energy consumption / year	51.45 TWh	51.45 TWh	0.78 TWh	51.45 TWh		51.45 TWh
		Energy consumption / transaction	116.2 kWh	116.2 kWh	9.6 kWh	116.2 kWh	2,77778e-7 kWh	116.2 kWh
		CO2 Footprint / year	24.44 Mt CO2	24.44 Mt CO2		24.44 Mt CO2		24.44 Mt CO2
		CO2 Footprint / transaction	55.19 kg CO2	55.19 kg CO2		55.19 kg CO2		55.19 kg CO2
	Contains actions for climate protection							
	Includes actions to protect ecosystems							
	Facilitates sustainable actions							
Social								
	Promotes awareness of sustainability							
	Focuses behavioral changes for more sustainability							
	Promotes gender equality							
	Promotes equity							
	Promotes independence and autonomy of stakeholders							
	Enables participatory processes							
	Employment							
Economic								
	Fair return in investments							
	Profits for operators and stakeholders							
	Considers given infrastructure and resources as well as general possibilities							
Further indicators								
	Characteristics	Blockchain technology	Ethereum	Ethereum	Polkadot	Ethereum	IBM Online Platform	Ethereum
		Consensus mechanism	A: PoW	A: PoW	PoS	A: PoW		A: PoW
		Transactions per second (TPS)	25	25	166 000	25	3 000 - 3 500	25
	Enables further process-oriented actions for the promotion of sustainability							
	Availability of scientific research							
	Promotes transparency			A			A	A
	Relevance of addressed topic							
	Measurement of the impact							
	Good solution for a relevant problem							
	Addressing the topics of SDGs	Total of 17	5/17	2/17	3/17	2/17	5/17	2/17

Figure 3: Results of the sustainability assessment framework.

4.2 Results: Use cases

As our framework aims to assess the sustainability of the implementation of blockchain technology in different projects on impact investments in a comprehensive manner, it is natural that some projects stand out in these aspects. After reviewing the general results, we present two of the use cases in the following section, where we elaborate on why both of these projects stood out as being particularly interesting examples of projects that use blockchain technology for impact investments.

Furthermore, it must be noted, that our use cases and their application area are in the starting phase and have not reached their full potential yet. Due to this, the available scientific data is scarce, simply because there has not yet been enough research. Thus, our results are also based on assumptions we have made based on the literature available.

Use case 1: BitGreen

One use case that stood out on many points is the cryptocurrency BitGreen. BitGreen has been around since 2017 and aims to provide an energy-efficient alternative to Bitcoin through its use of a Proof of Stake consensus mechanism instead of Bitcoin's Proof of Work verification method, which is very energy-intense (Everipedia, 2021). Through BitGreen, users are able to not only trade and use cryptocurrency, but also discover and act on impact opportunities, such as using bike sharing programs or volunteering (BitGreen, 2021). These actions are rewarded with BitGreen coins through the BitGreen light wallet app (Everipedia, 2021). In sum, BitGreen is a "green" version of Bitcoin and aims to promote behavioral changes for more sustainability.

In terms of ecological indicators and, above all, BitGreen's environmental impact, it was rather difficult to find any data. BitGreen's own authors states that the energy consumption per year and per transaction amounts to 0.6% of the energy consumption of a normal Bitcoin (BitGreen, 2021)g. When using the numbers provided by Digiconomist (Digiconomist, 2021a), this means that the annual energy consumption amounts to 0.78 TWh and the energy consumption per transaction is 9.6 kWh. These numbers are lower than the other projects in our case study that are based on Ethereum, which consumes 51.45 TWh of energy per year and 116.2 kWh per transaction (Digiconomist, 2021b). Besides the environmental impact, BitGreen also enables actions for climate change protection and facilitates sustainable actions through its rewards system for sustainable behavior, which were two other criteria set as ecological indicators.

As to the social indicators, BitGreen does attempt to promote awareness for sustainability in that it incentivizes sustainable behaviors. Furthermore, it focuses on behavioral changes for more sustainability and enables participatory processes. BitGreen is also built as a community, where the members of the network can nominate which behaviors and projects should be funded (Everipedia, 2021).

The smaller indicator-group in the economic dimension found that BitGreen takes given infrastructure and resources into consideration, because it is based on an already known and working concept of cryptocurrencies. Moreover, BitGreen considers general possibilities, due to its aim to function as a Bitcoin, but with less environmental impact and its use of a reward system for sustainable behavior.

Regarding the technical features, BitGreen has used the low-energy Proof of Stake consensus mechanism from the beginning. Also, BitGreen is changing the blockchain platform from BitGreen blockchain to Polkadot later in 2021 (Saudu, 2021). The Polkadot ecosystem does come with advantages, for example, it has the potential to process over 166,000 transactions per second (Klee, 2020), which is a very high number when comparing to Bitcoin (which is 3-5 TPS) or even VISA-Card transactions, which can achieve 65,000 TPS (Klee, 2020).

Additionally, BitGreen enables further process-oriented actions for the promotion of sustainability through its rewarding system for sustainable behavior. From this point of view, the topic is highly relevant in terms of sustainability. BitGreen also appears to deliver a good solution for a relevant challenge, where the problem is the alternative cryptocurrency Bitcoin and its large, negative environmental impact. Lastly, BitGreen has the potential to contribute in terms of impact investing for achieving SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), and SDG 13 (climate action). Nevertheless, how and to what extent we can measure this impact remains unclear for now.

Use case 2: Plastic Bank

Next to BitGreen as a sustainable use case in the category of cryptocurrencies, Plastic Bank is another highly positive use case regarding blockchain implementation for sustainability causes.

The project was established 2013 and is a plastic offset program that rewards people with tokens or fiat currency for collecting plastic waste and taking it to recycling centers (Uzsoki and Guerdat, 2019). The program is running in Haiti, the Philippines, Brazil, and South Africa (Uzsoki and Guerdat, 2019) but according to their own plan, many more destinations will to be opening up in the future (Frankson, 2021). Plastic Bank describes their aim as “Cleaning up the planet and empowering people to lift themselves out of poverty” (IBM, 2021). This also highlights the tasks and activities of the use case at the same time.

Beyond these basic activities, the project has established a recycling process after the collection of the plastic. So far, more than 24 million kg of plastic have been recycled (Plastic Bank, 2021). The recycled plastic is used as ink for 3D printers, which can be used by the collectors or sold to cooperation partners, who use the plastic for example for shampoo bottles (Plastic Bank, 2021).

Besides these ecological factors, the social parameters are highlighted as well. First, the project focuses on gender equivalent opportunities and pays particular attention to the earning potential of women and children in their respective countries (Uzsoki and Guerdat, 2019). They also focus on known problems such as robberies with the theft of cash. A solution by Plastic Bank is that fiat currency as well as digital wallets can be implemented. In addition to these options, the conversion of money into services such as groceries, cooking fuel, school tuition, and health insurance is also possible (Uzsoki and Guerdat, 2019).

Regarding the economic dimension, the financial attractiveness of Plastic Bank is ensured because the project pays a globally uniform price, which is 0.50 USD for 1 kg of plastic (21 Grad, 2021). 1 kg of plastic is equal to approximately 50 plastic bottles.

The technical aspect also promotes lower energy consumption. Plastic Bank uses the Hyperledger Fabric blockchain platform, on the IBM LinuxONE servers in the IBM cloud (Frankson, 2021). This blockchain needs 1 Joule per transaction and has the possibility of 3,000-3,500 transactions per second, which can be scaled up to 20,000 transactions per second (Krisha, 2021; Sedlmeir et al., 2020). This promotes a lower total energy consumption, which is always a big point of criticism in the sustainability context of blockchains.

At the same time, transparency is a main aspect during the work of Plastic Bank. Because of this, Plastic Bank generates full transparency over the whole supply chain to make sure

that the correct amount of money goes to the right people and that Plastic Bank's customers such as Henkel (German producer of consumer goods) have full traceability (Frankson, 2021).

Lastly, Plastic Bank also has the potential to make contributions in terms of impact investing for SDG 5 (gender equality), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production), SDG 14 (life below water), and SDG 15 (life on land) (Uzsoki and Guerdat, 2019).

5. Discussion and Outlook

Many aspects of our sustainability assessment and its results point to a relatively new field of technology and technology implementation, which is characterized by constant development. A particularly important aspect where this ongoing development becomes clear is in the lack of scientific data and in the corresponding, scientifically based literature. This data must first be generated and validated. Yet currently, only the first and more established blockchains, such as Ethereum and Bitcoin, can provide this data.

However, this change not only reveals the ongoing gaps in the literature, but also allows great possibilities for future development. Thus, despite the lack of data, we can already see a great opportunity for blockchains to act as enablers for sustainable development, for instance, by breaking up traditional approaches or by simplifying lengthy bureaucratic processes.

Another challenge in the present case is decentralization, which makes it particularly difficult to determine sustainability indicators such as energy consumption or the resulting CO_2 emissions. Nevertheless, it is obvious from the use cases that many areas of application are likely to expand significantly in the future. Major advantages are efficiency, speed, and transparency. Transparency is especially important in terms of economic aspects, as it is an increasing requirement of our society, which also goes hand in hand with participation. According to preliminary estimations, current points of criticism such as excessive energy consumption will most likely be minimized as technological developments continue to progress. Increasing the transactions per second is already one example of efficiency improvements. Another case for this is Polkadot, which enables a very high TPS (up to 166,000) (Klee, 2020), as mentioned in the results. The energy consumption criterion is important and should not be neglected, but it should not be the only exclusion criteria. In addition, projects such as the use cases presented in this paper might not even be feasible without blockchain technology. This dilemma of possible advantages and disadvantages creates future challenges in making sustainable decisions regarding the implementation of blockchain technology for impact investments. These challenges must be solved by moving away from positions and critically questioning information.

It must be mentioned that so far, our research is still very limited. The framework presented here is a first step towards an objective sustainability perspective on these technologies and addresses a variety of current social topics. It particularly emphasizes the

positive factors of use. The indicators we have used should be further expanded and specified individually. We have already taken this step, as we presented our framework at the digital Symposium “smart:sustainable” on blockchain technology & decentralized finance (DeFi) and its use for sustainable development on July 1, 2021. At this event, we discussed further improvement and possible additional indicators. As improvements, for example, the following indicators were mentioned:

- Fresh water use (because of the required cooling systems for servers)
- Costs for the usage of the different blockchains (Attractiveness and frequency of use)
- Impact on biodiversity (as a specified environmental indicator)

A further comment on the original indicator, "Fair return on investments and profits", was made regarding the perspective for whom this indicator applies. We also recognized this problem, which is why we made two indicators out of it in an initial adjustment in order to take both the side of the investors and the actors individually into account.

To sum up, there are further possibilities for adaptation and improvement for the basic framework. Another point for future application and optimization is the improved scientific data basis, which could significantly increase the quality of the methodology.

As a further outlook, we want to discuss the possibilities for applying our sustainability assessment framework. We mentioned in the introduction, that this research field does not currently have a framework for assessing the sustainability of the implementation of blockchain technology in a comprehensive manner. However, this also raises the question about the benefits our framework might provide to the research field. We estimate that a sustainability assessment framework like ours can be implemented in many areas of use. For example, the framework can be used as a part of a technology assessment of blockchain technology. A technology assessment is a great tool to examine short- and long-term consequences of the application of technology, but it does not focus specifically on sustainability aspects, although it does not per se neglect them either (Banta, 2009). However, our framework provides a solid base for evaluating what is relevant from a sustainability perspective, especially when it comes to blockchain technology implementation. Thus, a technology assessment aiming to address sustainability aspects of technology would gain added value from our framework. The addressees of this kind of framework are, from our point of view, government institutions, private actors, and others that deal with these kinds of topics.

6. Conclusion

The underlying research question of this paper was *“Where is blockchain technology used for impact investments so far, and how can this implementation be evaluated from a sustainability perspective?”*. To answer this, we have presented a sustainability assessment framework that serves two purposes. First, it helps us to identify projects that use blockchain technology for impact investments. Second, it allows us to make a comprehensive

sustainability assessment as well as to analyze, evaluate, and compare different projects that use blockchain technology for impact investments.

With the help of an extensive literature review, we identified six use cases to implement into our framework. Regarding our framework, we have formed indicators and sub-indicators that are relevant for a sustainability assessment based on well-known concepts of sustainability, criteria from impact measurements, as well as our own knowledge regarding this topic. We used the chosen use cases and implemented them in the framework to exemplify how these projects can be evaluated from a sustainability perspective.

Our results show that many projects use blockchain technology for impact investments. However, these projects are in the starting phase, which leaves room for improvements, in regard to both the technological features and their direct impact on the environment, as well as how to measure the general sustainability impact that our framework considers. However, we were able to notice several positive developments in the use cases: for example, BitGreen has an exceptionally low environmental impact compared to the traditional Bitcoin (BitGreen, 2021), and Plastic Bank is already able to present how their impact can be measured, e.g., how much plastic has been recycled (Plastic Bank, 2021). In addition, regarding the ecological sustainability challenges of the implementation of blockchain technology, it is a technology field in constant development. This means that the current points of criticism, such as the high level of energy consumption, will most likely be minimized in the future. Furthermore, as with any technology, there are both advantages and disadvantages. These can be evaluated in a technology assessment, where we estimate our framework to serve as a support in the future.

Our work also presents some challenges and limitations. Above all, the lack of scientific research in this field makes it difficult to present a complete picture of the sustainability impact of these projects. Although it was not a part of our research question to assess the quality of the scientific research, it would make the results of the framework more expressive when available. We estimate that this data will become available in the future, which is why it is important to continue to both develop our framework and revise it regularly.

In summary, the usage of our sustainability assessment framework has shown that blockchain technology is a technology field with great potential for the future, especially for enabling impact investments and for achieving the SDGs. The use cases show a wide range of possible application areas, which clearly go beyond the current concept of Bitcoin, as they focus more or less exclusively on sustainability. For this urgent task, our sustainability assessment framework is situated right at the nexus of important aspects to consider when implementing technology to change the course of action in the world and achieve sustainable development.

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Blockchain as an Assistive Technology to Reduce Gender Inequality within Identity Management in Nigeria

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Abstract – Identity is an important element in achieving gender equality. Using blockchain technology for identity management can promote equality. The aim of this literature review is to analyze which reasons prevent women specifically in Nigeria from registering and to what extent the application of blockchain technology for identity management can lift these barriers. A semi-systematic literature review was carried out to analyze gender issues as well as the registration system in Nigeria and deduce ensuing barriers. By searching five databases and the web with defined keywords, 26 sources were found that were suitable for this paper. The investigation showed that blockchain is a promising technology for overcoming existing technical and organisational barriers in Nigeria. As a technology, blockchain alone cannot bring about change to affect complex sociocultural challenges, like patriarchal structures. Technology on its own only changes the range of actions of its user, but not the environment around them. However, social structures can be influenced using blockchain in the form of side effects.

Keywords – blockchain, gender equality, identity management, literature review, Nigeria

1. Introduction

In 2018, just under 1 billion people worldwide did not have a legal proof of their own identity (World Bank, 2019). Without identity, participation in modern society in a democratic, educative, and economic way is not viable. Having an identity is in fact a human right before three universal rights. Article 7 of the Convention on the Rights of the Child (General Assembly, 1990), Article 6 of the Universal Declaration of Human Rights (General Assembly, 1948), and Article 16 of the International Covenant on Civil and Political Rights (General Assembly, 1976). These three articles state that everyone shall have the right to be recognized as a person before the law. This begins at birth with the right to a name, the right to acquire a nationality and the right to know and be cared for. Next to these rights, having a proof of identity is part of the 2030 Agenda for Sustainable Development. Sustainable Development Goals (SDG) 16.9 on providing legal identity for all describes the importance of having a proof of identity for a sustainable development (General Assembly, 2015). In Nigeria, different barriers occur which affect the identity management system. Overall, only 42.6 percent of children under the age of 5 are registered with civil authority (Sachs et al., 2020). Women and children are facing more difficulties regarding registration (World Bank, 2021d). In the following paper, the focus will be on how these barriers arise and what specific challenges women and other disadvantaged groups must experience and how

blockchain technology can support the implementation of a fair and nondiscriminating registration process. The best case for this process would be the achievement of gender equality and the related reduction of patriarchal structures.

Gender equality, as defined by SDG 5, is not only a fundamental human right (General Assembly, 2015), but is widely considered a prerequisite for a prosperous, peaceful, and sustainable world. Blockchain is a decentralized protocol for digital interactions between entities without the verification or authentication provided by a third party, where every record is transparently and immutably stored (Lopez et al., 2019; Thylin and Duarte, 2019). It was developed by someone known as Nakamoto in the year 2008. It can be used as a solution for identity management and gives vulnerable groups like women and girls more control and power over their own data (Kamath, 2018).

