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RESEARCH ARTICLE

Decentralization, Blockchains, and the Development of Smart Communities in Economically Challenging Environments

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Abstract. Current implementations of blockchain technologies for smart cities assume environments with ample socio-technical resources. In this paper, we analyze four particular cases to show how blockchains can be used to create smart communities within under-developed and resource-poor environments. In these contexts, blockchains were critical in developing and maintaining trust within the community while meeting specific social needs. Our analysis of these specific cases was then used to derive a definition of a "smart community". We provide a schematic outline of the foundational elements for the development of smart communities using blockchain technology. The goal of our paper is to show that blockchains hold promise not just for building smart cities in resource-rich contexts, but also for building smart communities in resource-impoverished contexts using a bottom-up, problem-driven approach.

1. Introduction

A lot of excellent work has been done charting the ways blockchains can be used to protect data and functionality in smart cities.[1-3] In general, blockchains offer the various users of smart technology pseudonymity, data protection, and transparency.[4-8] The need for these protective measures is pervasive in a smart city, given its reliance on personally sensitive data. Within such modern urban environments, blockchains can facilitate various smart city goals and functions. When addressing the needs of people in economically-challenged environments, however, this facilitating role is inappropriate. In such environments, basic urban services, including banking and logistical support, are intermittent or seriously hampered. Blockchains can offer a means of developing such services amidst these difficult circumstances and can thus act like a seed from which smart city functions can emerge.[9, 10] Thus, instead of acting as a support function, like they do in high-income smart cities, in impoverished urban environments, blockchains have the potential to become the functional core around which aspects of a smart city can begin to form. In these contexts, blockchains can actually help solve concrete, basic problems at a fundamental everyday level for a community. In such a situation, a blockchain serves as a seed not for a smart city, but for a smart localized community, focused on essential economic needs and sustained from the bottom up, that is, sustained by people and not just institutions.[11]

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While there are instances of such problem-focused implementations of smart technology in developed countries,[12,13] in this paper we will explore a few ways in which blockchain implementations can be used to build socio-economic relationships and create communities of trust in order to fulfill various economic and social needs in less developed environments. The importance of trust in social life is, of course, ubiquitous and fundamental.

Some work has been done on developing models to encourage the governance of common resources and common spaces using blockchain technology that side-steps the transition to hierarchical organizations. These studies, for the most part, discuss the decentralizing pressures and potential of blockchains within a developed, modern society, in which centralization and advanced infrastructure are well-developed and embedded in urban life. Our research question is as follows: *How can blockchain technologies be used in situations where basic technological infrastructure is lacking?* To study this question and the related basic and simple concerns, we look at blockchain implementation in food transactions and identity management for refugees, smart banking for rural underbanked areas, and mechanisms for identity management and identity verification in socio-technically under-resourced areas.

Existing research concerning the role of blockchains in the development and function of smart cities has focused primarily on technological implementations of various applications such as record-keeping, security, and supply chain management, which are typically implemented in resource-rich environments. To the best of our knowledge, there are no academic papers that analyze the role of blockchains as a significant technological tool in creating smarter living conditions for people in resource-impoverished environments. Given this, the contributions of our paper are two-fold. First, we situate the role of blockchains and smart technology within the interplay of the forces of centralization and decentralization within communities and cities. These forces will function in importantly different ways in under-developed and resource poor countries. Second, unlike the bulk of existing research that has studied trends and challenges in blockchain implementation for smart cities with ample socio-technical resources, we want to examine four cases in which blockchains have been used in regions where communities have little or no socio-technical resources. There is not much information, and almost no studies, on such usages of blockchains.

In "When Ostrom Meets Blockchain," David Rozas and his coauthors show that Blockchain technologies can enable or facilitate tokenization, self-enforcement and formalization, autonomous automatization, decentralization of power over infrastructure, increasing transparency, and codification of trust to help in coordination of the various processes involved in the governance of commons.[14] The commons referred to in their work derive their context from an earlier definition of commons-based peer production (CBPP) communities that refers to a decentralized model of socioeconomic production in which "groups of individuals cooperate with each other to produce shared resources without a traditional hierarchical organization."[15] However, there is an important difference in these contexts of the commons when compared to the context of our article. The blockchain-facilitated governance of commons is situated within the context of a community network, in which the participants provide and manage technical infrastructure (such as computer networks) as a common resource to provide internet access, without the need for internet service providers. Likewise, the primary context in the CBPP was that of the information-production commons, which involves collaborations in digital networked environments. Both of these commons, while well-suited for the adoption of blockchains, assume the presence of socio-technical infrastructure. In contrast, the work in

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our article focuses on the application of blockchain technology in the absence of underlying socio-technical infrastructure, where a blockchain creates a smart community while meeting a crucial underlying need.

There have been, however, numerous studies of how to develop economic systems and infrastructure in rural and impoverished communities. Elinor Ostrom's work, in particular, famously sets out some parameters and rules of governance to maximize the growth of the community and not just individual agents or small subsets of the community.[16] We would have liked to study how her basic principles might fit our specific examples, but there is simply not enough information or data available. Instead, we analyze four particular cases in which blockchain implementations served as the critical and foundational element in developing a smart technology solution for specific socio-economic needs and challenges in under-developed contexts. The needs of people in these under-developed contexts are basic. In particular, they need a way of establishing a public identity that is recognizable not simply in their communities, but within the more anonymous financial systems that are either broken or non-existent within their communities. Finally, we use our analysis of these specific cases to derive a definition of what we call a *smart community* and provide a schematic outline of the role blockchain technology can play in developing such smart communities in infrastructure-poor communities.

1.1 Centralization, Decentralization, Smart Cities, and Smart Communities—Our communal environments are always a mixture of willful design and accidental emergence. Similarly, there exist various pressures towards centralizing housing, services, and authority, as well as various counter-pressures towards decentralizing the same, as cities grow and neighborhoods become defined. For our purposes, there exist four related factors and forces that can help us describe the development of cities, including suburbs: centralization, decentralization, top-down design, and bottom-up convergence. Cities are complex systems that evolve over time. Instead of describing in some general way the structures of centralization and decentralization, as well as top-down and bottom-up forces in the functioning and governance of cities, we will delineate these structures through a brief analysis of key elements in a modern smart city within the developed world.

Much of smart technology augments already-existing urban infrastructure.[17-20] Smart technology generally requires the prior existence of such infrastructure. This fact makes the development of smart cities in more impoverished environments difficult, at least if smart cities are understood in the way they currently are. The first and primary value of a smart city is to increase the efficiency of various services and systems: to marshal and utilize resources more effectively in solving particular issues (like crime) and by improving the quality of city life. The role of blockchain technologies in such cities is important but secondary. Given the extraction and reliance on data, blockchain applications can serve to protect and secure this data. The protection of data is of paramount importance, but it is not integral to what makes a city smart. It is integral in making sure a city *stays* smart.

