DISCUSSION PAPER

BLOCKCHAIN FOR URBAN DEVELOPMENT

Guidance for Urban Managers

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BLOCKCHAIN FOR URBAN DEVELOPMENT

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Introduction

Rapid urbanization and technological advancements are among the megatrends reshaping the world.[1] Today, more than half of the world population lives in urban areas, compared to roughly 30% in 1950. It is projected that two-thirds of the world population will reside in urban areas by 2050.[2] These projections have significant sustainability implications as much of the world's economic, social, and cultural activities are concentrated in urban areas. On the other hand, rapid improvements in connectivity, internet penetration and speed, and new technologies (such as cloud computing), are accelerating digitization and making frontier technologies more efficient. These technological breakthroughs are changing how society lives, does business and governs itself. In addition, they are becoming increasingly critical in addressing long-standing issues related to urban development such as limited tenure security, livelihood generation activities, and access to basic services.

Blockchain is one of the relatively new and rapidly developing technologies that could assist in accelerating the achievement of the 2030 Sustainable Development Goals.[3] While blockchain has been applied somewhat successfully in the financial sector, its applications are now being sought in areas such as land management, energy management, and governance. UN System organizations are experimenting with the technology and piloting its use in the areas of "supply chain, digital payments, tracing of livestock, digital identity and land registration".[4] Policies, standards and close examination of the legal aspects of blockchain use are deemed critical in reducing the legal uncertainty and henceforth accelerating the adoption of blockchain in the UN System.

This paper, by UN-Habitat, discusses blockchain's unique features in relation to urban development. Specifically, the paper explores potential applications of blockchain in addressing challenges related to sustainable urbanization as well as the risks and challenges associated with its implementation. The paper targets city leaders, managers and policymakers who may be interested in adopting blockchain technologies in the provision of services, as well as other stakeholders such as the private sector, donors, civil society, and UN agencies. The main objective of the paper is to critically discuss the potential of, and concerns about blockchain through an urban looking glass. It aims to expand discussion on potential applications of blockchain to include sustainable urban development.

A key argument of this paper is that, like many technologies, blockchain itself is not a panacea for addressing sustainability challenges in urban areas and must be adopted whilst integrating human-centered approaches and robust business processes. It must also consider adequacy of capacity including financial resources, human resources, local culture, infrastructure, and governance systems, while minimizing exacerbation of inequality in access and benefits.

The paper is comprised of eight sections. Section one provides the general orientation of the paper. Section two introduces blockchain technology, briefly describing how it works and the distinct types of blockchain. Section three briefly describes the usage of blockchain by United Nations agencies. Section four discusses the potential applications of blockchain technology for urban management. This section also provides several case studies of cities implementing blockchain. The fifth section discusses the risks and concerns associated with implementation of blockchain. Section six analyses the preconditions necessary for successful implementation of blockchain in cities. In sections seven and eight, the paper provides a set of recommendations to guide urban managers in cities seeking to adopt this technology.

1 https://www.pwc.co.uk/issues/megatrends.html
2 https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf
3 https://www.un.org/en/newtechnologies/
4 https://www.unjiu.org/sites/www.unjiu.org/files/jiu_rep_2020_7_english.pdf

CHAPTER 01

What is Blockchain?

The concept of blockchain was introduced in a white paper by "Satoshi Nakamoto"[5] in 2008 as the underlying technology for bitcoin, "[a] peer-to-peer version of electronic cash that would allow online payments to be sent directly from one party to another without going through a financial institution."[6] To address the commonly known "double spending" problem – the risk that a digital currency can be spent twice[7] – the paper proposed a system where "[t]he network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work."[8] While Bitcoin was the first use of blockchain, it is only one application of how the technology can be used to store information.

Since this initial paper, blockchain has developed to be understood as "a distributed append-only time stamped data structure"[9] that keeps records of transactions in the form of »block" of information, connected in a chain-like format, that can be shared securely across computers on a shared network. Put another way, blockchain is a shared digital database that can be used simultaneously by everyone on the network (peers or participants) and all computers in the network can view and retain a copy of all records. The "peers" or stakeholders in the blockchain network agree among themselves to any changes made to the shared database without the intervention of a third party.

Although blockchain is similar to other database technologies in the way it stores information, it has attributes that make it unique and preferred in many of its applications.

First, even though the system is not "hack-proof", blockchain systems are considered to be less vulnerable[10] (at least as compared to other databases) in many contexts. Most transactions take place across an interlinked peer-to-peer network, and records are replicated completely or partially across several interconnected systems. Communication between parties is also secured through cryptography and any information intercepted is usually not comprehensible.

Second, it is impossible to change records (immutability) as every 'block' with a record is uniquely connected via a digital signature to another 'block'. The entire history of a record is available over a blockchain and once a transaction is completed, it can never be reverted.