Several studies show the potential of blockchain technology to reduce gender inequality, such as Lopez et al. (2019) or Kamath (2018), or how blockchain technology can be used for identity management, such as Bhattacharya (2021). However, the issues of identity management in sub-Saharan Africa and the application of blockchain for identity management have not yet been analyzed in combination, which we therefore consider a research gap. In our research, we have brought both topics together and have analyzed them under the aspect of gender equality. This purpose has resulted in the following research questions:

1. What are the impeding reasons why women in Nigeria do not have proof of identity within the current registration system?
2. How can the introduction of blockchain-based identity management lift existing barriers before and during the registration process?

To answer these research questions, the framework of a semi-systematic literature review according to vom Brocke et al. (2009) has been followed. Three categories of barriers were identified. These apply to all Nigerians regardless from their gender but some weigh even greater for women and other marginalized groups. Blockchain technology can be a help for implementing a safe and sustainable identity management in Nigeria and other countries. However, not all barriers can be affected using blockchain technology. Human habits and culture are rooted in society and therefore cannot be simply changed by a technology.

2. Methodology

There are three approaches to conducting a literature review: Systematic, semi-systematic and integrative (Snyder, 2019). This review follows the characteristics of the semi-systematic approach since it is, according to Snyder (2019), a suiting choice to identify knowledge gaps in the literature and give a broader overview of studies within different disciplines (Snyder, 2019). The characteristics of a semi-systematic review are:

- Typical purpose: Overview research area and track development over time

- Research questions: Broad
- Search strategy: May or may not be systematic
- Sample characteristics: Research articles
- Analysis and evaluation: Qualitative and quantitative
- Examples of contribution: State of knowledge, themes in literature, historical overview, research agenda, theoretical model (Snyder, 2019)

In this review, the five steps to collect and present literature by vom Brocke et al. (2009) are followed as a framework. First, an appropriate scope of the review is defined (section 2.1). Next, the conceptualization of the topic is presented (section 2.2) while in phase 3 the process of the literature search is explained, and the final set of papers presented (section 2.3). After this, the findings of the literature analysis and synthesis are reported in a structured way according to the research questions in section 3 – Results. Finally, a research agenda resulting from the synthesis of literature is to be developed to give an outlook for further research on this topic (section 4 – Discussion and Conclusion).

Table 1: Taxonomy of literature reviews (following Cooper, 1988, p. 109).

Number	Characteristics	Categories			
1	focus	**research outcomes**	research methods	theories	**applications**
2	goal	**integration**	criticism	central issues	
3	organisation	historical	**conceptual**	methodological	
4	perspective	**neutral representation**	espousal of position		
5	audience	specialized scholars	**general scholars**	practitioners/politicians	general public
6	coverage	exhaustive	exhaustive and selective	**representative**	central/pivotal

2.1 Review Scope

We applied the taxonomy of literature reviews by Cooper (1988), suggested by vom Brocke et al. (2009) in order to define the scope of the review and clarify the search process. It contains six constituent characteristics with multiple categories each (see Table 1).

The review focuses on existing research outcomes and applications. It aims to identify key issues and integrate the findings into a new context from a neutral perspective understandable for general scholars. As we focus on a very specific and narrowed down topic, we have chosen not to use all the literature ever published on all topics, but rather stay within the limit of representative literature from each topic area (see main keywords).

2.2 Conceptualization

This phase is important for starting and to get a broad overview over the topic and define the main keywords. Since this work is a study project, we were assigned a rough topic to work on: gender equality and blockchain. We used these as primary keywords to gain knowledge about these two topics and more importantly about the connection between

blockchain and gender equality. During the research of these two keywords, we discovered the application of blockchain technology for storing and managing identities. As stated in the introduction, giving an identity to women and girls is a main enabler for gender equality (Kamath, 2018), so we decided to focus on that in our review. Therefore, we added the terms identity management and digital identity as keywords for the research. Since sub-Saharan Africa is the region with the highest percentage of unregistered people, we decided to take a closer look at that area. We chose Nigeria as a representative case study as a high data basis is available. This process led to our final and specified research topic.

2.3 Literature search method

The process of the literature search is aligned with phase 3 (vom Brocke et al., 2009), including the selection of databases, a keyword search, and a backward search. The identification of specific journals was not feasible due to the broadness of the topic. A forward search was not conducted either. This is justified in the complexity of the topic. The selection of the databases was constructed around the accessibility of the students' free online databases and the claim to a high scientific aspiration. The chosen databases are presented in Figure 1. For the keyword search within these databases and the following backward search, we formulated three inclusion criteria (IC) and three exclusion criteria (EC).

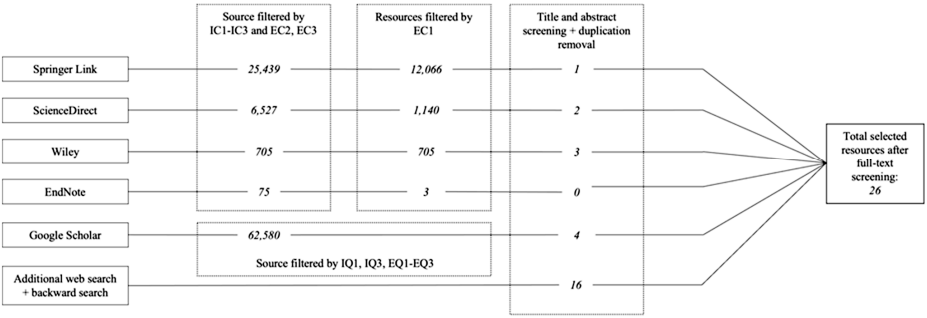

Figure 1: Used data bases and number of sources within different filtering steps after IC and EC.

The period for IC1 was chosen due to the release of the United Nations (General Assembly, 2015) SDGs. Therefore, reports and other grey literature from 2015 and later were included. The narrower period for scientific papers was assigned. Figure 1 shows the different steps of the literature filtration process. All in all, 26 resources were used to analyze the topic of identity management with blockchain technology. Table 2 shows an overview of the scientific papers used, including the relevant keywords. All included main keywords are marked with an 'x'. If one of the identified keywords is partly discussed in this paper, but not central to the main topic the table shows an '(x)'.

INCLUSION CRITERIA

IC1	Scientific papers should not be published before 2018; Grey literature should not be published before 2015
IC2	Scientific papers must be from journals or academic institutions
IC3	Literature must be relevant for at least one of the research questions and needs to include at least one main keyword

EXCLUSION CRITERIA

EC1	Disclosed papers (only open access papers)
EC2	Literature in other languages than English and German
EC3	Older versions of papers and reports

4. Results

Based on the found literature, an analysis of the current situation in Nigeria regarding gender issues and the registration system was carried out. This information serves as a basis for deriving the reasons and barriers as to why women in Nigeria are not registered.

Gender issues and registration system in Nigeria

Nigeria is a society strongly shaped by patriarchal structures. Therefore, there is a distinct dichotomy in gender roles between the two state-recognized genders - man and woman. Gender in Nigeria follows the structural-functionalist theory, which sees gender roles as complementary to sustain the structural stability of society. This gives the man the 'instrumental role' in providing security for the family while the woman plays an 'expressive role' in maintaining the household and childcare (Amiesimaka and Payam, 2021). This situation can be explained by the fact that Nigeria's highly patriarchal culture is maintained by long-standing traditional norms and deeply rooted religious beliefs (Amiesimaka and Payam, 2021; Ajibade Adisa et al., 2020).

Table 2: Overview on main keywords and sources used

Reference	Main keywords				
	Blockchain	Identity (Management)	Digital Identity	Gender (In-) Equality	Nigeria
Ajibade Adisa et al., 2020				x	x
Amiesimaka and Payam, 2021				x	x
Atick, 2018		x	x		(x)
Bhattacharya, 2021	x	x	x		

Reference	Main keywords				
	Blockchain	Identity (Manage-ment)	Digital Identity	Gender (In-) Equality	Nigeria
Biscaye et al., 2015		x	x		
GSMA, 2020		x	x		
Kamath, 2018	x	x		x	
Lopez et al., 2019	x			(x)	
Olonade et al., 2020				x	x
Sachs et al., 2021		(x)		x	x
Singh et al., 2021	x		x		
Thylin and Duarte, 2019	x			x	
World Bank, 2021c		x	(x)	x	
World Bank, 2021d		x	(x)	x	

Although women make up half of the population of Nigeria, they experience extensive marginalization, disempowerment, and high levels of gender inequality (Amiesimaka and Payam, 2021; Olonade et al., 2021). This is evident in the common practice of valuing boys more than girls, with the latter often being subordinate to male supervision. The subordination of women to men leads to practices such as the preference of male over female children in education, the exclusion of women from inheritance rights, and the underrepresentation of women in positions of political power (Amiesimaka and Payam, 2021). Table 3 illustrates this situation using the indicators literacy rate as well as enrolment in primary education, where women perform poorer than men, with a difference of 18.6% and 12.9% respectively (World Economic Forum, 2021). A further analyzed indicator is the Global Gender Gap Index that measures the total development of gender gaps. In the report's edition from 2021, Nigeria ranks 139th out of 156 states (World Economic Forum, 2021).

The gender inequality in Nigeria also extends to identification. In 2020, 41 million Nigerians were registered for the National Identification number (NIN), but only 41% of these are women. However, only a small part, namely 20% of the total population, has been registered since implementation of the NIN in 2007 (World Bank, 2021d). In addition to the national ID given by the National Identity Management Commission (NIMC), there are at least three more functional ID schemes: the voters' register with 68 million registrations (in 2015), the Bank Verification Number with 54 million registrations (in 2015) and the driver's license (number unknown) (Atick, 2018; World Bank, 2021d). The implementation

of several identity cards led to a fragmentation of the ID system and enrolment fatigue among the Nigerian population. Currently, Nigeria is supported by the World Bank to be able to increase the number of registrations within the next five years (World Bank, 2021d). The NIMC aims to harmonise existing ID databases and integrate features such as bank verification, health insurance card or driver's licences into the national ID system (Biscaye et al., 2015).

Table 3: Sociocultural and organisational indicators in Nigeria.

Indicator	Nigerian population	
	Female	Male
% of children (< 5 years) whose births are reported to the national civil authorities (unicef, 2020)	42.60%	
Global Gender Gap Index 2021 ranking (World Economic Forum, 2021)	139 out of 156	
Literacy rate (World Economic Forum, 2021)	52.7%	71.3%
Enrolment in primary education (World Economic Forum, 2021)	58.1%	70.0%
Population 2020 (World Bank, 2021a)	206,139,587	
	101,669,950	104,469,637
Registered people in national ID (World Bank, 2021d)	41.2m	
	41%	59%
Access to registration services (NIMC, 2021)	37 Enrolment centers nationwide + additional enrolment locations	

Barriers

By carrying out the analysis, two categories of barriers that hinder women in Nigeria to register have been identified: organisational and sociocultural ones. Additionally, based on the literature review, the category of technical barriers was also identified, which applies to most sub-Saharan African countries to a lesser or greater extent.

The determined organisational barriers apply to both men and women, and are thus universal. People who live in rural areas in Nigeria and other countries in sub-Saharan Africa often have limited access to registration offices or must put up with long travel distances due to an insufficient infrastructure of governmental registration facilities (GSMA, 2020; World Bank 2021c). Along with this comes high direct and indirect costs for transportation and the loss of income during the travelling. There are also reports about the need of paying bribes to the registration staff (World Bank, 2016, World Bank, 2019, World Bank, 2021c). A further aspect is the lack of qualified staff to effectively cover the population's need for the provision of services (GSMA, 2020; World Bank, 2021c). Often multiple visits are required, e.g., for applying and picking up the ID, thereby increasing the difficulty of the process (World Bank, 2019). For women and girls, universal barriers are compounded by gender-specific constraints. Because poor facilities combined with long waiting times are hard for pregnant and nursing mothers, there is often a lack of provision for mothers (Amiesimaka and Payam, 2021; World Bank, 2021c).

In Nigeria, there is frequently a limited awareness about the uses of having an ID and, more commonly, about the enrolment procedure, which is a hindering reason for people not being registered according to the survey of the World Bank (2021d). Also, many people are unable to present all required biographic information, such as the birth certificate, as there is often a low level of awareness of the importance of birth registration among the population. Additional challenges are an insufficient coverage of systems such as birth registration and difficulties in accessing offices where documents can be obtained (World Bank, 2021d).

The patriarchal society of Nigeria is a source of several socio-cultural barriers for women and girls in particular. The World Bank (2021d) conducted an in-depth qualitative study in Nigeria to gather knowledge on women's and marginalised groups' use of and access to ID-cards to support the country's Digital Identification for Development Project. This project gave a valuable insight into the challenges that a patriarchal society poses for identity management. One important reason is the view that men are more likely to need an identity card. This attitude, held by men and women alike, stems from the gender-typical division of tasks, which assigns women mainly to the responsibility of running the household and men typically conducting all interactions outside the home that require an identity card. Therefore, it may be seen as unnecessary or unimportant to women. However, this statement varies among different communities based on their norms. It is more present in Muslim communities, in the North of Nigeria and in families with low income and education level. The survey of The World Bank (2021c) also showed that young girls married at under 18 years of age are less likely to be able to register. Because, due to social norms in Nigeria, the girls are restricted in their mobility and have a low social status. Furthermore, in order to register, women and girls must first receive permission from men, which the

latter can deny (World Bank, 2021c). As already stated, the registration process can consume much time, which women often do not have because of their household and childcare responsibilities at home (World Bank, 2021c).

In addition, several barriers that hamper registration could be identified by the World Bank (2021c) that may arise when visiting a registration centre. As mentioned in the analysis of the current situation in Nigeria, every second woman is illiterate. This leads to difficulties with filling out forms and going through the registration process. In the conservative North of the country, social norms forbid women's interactions in public and contact with men who do not belong to a woman's household. Therefore, obtaining photographs and fingerprints can be difficult and women often disapprove of being registered by men (World Bank, 2021c).

As a third category, general technical barriers that do not apply specifically to Nigeria but are common among many countries in sub-Sahara Africa have been identified (GSMA, 2020). First, there have been reports about corruption in contracts and tenders for establishing a registration system. A reason that this may happen is due to the limited transparency in the placing of contracts, which can also lead to a delay in implementation if the corruption becomes public (GSMA, 2020; Biscaye et al., 2015). Moreover, there can be problems with efficient data management, since the investment in digital data capture infrastructure is often low, which also leads to a lack of statistical data about the population (GSMA, 2020; Biscaye et al., 2015). A limited access to resources can be a challenge for carrying out effective registration processes. These challenges include broken or insufficient equipment and/or material, undertrained staff, or limited human resources. Furthermore, there can be a lack of logistical support or guidelines, which are important for raising awareness of the enrolment procedure in the population to inform about how and why to register (GSMA, 2020; Biscaye et al., 2015). Often the enrolment procedure is very complex due to a high level of centralization. This has an impact on the costs for maintaining the service, data management, and coverage of the registration service (GSMA, 2020).

Blockchain for identity management

Blockchain technology may help to overcome certain presented barriers in Nigeria and other sub-Saharan regions. Within different sources the implementation of blockchain technology for identity management is presented. Bhattacharya (2021) for example, describes the management as a system (see Figure 2). First, an identity issuer issues a verifiable credential to a person. This person is called the identity owner. Within this flow, the issuing party attaches its unique and immutable public decentralized identifier (DID). The credential is stored securely in a digital wallet of direct ownership of the identity owner and not directly on the blockchain. Simultaneously, the public DID is stored on the blockchain as an immutable data record of data. When information about the identity owner is needed, he/she can present extracted information to an identity verifier. As the identity owner alone is in possession of its information, the person may decide with whom he/she

shares data. This information is given together with the public DID of the identity issuer. To ensure the validity of the credential, the identity verifier checks the public DID of the identity issuer. Consequently, not the credential itself is checked but the reliability of the identity issuer. The blockchain works as an intermediary between the validity of the identity issuer and personal information.

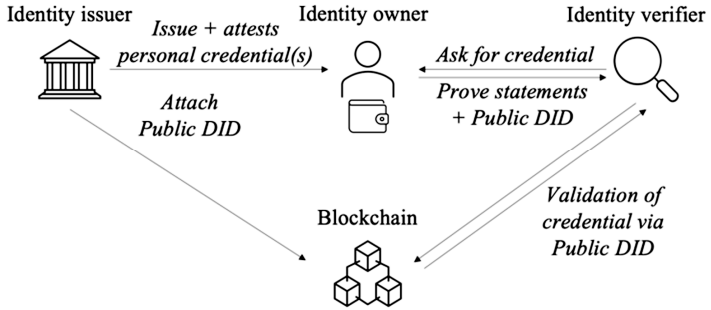

Figure 2: Scheme of a self-sovereign identity management system based on blockchain technology (Following Bhattacharya, 2021).