The development of smart cities represents, in general, an increase in the centralization of urban environments through technological and social systems of control. These systems of control and surveillance do not highlight the decentralizing potential of blockchain technology. This centralization that follows from these systems of control and surveillance should be seen as an extension of the bureaucratization of modern life. This follows directly from the fact that what makes a city smart is the collection, analysis, and use of data. Data is collected through means of technological surveillance and is funneled into various kinds of centralizing analytical

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systems. Using this information, patterns of behavior are derived and appropriate actions are chosen and implemented by those with the power and authority to initiate and implement these actions. This centralized use of data is not the only way that data can be used, however. In some cases, individuals within the environment can access the data and use it in planning travel routes, for example. This *decentralized* use is made possible by the centralization and analysis of the data.

We should remember that while centralization can create positive conditions of stability and growth, it also entails dangers and negative effects. On the positive side, centralization of various functions and services allows for the very existence of modern societies, with their complex economies and vast populations. Such centralization involves everything from roads and waste removal, to laws governing financial transactions, the means of adjudicating conflicts, and other related applications. The other side of this is that smart cities require an increase in the degree of human surveillance, and tracking by various governmental and corporate institutions undermines our privacy. This data can be used in both positive and negative ways, but the collection of it comes with risks, some of them serious.

This tension between the powers of centralization and the responsiveness and independence made possible through decentralization is an intrinsic aspect of cities and, in fact, of all organizations. A smart city has the potential to alleviate aspects of this tension. A smart city, at least relative to the core concerns for policing (security), health, and mobility, is a means of making centralized powers more sensitive and engaged at the local level. The best example of this is in the use of smart technology in urban policing. The success of a smart city in preventing and responding to crime depends on a suite of technologies and the development of systems and infrastructures to take advantage of these technologies. The majority of these require centralized control and management, as well as relatively high degrees of supporting systems and infrastructure.

In the next section, we will briefly examine four cases in which smart technologies were implemented in ways that do not fit the patterns we see in the implementation of smart cities in the developed world. Each of our examples highlights a different kind of social challenge, which allows us to delineate different ways that blockchains can be used in such circumstances. We chose these cases in order to offer the broadest range of social and economic conditions in which blockchain technology was used in a positive way. There are, however, very few examples, and so our options were limited, and the information available highly constrained. Despite having dozens of applications and use cases, blockchain case study research remains challenging due to the lack of a well-defined structure.[21] Since blockchain technologies are diverse and can be used in various applications in different sectors, blockchain case studies are more empirical than theoretical, and consequently, blockchain case study research does not follow the theoretical case study approach involving well-defined phenomena in real-world contexts.

In our examples, blockchain technology serves as a means of providing both an identity and financial history for individuals whose identities were local and not tractable for financial institutions. Blockchain technology functions, in these cases, as a means of establishing individual legitimacy for strangers, since such legitimacy is not provided by the local or state powers in these impoverished communities. Establishing these identities facilitates the creation of communal trust. This formation of trust through stable, technology-supported identities creates what we call *smart communities*, as distinct from the complex interplay of technologies and powers that make up a *smart city*.

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From our four cases, we will offer in conclusion three factors that distinguish smart communities from smart cities: initial decentralization and organization, establishing and maintaining trust, and newer pathways for integration. While these factors do not constitute a model for developing smart communities, they do suggest areas for further research and experimentation in developing smart communities in ways that address fundamental economic and political difficulties prevalent in economically challenging environments. Blockchains have a central and key role in the integration of smart technology in these smart communities.

2. Four Case Studies for Smart Communities

In this section, we offer four case studies that illustrate the challenges and the successes of blockchain implementations in under-developed environments. This kind of a smart community exists to empower individuals in impoverished environments who have been unable to access the resources required for socio-economic mobility.

We would like to offer a note about our case-study methodology. As we mentioned above, scholarly research into the possible uses of blockchains in under-developed countries is limited. In addition, the number of smart city initiatives pursued in under-developed countries is not plentiful. Consequently, what is required at this early stage of research is the basic examination of particular cases. In each case, we describe the basic problem for which a blockchain was designed, the corresponding blockchain technology solution and its implementation. We describe the various players involved and the consequences that followed from the implementation.

2.1 Methodology—In order to identify the blockchain case studies listed in the paper, we adopted previous guidelines to perform searches on the EBSCOhost, Google Scholar, and ScienceDirect databases.[22, 23] Further, we also parsed through the projects sponsored by EthicHub, a social enterprise that used blockchain technology to connect small farmers to sell their products directly to market. The keywords used were a combination of the following terms: "blockchain," "humanitarian," "case study," and/or "report". The articles obtained in the search results from these queries were further evaluated to fit our criteria of blockchain applications in the context of environments with little or no socio-technical infrastructure. The references from each of these articles were also examined to obtain additional information about the blockchain implementation itself. An additional criterion that we used for inclusion of a case study was the availability of public information regarding the implementation details of the specific blockchain and evidence of impact of the blockchain technology in that context. Although there are several applications of blockchain for humanitarian work,[24] and more broadly in the area of "social good" or the "common good", there is a dearth of detailed use cases that describe the specific implementation details in context. In an insightful article describing the importance of "knowing how" to implement a blockchain-based solution,[25] the author suggested a description of a blockchain application centered on four components: application interface, use cases, codebases, and blockchain protocols. Our choice to include the four case studies in this article followed this guidance. In this process of selection, we ended up with four use cases that are illustrative of the potential of using blockchains for building smart communities in the absence of existing socio-economic or technical infrastructure.

The specific case study methodology used to identify the four cases in this paper is that of *social construction of reality* (SCR). This approach is one of four case study approaches

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proposed that describe the spectrum of case study methodologies.[26] The other three methodologies are *no theory first* (NTF), *gaps and holes* (GAH), and *anomalies*. A brief explanation of each of these methodologies is as follows. The NTF methodology assumes the existence of a few preliminary important variables or constructs, without being limited by theories. Using descriptions, interviews, documents, and observations, the NTF methodology primarily uses qualitative data to provide evidence for the constructs and for eventually building a theory. In contrast, the GAH methodology looks for gaps and holes in existing theories with similar kinds of qualitative-focused methods as NTF. The focus in GAH, however, is on testing or developing theories, compared to the building of theories as in NTF. The SCR methodology is based on curiosity in the case itself, without the need for theory building, and aims to ascribe meaning to the case in its context. The fourth methodology, anomalies, looks for departures from the norm, and attempts to analyze surprising observations that do not fit existing theories. The analyses used in this methodology include observations of participants as well as dialogues between observer and participants in social situations.

The SCR approach of case study research was the most suited for our paper for three reasons. First, the SCR methodology allows for intrinsic case study in which sufficient information (thick description) is provided to the reader. This allows the reader to benefit from the direct interpretation offered, while also making some generalization based on other experiences. In each of our cases, we have described the socio-technical context in which a blockchain solution was implemented. Second, the absence of existing theories for what makes a blockchain implementation suitable for resource-poor environments allows for an SCR-type approach to understand each of the cases described in this paper. Third, the selection of cases in SCR does not imply representativeness. Rather, specific characteristics of each case are presented with the aim of holistic comprehension. The four cases described in our paper are not intended to be representative of how blockchains can be used for financial inclusion, identity management, or resource management. Instead, each of these cases presents ways of applying blockchain technologies in new and interesting ways in the absence of existing theories about the role of blockchains in economically challenging environments.