Third, (and in an ideal state), there is no need for a centralized third party or owner as information is transferred across the internet once all parties agree to a network verified transaction. Transactions are verified by a pre-determined set of rules. In addition, this removes the need for reconciliations hence allowing for automatic execution of agreed actions once predetermined conditions are met.

The attributes described above enable blockchains to perform three main functions:

1. store information,
2. track the exchange of value, and
3. digitize and automate rules through smart contracts (programs stored on blockchain that run when predetermined conditions are met).[11]

5 Satoshi Nakamoto is presumed to be a pseudonym, and no person named Satoshi Nakamoto has come forward or claimed ownership.
6 Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," October 31, 2008. Available at: https://bitcoin.org/ bitcoin.pdf
7 https://www.investopedia.com/terms/d/doublespending.asp
8 Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," October 31, 2008. Available at: https://bitcoin.org/ bitcoin.pdf
9 http://www.sciencedirect.com/science/article/pii/S0736585318306324
10 http://ficci.in/spdocument/22934/Blockchain.pdf
11 https://atrium.uninnovation.network/guide

Blockchain's unique features and functionalities can be leveraged to meet the need for complete, secure, authentic and trustworthy information exchange across various fields[12] and to promote transparency, efficiency and good data management practices which are basic building blocks for urban development solutions. For example, it can be used to make city management processes more secure, transparent, efficient and resilient. This may induce indirect positive effects in city management and productivity, such as in the streamlining of procurement, operational, and service-delivery processes.[13]

At the same time, it is worth noting that the technology is also considered to have some inherent limitations, partly because of the dynamic and fluid contexts in which it has to operate. Blockchain alone, for example, "is not a magic solution and information must be organized and digitized for blockchain to work". It does not exist outside a political, governance, cultural and social system, and the resources in place to manage such a system which can affect its ultimate operationalization. In some contexts, there is a shortage of expertise and technical skills to implement blockchain-based solutions, especially in developing and less developed countries. The pros and cons of blockchain are discussed later in the paper but the key message at this point is that the adoption of blockchain "should be approached with an open mind and a healthy dose of skepticism"[14]. Practitioners need to determine whether blockchain technology is the right fit for a particular problem, or whether an alternative tool may be more appropriate.

12 http://ficci.in/spdocument/22934/Blockchain.pdf
13 http://ficci.in/spdocument/22934/Blockchain.pdf
14 https://icma.org/articles/article/icma-releases-whitepaper-blockchain-technology-and-its-application-local-government

1.1. Different Types of Blockchain

There are four main types of blockchain based on the level of "openness of the platform (public or private) and the level of permissions required to add information to the blockchain (permissioned or permission-less)."[15]

Public blockchains can be viewed by anyone, while private blockchains are only open to a select group of people. On the other hand, permissioned[16] blockchains only allows authorized users to transact (commit and record transaction), while permission-less[17] blockchains permits anyone to do so.

Table 1: Main types of Blockchains segmented by permission model[18]

			READ	WRITE	COMMIT	EXAMPLE
BLOCKCHAIN TYPES	OPEN	Public 'permission-less'	Open to Anyone	Anyone	Anyone	Bitcoin, Ethereum
		Public permissioned	Open to anyone	Authorized participants	All or subset of authorized participants	Supply chain ledger for retail brand viewable by public
	CLOSED	Consortium	Restricted to an authorized set of participants	Authorized participants	All or subset of authorized participants	Multiple banks operating a shared ledger
		Private permissioned "enterprise"	Fully private or restricted to a limited set of authorized nodes	Network operator only	Network operator only	External bank ledger shared between parent company and subsidiaries

Source: Hileman & Rauchs, 2017

1.2. How Blockchains Work

Core architectural components of blockchain include a 'block – ' containing data, the hash of itself, and that of the block before it; 'node' – a user or a computer within the blockchain ecosystem; 'chain' – a sequence of blocks in a specific order; 'transaction' – verified and digitally signed records; 'consensus' – set of rules established to carry out every blockchain operation; and 'miners' – specific nodes which perform the block verification process.

The process begins after authentication, when a node requests a transaction by broadcasting it to other nodes. The users put information regarding their transaction into a cryptographic hashing algorithm – a complex mathematical formula – and receive a set of letters and numbers that are distinct to that transaction for security purposes. Secondly, other nodes in the network check if the data has been tampered with, and reject or accept accordingly, without seeing the details of the transaction[19]. Once verified upon consensus, the transaction is complete, and a new block is created and added to the existing blockchain.

Consensus occurs in the beginning when the miners "agree on which transaction should be included in new blocks of transaction" and in the end "when the new block of transactions is actually added to the chain."[20] In that way, the desired goal of maintaining the exact same copy of the history on all nodes is achieved.[21] Since blocks are replicated across multiple ledgers, it is impossible to delete or modify information previously stored on the chain. The graphic below, visualizes how blockchain works in four steps.