Three main advantages can relate to identity management with blockchain technology: decentralization, immutability, and transparency (Singh et al., 2021). Decentralization on a blockchain is given through the system itself. As there is no centralized owner of a blockchain, different entities may add their public DID or other information to the blockchain. The second advantage presented by Singh et al. (2021) is the immutability of the blockchain. Due to the decentralized system and public accessibility, it is nearly impossible to change the data on the blockchain. This is in consequence of using cryptographic elements like hashes. The third aspect of transparency is rooted in the fact that everyone who acts like an identity verifier can validate a credential on the blockchain regardless of the properties and possibilities of the identity owner. Blockchain technology is a tool for designing the process of digital identity management in a secure and resilient, persistent way (Bhattacharya, 2021). Blockchain-based identity management systems create a so-called self-sovereign identity (Bhattacharya, 2021), meaning that people are in control of their own identity. These properties can affect or even lift existing barriers when it comes to gender inequality regarding identity management.

Influence of blockchain-based identity management on barriers

Organisational barriers, which prevent Nigerians and especially Nigerian women to register for an identification document, can be partly overcome with the use of blockchain technology. The concept of blockchain is based on a decentralized idea (Singh et al., 2021). This enhances the possibility to build up an organisational decentralized system for everybody to register, regardless of their place of residence (Tykn, 2021). Through this flexible system, indirect and direct costs can be avoided (World Bank, 2021d). Decentralization is

also a booster for people who are restricted by the loss of income due to long travel distances, because their travel time is reduced or not even necessary. Barriers that arise at the registration centers might be alleviated completely. The system of identity management based on blockchain technology does not need a permanent registration centre or office. Identity issuers may be official public authorities or other organizations that have been commissioned by an official and trustworthy organization. This could be a government but also non-governmental organizations or aid organizations (Tykn, 2021). Geographic decentralization is also contributing to the elimination of gender-specific barriers at the registration centers like the lack of provision for nursing or pregnant women.

Patriarchal structures are nationwide established (Amiesimaka and Payam, 2021). The lack of awareness on why having a proof of identity is important will not be overcome with blockchain technology. Furthermore, the illiteracy rate of Nigeria will not be influenced directly by blockchain. But some aspects of the sociocultural barriers can be affected by blockchain. When women can register themselves, the treatment at the place of the identity issuer could function as a neutral place. Because independent organizations can issue a credential, women would be treated fairly at the place where the credential is be issued (World Bank, 2021d). If women can register, they are in possession of their own identity. This creates a higher independency from men (Lopez et al., 2019; Thylin and Duarte, 2019).

The last category of barriers concerns technical aspects. As a technology, blockchain can contribute to lift these. Corruption can be prevented through the decentralized system of the blockchain (Lopez et al., 2019). The DIDs on the blockchain are immutable and that is why nobody can change the information on the blockchain (Singh et al., 2021). Next to corruption, fraud is reduced for the same reason. Moreover, the decentralized system simplifies the registration process. Nigerians could be motivated to register more and the ability of gaining more statistical data about the population may be realized (UN LIEG, 2019). In 2014, so-called smart cards were established in Nigeria. This type of e-ID has helped to establish more administrations in the state (Singh et al., 2021). Therefore, the number of citizens registered may rise as a result. Especially in low-income countries like Nigeria, where there are low investments in digital data capture infrastructure, blockchain technology enables an easier way of capturing data and ensures its safety (Biscaye et al., 2015). An important aspect of motivating citizens for registration is raising the awareness and knowledge about what having proof of identity is good for. If a certain awareness level is reached, blockchain has a high potential to help secure the process of registration for the citizens (Kamath, 2018). A further hindrance to registration is a limited access to resources. This includes the various technical equipment needed for the registration process. If a blockchain-based management system is implemented, the use of specific technical resources can potentially be reduced, for example, fax machines or printers. The digitized process ensures the use of less paper and plastic as the credentials are stored

on e.g., a digital device (Biscaye et al., 2015). Moreover, less human resources and qualified personnel are needed because of the digitalized procedure (Tykn, 2021).

5. Discussion and Conclusion

Even though the implementation of blockchain technology for ID management can be a driver for female empowerment and independency from men, it is not possible to lift the patriarchal structures within the cultures of Nigerians. Sociocultural barriers for implementing blockchain technology for identity management mainly arise through these patriarchal structures. According to the World Bank (2021b) the registration process in a sustainable future should include three pillars: inclusion, design, and governance. With a self-sovereign blockchain-based identity management this outlook may be fulfilled. The aim of the World Bank (2021b) is to create a management system that includes everybody regardless of any abilities and has high safety standards and useful platforms that are understandable for everybody. From a governance point of view these management systems should create information for governments and enforce legal frameworks. Using blockchain for identity management can meet these predictions. Consequently, it can be stated that blockchain represents a promising technology for registration. Around 165 million Nigerians are not registered (World Bank, 2021a; World Bank, 2021d). Women are facing a lot of challenges when trying to register for a proof of identity. Men are not confronted with as many barriers as women due to the mostly patriarchal structures, but they are not all registered either. Regarding the prior identified barriers, it can be said that there is a gender gap in the registration process for Nigerians. However, the use of blockchain-based identity management offers great potential for a safe and progressive system that can operate in Nigeria and other countries all around the world. Due to its properties, this technology provides new possibilities for existing independently of governments, corruption, and discrimination. If the technical requirements are met, then it is possible to implement blockchain-based identity management with a comparatively low consumption of resources and the many other advantages just mentioned. Thus blockchain-based identity management has the potential to contribute to sustainable development. Nevertheless, it should be noted that this is a technology, which by itself cannot ensure that the knowledge of why an identity is important is understood within society, nor can it ensure that patriarchal structures are loosened. Since technology is about the availability of a non-disposable nature, humans always play the role of implementing the benefits. Therefore, it is indispensable to involve society if socio-cultural barriers are to be dismantled and to raise awareness, e.g., through better education about this topic, in order to ensure that more people can be registered.

When applying blockchain technology for identity management several SDGs can be indirectly met. First, SDG 16.9 as already mentioned would have the potential to be achieved if more people would get registered. Blockchain for identity management would have an

indirect influence on this goal. Second, SDG 5 on achieving gender equality. Even if blockchain cannot change gender discrimination, the properties of the technology can influence the system of registration. Furthermore, SDG 9 on building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation is influenced by the implementation in some parts. Using blockchain technology a certain digitalization level can be achieved. It supports technology development and enables sustainable and resilient digital infrastructure with less resource-use. Other SDGs are influenced by an increased presence of registrations. For example, SDG 3 on good health and well-being is impacted by the fact that people can access medical services with the help of a proof of identity. In addition, by registering the population, access to the school system can be improved, and children and young people will have a better chance of education (SDG 4). Furthermore, economic goals are also influenced. By tracking proprietary opportunities, such as ownership of land, or access to financial institutions, SDG 8 on decent work can be influenced. Furthermore, the existence of proof of identity can help facilitate democracy, which according to the United Nations is indispensable for sustainable development. These examples show only small applications and impacts that arise when blockchain technology is used for identity management. In summary, a positive impact on the SDGs can be identified.

Limitations of this paper are the targeted focus on the barriers and the selection of sources in a year of a pandemic. Alongside the barriers that are affected or lifted using blockchain technology for identity management, there will be other aspects such as certain drivers that are influenced. Moreover, more critical aspects on the use of blockchain technology for identity management should be examined. When future work is conducted it is advisable to use current research. Due to the Covid-19 pandemic some projects were on hold and new research was coming up from mid-2021. Therefore, it would be recommendable to keep the status up to date.

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Decentralized Finance - Use Cases in Africa: Blockchain-based Local Cryptocurrencies for Communities in Developing Countries

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Abstract – What is the current status of local cryptocurrencies in African communities and what is their estimated potential for the future? What opportunities do these digital currencies offer, but also, what barriers and challenges do they face? The following research aims to answer these questions.

In this study, local cryptocurrencies can be understood as a community-driven monetary system based on the blockchain technology. The digital currency enables locals to exchange goods and services within the community. This guarantees the provision of basic needs, leads to financial inclusion and supports the fulfillment of the Sustainable Development Goals. The aim of this study is to determine the current situation and to examine the potential for future development. To investigate these issues the current study sheds light on potential opportunities but also identifies important barriers that must be overcome before local cryptocurrencies can gain widespread acceptance.

This research is of importance due to the increasing relevance of cryptocurrencies based on blockchain technology and presents the research results of this topic in African communities. This work aims to answer the above questions and should lead to further knowledge in this field.

Keywords – blockchain, decentralized finance, developing countries, local cryptocurrency, sustainable development

1. Introduction

Cryptocurrencies are one of the innovations of the last two decades and have brought about several benefits but also some barriers. The once unknown technology is now getting more attention than ever before (Ahishakiye, Niyonzima, & Diko Wario, 2018). Today cryptocurrencies are used in many exchanges in the whole world (Linton, Teo, Bommes, & Chen, 2016). The main use of cryptocurrencies is in the finance sector. They are also called virtual currencies because they are not money but a unit of account which work in a decentralized way (Brühl, 2017). Because they are “decentralized by nature” and based on blockchain technology, they could help to avoid corruption, land-grabbing and forgeries of academic documents (Ahishakiye et al., 2018; Foster, MacDonald, & Johnson, 2021). The application could also help developing countries to overcome their barriers, to be independent from big players and to support communities in development countries (Ahishakiye et al., 2018; Wilhelm, 2019).

Therefore, the focus of this research is to show, in which way the local cryptocurrencies can play a decisive role for the area of sustainable development. It needs to be stated that the foundation for sustainable development related to blockchain technology was first laid out at the 2017 World Economic Forum. During that forum, the technology was placed in the context of business, economy and government and a 20-year version was designed for the adoption of the technology (Tapscott & Tapscott, 2017).The Sustainable Development Goals (SDGs), which are defined by the United Nations (2015) and are based on the Millenium Development Goals (MDG´s), include 17 sustainable development goals with 169 targets to improve global development with the focus on the five P's "People, Planet, Prosperity, Peace and Partnership" (United Nations, 2015).

With the focus on the five P's, the SDGs contain the three dimensions of sustainability – the economy, the ecology and the social component (Hamele, 2017). It should also be mentioned at this point, that blockchain technology does not address just one SDG, but is part of multiple targets, as the SDGs are closely related to each other (Aysan, Bergigui, & Disli, 2021). However, the implementation of these goals has proven to be difficult (Foster et al., 2021). This is because blockchain is just beginning to reach its peak and is now slowly moving towards practical use (BDO, 2020).

As the state of research shows, blockchain-based local cryptocurrencies in Africa are a current topic. Nevertheless, the focus of published research remains on well-known cryptocurrencies such as Bitcoin and Ethereum. However, there are almost no published case studies on local cryptocurrencies in African communities. This study aims to fill this gap and tries to reveal the extent to which local cryptocurrencies have already been implemented and whether they can make a positive contribution to the sustainable development of developing countries. The main question, "Do local cryptocurrencies have a future in African communities?" should help to answer whether or not cryptocurrencies can lead the way to a sustainable future.

Therefore, in the first part, the paper gives a theoretical overview of what decentralized finance, blockchain, and cryptocurrencies mean before going on to explore information about developing countries, Africa and its communities. After that, the second part of this paper follows with the research. First, the choice of methodology is stated in the theoretical context. Second, the description of the analysis sections is presented. Third, the evaluations of the expert interviews are analyzed. And last, the results will be discussed and the research questions will be answered.

2. Theoretical Background

This chapter deals with the background of decentralized finances like blockchain and the several blockchain-based cryptocurrencies. As this paper focuses on different cryptocurrencies based on a case study in Africa, this chapter will also provide information about Africa, the communities and the local cryptocurrencies that are used by the African communities.

Decentralized Finance

The decentralized financial system is known as a new, secure and cost-saving technology compared to the traditional centralized financial system (Ozcan, 2021). Decentralized Finance (DeFi) is a “Blockchain-based financial infrastructure” where the financial services are transacted via a decentralized platform (Schär, 2021). One of those decentralized platforms is called blockchain which will be explained in detail in this section (Gayvoronskaya & Meinel, 2021). Decentralized means that a transaction can take place without the need for a third party that controls every transaction (BNetzA, 2019) and that all the transactions are saved not only on one server but on every server that is registered in the network (Houben & Snyers, 2018). As a result, advantages such as financial inclusion and transparency as well as a quick and anonymous payment could be created (Ozcan, 2021). Another opportunity that DeFi provides is that anyone can access the services from anywhere in the world (Ozcan, 2021). It also avoids the misuse of data because no one can debit your own wallet and every data is crypted (Houben & Snyers, 2018). Yet, it is not accepted by most of the people worldwide because it is still an unknown technology and needs more regulations in order to be implemented (Ozcan, 2021). With regard to African communities, where central infrastructures such as trusted registries or banking systems are often lacking, the decentralized approach can help to save costs (Ozcan, 2021). This can be achieved by eliminating the need of an intermediary (third party) to verify and approve transactions (Brühl, 2017). In addition, dispensing with an intermediary can help speed up these processes and simplify access to goods and services (Welzel, Eckert, Kirstein, & Jacumeit, 2017). As cryptocurrencies are based on blockchain technology and this technology works in a decentralized fashion, the following chapter should give an overview of how it works.

Blockchain

Blockchain technology, also called a distributed ledger system (Bose, Dong, & Simpson, 2019), gained significance in recent years (Ahishakiye et al., 2018). Back in 2008, blockchain was firstly mentioned by Satoshi Nakamoto who is the founder of the technology. Nakamoto laid the foundation with his publication "Bitcoin: A Peer-to-Peer Electronic Cash System" (Meinel & Gayvoronskaya, 2020). In the following year, he published the first version of the Bitcoin-Open-Source-Software (Meinel & Gayvoronskaya, 2020). Although Bitcoin already had a high profile back in 2008, interest in the technology has increased significantly in recent years (Welzel et al., 2017).

So, what is behind blockchain technology and how does it work? Blockchain was decentrally programmed with mathematical algorithms, also called cryptographics (Houben & Snyers, 2018) and is used mainly in the finance sector with the aim to create more “transparency, traceability and security” (Saberi, Kouhizadeh, Sarkis, & Shen, 2019). The name of blockchain comes from the technology and the structure itself. A blockchain consists of various data sets, which in turn are composed of a chain of data blocks (Natora, 2021).

A block comprises several transactions. The hash value and a nonce ensure the integrity of the previous block, preventing fraud (Atzori, 2017). A consensus mechanism then safeguards that the stored data cannot be changed or regulated by a third party and is therefore immutable and traceable (Houben & Snyers, 2018; Calcaterra & Kaal, 2021; Welzel et al., 2017). In this way, it ensures that transferring money and assets take place in a secure way (Nofer, Gomber, Hinz, & Schiereck, 2017).

With the focus on the application of blockchain in the finance sector, its uses can be divided in three different categories. Firstly, it is used for the storage of value such as information or data (Kubát, 2015); secondly, for financial transactions (Wendt, 2021); and lastly, for smart contracts (BNetzA, 2019). In addition, blockchain can also be used in various sectors like healthcare, for tracking the supply chain or in the field of public administration (Houben & Snyers, 2018). But this paper aims to mainly focus on the financial sector, as this is the sector that has seen the greatest application of blockchain so far (Nofer et al., 2017; Meinel & Gayvoronskaya, 2020). Blockchain has the ability to enhance the administration of public services, which offers significant potential with regard to developing countries and their frequent lack of infrastructure (Wilhelm, 2019).

However, blockchain technology does not only have advantages, but also comes with various barriers that should be considered when implementing it within African communities. Up to now, only a few organizations have gathered practical experience due to the fact that implementation has been very expensive so far and because there is still a lack of regulation. Policy makers are still not ready to implement blockchain technology in the open sector (BDO, 2020). In addition, it could potentially be used for illegitimate activities because of the anonymity (Houben & Snyers, 2018). If the private code of a network user is hacked by another party, the hacker could “use [it] to sign transactions and, in the case of cryptocurrency, steal the money” (Welzel et al., 2017). With a focus on signing a smart contract, the anonymity could also lead to mistrust between the two parties (Meinel & Gayvoronskaya, 2020), which may make it more difficult to conclude a contract. One last important barrier to be mentioned at this point is the high energy consumption (Wilhelm, 2019). Because every hash includes the code of all other hashes, a change in the system has the effect that every other hash has to be changed which as well consumes an enormous amount of energy (Saberi et al., 2019). The presented barriers show that there is still a discrepancy between benefits and barriers. Welzel et al. (2017) summarized the discrepancy in the following sentence: “Blockchain still faces the balance of the three components: security, acceptance and effectiveness” (Welzel et al., 2017). This statement also includes local cryptocurrencies as they also have to face these challenges to achieve complete implementation.