2.2. Case Study 1: Food Distribution, Financial Transactions, and Identity: Tracking in Jordanian Refugee Settlements—The World Food Programme (WFP) piloted a blockchain-based food distribution system in Pakistan, called Building Blocks,[27] which was later fully implemented in a refugee camp in Jordan.[28] This refugee camp housed over 600,000 Syrian war refugees. Prior to the blockchain implementation, families in these camps were given a weekly allowance in the form of cash to buy food at the camp's grocery facility. This cash-based system had numerous problems. There were no records by which the identity of refugees could be confirmed, and thus basic accounting was impossible. There was no way for families to monitor how much money they had available to use. There were also no records of what people purchased. In other words, the Jordanian refugee camp lacked the infrastructure to support banking and credit. Product tracking was not possible. Consequently, the management of products and of family financial resources were poor, leading to financial problems for the families and stocking problems for the stores. Even with the implementation of an electronic payment system problems remained, and this payment system incurred significant transaction fees.

In response to these authentication problems, the WFP implemented an iris-recognition technology called EyePay to provide an adequate system of identification in a context in which

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the institutional system for such identification management was not present. For refugees with no smartphones or internet connections to receive and validate identities using multifactor-like authentication mechanisms, EyePay served to confirm identities with an iris scanning technology.

The Building Blocks food distribution system was developed by Innovation Accelerator, a project of the WFP that “sources, supports, and scales high performance solutions to end hunger worldwide.” The aim of Building Blocks is to enable inter-organizational collaboration, so that assistance can be delivered to people in need and redeemed seamlessly. In this way, Building Blocks uses blockchain technology to circumvent the traditional banking systems for helping cash-poor communities.[27]

Following the initial pilot of Building Blocks in Pakistan, it was then targeted to serve over 100,000 refugees in the Azraq refugee camp in Jordan. Prior to Building Blocks, the WFP would have to create a list of beneficiaries and provide this list to intermediaries, such as banking institutions, food suppliers, and stores. Based on this list, the WFP would provide cash to these intermediaries to support the refugees. The banking institutions would create accounts for each beneficiary, and vouchers or debit cards for beneficiaries to redeem. The beneficiaries would redeem these vouchers or use the debit cards at local stores. The stores would then be reimbursed by the vendors.

Building Blocks eliminated many of the intermediaries by using a blockchain in the backend to verify identities, and provided transaction platforms for both the refugees and the vendors.[29] Blockchain wallets maintained detailed transaction records while also providing a tamper-proof and unique identity management platform. The use of blockchain technology streamlined the movement of cash through the network of vendors, banks, and refugees, reducing both time and cost expenditures. With the Building Blocks blockchain, the WFP saved $150,000 a month, eliminating 98% of banking fees. At the end of the pilot in Jordan, WFP reported a decrease in the number of upfront cash payments to vendors from 10,000 to only 200 a month.[30]

Building Blocks was built on the public Ethereum blockchain, but at the conclusion of the pilot, the full-scale implementation of Building Blocks was executed on a private permissioned blockchain. Private permissioned blockchains offer greater transaction speeds, privacy, and reduced transaction costs compared to public, permissionless blockchains. But these benefits of speed and reduced costs in private permissioned blockchains are accompanied by the disadvantages of reduced overall security. This is because the public permissionless blockchains are “trustless”, where the trust factor is implemented with consensus algorithms such as Proof of Work (PoW) or Proof of Stake (PoS). In contrast, in private permissioned blockchains, the trust factor is implemented with human identity validation and other traditional authentication mechanisms, which makes systems with Proof of Authority (PoA) more vulnerable to attacks. (More about these consensus mechanisms is later in this paper.) Since the implementation of Building Blocks was private permissioned, the members of the private blockchain are responsible for operational costs of maintaining the private blockchain. In return, these members possess complete rights for the governance, operation, and ownership of this blockchain.

Currently, Building Blocks has two members: UN Women and the WFP. Building Blocks is not currently open-source, although some of its constituent software components are open-source. A privacy-by-design approach is employed that uses pseudonymous identifiers, instead of sensitive personal information such as the name, date-of-birth, and biometric data. The transaction details are also stored at a high level of granularity, for example: the label “food” is

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used instead of rice to reduce the risk of reidentification. Blockchain data is only shared with humanitarian organizations.

Each member of the Building Blocks blockchain operates identical validator nodes. The validation of blocks is performed using a protocol called Proof of Authority (PoA), instead of the widely known protocols such as Proof of Work (PoW) in the Bitcoin blockchain and Proof of Stake (PoS) in the Ethereum blockchain. The former is a test of computational capacity, where the first node to solve a cryptographic puzzle involving hash functions is said to have successfully “mined” a block and the user receives a reward for the mining efforts. On the other hand, PoS uses randomly selected nodes called validators that verify the blocks. The selection of blocks for validation depends on the quantity of assets held by nodes (their “stake”) in the blockchain, where nodes with higher stakes have a higher probability of being selected for validation. Another distinction between PoW and PoS is that in PoW, miners can stop at any time without any repercussions, and there is no global list of validators which can be used to distribute mining loads. PoS, on the other hand, has a list of approved block creators along with their corresponding staking which makes it possible to distribute network loads for validation activities.

In contrast to the design of PoW and PoS, PoA validators earn a reputation for their validation activities. The PoA protocol in Building Blocks is implemented on the Ethereum blockchain, and is designed to be a lightweight, fast and secure Ethereum client. In the case of PoA, the asset being staked is reputation tied to identity, versus computational power (*e.g.* PoW in Bitcoin) and staked Ethereum (*e.g.* PoS in Ethereum). In PoA, the trustworthiness of the validator is central to the sustenance of the blockchain, and therefore thorough vetting of the member nodes’ online and offline identities is performed and disclosed on the blockchain prior to being chosen as validators. This decision to reveal validator identities is made to increase the transaction speed and reduce the computational complexity involved in recording transactions. The validator is responsible for creating new blocks and broadcasting this information to other nodes on the networks by using a single root key to manage the chain’s history.

The Building Blocks blockchain system was implemented in order to allow for and track electronic financial transactions, without the need for banks and their associated middleman fees. Furthermore, the blockchain technology was implemented seamlessly into the background such that people did not see any change in the way they shopped or accessed funds. The only apparent change in procedure was the use of the iris-scanning biometric identification system for checking account balances.

While in this case, the blockchain technology was built into an established system of transactions, that system as it stood prior to the integration was ineffective. Integrating the iris identification system with the blockchain ledger allowed for the development of a true smart technology system in a context that was not really a city at all, and certainly lacked the institutional structures of a city. In effect, the smart technology provided the background means to sustain the basic communal functions of shopping for essential products. In this case, we have the transformation of a traditional community organized around essential needs into a smart community. While this was certainly a top-down driven initiative, it was built to solve a basic set of concrete everyday problems. If these problems were not solved, the basic shopping and banking system would have degraded and become dysfunctional.

2.3. Case Study 2: Developing a Smart System of Banking: A Crisis in Rural Kenya—Smart financial systems can be built in contexts in which the current system has failed and elements

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of even the banking infrastructure present in Jordanian camps are absent. We can see this in a successful project in Kenya, in 2019.

The Red Cross societies of Norway, Denmark, and Kenya created a blockchain-based smartphone application to distribute quasi-currency in the form of tokens to people in drought-stricken communities in Kenya.[31, 32] This system replaced the previous cash economy, which was failing. The poverty and dire circumstances of these Kenyan communities means that people are cash-poor. A blockchain open-loop payment system was developed that could be accessed through smart phone apps. Payments from work or the sale of produce were converted into blockchain tokens, obviating the need for both currency and more traditional accounting and banking mechanisms. This blockchain open-loop payment system bolsters the local economy without the need to hold Kenyan shillings, and this system has been extended to Kenyan farmers through the Grassroots Economics program. Farmers use a Kenyan cryptocurrency, Sarafu, to sell produce, buy farming supplies, and participate in the local economy without the need to use cash.

This smart system of banking was developed as an outcome of a collaboration between the Norwegian Red Cross, Danish Red Cross, Kenya Red Cross, International Federation of Red Cross and Red Crescent Societies (IFRC), the Grassroots Economics Foundation, and a payment platform provider. The collaboration resulted in a blockchain project called Community Inclusion Currencies (CIC) that was launched for enabling trade in fragile communities.[33] The first token minted through this project was called Sarafu, which means “coin” or “currency” in Swahili. At the end of 2021, nearly 60,000 Kenyan households were using the Sarafu CIC with a total of USD 140,000 tokens in circulation (1 Sarafu is approximately equal to 1 Kenyan Shilling). The result of the CIC-enabled economy enabled roughly USD 2.7M in trade value.[34,35]

CICs work on trust built in communities.[36] The Sarafu CIC is anchored to the Kenyan national currency, and is backed by the Mpesa mobile banking system. This scenario of blockchain usage might seem similar to the WFP Building Blocks blockchain, since both of these blockchains deal with currency distribution; however, the CIC blockchain differs from the Building Blocks blockchain in that the CIC blockchain and its currency are backed by the Kenyan national currency.

Users in the Sarafu CIC were uniquely identified by a combination of their phone number and a personal authentication code (PIN). In addition, users could optionally provide their name, gender, home location, and a description of goods or services they were able to offer the community. New accounts automatically received a starting Sarafu balance, which was 400 Sarafu initially but was later reduced to 50 Sarafu. Users received bonus tokens for contacting the support team and verifying their accounts, maintaining an active transaction profile, and referring new users.

The specific blockchain used in Sarafu is a public sidechain of the Ethereum blockchain called Gnosis. The Gnosis token called xDAI was used to create Sarafu tokens. The underlying blockchain, Gnosis, was initially a PoA-based sidechain of Ethereum, which was later changed to a PoS-based chain using the xDAI token. The xDAI token is a derivative of the DAI token, where the name Dai, according to its creator Rune Christensen, stands for a Chinese character that means “to lend capital for a loan.” Dai is a *stablecoin*, which means that its value is pegged as close as possible to the USD, avoiding volatility in the value of the cryptocurrency. The Gnosis blockchain runs using the same client software as ETH, but Gnosis’s DAI token is a stablecoin, and has faster speeds and lower transaction fees than ETH. The consensus algorithm

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was initially the Proof of Stake Decentralized Autonomous Organization (POSDAO), where users stake tokens in an effort to become validators. Delegators stake tokens in support for candidate validators, which is similar to casting a vote for a certain validator. Validators are chosen based on the size of their pools and a random beacon. POSDAO has now been replaced by a consensus layer beacon chain, that uses a network of over 120,000 validators.

The minimum stake required in Gnosis is 1 GNO (approximately 11 USD) versus 32 ETH (approximately 100,000 USD at the time of this writing). Validator tasks include block proposal (submitting a new block for inclusion on the chain) and block attestation (acknowledging other validators' proposals). Gnosis nodes receive rewards for active validator tasks, and also suffer penalties such as slashed stakes, permanent removal, or penalties for inactivity for disruptive activities such as going offline for extended periods, or tardiness in proposing or attesting blocks. Penalties are also imposed on malicious activities that alter the view of the blockchain such as double signing (validator proposes and signs two different blocks at the same time), and double voting (attesting two transactions for the same block).

To prevent unauthorized access to sensitive data on this public blockchain, additional restrictions on the access and reuse of data were enforced. These restrictions included limiting access to those registered with the UK Data Service and the enforcement of these restrictions was facilitated by their end user license agreements (EULA). Each transaction had the following attributes: timestamp, transaction type (such as regular transfer, exchange of Sarafu with the Kenyan shilling, disbursement, reclamation, and others), amount of the transaction, wallet addresses of sender and receiver, and token name. Similarly, user attributes linked to a transaction include user ID, token balance, geographic location, network role, business type (such as labor, food, farming, and the like), and transaction volume metrics.

In this case, using a blockchain-based solution in effect allowed the formation of a banking and financial exchange network, utilizing the minimal infrastructure offered by cellphones and the blockchain system itself. A smart city financial service network was thus constructed not by integrating new technology into a current infrastructure, nor by adding a blockchain into the network as a second order privacy or security device, but rather by using a blockchain as the foundational means by which the financial network was developed. This blockchain open-loop payment system obviously depends on other aspects of the broader Kenyan economy, but it leap-frogs over the older forms of currency exchange and traditional banking services and establishes a system that is not dependent on those, since these older systems are weak or ineffective in these rural Kenyan communities. This leap-frog effect is another example of the creation of a smart community outside of the context of an urban environment.

2.4. Case Study 3: Formal Verifiable Identities for Financial Inclusion: The Case of Sierra Leone—Kiva is best known for micro-lending initiatives that enable lenders to issue loans to low-income entrepreneurs and students around the world. More recently, Kiva has augmented their micro-finance portfolio with an initiative whose goal is to extend financial inclusion and provide mechanisms for identity management using a blockchain. Specifically, the Kiva protocol provides mechanisms for creating digital wallets with identity information, which are then linked to financial records thus establishing a framework for credit management and reporting. Historically, the lack of formal, verifiable identities has prevented low-income individuals from creating bank accounts or accessing credit, since most of the lending activity takes place as informal transactions. These formal identity verification mechanisms are part of the Know Your Client (KYC) framework, that require identity records as established by several

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predetermined records such as certificates of birth, death, and marriage; education and property records; passports; vehicle license records; and in some cases, banking and credit history. People from low-income communities that do not always have access to these identity records fail to meet the requirements of the KYC framework and are barred from access to traditional financial resources.

One implementation of the Kiva protocol is the National Digital Identity Platform (NDIP) that was developed in collaboration with the government of Sierra Leone and the UN for establishing a nationwide repository of digital identity that also enables access to financial institutions.[37] Sierra Leone is a nation of seven million people with a per capita annual GDP of $500. Only about 20% of the population has a bank account. The NDIP program resulted in an enrollment of 5.1 million people, who potentially have access to banking resources and credit histories through their blockchain-enabled digital identity records. Further, the identity records are tied to transactions in both formal and informal settings, such as at banks and the local shops. This comprehensive record-keeping is part of the national initiative for developing federated credit histories, while also giving individuals the rights to control access to their data that is stored on a blockchain.