Locally-based cryptocurrencies

Blockchain uses monetary so-called tokens as a currency (Saberi et al., 2019; UNRISD, 2016). There are several cryptocurrencies, which are used and known worldwide, but the

most common ones are Bitcoin, Litecoin, Ripple, Monero (Nofer et al., 2017) and Ethereum (Tapscott & Tapscott, 2017). In comparison, local currencies are mostly used by a specific community and are therefore also called community-driven monetary systems (Mqamelo, 2021). Local cryptocurrencies are defined as digital cash and are also based on blockchain technology. Local cryptocurrencies offer the potential for financial inclusion (Sander & Schmidt, 2017). Especially in times where access to a bank account seems to be difficult, the barriers to accessing a cryptocurrency are very low (Sander & Schmidt, 2017). Accordingly, local cryptocurrencies are crisis independent (Mqamelo, 2021). In addition, payment processes are greatly simplified, requiring only an app and a cellphone to complete a transaction (Schaw, 2018). This platform (app), which is needed to transfer cryptocurrencies, is called decentralized application (Houben & Snyers, 2018). Local cryptocurrencies can be particularly significant for small businesses in this regard. Citizens can thus participate in commercial transactions and support local businesses, while also having the opportunity to earn cryptocurrencies in addition to making payments (Shaw, 2018). Thus, it can attract new customers, support local businesses (Shaw, 2018) and open new markets which leads to the result of increasing added values (Foster et al., 2021).

But there are some challenges that the local-based cryptocurrencies have to overcome, such as “heterogeneity, incentives, and credibility” (Foster et al., 2021). Heterogeneity is understood as the fact that there is no standardization of blockchain applications for sustainable development so far (Foster et al., 2021).

The other incentives mentioned above are a challenge as well because most of the local projects have a high value with low cost. This often leads to competition instead of the sustainability. Furthermore, the issue of credibility leads to the “risk [of] increasing the digital divide” (Foster et al., 2021). Another big challenge with local cryptocurrencies is transferability (Sander & Schmidt, 2017). This is because most of the payments are made with fiat money and the people thus have to exchange their digital coins for fiat money, which can be a problem in rural communities without technical infrastructure (Foster et al., 2021; Sander & Schmidt, 2017). Fiat money is understood as money, which is “not convertible into coin or specie of equivalent value” (Merriam-Webster, 2021). This suggests that the adoption of local cryptocurrencies in rural communities faces a major challenge that significantly reduces the likelihood of successful implementation (Foster et al., 2021; Sander & Schmidt, 2017). This problem is particularly visible in developing countries, which will be discussed below.

Developing Countries

According to the German Federal Ministry for Economic Cooperation and Development, a developing country has several characteristics. These are poor food supply for large groups of the population, resulting in malnutrition and hunger; a low per capita income and poverty. In addition, they also generally have no or inadequate health care, high infant

mortality rate and low average life expectancy. Furthermore, inadequate educational opportunities and a high illiteracy rate, high unemployment, an overall lows standard of living and an often extremely unequal distribution of available goods are also characteristics of these nations (Federal Ministry for Economic Cooperation and Development, 2021).

Developing countries are considered to be those with similar social and economic poverty levels (Ahishakiye et al., 2018). This economic poverty level exists because of weak institutions, corruption, low level of social trust, education levels, power concentration and the role of financial intermediaries (Sander & Schmidt, 2017).

Status Quo

Financial exclusion in developing countries is still a problem that many people face (Sander & Schmidt, 2017). They often cannot open a bank account, which stops them from participating, covering their insurance or getting small loans to build up their businesses. This exclusion triggers social inequality because it increases the gap between the rich and poor (Sander & Schmidt, 2017). In addition, international organizations are still challenged with the lack of transparency, money laundry and the misuse of funds while offering cash assistance in developing countries (Ahishakiye et al., 2018). According to the United Nations Research Institute for Social Development (UNRISD), blockchain technology still has little connection to the people in poor countries (UNRISD, 2016). Therefore, the question is whether the technology can empower previously excluded communities and thus have a positive impact on the financial sector. By implementing local cryptocurrencies, developing countries may have the opportunity to progress further (Wilhelm, 2019; Ahishakiye et al., 2018) by developing the lack of infrastructure (Atzori, 2017). However, insufficient access to new technologies and the lack of infrastructure hinder this development (Wilhelm, 2019). The advantages and disadvantages, which will be presented in the following chapter, will examine these barriers.

Advantages and Disadvantages of Blockchain for Developing Countries

Especially in poor countries, a big advantage of the technology is that it can provide more efficient functionality through decentralization so that wealth can be better protected (Atzori, 2017). However, local cryptocurrency can also be regarded as being safer than fiat money, especially in countries with high inflation rates and strong government control (Sander & Schmidt, 2017). Money can be saved in the online wallet, which could help citizens of countries with a poor money structure and a big dependence on cash. Local cryptocurrencies can be used not only as a supplement, but also as a substitute currency in countries with a declining monetary system (UNRISD, 2016). Moreover, local cryptocurrencies are accessible to everyone and a bank account is not necessary (Foster et al., 2021). Blockchain, with its transparency and integrity, could also reduce the problem of corruption and bribery (Tapscott & Tapscott, 2017). Nevertheless, in order to achieve the desired success of sustainable development, it is essential that all stakeholders become involved (Tapscott & Tapscott, 2017; Foster et al., 2021). Necessary stakeholders could

be, for example, “innovators, venture capitalists, banks and financial services, developers, academics, non-governmental organizations (NGOs), government bodies, [regulators and law enforcement], and users or citizens” (Tapscott & Tapscott, 2017).

Overall, it can be assumed that blockchain technology can help citizens in poorer countries to develop their economy. This is because it is possible to lower costs by reducing the transaction fees (Sander & Schmidt, 2017). It offers the opportunity to have a global decentralized bank account without setting up at a formal banking institution. As a result, an excluded citizen thus has the opportunity to use the local cryptocurrency for various financial services and could eventually achieve financial inclusion (UNRISD, 2016; Sander & Schmidt, 2017). “But just because [B]lockchain and related technologies reduce the costs of peer-to-peer transactions does not mean that such transactions are cheaper than centralized trading on exchanges.” (Pirrong, 2019). However, aside from that, there are also some disadvantages and barriers. Decentralization can lead to the disempowerment of citizens and a stateless global society (Atzori, 2017). Therefore, this technology should be treated with caution, especially in initiatives for sustainable development, as there is often a lack of state supervision (Foster et al., 2021). In addition, the knowledge about cryptocurrencies, their structure and their correct use is still lacking (Sander & Schmidt, 2017).

Many developing countries that are facing the advantages and disadvantages of blockchain technology are localized in Africa. Therefore, the next chapter presents facts about the continent of Africa, its countries and their economic wealth.

Africa

The continent of Africa consists of 55 independent states and is twenty times the size of Europe. Africa cannot be perceived as homogeneous, as the countries differ greatly from one another economically, politically and culturally (Tetzlaff, 2018). The continent still has regions such as the Middle East and North Africa, where extreme poverty exists and has even doubled between 2015 and 2018 (World Bank, 2020). Corral, Irwin, Krishnan, Mahler, & Vishwanath (2020) state that most of the 43 poorest economies are in Sub-Saharan Africa (Corral et al., 2020) which is also confirmed by the World Bank in 2020 (World Bank, 2020). In contrast, the extreme poverty rate decreased in some countries like Kenya, Ethiopia and Namibia (World Bank, 2020).

Blockchain in Africa

Not only in technologically advanced parts of the world like U.S., but also in Africa, innovation relating to blockchain has found ways to advance and knowledge about it has increased over the years. In 2014, special events were founded by Sonya Kuhnel and Theo Sauls with the aim to educate and inform people from the private and public sector about cryptocurrencies. The founders organized several events with titles like: “Blockchain Af-

rica Conference", "Crypto Fest" and "DeFi Conference" (Blockchain in Africa, 2021). Specific countries like Uganda also hosted a conference in 2018 with a special focus on blockchain technology. The conference was organized by The Blockchain Association of Uganda, and it was discussed in which way blockchain could help Uganda and the other African countries to increase their economic growth (Mayanja, 2018). These examples should help demonstrate the increasing relevance of the technology in African countries.

Local cryptocurrencies in Africa

Well-implemented examples of local cryptocurrencies in African communities are Sarafu (Mqamelo, 2021), BitPesa (Sander & Schmidt, 2017), e-Ora (Madore, 2019) and KuBitX (KuBitX, 2020). These cryptocurrencies are used primarily for the exchange of goods and services within the community to guarantee the provision of basic needs (Grassrouts Economics, 2021). BitPesa is based on blockchain and offers payment possibilities in every main African currency. It was established and licensed in the year of 2013 (BitPesa, 2021). At the Blockchain Africa Conference in 2021, Mr. Chut Chimezie from Nigeria stated that the infrastructure (especially electricity) is still lacking for the adoption of blockchain technology. He mentioned that the African countries should focus on expanding their electrical power infrastructure, e.g., by using solar power. If the infrastructure would exist, the continent would have the possibility to be independent from the West and especially from the big players that dominate the blockchain networks (Chimezie, 2021). But what does it mean for communities?

Communities

A community refers to the municipality or social unit that can be assigned to a geographical unit. However, this is rarely homogeneous, but rather has heterogeneous structures and subgroups that are based on different ethnicities, beliefs, views and opinions. Nevertheless, viewed from the outside, a community is part of a larger entity that has its own shared structure as a result of social, political and cultural events. Another characteristic is that communities usually share similar interests (Stefanie Vogt and Melanie Werner, 2014) and is thus again perceived as homogeneous (König & Hammerich, 2021).

There are several chances of blockchain applications for communities because the technology is suitable for social groups of any size. However, there are also doubts, since a newer smartphone is needed for the application (Foster et al., 2021). The Internet connection and the power grid must also be well developed. The most important point of financial inclusion of poorer communities is to ensure that small farmers or other local groups can invest money and thus have stable, long-term access to credit and other financial services. This also generally highlights the problem that blockchain has been criticized for only creating a short-term solution for developing countries. Ultimately, however, long-term solutions must be developed that address the core issues of the problem. For example, it is criticized that only social elites with access to new networks continue

to benefit from it (UNRISD, 2016). Therefore, even though blockchain can generally contribute to sustainable development, there are still many intentions that lead in the wrong direction and thus do not contribute to sustainable development (Foster et al., 2021). To explore this issue further and to find an answer to that problem, expert interviews were conducted as part of the methodology of this paper.

3. Methodology

In the previous chapter, the relevance and suitability of blockchain technologies and local cryptocurrencies were comprehensively explained. Next, the methodology will be discussed by presenting the research questions and the research methodology itself, followed by showing the data collection and an explanation of the data analysis procedure.

The Research Questions

Based on the literature review, research questions were developed for the structured and systematic investigation of the local based cryptocurrencies in Africa. These were used to define the evaluation object and objectives and to conduct qualitative interviews with experts in order to answer the main research question of the paper (Kuckartz, Dresing, Rädiker, & Stefer, 2008):

Main question:

- Do local cryptocurrencies have a future in African communities?

Sub-questions:

- What are the opportunities of local cryptocurrencies for African communities?
- Which challenges do developing countries in Africa face while implementing local cryptocurrencies successfully?

Chosen Research Methodology

Empirical research can be basically divided into quantitative and qualitative research. For this research, a qualitative approach was chosen, which meant that a small set of cases were selected and considered in more detail (Brüsemeister, 2008). This method has a high level of flexibility and a large information content (Berger, 2016). In the context of qualitative research, so-called experts interviews can be conducted (Kuß, 2012). They can be defined as a systematic and theory-driven procedure of data collection in the form of interviewing people who have exclusive, insider knowledge (Kaiser, 2014). While this method has a great deal of practical relevance, there are also some disadvantages; for example, the problem of non-standardization, an insufficient means for verifying results (Kaiser, 2014) and difficulties regarding the comparability of the interviews. Likewise, linguistic problems, cultural differences related to language meanings (Pickel & Pickel, 2009) and interviewing bias can impair the evaluation (Glantz & Michael, 2014). Accordingly, essential quality criteria for reliability, objectivity, and validity must be taken into consideration (Berekoven, Eckert, & Ellenrieder, 2007). Nevertheless, after weighing the

advantages and disadvantages, the authors of this paper concluded that this methodology is suitable for the work presented here.

Data Collection

A semi-structured interview guide was chosen as the instrument for conducting the expert interviews. An interview guideline represents the written formulation of the research interest (Liebold & Trinczek, 2009). It structures and guides the interview (Kuckartz et al., 2008) so that comparability between interviews is ensured (Meuser & Nagel, 2009). The research questions are not posed directly but are first written down and operationalized into interview questions (Kaiser, 2014; Gläser & Laudel, 2010). Due to the principle of openness, it is explicitly possible to deviate from the guideline during the course of the interview (Kaiser, 2014). Thus, the guide provides a structure but does not determine the course of the interview (Liebold & Trinczek, 2009).

Before conducting the semi-structured interviews, two pre-tests were conducted and, based on this, the interview guideline was finalized (Kaiser, 2014). In this way a successful implementation of the main research was ensured (Jacob, Heinz, & Décieux, 2013). It can be divided into two main blocks, each covering the same topics. This allowed the expert to focus on just one topic during the interview (Jacob et al., 2013). The first topic block ("General questions") included the introductory questions and those regarding the main research question. The second thematic block ("Specific questions") included the research sub-questions and addressed the “opportunities” and the “challenges”. In total, the guideline was based on seven questions.

In following data collection phase, the interviews were conducted, recorded, and transcribed (Kuckartz et al., 2008). Contact was initiated by the University of Bochum, via E-mail or internet-based social media services (LinkedIn and Facebook). After receiving positive feedback from an expert, the semi-structured interview guide was sent to that expert so he or she could familiarize themselves with the questions in advance. The actual interview was conducted via the video conferencing software “Zoom”. The interview was recorded with the consent of the expert. After conducting the interview, an interview transcript was prepared. Transcription is understood here as the writing down of interview transcripts (Deppermann, 2008). The audio recordings of the interviews were used as the basis of the transcripts in this research. There are different opinions about the extent to which expert interviews have to be transcribed and which rules have to be followed. According to Meuser & Nagel (2009) and Gläser & Laudel (2010) it is not necessary to note all paraverbal utterances. This work is therefore based on the transcription rules of Dresing & Pehl (2018), which are based on the set of rules of Kuckartz et al. (2008). At this point, content semantic transcription was used because these rules deliberately focus on the speech contribution (Dresing & Pehl, 2018). The transcription rules were applied to smooth the speech and align it with written language (Kuckartz et al., 2008). The experts

were anonymously documented (Dresing & Pehl, 2018). Following the transcription of the expert interviews, the data could be analyzed.

Data Analysis of the Research

Our research was based on three expert interviews, which were conducted from May until June 2021. The average interview duration was approximately 32 minutes. In summary, there were three participants, all of which were male and worked in the blockchain industry. One expert was of German nationality and two others were from Africa.

The results are based on a qualitative content analysis (Kaiser, 2014). The researchers applied the qualitative content analysis according to Mayring (2020), which aimed to answer the above presented research questions. Therefore, deductive upper categories and inductive subcategories were obtained based on the interview material. This represents a common combination in research with qualitative content analyses (Vogt & Werner, 2014). The deductive category formation according to Mayring (2020) structured and systematized the material. For this purpose, suitable text passages of the transcripts were assigned to the previously created categories, which required interpretive decisions. The coding guide includes the upper categories, a definition, an anchor example and the coding rule (ibid.). The coding rules intended to facilitate the assignment of text passages to the appropriate categories and to ensure clear delineation of these classifications (Scheibler, 2021). The six upper categories developed were based on the guide, which in turn was based on the research questions. After finalization of the upper categories, the interviews were coded according to the coding rules and the assignment of the relevant text passages to a category is thus referred to as "coding." (Kuckartz et al., 2008). This process was done using the computer-assisted analysis MAXQDA. Figure 1 below depicts the deductively formed upper categories.

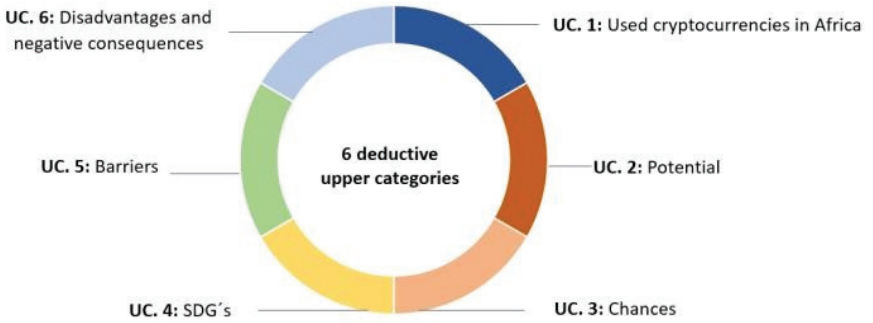

Figure 1: Upper categories (own illustration, 2021).

After the completed formation of the upper categories and the corresponding coding of the text material with the help of MAXQDA, a further analysis of the data took place. For this purpose, the analysis technique known as summary content analysis was applied. It reduces the material to such an extent that the text is limited to its essential components.