The Kiva protocol is built on Hyperledger. Hyperledger is a suite of consortium blockchain solutions developed by the Hyperledger Foundation, which is a part of the Linux Foundation. Hyperledger solutions aim to provide distributed ledger solutions for enterprises using consortium blockchain protocols, and are not available for public blockchain applications. Hyperledger solutions are vendor neutral, and are tailored for consortium networks for a range of applications such as supply chain, healthcare, digital identity, and international trade.

Consortium blockchain networks represent a combination of the design philosophies of public and private blockchains. In a consortium network, a group of organizations (usually limited to 30) called members adopt a blockchain solution that is tailored for the specific domain of operation, such as healthcare records, automobile supply chains, produce supply chains, and others.[38] These members are responsible for governance and operation of the blockchain, and the records are only visible to the member nodes. Consensus protocols for consortium blockchains differ from the more widely known consensus protocols too.

While Hyperledger has several solutions for diverse applications, the Kiva protocol was built using a Hyperledger stack composed of Indy, Aries, and Ursa.[39] The goal of the Kiva protocol is to offer digital identity solutions in a time-efficient manner. Indy is a decentralized ledger solution for providing portable, digital identity; Aries is a library supporting peer-to-peer infrastructure between blockchains for decentralized identity solutions; and Ursa, while now defunct, was used to support cryptographic sharing of modules.

Indy operates as a permissioned ledger, where validators are trusted entities. Validator nodes operate using the Plenum protocol, using a consensus mechanism called redundant Byzantine fault tolerance. Consensus protocols can be broadly categorized as those engineered for resilience in the face of crashes or faults (crash fault tolerance, or CFT), or those engineered for resilience against malicious activities (Byzantine fault tolerance, or BFT). Indy uses a redundant BFT protocol (or RBFT), which addresses the potential for malicious nodes to send inaccurate information to the network thereby distorting the view of the blockchain. In RBFT consensus protocols, redundancy is a key component of the design. Each node runs multiple instances, where one serves as a master and the rest are backups. Additionally, instances also have their own replicas. Indy also uses decentralized identifiers for identity management, as part of the

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movement toward using blockchain solutions for creating self-sovereign identities (SSI). SSIs differ from centralized or federated identity solutions that rely on a central government or a third party to issue and store identity attributes. SSIs leverage the cryptographic trust mechanisms in blockchains to store and verify identities with public-private key pairs. Since only individuals with their private keys can sign identity-related transactions, SSI offers mechanisms for lifetime, decentralized, portable identity solutions.

2.5. Case Study 4: Identity Management for Refugees: Refugees in Finland—In another example of blockchain usage in identity management, the Finnish government launched a blockchain-based identity management program for refugees that was also linked to resources for providing financial assistance for refugees, finding employment, getting paid, and electronic bill payment.[40] Similar to the KYC solution offered by the Kiva protocol in Sierra Leone for both identity management and financial inclusion, this blockchain implementation has offered a KYC solution for refugees and asylum seekers to find ways of integration into the financial and healthcare system in Finland.

The absence of legal identity is a serious impediment for refugees.[41] According to a 2016 Reuters report, roughly 70% of Syrian refugee children born abroad after the 2011 civil war in Syria were not legally registered at birth, making it difficult to prove their citizenship later.[42] Similarly, a World Bank report found that roughly 90% of rural land in Africa is unregistered. The use of blockchains offers the potential for humanitarian and development aid for people in crises, to reduce losses due to corruption, protection from human trafficking, and to maintain reliable records of property rights.[43]

Refugees entering into Europe often lack passports and credit histories. Consequently, they cannot easily use modern financial and healthcare systems. Without proper identification, refugees face a string of linked problems: they face difficulties obtaining credit, cannot open bank accounts, have limited access to the healthcare and education systems, and have reduced chances of finding employment, since employers hesitate to hire individuals who can only be paid in cash. The Finnish government initiated a program to remedy these difficulties using a blockchain.

The Finnish IDs for refugees were linked to unique identities on a blockchain, which also served as government-issued IDs. This trial terminated in May 2019. One of the targets of the UN Sustainable Development Goals (SDGs) is ensuring identity for all individuals. Target 16.9 of the UN SDG aims to provide legal identities to all individuals by 2030, including asylum seekers and displaced persons.[44] The lack of a legal identity for approximately one billion people around the world puts them at a disadvantage since they cannot access civil services or participate in social activities, have limited economic mobility, and are left vulnerable to abuse and exploitation.

Blockchain-based identity management creates an identity wallet for user-centric identity management, similar to a wallet of cryptocurrency tokens. An identity wallet allows users to have complete control over their wallet, letting them share elements of the wallet with certain providers. Such an identity would be influenced more heavily by platform governance, rather than by geopolitical factors.[45] Other work on blockchain implementations for identity management includes a survey of blockchain applications for government-issued identification around the world including UAE, Finland, Estonia, Luxembourg, and Switzerland,[46] and blockchain applications for migrant and refugee health,[47] government issued identification,[48] and refugee identity solutions.[49]

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A blockchain, as a third-party neutral ledger, can be trusted by both governments and refugees. In addition, the Finnish government does not track specific individuals, but instead uses the data collected to determine patterns of need. Identities are recorded, but they are not revealed. Instead, spending patterns, employment records, and credit histories are tracked in order to determine patterns of economic activity. This allows the government to then develop and make available the resources that best fit the needs of individual refugees.

3. Conceptual Elements of a Smart Community

We now derive the basic elements of smart communities that address fundamental socio-economic and political difficulties (see Figure 1). The blockchain serves as the core component that integrates technology into the solutions developed to address the problems faced by these communities.

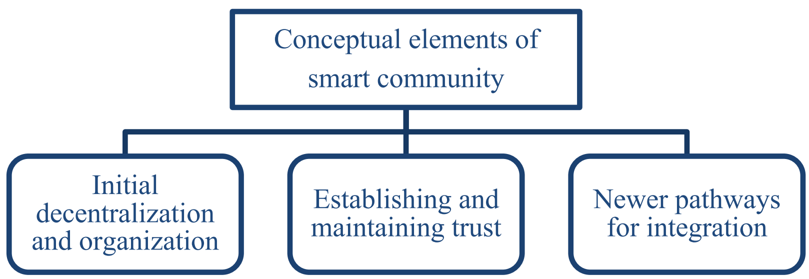

Fig. 1. Conceptual elements of smart communities facilitated by blockchain technologies in economically challenged environments.

3.1. Initial Decentralization and Organization—Rural social environments are naturally more decentralized than urban environments. The decentralized situation in Kenya was exacerbated by the drought and by the collapse of the currency. Consequently, technology could have a positive centralizing effect. The lack of urban infrastructure allowed blockchain-integrated technology to function as the seed for building an infrastructure that gives people access to financial services. The new banking system, instead of piggy-backing on an existing system, is founded on the security of a blockchain.

The Jordanian refugee camp was also decentralized, although to a lesser degree. The difficulty in establishing personal identity within the decentralized context of the camp made financial transactions unsafe. There was no centralizing capacity to organize a system with which to solve this problem: that is, there were no adequate institutions with enough resources or authority to accomplish this task in traditional ways. Similarly, the lack of effective book-keeping and of a record of transactions meant that aspects of the market and financial system were *ad hoc* and without adequate security and oversight. These are classic aspects of a negative decentralization. Blockchains provided centralizing technology without requiring the development of a complex social institution. It had to be developed and implemented, of course, and that required the authority and resources of outside agents. Blockchain technologies,

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therefore, can play a central role in developing infrastructure and smart communities in such decentralized environments.

3.2. Establishing and Maintaining Trust—Many of the functions and services of high-income smart cities increase the efficient use of resources, people, and information. In impoverished environments or in socially volatile communities, basic urban infrastructure can be poor or non-existent, such that efficiency is not the issue. There is nothing to improve since there is nothing functionally there. In such cases, new services can be developed only if there is trust in those services, a trust that cannot be developed through established institutions and inter-

Table 1. Overview of the conceptual elements of blockchain-assisted smart communities in the case studies examined in this paper.

	Building Blocks	Community Inclusion Currencies	National Digital Identity Platform	Finnish Blockchain ID
Region	Pakistan, Jordan	Kenya	Sierra Leone	Finland
Sponsoring organization	World Food Programme, UN Women	Red Cross Societies of Norway, Denmark, and Kenya	Kiva	Finnish government
Goals	Food distribution, financial transactions, and identity verification	Formation of a banking and financial exchange network	Identity verification for financial inclusion	Identity management for refugees
Initial decentralization and organization challenges	Establishing personal identity and maintaining transaction records	Unbanked/under-banked people in accessing resources	Lack of identity-proving documents for Know Your Customer (KYC) framework	Limited opportunities for refugees to access employment and assistance resources
Establish and maintain trust	Iris verification, accurate transaction records, privacy	Blockchain payment system enabled trade of farming supplies and created economy	Nationwide repository of digital identity, enabled access to banking and federated credit resources	Blockchain-based identity wallet trusted by both government agencies and refugees
Newer pathways for integration	Seamless transactions between vendors, intermediaries, and financial institutions	Anchored to Kenyan national currency, backed by the mobile banking system	Access to financial and banking resources nationwide	Access to financial assistance, employment, education, and healthcare

-ests. Blockchains are perfectly suited for such environments. Blockchains' transaction records are independent of established authorities. Thus, in a situation in which trust is low and in which

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people cannot rely on preexisting institutions, a blockchain's immutability offers a system in which people can place a high degree of trust.

3.3. Newer Pathways for Integration—Even in the case of a developed country like Finland, the need to establish trust was critical if the refugees were to form a smart community. The refugees entering the country were in a *decentralized condition*—lacking proper identification, and not yet integrated into the Finnish social system or economy. They existed as a decentralized group relative to the centralized financial and health systems that they wanted to be able to use. The Finns and the refugees naturally mistrusted each other given that decentralized condition. The blockchain-based identity management program not only established a secure means of integrating the refugees in a basic way into the Finnish social system, it also established the conditions for trust. The blockchain here not only provides a secure ledger recording the identities of individuals, it does this in a neutral third-party way that engenders this trust.

Social conditions in some communities are such that one cannot just offer services or extend infrastructure elements into the environment and expect people to use these services. Instead, these conditions require a new kind of community by developing pathways by means of which people can engage with these new services. Blockchains can offer such a pathway. The Kenyan banking initiative as well as Kiva micro-lending are both examples of this. In the case of the Jordanian refugee camp, the current system was failing, and so new ways of integrating people into the system was necessary. This integration function in effect builds a community through the integrity and trust in a blockchain. The community is relative to the service function organized through the blockchain. This fits our definition of a smart community above: a smart community consists of a set of agents that are more-or-less equivalent relative to a particular function, service, or network relation that is at issue. In all the cases we have examined, the smart systems were linked to a larger network of services. Table 1 provides an overview of the conceptual elements of the blockchain-facilitated smart communities in each of the cases examined in this paper. These smart systems, however, do not constitute a smart city. They are not part of a city as a whole, but rather they are locally defined and allow for participation in systems that go beyond the specific urban (or rural) environment. The blockchain systems, therefore, allow for the emergence of specifically defined communities organized around the services they provide, allowing people to leapfrog over cities and participate in larger networks and communities.

3.4. Blockchain Implementations for Smart Communities—In our descriptions of the four blockchain project case studies, we have emphasized the communal nature of the blockchain solutions. In each of these projects, smart technology is not integrated into existing urban infrastructure; instead it is used to build a local version of such infrastructure. As such, what is driving the technological implementation is bottom-up economic need. This bottom-up need is then matched by top-down design developments, the primary goal of which is to allow for local access to broader economic and social networks. In such contexts that lack advanced infrastructure, blockchains can be used to begin to build that infrastructure in direct response to specific problems and challenges that people have in their lives. Without such smart technology many people would remain outside of basic financial and social systems. Blockchain applications facilitate the development of communities that are able to engage and interact with larger networks and systems.

These blockchain networks should be understood as smart communities. We want to offer a brief justification for calling these blockchain-based networks *communities*, and not nascent

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or miniaturized smart cities. A city is not simply a large community. It might consist of multiple communities, but that does not mean that it is an aggregate of communities. A city, to function economically and politically, requires a defining order and organization: a hierarchy of structures within which communities are embedded. This hierarchy of structures includes not only political powers and laws (including some means of enforcing these laws), but also the creation and maintenance of essential infrastructures and services, from roads to waste removal. Each of the four cases we have examined includes weak infrastructure, fragmentation, political volatility, and economic weakness. Thus, in critical ways in these four cases, there exists no sufficient defining order and organization. The refugees in Jordan and Finland live in a relative state of disorganization in comparison with their host countries. The situations in Kenya and Sierra Leone included a mix of political, economic, and social challenges that undermined the established infrastructure and financial services.

In an everyday sense, communities can be defined as collections of people who have a specifically defined commonality.[50] A community is facilitated by top-down factors, but it emerges through bottom-up interests and the particularity of the people involved. A community cannot be created from the top down by fiat. It must emerge through interactions and common interests.[51] A smart community is, of course, a particular kind of community, a technologically-facilitated community. At a very basic level, the technology in a smart community allows for or facilitates the interaction among the relevant agents. Even in the Finnish case, in which patterns of behavior lead to the top-down allocation of resources, the actual social and economic interactions are what constitutes the community, which is facilitated by technological means. In the other three cases, a problem involving local interactions is resolved or diminished by the blockchain-based smart technology. In all of these cases, the blockchain implementation can be effective because all agents, all members of the community, including the financial service providers, can trust the context of their interaction, creating a stable and predictable context of interaction. These blockchains ensure that trust.