This is done by an inductive formation of subcategories. The categories formed help to ensure a good level of verifiability so that reproducible results emerge and a generalizing evaluation is made possible (Mayring, 2020). The expert interviews can then be compared with each other and commonalities and differences become apparent (Meuser & Nagel, 2009).

As part of the summary content analysis, the paraphrasing step involved first deleting all insignificant content. Subsequently, the generalization to the abstraction level took place, whereby the contents were prepared and processed in the same way and statements with the same content could be deleted. This was followed by the reduction process, where only the most important content, the subcategories, were retained (Mayring, 2020). Following the inductive category formation, the subcategories were again assigned to the upper categories. The subcategories are assigned to the interview partners and grouped according to the deductively ordered upper category. In addition, it can be seen in which evaluation unit corresponding subcategories were thematized. Figure 2 below shows the inductively formed subcategories.

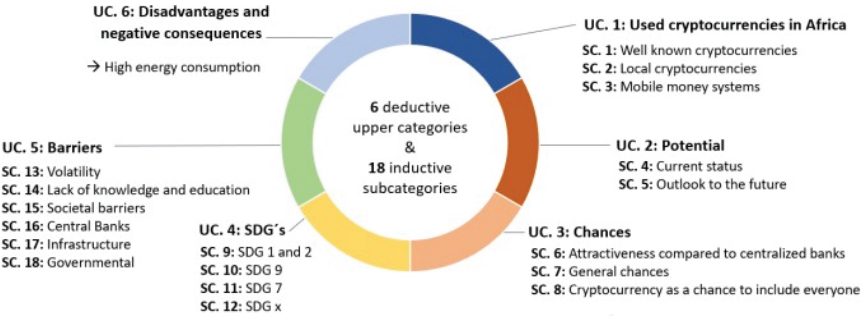

Figure 2: Subcategories (own illustration, 2021).

After obtaining the subcategories, the answers could be linked and compared with the results of the literature review (Meuser & Nagel, 2009). Thus, after conducting the summary content analysis, the most important key statements were identified. Thereupon, the obtained data could be interpreted regarding the research proposal (Kaiser, 2014).

4. Results

In this chapter, the main question will be answered first, followed by the sub-questions, which will be discussed in the sub-sections below. The results are based on the three expert interviews and therefore cannot be applied to the general public. It is solely a first attempt to answer the research questions.

Answering the Main Research Question

In order to answer the main research question (“Do local cryptocurrencies have a future in African communities?”), the results of the deductively formed upper categories "Used

cryptocurrencies in Africa" (UC. 1) and "Potential" (UC. 2) are used. These upper categories are subdivided into further inductively formed subcategories (see Appendix E).

To evaluate the cryptocurrencies in use in Africa, the subcategories SC. 1 ("Well-known cryptocurrencies"), SC. 2 ("Local cryptocurrencies") and SC. 3 ("Mobile money systems") were utilized.

The analysis of the three expert interviews revealed that well-known blockchain technologies have already been recognized and are currently being implemented in Africa. Bitcoin and Ether in particular were cited as examples of digital currencies in use ((e.g., R3: "*But then Bitcoin is king. Everywhere you go, including Africa.*" (L. 316)) (SC. 1). However, when it comes to local cryptocurrencies, the experts agreed that (almost) no local currencies have been adopted so far in Africa ((e.g., R1: "*In terms of like actual adoption in terms of local coins, we don't really have any."* (L. 113-114)) (SC. 2). Instead, however, mobile applications for money transfer services based on blockchain technologies, such as M-Pesa, are already in widespread use ((e.g., R1: „*So M-Pesa has been really prevalent here.*" (L. 129-130)) (SC. 3). The knowledge that both global blockchain applications and mobile money systems are already popular in Africa suggests that there is a very large potential for the implementation of local cryptocurrencies in African communities.

To investigate the potential of local cryptocurrencies, the subcategories SC. 4 ("Current status") and SC. 5 ("Outlook to the future") were applied. Results of this analysis showed that local cryptocurrencies have not yet enjoyed a high level of awareness ((e.g., R3: "*It is not getting popular yet in Africa." (*L. 41-42)) (SC. 4). However, the study showed that although it will take time to adopt local cryptocurrencies, this is expected to happen sometime in the future (e.g., R3: "*But I think in a sentence, that will pick up sooner than later.*" (L. 42); "*It might take a while for Africa to get there.*" (L. 71) (SC. 5)).

Thus, as an answer to the main research question, it is possible to summarize, that global cryptocurrencies such as Bitcoin, as well as mobile money systems, already enjoy a wide application in Africa, while local cryptocurrencies do not yet enjoy this recognition. However, they are expected to gain acceptance in the future, even if the experts are not clear about when this will happen.

Answering the Sub-Questions

To answer the first sub-question ("What are the opportunities of local cryptocurrencies for African communities?"), the results of the deductively formed upper categories "Chances" (UC. 3) and "SDGs" (UC. 4) were used. These upper categories were subdivided into further inductively formed subcategories.

To assess the chances, the subcategories SC. 6 ("Attractiveness compared to centralized banks"), SC. 7 ("General chances") and SC. 8 ("Cryptocurrencies as a chance to include everyone") were applied. In this regard the experts stated that there are several chances and advantages of using local cryptocurrencies. Such as easy transaction fees and the

possibility to cope with high inflation rates ((e.g. R2: „*And this local currency helps people really to cope with high inflation rate.*" (L. 34-35)) (SC. 6). Besides those chances, it is also visible that the cryptocurrencies are based on a streamlined and transparent system, which makes the entire transaction process easier and more accessible. By using local coins as currency, it can also bring more wealth to the community ((e.g., R2: "*Yes, it can help to become wealthier*." (L. 120-121)) (SC. 7). Another advantage revealed by this research was the possibility to directly include people in the trading within their own society ((e.g., R1: "*But then if we introduce a cryptocurrency, they can help them trade within one another*." (L. 241)) (SC. 8). Accordingly, it can be seen that the application of local cryptocurrencies can promote the sustainable development of African communities.

To assess the chances of the Sustainable Development Goals the subcategories SC. 9 ("SDG 1 and 2"), SC. 10 ("SDG 9") and SC. 11 ("SDG 7") and SC. 12 ("SDG x") were utilized. The study of these categories revealed that local cryptocurrencies do have the potential to fulfill the SDGs, even though every expert mentioned different SDGs. One expert stated that the fulfilment of SDG 1 (No Poverty) and SDG 2 (Zero Hunger) (R1: "*I'm leaning towards goal number one and goal number two*." (L. 261-262)) (SC. 9) and SDG 9 (Industry, Innovation and Infrastructure) are possible (R1: "*I think it's industry innovation and infrastructure. So yeah, like, I think that's like, number nine. So if there was an SDG, I'll go with it.*" (L. 274-276)) (SC. 10). Another expert leaned toward the fulfilment of SDG 7 (Affordable and clean energy) as a possibility ((R. 2: "*SDG number seven, which is energy, sufficient energy supply. It's a major goal.*" (L. 107)) (SC. 11). The last expert didn't mention a specific goal but highlighted the importance of the possibility of fulfilling the SDGs through the local cryptocurrencies by giving people a chance for financial inclusion who otherwise don´t have a bank account ((R3: "*It can help realize the SDGs when it comes to financial inclusion*." (L. 203-204)) (SC. 12).

In summary to our first sub-question above about the opportunities for local cryptocurrencies in Africa, it became apparent through our analysis of the SDGs that such cryptocurrencies have a diversity of opportunities and possibilities. The experts agree that opportunities such as financial integration into society, as well as independence from inflation rates, for example, can potentially have positive effects overall. This is demonstrated not only by the various examples of application of the SDGs but also directly, for example, by the possibility of enabling easy access to financial resources.

In order to answer the second sub-question of the research ("Which challenges do developing countries in Africa face while implementing local cryptocurrencies successfully?"), the results of the deductively formed upper categories "Barriers" (UC. 5) and "Disadvantages and negative consequences" (UC. 6) are used. These upper categories are subdivided into further inductively formed subcategories (see Appendix E).

To assess the barriers the subcategories SC. 13 ("Volatility"), SC. 14 ("Lack of knowledge and education"), SC. 15 ("Societal barriers"), SC. 16 (“Central Banks”), SC. 17 (“Infrastructure”) and SC. 18 (“Governmental”) are utilized. Through the study, it became clear what barriers and hurdles need to be overcome before local cryptocurrencies can enjoy wide recognition in Africa. For example, the volatility of blockchain-based applications was mentioned ((e.g., R2: “*The volatility upsets cryptocurrencies as a huge problem.*” (L. 170)) (SC. 13), as well as societal barriers, such as general resistance to this application possibility (((e.g., R2: “*There's a lot of resistance.*” (L. 168)). African communities are also characterized by their laissez-faire attitude and cash-driven purchasing behavior, which makes it harder for local cryptocurrencies to get accepted (SC. 15). Another barrier that was mentioned by all experts is the lack of knowledge and education ((e.g. R1: “*I think the biggest challenge is education.*” (L. 219)) (SC. 14). They mentioned that it is hard for people to classify the cryptocurrencies and that they often have negative and wrong impressions, which leads to trust problems. The root of this is that a generally low level of understanding of this technology is present within the society and the applications are usually only known in certain target groups ((R1: “*The demographic tends to lean mostly male, college educated, young, with some sort of tech backgrounds*” (L. 49-50)). Another challenge identified is the hurdle of central banks, which fear losing their power through local cryptocurrencies ((e.g., R2: “*He's facing a lot of resistance from classical banks. The banks have the fear, they will become obsolete somehow.*” (L. 50-51)) (SC. 16). The same is the case for governments and politicians, who are therefore trying to restrict the use of cryptocurrencies in some African countries ((R3: “*Looking at how tyrannical African leaders are, it might take a while.*” (L. 66-67)) (SC. 18). The final hurdle is the development of the infrastructure that is needed to convert digital coins into fiat money. This requires an agent-banking infrastructure, which still has to be built up. In addition, the need for sufficient energy is also identified as an infrastructural hurdle, as not all communities have sufficient access to electricity and to the internet, which means local cryptocurrencies cannot be used (e.g., R2: “*So if there's no electricity, then there is no internet and if there’s no internet, there's no blockchain and there is no cryptocurrency.*” (L. 82-83)) (SC. 17). However, besides those described barriers, there are some disadvantages and negative consequences to consider when implementing cryptocurrencies.

To assess the “disadvantages and negative consequences” only the upper category itself is used (UC. 6). The study revealed that all the experts interviewed agreed that the enormous energy consumption of blockchain applications poses a particular risk (e.g., R2: “*So, blockchain as such, if you think about, I mentioned Bitcoin, Ethereum, currently, they have a very energy consuming consensus algorithm*.” (L. 112-113)). Accordingly, it can be assumed at this point that local cryptocurrencies have not yet fully contributed to sustainable development.

In answer to the second sub-question of the research, it is possible at this point to summarize that local cryptocurrency is facing several barriers and some negative consequences. These include the volatility, the lack of knowledge and education, societal barriers, central banks, infrastructure and governmental barriers, as well as the enormous power consumption. In summary, therefore, local cryptocurrencies must overcome some hard hurdles, challenges, and negative consequences before it can eventually become a widespread local application.

5. Discussion and Outlook

In order to make sustainable development more possible in the future through the use of local cryptocurrencies, some recommendations for action can be made at this point. A possible way could be for example a government fund to develop the needed infrastructure and ensure a reliable energy supply. If it cannot be implemented by the government, organizations should take the responsibility and raise the pressure on the government(s). Also, it is important to lower the energy demand for those applications. However, it is likely that energy needs can be created in the future through sustainable energy reserves, which would reduce the negative impacts.

Outreach and improved education in this area would also increase knowledge of possible applications as well as the resulting opportunities. For now, lack of education and knowledge hinders the potential, causing societal barriers and rejection by central banks and governments. To overcome this problem, it must be first ensured that such technologies are more widely recognized and are thus validated by the state. However, if developing countries manage to apply blockchain-based local cryptocurrencies successfully, this technology could contribute to the development of the following segments: “overcoming weak institutions and corruption, increasing financial inclusion and empowering people.” (Sander & Schmidt, 2017; Ahishakiye et al., 2018).

6. Conclusion

The presented paper dealt with local cryptocurrencies in African communities. In addition to gaining insights for science, this work has provided an improved understanding of the topic and has raised attention for it as well.

When considering the research findings, it must be noted that the paper is based on only three expert interviews. Furthermore, only six upper categories were compared, resulting in 18 subcategories, in order to keep the work within a specific framework. A consideration of further criteria could lead to a complementary view of this study and achieve further interesting research results. Nonetheless, the three expert interviews provided valuable insights into the current situation of local cryptocurrencies in African communities in an exemplary fashion. Thus, the results of this study allow an investigative assessment of the potential future of local cryptocurrencies in Africa in terms of their opportunities and their challenges. The aim of this paper, which was to explore the local cryptocurrencies

in African communities, has thus been achieved. In this regard, it can be said at this point that the local cryptocurrencies in Africa offer new approaches and chances that contribute to a sustainable development and support the SDGs. Therefore, they have a potential to be fully established in the future. However, the identified barriers, disadvantages, and negative consequences weaken the current potential and prevent the spread of digital currencies. In addition, the extent to which the barriers and negative consequences described could be disputed in the future is something that further research on this topic could specialize in. Furthermore, as this paper was only meant to provide an overview into the topic, further research is needed to investigate a concrete case study of local cryptocurrencies in an African community and thus gain deeper insights into the topic. Yet the findings of this study can still enable stakeholders to respond accordingly to the strategies and recommended actions presented here. In this way, the promotion and optimization of this niche segment could be achieved to ensure its continued sustainable development in the future and to help it realize its diverse growth potential.

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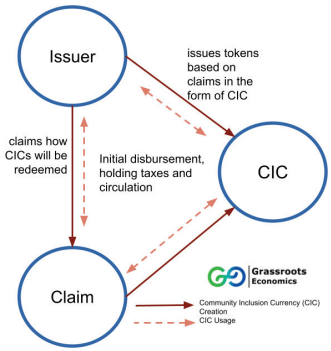
Community Inclusion Currencies in Kenya

Will Ruddick
Grassroots Economics
willruddick@gmail.com

Summary Workshop

Will Ruddick is the founder of Grassroots Economics; a physicist turned development economist, father and humanitarian who has lived in Kenya for 12 years. He will demonstrate and talk about the concept of Community Inclusion Currencies (CICs) and how various technologies, including blockchains, have been adopted in urban and rural populations, through the organization he founded, Grassroots Economics. (grassecon.org)

Grassroots Economics is a non-profit foundation that seeks to empower marginalized communities to take charge of their own livelihoods and economic future. We focus on community development through economic empowerment, basic income and community currency programs. Beneficiaries of our programs include small businesses and people living in informal settlements as well as rural areas. Our goal is to improve the lives of those who are most vulnerable.



Following COVID-19 implication in 2020, Grassroots Economics Foundation, in conjunction with the Red Cross Society, local administrations, local businesses, mosques, churches, chamas, schools, and individuals alike are working to create healthy and sustainable communities in the face of hard economic conditions through the introduction of a CIC system called Sarafu Network. Since 2020, over 55,000 households and small businesses have joined Sarafu Network and over 300 Million Sarafu have circulated among users to support each other to trade food, water, education, labour and more.

Sarafu Network aims to empower and support vulnerable Kenyan groups, businesses and households by creating a cushion in times of financial crisis through the introduction of a local medium of exchange. The charitable acceptance and usage of Sarafu tokens by both businesses and communities helps vulnerable households receive support and in turn helps local economies to keep moving during a crisis or when Kenyan Shillings are lacking (like barter trade). Data based on Sarafu usage gives donors, as well as lenders and insurers a way to gauge the impacts and risks of supporting local groups. That data can identify the volume of trade within a specific community, how connected businesses are together, how well they honor debts amongst each other and other metrics.