4. Conclusion

In the development of smart cities within modern, developed countries, blockchains serve as a facilitator of the various smart city functions implemented. These functions increase efficiency, safety, and comfort of citizens, at the cost of requiring increased surveillance and tracking by embedded smart systems. Blockchain technology not only enables some of these smart functions, it also creates a counter, decentralizing pressure to mitigate some of the increase of centralized authorities. In under-developed countries and communities, the situation is very different. In these cases, a blockchain can function as an essential infrastructural element, providing a means of establishing a financial identity separate from local conditions. Such an identity is necessary in order for people to participate in more modern financial institutions. From the establishment of such identities new forms of trust can emerge, building a kind of smart community around the blockchain technology. The technology provides both the seed and an essential element for the bottom-up growth of smart solutions to problems faced by people in economically challenged environments.

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Author Contributions

BB and RM were equally responsible for the development of the ideas and they both contributed equally to manuscript preparation.

Notes and References

[1] Allam, Z., Dhunny, Z. A. "On Big Data, Artificial Intelligence and Smart Cities." *Cities* **89** 80-91 (2019) https://doi.org/10.1016/j.cities.2019.01.032.

[2] Kosowatz, J. "Top 10 Growing Smart Cities." *American Society of Mechanical Engineers Report* (accessed on 19 March 2023) https://www.asme.org/topics-resources/content/top-10-growing-smartcities.

[3] No Author. "Smart Cities: Digital Solutions for a More Livable Future." *McKinsey Global Institute* (5 June 2018) (accessed on 19 March 2023) https://www.mckinsey.com/capabilities/operations/our-insights/smart-cities-digital-solutions-for-a-more-livable-future.

[4] Bhushan, B., Khamparia, A., Sagayam, K. M., Sharma, S. K., Ahad, M. A., Debnath, N. C. "Blockchain For Smart Cities: A Review of Architectures, Integration Trends and Future Research Directions." *Sustainable Cities and Society* **61.102360** (2020) https://doi.org/10.1016/j.scs.2020.102360.

[5] Xie, J., Tang, H., Huang, T., Yu, F. R., Xie, R., Liu, J., Liu, Y. "A Survey of Blockchain Technology Applied to Smart Cities: Research Issues and Challenges." *IEEE Communications Surveys & Tutorials* **21.3**, 2794-2830 (2019) https://doi.org/10.1109/comst.2019.2899617.

[6] Tan, L., Xiao, H., Yu, K., Aloqaily, M., Jararweh, Y. "A Blockchain-Empowered Crowdsourcing System for 5G-Enabled Smart Cities." *Computer Standards & Interfaces* **76** 103517 (2021) https://doi.org/10.1016/j.csi.2021.103517.

[7] Alexopoulos, C., Charalabidis, Y., Androutsopoulou, A., Loutsaris, M.A., Lachana, Z. "Benefits and Obstacles of Blockchain Applications in e-Government." In Proceedings of the 52nd Hawaii International Conference on System Sciences (2019) https://doi.org/10.24251/hicss.2019.408.

[8] Hjálmarsson, F. Þ., Hreiðarsson, G. K., Hamdaqa, M., Hjálmtýsson, G. "Blockchain-Based e-Voting System." In *Proceedings of the 11th IEEE International Conference on Cloud Computing (CLOUD)* 983-986 (2018) https://doi.org/10.1109/CLOUD.2018.00151.

[9] Majeed, U., Khan, L. U., Yaqoob, I., Kazmi, S. A., Salah, K., Hong, C. S. "Blockchain for IoT-based Smart Cities: Recent Advances, Requirements, and Future Challenges." *Journal of Network and Computer Applications* **181** 103007 (2021) https://doi.org/10.1016/j.jnca.2021.103007.

[10] Herian, R. "Legal Recognition of Blockchain Registries and Smart Contracts." *EU Blockchain Observatory and Forum* (2018) http://dx.doi.org/10.13140/RG.2.2.12449.86886/1.

ISSN 2379-5980 (online)
DOI 10.5915/LEDGER.2024.302

[11] Albino, V., Berardi, U., Dangelico, R. M. "Smart Cities: Definitions, Dimensions, Performance, and Initiatives." *Journal of Urban Technology* **22.1** 3-21 (2015) https://doi.org/10.1080/10630732.2014.942092.

[12] Truntsevsky, Y. V., Lukiny, I. I., Sumachev, A. V., Kopytova, A. V. "A Smart City is a Safe City: The Current Status of Street Crime and its Victim Prevention Using a Digital Application." In Proceedings of the MATEC Web of Conferences **170** (2018) https://doi.org/10.1051/matecconf/201817001067.

[13] Thomason, J., *et al.* "Blockchain—Powering and Empowering the Poor in Developing Countries." In A. Marke (Ed.), *Transforming Climate Finance and Green Investment with Blockchains* 137-152 (2018) https://doi.org/10.1016/b978-0-12-814447-3.00010-0.

[14] Rozas, D., Tenorio-Fornés, A., Díaz-Molina, S., Hassan, S. "When Ostrom Meets Blockchain: Exploring the Potentials of Blockchain for Commons Governance." *Sage Open* **11.1** 1–14 (2021) https://doi.org/10.1177/21582440211002526.

[15] Benkler, Y. "Coase's Penguin, or, Linux and "The Nature of the Firm."" *The Yale Law Journal* **112.3** 369–446 (2002) https://doi.org/10.2307/1562247.

[16] Ostrom, E. "Governing the Commons: The Evolution of Institutions for Collective Action." *Cambridge University Press* (1990) https://doi.org/10.1017/cbo9780511807763.

[17] Albino, V., Berardi, U., Dangelico, R. M. "Smart Cities: Definitions, Dimensions, Performance, and Initiatives." *Journal of Urban Technology* **22.1** 3-21 (2015) https://doi.org/10.1080/10630732.2014.942092.

[18] Park, M. S., Lee, H. "Smart City Crime Prevention Services: The Incheon Free Economic Zone Case." *Sustainability* **12.14** 5658 (2020) https://doi.org/10.3390/su12145658.

[19] Goldsmith, S. "Digital Transformation: Wiring the Smart City." *Manhattan Institute* (2014) https://manhattan.institute/article/digital-transformation-wiring-the-responsive-city.

[20] Ghosh, D., Chun, S. A., Shafiq, B., Adam, N. R. "Big Data-Based Smart City Platform: Real-Time Crime Analysis." In Y. Kim, M. Liu (Eds.), *Proceedings of the 17th International Digital Government Research Conference on Digital Government Research* (2016) https://doi.org/10.1145/2912160.2912205.

[21] Treiblmaier, H. (2019). "Toward More Rigorous Blockchain Research: Recommendations for Writing Blockchain Case Studies." *Frontiers in Blockchain* **2.3** 1–15 (2019) https://doi.org/10.3389/fbloc.2019.00003.

[22] Watson, R. T. "Beyond Being Systematic in Literature Reviews in IS." *Journal of Information Technology*, **30.2** 185-187 (2015) https://doi.org/10.1057/jit.2015.12.

[23] Ngai, E. W., Gunasekaran, A. "A Review for Mobile Commerce Research and Applications." *Decision Support Systems* **43.1** 3-15 (2007) https://doi.org/10.1016/j.dss.2005.05.003.