Community Inclusion Currencies

bloxberg

Grassroots Economics

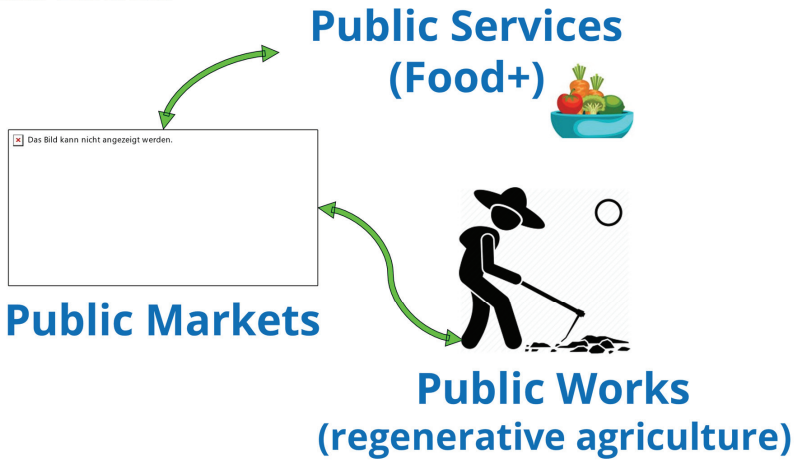
Founder and Director
Will Ruddick
will@grassecon.org

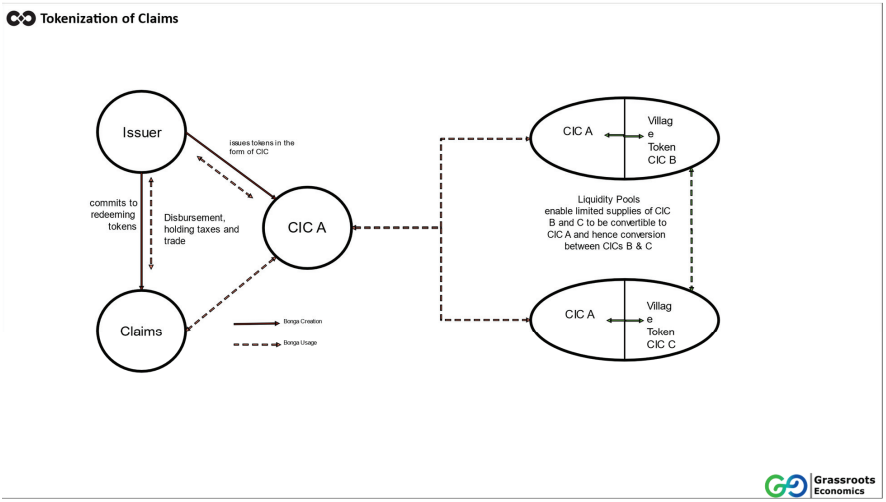
Community Inclusion Currencies

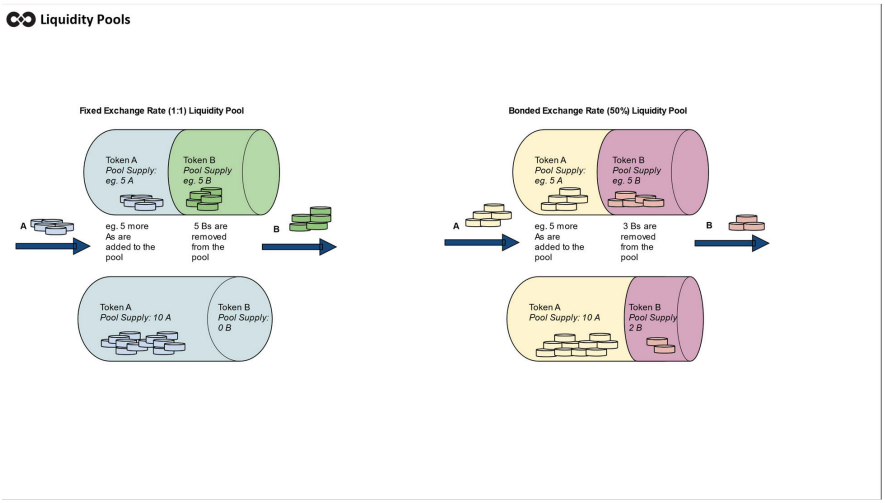
Stay in circulation -

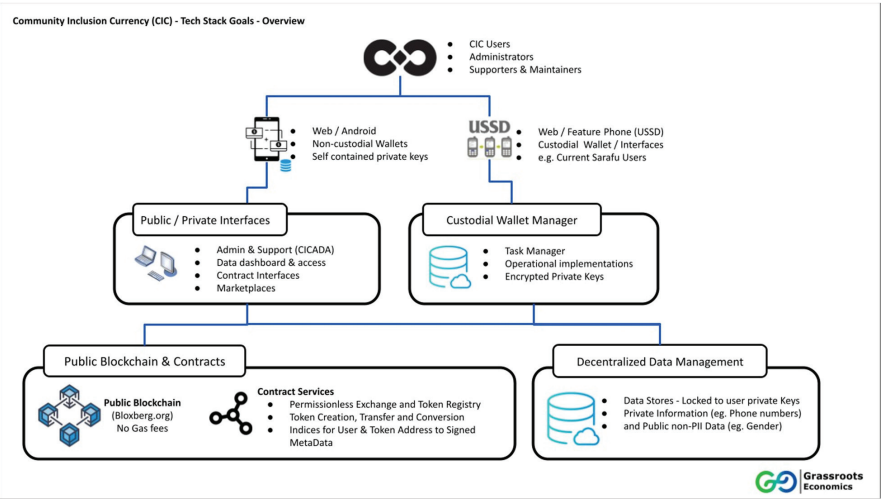
Backed by goods and services of the community

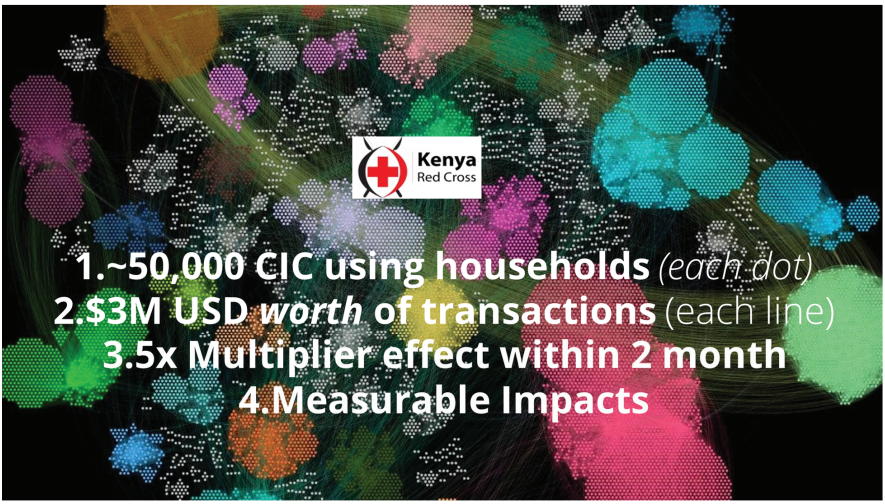
Circular Economies









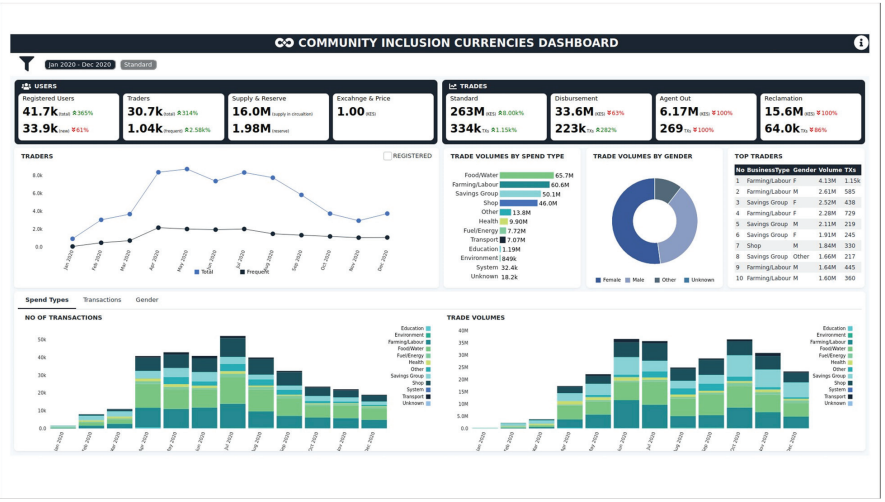


Next Steps

Private Sector & Humanitarian Partners in collaboration and support

giz

1. **Research Infrastructure:** Enable RCTs, data analysis
1. **Contract Creation:** Enables researchers and communities to develop CICs as well as other contracts
1. **Block Explorer:** Enable access to live data



Data

- **On Chain**
  - **Transactional Data:** Time, token, amount, sender and receiver wallet IDs
  - **Token Information:** Public claims, token supply, token holders (wallet IDs)

- **Off chain**
  - **User Data:** Name, phone number, gender, location, product offering, transaction notes
  - **Public User Data:** Wallet IDs, gender, regional location, product category
  - **Experimental Data:** Changes to operations, RCT trials

1. **Access:** Enabling access to blockchain / and community finance and empowering communities

1. **On boarding:** Bringing on Safaricom customers that were too poor or locked into debts.

1. **Humanitarian Linkages:** Promote SDGs and enable humanitarian organizations to support the vulnerable communities

1. **Promoting Resilience vs Reliance:** Being on the cutting edge of humanitarian innovation and ending traditional aid models.

Blockchain for sustainability - Towards a safe and just operating system for humanity

Dr. ir. Niels Faber

University of Groningen - University Campus Fryslân
n.r.faber@rug.nl

Summary Workshop

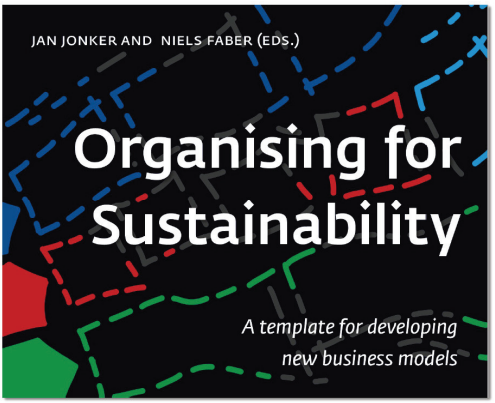
Ever since Satoshi Nakamoto's seminal paper on Bitcoin as an application of distributed ledger technology (such as Blockchain), much attention has given to the creation and utilization of cryptocurrencies. It inspired the development of the field of FinTech (financial technology). Seemingly, the richness early adopters of Bitcoin currencies managed to acquire, has inspired many to step in and give it a try as well. Despite its financial praise, in recent years Bitcoin has received criticism due to the excessive energy consumption of the IT platform on which it depends. Also, for many adopters apply it to overcome shortcomings attached to fiat-currencies, such as taxation, transaction oversight by banks, exchange rates, and so forth, public opinion and political opposition are shifting towards more governmental control on these 'outlaw' currencies. These counter movements however do not change the narrow focus on financial applications, which has chiefly limited further exploration of the potential of distributed ledger technology.

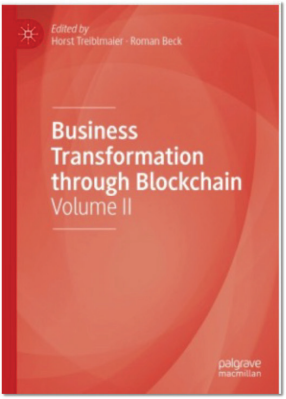
This workshop aims to explore this potential of ledger technology when applied to the wicked problem of sustainability. Point of departure is the observation of various generations of Blockchain and distributed ledger technology. Conceptually, this means that distributed ledger technology is not perceived exclusively as a platform for financial transactions. In essence, distributed ledger technology is nothing but a distributed, transactional database that allows for the registration of any form of digital object. This may be currency, but may very well also concern photographs, films, school projects, newspapers, et cetera.

Consequently, the workshop exploration starts with Blockchain application in the realm of cryptocurrencies, designated as generation 1. Key here is firstly the creation of coins and secondly using the Blockchain as a means for financial transactions. Generation 2 concerns so-called smart objects. These are digital products that normally are issued for instance by governments or authorities, stating something about an entity in physical reality. Think about your passport or birth certificate, declaring who you are and when and where you were born, the deed of a house, indicating its owner, or the DAO (Distributed Autonomous Organization). The latter concerns an organization that fully resides on the

Blockchain, represented as computer rules. Lastly, generation 3 adds a layer of coordination, fairness, and justice to the set.

Finally, the workshop reflects on various hurdles that still need to be resolved to make Blockchain for sustainability work. The link between the digital realm of Blockchain and physical reality gives rise to the issues of tokenization and the preservation of the digital-physical link, and delayed transactions. On the technological frontier, various choices remain pertaining to the platform used and specific setting of Blockchain parameters. Lastly, the context of application and the Blockchain generation required is debated.