ISSN 2379-5980 (online)
DOI 10.5915/LEDGER.2024.302

[24] Coppi, G., Fast, L. "Blockchain and Distributed Ledger Technologies in the Humanitarian Sector." HPG Commissioned Report, Overseas Development Institute (2019) (accessed 28 March 2024) `https://www.econstor.eu/bitstream/10419/193658/1/1067430997.pdf`.

[25] Lacity, M. C., *A Manager's Guide to Blockchains for Business: From Knowing What to Knowing How*. Stratford-upon-Avon: SB Publishing (2018).

[26] Ridder, H. G. "The Theory Contribution of Case Study Research Designs." *Business Research* **10** 281-305 (2017) `https://doi.org/10.1007/s40685-017-0045-z`.

[27] Zambrano, R., Young, A., Verhulst, S. "Connecting Refugees to Aid through Blockchain-Enabled ID Management: World Food Programme's Building Blocks." GovLab October (2018) `https://blockchan.ge/blockchange-resource-provision.pdf`.

[28] World Food Programme Report. "Blockchain Against Hunger: Harnessing Technology in Support of Syrian Refugees." (accessed 19 March 2023) `https://innovation.wfp.org/blog/blockchain-against-hunger-harnessing-technology-support-syrian-refugees`.

[29] Shin, E. J., Kang, H. G., Bae, K. "A Study on the Sustainable Development of NPOs With Blockchain Technology." *Sustainability* **12.15** 6158 (2020) `https://doi.org/10.3390/su12156158`.

[30] No Author. "Building Blocks FAQs." *World Food Programme* (accessed on 4 September 2023) `https://docs.wfp.org/api/documents/WFP-0000146542/download/`.

[31] Goering, L. "Red Cross Boosts Disaster-Prone Communities with Blockchain 'Cash'." *Thomson Reuters* (26 November 2019) (accessed 19 March 2023) `https://news.trust.org/item/20191126123058-xtxvz/`.

[32] Barinaga, E. "Sarafu: A Cryptocurrency for Kenyan Rural Communities." *SAGE Publications: SAGE Business Cases Originals* (2022) `https://doi.org/10.4135/9781529789898`.

[33] No Author. "Community Inclusion Currencies." *The Humanitarian Innovation Programme* (accessed 4 September 2023) `https://hip.innovationnorway.com/article/community-inclusion-currencies`.

[34] Mattsson, C. E., Criscione, T., Ruddick, W. O. "Sarafu Community Inclusion Currency 2020–2021." *Scientific Data* **9.1** 426 (2022) `https://doi.org/10.1038/s41597-022-01539-4`.

[35] Mqamelo, R. "Community Currencies as Crisis Response: Results from a Randomized Control Trial in Kenya." *Frontiers in Blockchain* **4** 739751 (2022) `https://doi.org/10.3389/fbloc.2021.739751`.

[36] Blakstad, S., Melkun, C., Shreves, R. "The Next Generation Humanitarian Distributed Platform." Copenhagen: Danish Red Cross, Mercy Corps, and hiveonline (accessed 4 September 2023) `https://www.mercycorps.org/sites/default/files/2020-11/The-Next-Generation-Humanitarian-Distributed-Platform-v3.pdf`.

ISSN 2379-5980 (online)
DOI 10.5915/LEDGER.2024.302

[37] No Author. "Sierra Leone's Thumbprint Breakthrough to Sign Up Unbanked." Financial Times (accessed 19 March 2023) https://www.ft.com/content/40980b7c-c350-11e9-a8e9-296ca66511c9.

[38] Yao, W., Deek, F. P., Murimi, R., Wang, G. "SOK: A Taxonomy for Critical Analysis of Consensus Mechanisms in Consortium Blockchain." *IEEE Access* **11** 79572-79587 (2023) https://doi.org/10.1109/ACCESS.2023.3298675.

[39] No Author. "Kiva Protocol, Built on Hyperledger Indy, Ursa And Aries, Powers Africa's First Decentralized National ID System." *Hyperledger Foundation Blog* (20 January 2021) (accessed 4 September 2023) https://www.hyperledger.org/blog/2021/01/20/kiva-protocol-built-on-hyperledger-indy-ursa-and-aries-powers-africas-first-decentralized-national-id-system.

[40] Suberg, W. "Finland Solves Refugee Identity with Blockchain Debit Cards." *Cointelegraph* (5 September 2017) https://cointelegraph.com/news/finland-solves-refugee-identity-with-blockchain-debit-cards.

[41] Pisa, M., Juden, M. "Blockchain and Economic Development: Hype vs. Reality." *Center for Global Development Policy Paper* **107** 150 (2017) https://www.cgdev.org/publication/blockchain-and-economic-development-hype-vs-reality.

[42] Davison, J. "A Generation of Syrian Children Who Don't Count." *Reuters Investigates* (3 May 2016) https://www.reuters.com/investigates/special-report/syria-refugees-stateless/.

[43] Zwitter, A., Boisse-Despiaux, M. "Blockchain for Humanitarian Action and Development Aid." *Journal of International Humanitarian Action* **3** 16 (2018) https://doi.org/10.1186/s41018-018-0044-5.

[44] No Author. "UN SDG Indicators." *SDSN* (accessed 4 September 2023) https://indicators.report/targets/16-9/.

[45] Terranova, G. "The New Geography of Asylum: Digital Identity, Artificial Intelligence and Blockchain." *AIMS Geosciences* **8.3** 385-397 (2022) https://doi.org/10.3934/geosci.2022022.

[46] Kuperberg, M., Kemper, S., Durak, C. "Blockchain Usage for Government-Issued Electronic IDs: A Survey." In *International Conference on Advanced Information Systems Engineering* 155-167 (2019) https://doi.org/10.1007/978-3-030-20948-3_14.

[47] Corte-Real, A., Nunes, T., da Cunha, P. R. "Blockchain Technology in Migrant and Refugee Health: A Scoping Review." *Journal of Global Health* **12** (2022) https://doi.org/10.7189/jogh.12.04047.

[48] Ngo, T. T., Dang, T. A., Huynh, V. V., Le, T. C. "A Systematic Literature Mapping on Using Blockchain Technology in Identity Management." *IEEE Access* **11** 26004-26032 (2023) https://doi.org/10.1109/access.2023.3256519.

ISSN 2379-5980 (online)
DOI 10.5915/LEDGER.2024.302

[49] Cheesman, M., Slavin, A. "Self-sovereign Identity and Forced Migration: Slippery Terms and the Refugee Data Apparatus." *Digital Identity, Virtual Borders and Social Media* 10-32 (2021) https://doi.org/10.4337/9781789909159.00006.

[50] McMillan, D. W., Chavis, D. M. "Sense of Community: A Definition and Theory." *Journal of Community Psychology* **14.1** 6-23 1986 https://doi.org/10.1002/1520-6629(198601)14:1<6::AID-JCOP2290140103>3.0.CO;2-I.

[51] Granovetter, M. S. "The Strength of Weak Ties." *American Journal of Sociology* **78.6** 1360-1380 (1973) https://doi.org/10.1093/oso/9780195159509.003.0010.

ISSN 2379-5980 (online)
DOI 10.5915/LEDGER.2024.302