CONTENT

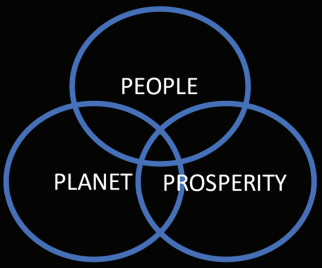
(1) The problem of sustainability

(2) Blockchain to the rescue

(3) Technological challenges

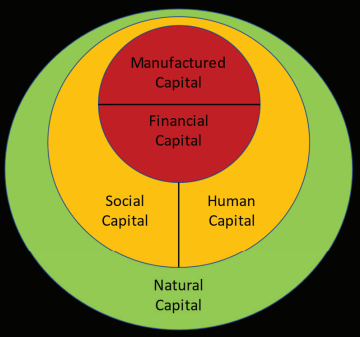
SUSTAINABILITY

TRIPLE BOTTOM LINE



John Elkington

FIVE SUSTAINABLE CAPITALS

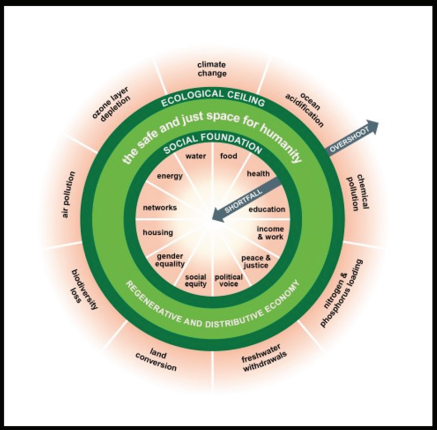


Jonathan Porritt

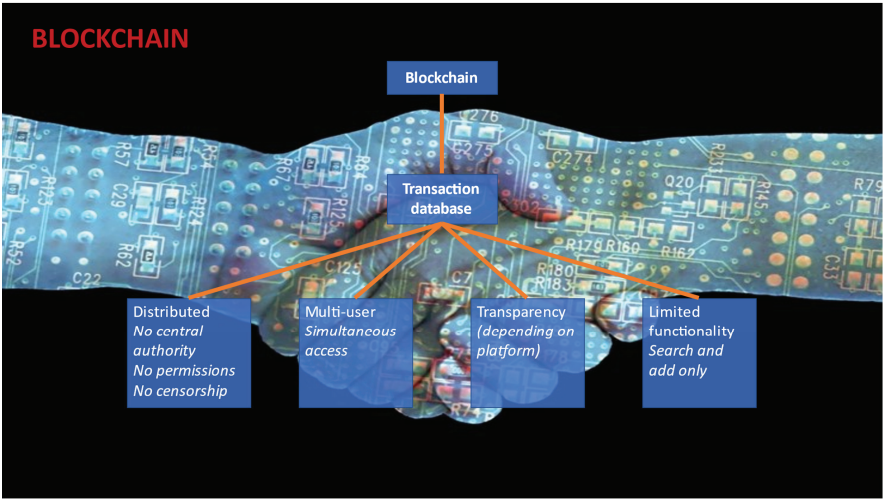
SUSTAINABILITY

DONUT ECONOMY

Kate Raworth

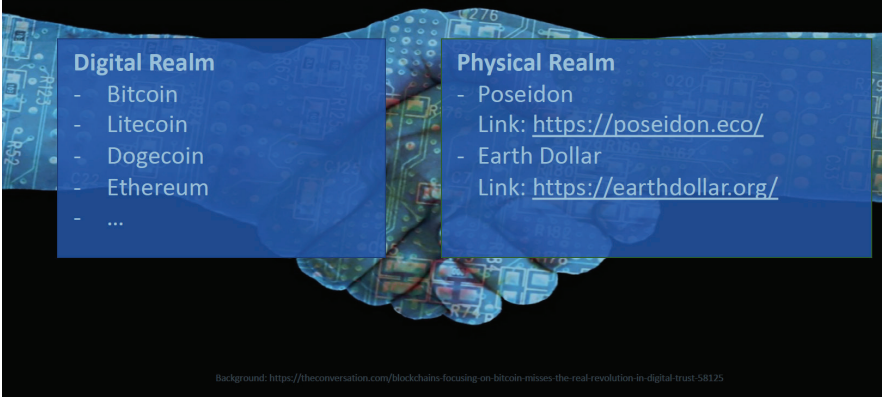


BLOCKCHAIN



BLOCKCHAIN

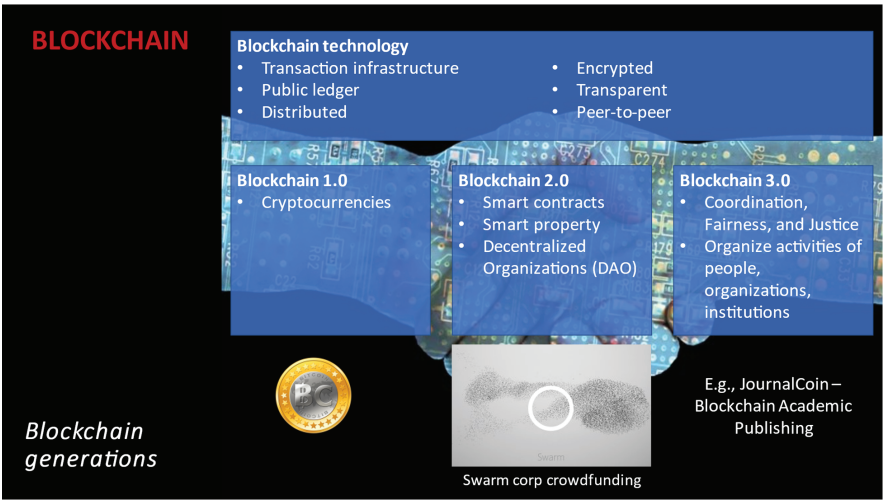
Currencies for sustainability



BLOCKCHAIN

Currencies for sustainability

CO_2 market on Blockchain

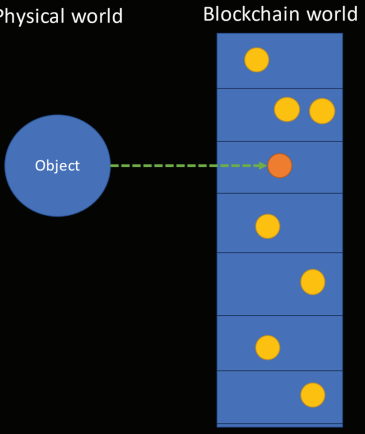


BLOCKCHAIN

Tokenization
1. Intangible assets
2. Fungible assets
3. Unique physical assets

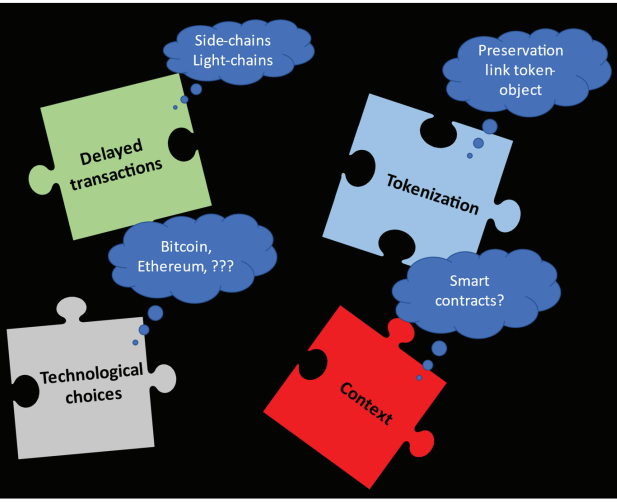
Transactions
1. Transfer ownership
2. Transfer limited rights

Models
1. Licensing
2. Trading
3. Redemption
4. Vaults & Smart contracts



https://bitcoinmagazine.com/articles/op-ed-how-tokenization-putting-real-world-assets-blockchains/

CHALLENGES



ASSIGNMENT

Objective: explore possible applications of Blockchain technology that support a safe and just space for humanity

1) Phase 1: explore the problem
2) Phase 2: ideate – How may Blockchain help to solve this?
3) Phase 3: converge – What solutions seem feasible?
4) Phase 4: implementation – What do we need?
5) Phase 5: summary

ASSIGNMENT - TOPICS

1. Circular economy
2. Sustainable Supply Chains
3. Asset sharing
4. Sustainable energy
5. Climate change

GAMB's cryptocurrencies and their benefits for sustainable development

Dr. Wolfgang Pinegger
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wolfgang@glbrain.com

Summary Workshop

Dr. Wolfgang Pinegger is the founder of GL Brain, a company that offers unique functions for managing online communities using blockchain, hyperchain and chaincode technologies. During his workshop, he first introduced the participants to the core idea behind his company and the advantages it offers to its clients. As management systems for online communities, such as the one developed by GL Brain, require a high level of privacy and scalability, customization as well as trust and transparency, GL Brain ensures the fulfillment of these criteria by using a revolutionary patent pending ledger technology. This allows for total privacy where wanted, which stands out as a key advantage of the system. Businesses and communities can furthermore purchase access to the so-called GL Mall, which can be described as a digital shopping center where users can purchase or rent products and real estate, book services, find their dream job or qualified employees, and more.

Dr. Pinegger also provided insights to parallel cryptocurrency systems and explained how they contribute to the United Nations' Sustainable Development Goals (SDGs). GL Brain developed their own cryptocurrency systems - GMB/GMBT Tokens - allowing crypto payment in day-to-day e-commerce without any transaction fees and at unprecedented speeds. This was achieved by using the patent pending technology of using a parallel token called the GMBT. The Tokens can be used on the GAMB marketplace.

On top of the GMB/GMBT Tokens, GL Brain developed SDG coins which can directly impact the fulfillment of various SDGs. They identified low levels of transparency on donation platforms, and consequently a lack of trust, as a source of hesitancy to help and donate for people in need. Their solution is a secure execution environment for donations, which provides transparency and measurable aid impact. It relies on a so-called Coin Operating Authority (COA) (local NGOs), which verifies persons in need of aid, and certifies local providers. The coins are issued by the Coin Supplying Authority (CSA) (World Bank & GL Brain), who first selects and verifies COAs, and issues tokens for people verifies by the COAs. They also manage the payment system and the exchange of tokens back into FIAT after the donation has been rendered.

Globra FZ-LLC

The Global Brain

GL Brain®

Smart Communities and Communication

Presented by Dr. Wolfgang Pinegger

COMMUNITY MANAGEMENT

GL Brain®

Industrial Communities

- Manufacturing Industry
- Logistics
- Banking and Other Financial Services
- Trading

SAP®

Online Communities

- Private Communities
- Business Communities
- Other Online Communities
  (NGO's Smart Campus, Smart Cities.)

GL Brain®

1

THE TECHNICAL BASIS

GL Brain

SAP

GL Brain

Management Systems Industrial Communities

- Use of **Relational Databases**
- User operates his own platform and owns / manages all his data (**PRIVACY**, **CUSTOMIZATION**)
- No algorithmic programming
- No **SCALABILITY** issues because of restricted user access
- **TRUST** and **TRANSPARENCY** not needed

Management System Online Communities

Relational Database Concept
using a revolutionary patent pending ledger technology

CHAINCODE — **PRIVACY** and **SCALABILITY**

HYPERCHAIN — **CUSTOMIZATION**

BLOCKCHAIN — **TRUST** and **TRANSPARENCY**

2

TOTAL PRIVACY WHERE WANTED, TOTAL TRUST WHEN NEEDED

GL Brain

CHAINCODE

PRIVACY & **SCALABILITY**
Standard chains
Internal Ledger
Auto translation
API to Blockchain

HYPERCHAIN

CUSTOMIZATION
Customized Chains
API to GLBrain Blockchain
API to customized Blockchains
Customized crypto currencies

BLOCKCHAIN

TRUST & **TRANSPARENCY**
Sky Ledger Technology
Decentralized Obelisk consensus
No mining / no energy cost
Free and fast transactions

THE USER WITHIN GLBrain

Uses Basic Functions

Social Network – Presentation – Content

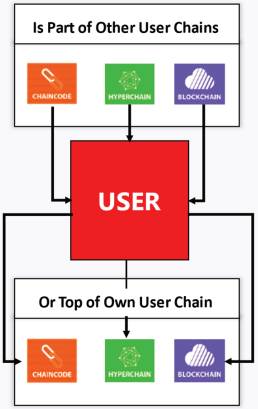
Geography - Languages – Translation

Communication and use of existing

online communication channels

GL Brain

GL Brain myLife



Uses Business Functions

Online Marketplace – Advertising

Community Profit Sharing

GLBrain+ Seller and Agent System

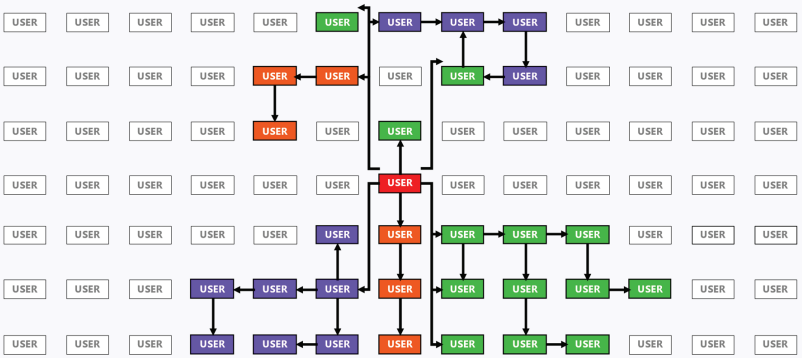
GLBrain Blogger Tool

GL Mall

GL Wallet

3

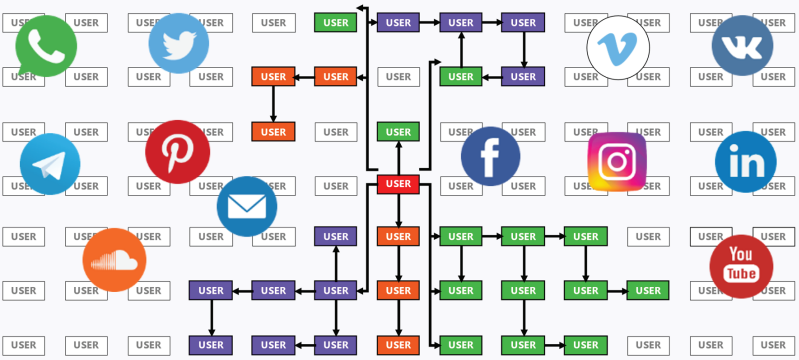
AND THE WHOLE COMMUNITY



4

AND THE WHOLE COMMUNITY

GL Brain



4

SOLUTIONS FOR PRIVATE USERS, BUSINESS AND COMMUNITIES

GL Brain

PRIVATE USER LIKING THE PRIVACY

SME COMPANY USING THE LOCAL MALL

PRIVATE BLOCKCHAINS FOR INDUSTRIAL USE

FOREIGN AID NGO's AND MIGRATION

ENVIRONMENT AND CHANGE OF BEHAVIOR

RURAL DEVELOPMENT AND EDUCATION

7

PARALLEL CRYPTOCURRENCY TO SOLVE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

- Cooperation with Prof. Dr. Dr. Stefan Brunnhuber (World Academy of Science)
- GLBrain building all execution interfaces for the SDG economy
- GLBrain building relatedblockchain infrastructure
- GLBrain building SDG parallel currency

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SUSTAINABLE DEVELOPMENT GOALS SDG

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Need related SDGs

GL Brain

SDGs related to basic needs

- No Poverty
- No Hunger
- Good Health for all
- Quality Education
- Clean Water for all
- Affordable Energy for all

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Environment related SDGs

GL Brain

SDGs related to Environment

- Sustainable Cities and Communities
- Responsible Consumption & Production
- Climate Action
- Life below Water
- Life on Land

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SDGs not directly related toa SDG Coin Economy

GL Brain

General SDGs / Indirect Help

- Gender Equality
- Descent Work and Economic Growth
- Industry, Innovation & Infrastructure
- Reduced inequalities
- Peace Justice and Strong Organizations
- Partnerships for the Goals

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TOKEN CREATION

GL Brain

SDG Coins mined for and used by

- A verified person in need of food, education, medical services, water or energy
- Coins sent to a verified Person in Need
- Coins to be spent for dedicated purpose only
- With a verified local providers
- Then entering the second SDG Market

SDG Coins mined for Environmental

- Verified people and organizations helping this 5 SDG's
- For verified and measurable SDG Actions (CO2 Reducers e.g.)
- Sent to verified user for verified purpose
- Sold in FIAT to verifiede.g. CO2 Producers and given back to Coin Issuing Authority
- Or entering the second SDG Market

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HOW IT WORKS

The Authorities

Coin Operating Authority (COA)	Coin Supplying Authority (CSA)
Can be any organization in the field (NGO)	**Any Organization / UN / Government**
• Verifies people in need • Verifies environmental contributors • Verifies local providers • Asks CIO to issue coins to the verified recipients	• Verifies Coin Operating Authorities (COA) • Issue coins for those verified by the Coin Operating Authority • Manages payment system for coin related environmental certificates and coins not going to the secondary market

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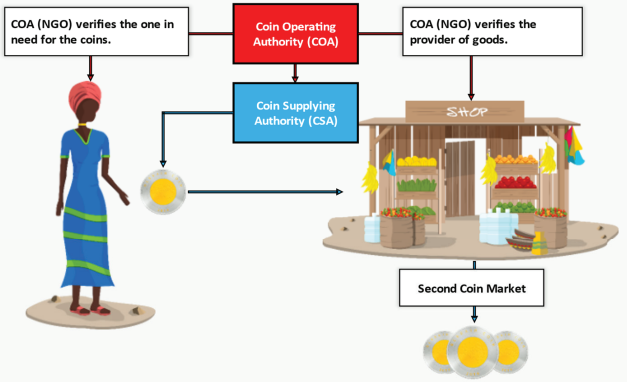
HOW IT WORKS

Tokens created for people in need



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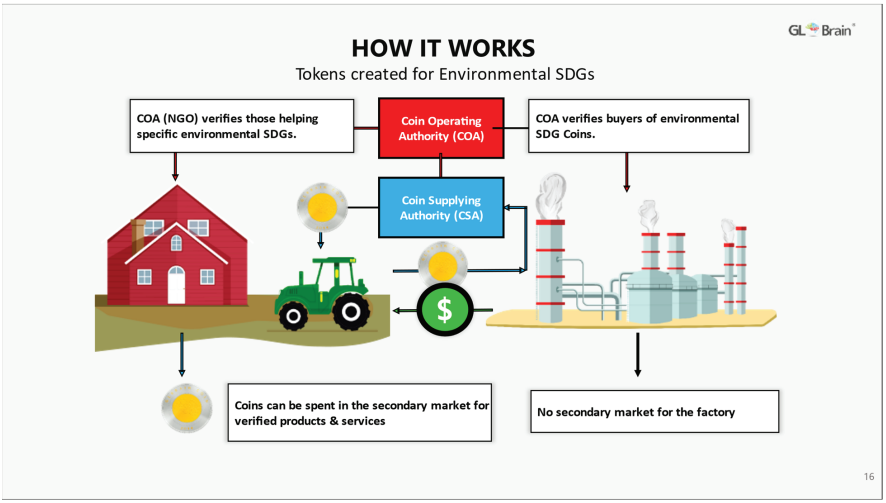
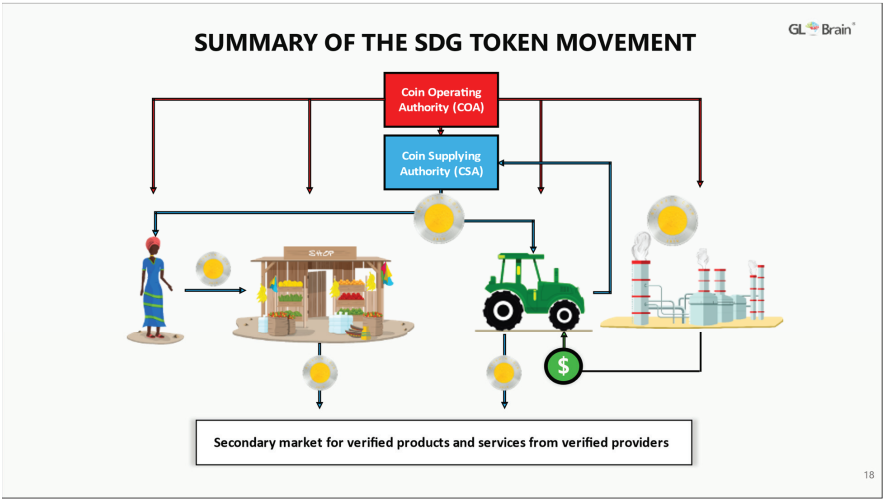
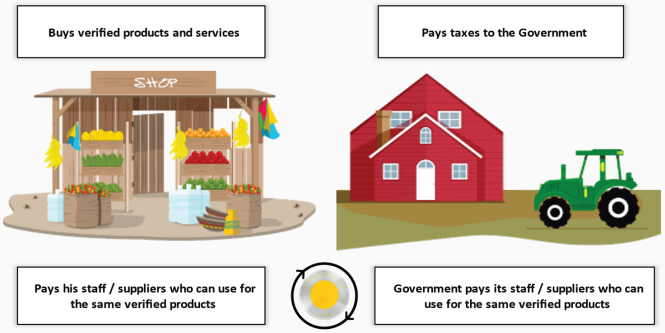




HOW THE SECONDARY MARKET WORKS

SDG Coins entering the secondary market can be used freely for purchasing any verified product or services from any verified provider



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GL Brain®

Thank you!

How sustainable is the blockchain technology? How can it be more sustainable?

Alex de Vries
Digiconomist
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Summary Presentation

In 2008 the pseudonymous author Satoshi Nakamoto in 2008 introduced the world to blockchain technology, along with the digital currency Bitcoin. This new currency was intended as an open peer-to-peer (P2P) payment network. This would eliminate the need to go through a financial institution to make a payment. When creating Bitcoin, Satoshi Nakamoto defined a hard limit of 21 million coins that would ever be created. The Bitcoin software slowly issues these coins over time as a reward for anyone that uses their computer hardware to participate in creating new blocks of transactions for Bitcoin's underlying blockchain. This incentive ensures that the system is maintained, despite not anyone being in charge of it.

Satoshi Nakamoto, however, also purposely made it difficult to create a new block. In order to do so, participating machines need to generate a so-called proof-of-work. This proof-of-work can only be obtained through a process of trial-and-error, which effectively turns it into a game of "guess the number." Only a correct guess will allow a participating machine to finish a block and reap the associated reward. In 2021, the whole Bitcoin network is generating quintillions of such guesses every second of the day, non-stop. Even so, a new block is only generated every 10 minutes on average. The Bitcoin software adjusts the difficulty of guessing correctly, based on the amount of computational power in the network, to keep the issuance rate constant. As energy has to be expended to run the participating computer hardware in the first place, the whole process has been described as "analogous to gold miners expending resources to add gold to circulation."(Nakamoto, 2008)

It is estimated that all of these Bitcoin mining devices around the world are consuming as much electrical energy as a country like Argentina. The carbon footprint associated with this energy consumption is estimated to exceed the net CO2-savings from deploying electric vehicles around the world.(de Vries et al., 2021) This environmental impact continues to go up as the value of Bitcoin keeps on increasing. Any increase in the price of Bitcoin also increases the value of the Bitcoins obtained through mining. As the profitability of mining goes up, so does the incentive to add more energy-consuming hardware to the network.(de Vries, 2021) This doesn't just increase energy demand, but the specialized and short-lived nature of the machines also affects the global semiconductor supply chain and leads to increased amounts of electronic waste.(de Vries, 2019) Other consequences

may include air and water pollution, or increased utility bills and even power outages on a local level.(de Vries et al., 2021)

Because the aforementioned consequences have received a lot of attention in international media and research, blockchain technology has gained a reputation of being extremely inefficient technology. It is, however, possible to make a blockchain work without the proof-of-work mechanism used on Bitcoin's blockchain. There are hundreds of public cryptocurrencies like Bitcoin already running on alternatives like proof-of-stake. This alternative isn't built on requiring computational effort and could save 99.95% of the energy consumed by the Bitcoin network, if the latter software used this alternative instead of the proof-of-work mechanism. Other solutions, like the Hyperledger Fabric used to build enterprise blockchain projects, don't make use of proof-of-work either. It's thus important to keep in mind that the energy-hungry Bitcoin blockchain is far from representative for blockchain technology in general.

External policies that aim to reduce the impact Bitcoin network specifically could try to increase the electricity costs of mining (resulting in miners not being able to afford as much energy), by cutting these miners off from the cheapest sources of electricity. They could also target the value of Bitcoin by making investing in Bitcoin less appealing (e.g. through taxes) or by prohibiting investments altogether. The effectiveness of these policies depend on how widely they are implemented (as Bitcoin is a global system) and don't change that replacing proof-of-work (though this is not externally enforceable) would be the superior solution.

References

de Vries, A., Gallersdörfer, U., Klaaßen, L., and Stoll, C. (2021). The true costs of digital currencies: Exploring impact beyond energy use. One Earth 4, 786–789.

de Vries, A. (2021). Bitcoin Boom: What Rising Prices Mean for the Network's Energy Consumption. Joule.

de Vries, A. (2019). Renewable Energy Will Not Solve Bitcoin's Sustainability Problem. Joule 3, 893–898.

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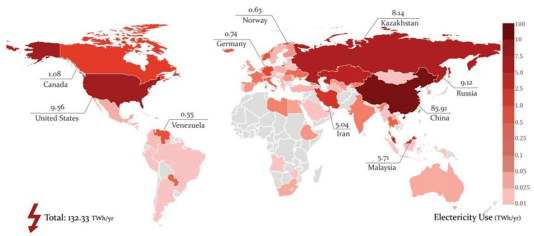
How sustainable is the blockchain technology? How can it be more sustainable?

By Alex de Vries

Proof-of-Work mining

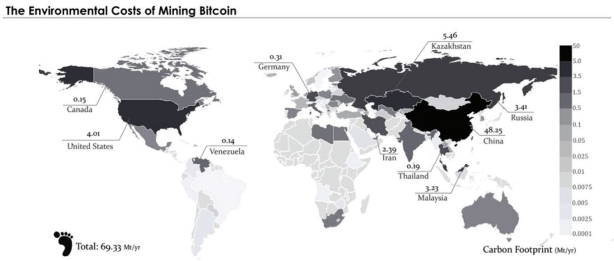
- Bitcoin's underlying blockchain runs on what is known as proof-of-work mining.
- Before a new block can be created miners first have to play a game of "guess the number".
- The Bitcoin network as a whole is generating around 150 quintillion guesses every second of the day non-stop.
- Millions of devices all around the world are contributing to this; and consuming a lot of energy in the process.

Energy Consumption Map

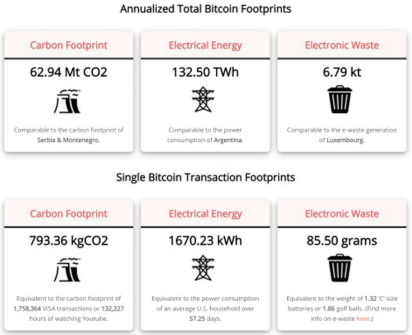


Annual electricity use of BTC mining across the world, as of April 2021

Carbon Footprint Map



Bitcoin Footprints



It's not just energy consumption!

"Nvidia tries to stop its chips being used for crypto mining"

'Green' bitcoin alternative Chia is leading to hard disc shortages

Study: Iran Using Crypto Mining To Evade Sanctions

24 May 2021

SUSTAINABLE INVESTING?

Bitcoin has a Xinjiang problem

External policies

- Restricting/banning mining > only drives up the cost of electricity.
- Making the user feel the environmental costs > carbon tax.
- Restricting access to proof-of-work assets > reduces value/energy expenses.

- Bitcoin is a global system: beware of waterbed effect!

There is a fix!

Thank you

Connect2Evolve – Access to electricity in Senegal through solartainers

Frank Vossnacker
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Summary Presentation

Access to electricity is a key necessity for economic growth and quality of life. More than 700 million people still do not have access to electricity and much more only have unreliable electricity. In addition, in many cases Diesel generators are used to produce electricity that are pollutive, expensive and not sustainable. Why is there not enough investment in energy projects for certain countries while on the other hand there is a huge need for electricity?

This dilemma was the starting point for our project three years ago. We started our project as a self-organized team of diverse people from different locations and departments within Siemens AG funded by the internal Innovations Fonds. Our project is aiming to empower local engagement by providing infrastructure and building wealth. Together with our solar container manufacturer Africa GreenTec we identified a rural area in Senegal needing sustainable energy supply. The target of this project is the installation of a Solartainer with 42 kWp serving 3000 people in 300 households and local enterprises with sustainable energy. We want to connect local consumers to a microgrid, provide them with a Smart Meter and offer a pre-paid service to purchase electricity from the Solartainer. On the other hand, many donors should be given the possibility to participate in this project to make this happen. Every donor should be given the opportunity to experience the impact of his or her donation.

The original goal of this project was to raise the necessary money for a solar container via blockchain-based crowdfunding. Due to the lack of BaFin regulations at the start time of our project, we switched to a donation project. We approached Siemens employees, families, and friends as well as external parties to participate in our donation project. We chose Africa GreenTec as our technology partner because they have vast experience in installing Solartainers in the Sub-Saharan region. The SME Swarm developed a digital platform for us to collect the donations and process the financial transactions on the back end. Now that we have raised enough donations to install the Solartainer, Swarm will

implement so called Impact Tokens. Each Impact Token represents one kWh of sustainable energy that will be fed into the local power grid. Once the Solartainer is installed, each donor will receive Impact Tokens equal to the amount donated. The Impact Tokens are visualized on a personal dashboard and can be claimed via blockchain functionality.

Needs in Emerging Countries

SIEMENS energy

There are around 600 million people* without electricity only in Africa!

Africa's power demand will rice from 700 TWh* today to approx. 1400 TWh* until 2040

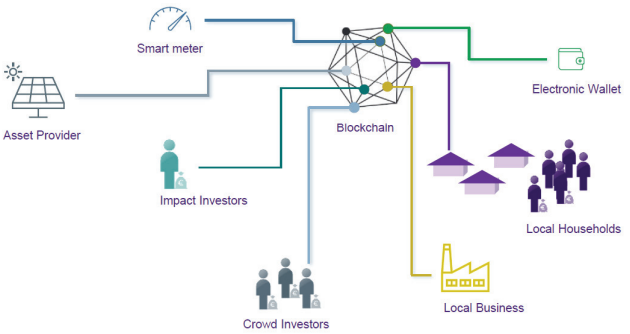
People / SMEs need reliable, affordable and green **power** **to** **run** or open their **businesses** and for their **daily life**

Project developer need **financing** **to** **provide energy** supply with at least a break-even

Investors (individual or institutional) look for attractive **investment opportunities** **for** combine investment with **impact**

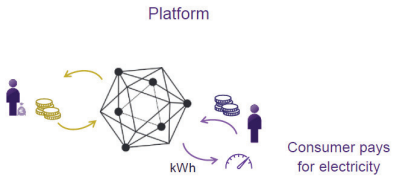
* International Energy Agency: https://www.iea.org/reports/africa-energy-outlook-2019

Connecting People
Matching investors and project stakeholder



Blockchain based Donation Project

SIEMENS energy



- Alternative financing model: crowd-invest into a power generation asset
- Allow also local people to become share holders

- Blockchain / Smart contracts allow transparent, immutable transactions
- Blockchain is used for reporting the impact based on generated green kWh in relation to the donation amount

- In future Blockchain can be used for energy billing and payment (using smart metering)

Showing Impact

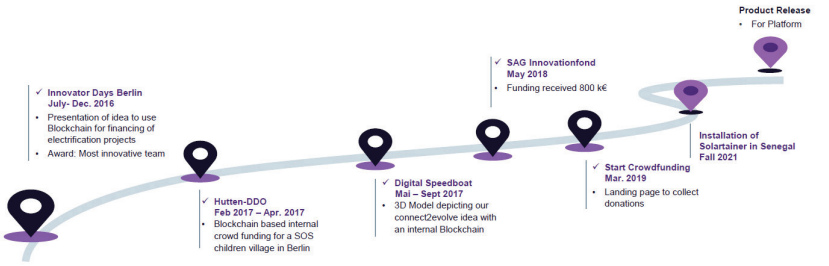
SIEMENS energy

Impact token

- Blockchain technology is used to issue impact token as virtual equivalent for renewable generated kWh delivered to the grid
- These impact token represent the support to SDG 7 "Affordable and Clean Energy"
- Investors will receive **impact tokens** according to their amount of donation
- these impact tokens can also be translated in **avoided CO2** emissions

Roadmap

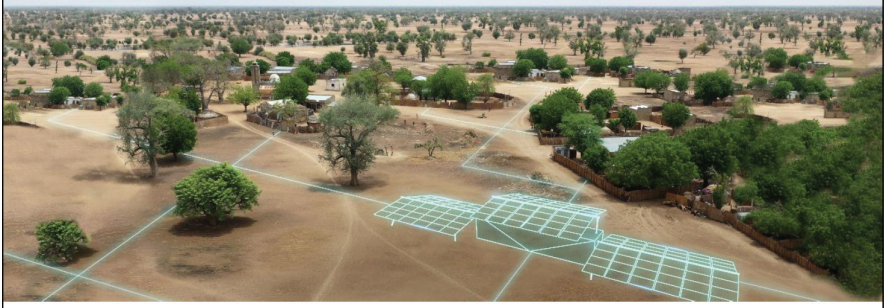
SIEMENS energy



Powering ~3,000 people in Senegal with green energy by a solar container:

SIEMENS energy

https://www.siemens-energy.com/global/en/news/key-topics/connect2evolve.html



Pilot Project
provide green energy to ≈ 3,000 people

SIEMENS energy

Partner

Siemens Energy

AGT help e.V.

AFRICA GREENTEC
www.Africa GreenTec.com

SWARM
swarmnetwork.org

Product

Solartainer® – 42 kWp
2-3 hours battery storage,
micro grid, prepay smart meter,
provides live data via satellite

Location

3,000 people / 300 households
Rural area: Bacco Ndieme
Senegal (Africa)

Clear targets support our ambition to become a sustainability leader in our industry

SIEMENS energy

Climate-neutral	Green electricity	Gender diversity	Safety leader	Compliance: Zero tolerance
in own operations by 2030	100% of own power consumption by 2023	25% by 2025 30% by 2030 (females in mgmt level 1 and 2)	in our industry through the activities launched within our "Zero Harm" program	towards corruption, violations of the principle of fair competition, and other breaches of law

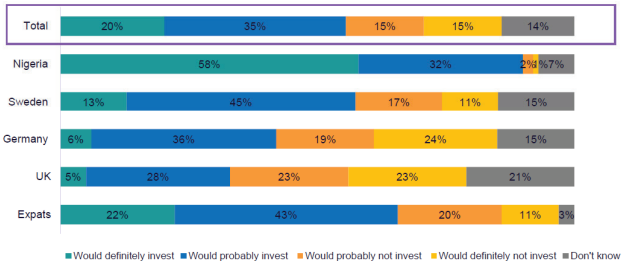
… supporting the UN Sustainable Development Goals

13 CLIMATE ACTION · 7 AFFORDABLE AND CLEAN ENERGY · 5 GENDER EQUALITY · 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE · 8 DECENT WORK AND ECONOMIC GROWTH · United Nations Global Compact

Market Study

SIEMENS energy

Willingness to invest in crowd invested energy generation projects in emerging countries



Ipsos

Key findings

- >50% would definitely or probably invest
- Similar pattern across countries
- Willingness to invest is very high among Nigerian respondents
- Among the European countries, Sweden shows the highest willingness to invest

Security Token Offering Platform for Energy Decentralized Financing (DeFi)

SIEMENS energy

DeFi market hits record high of **USD 4 billion** in invested assets for the first time (2020)

STO democratize access to capital

- Easier, faster, cheaper to raise capital
- Access to larger investor base
- Liquidity and 24/7 exchange
- Fractional asset access

STO ... Security Token Offering

Who we are …

SIEMENS energy

Yohannes Ghermay

Sylvia Niewiem

Tanja Romahn

Frank Vossnacker

Petra Michalke

Jens Kühnert

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Conclusion

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First, we would like to thank all participants and presenters for their active participation in our digital symposium. The discussions that arose during the event provided interesting and valuable insights, and opened up new perspectives for all of us.

The organisation of the event was part of the project study *Sustainable Energy Impact - bringing power to the people* of the Bochum University of Applied Sciences, which investigates and develops sustainable energy concepts. Our taskforce was created specifically for the purpose of organising the event, which helped ensuring sufficient capacities and a thoroughly planned event. During the organisation process, we familiarised ourselves with the topic and came to understand its relevance for sustainable development. This allowed for even higher levels of dedication, as we wanted all participants to gain those insights and to develop a profound awareness of the potential that these technologies hold.

The remarkable benefits of the blockchain technology for sustainable development are well known within the industry, but have not yet found their way to the general public. The aim of the symposium smart:sustainable was to share the technology's sustainability potential with academics and the interested public for the development of further research topics and projects. While the students' presentations showed that blockchain technology can enable sustainable impact investing and support gender justice, the workshops illustrated its potential to realise a transparent operating space for humanity and contribute to a community's financial independence. As the presentation on decentralized finance use cases in Africa showed, the technology holds a lot of opportunities and possibilities. This impression was further supported by the presentation of Will Ruddick, who has already successfully introduced a municipal currency in Kenya and is expecting to expand this further with the help of blockchain technology.

While the blockchain technology holds many opportunities, it also faces challenges as the implementation requires the right framework conditions, which have not yet been established. Additionally, the technology should be more user-friendly to enable it to spread from a niche to more sectors. In the future, we need to promote a sustainable use of the technology, while the technology itself operates less resource-intensively.

In conclusion, we are thankful for having been given the opportunity to organise the event. We would like to express our gratitude to Prof. Dr. Semih Severengiz and Dr. Sebastian Finke, who contributed with their knowledge and experience in the field.

We are very excited for future research topics and projects targeting the potential of blockchain and decentralized finance for sustainable development.