Blockchain for Smart Sustainable Cities

A U4SSC deliverable

Urban challenges

Cities face challenges related to rapid urbanization, including:

Inadequate housing and infrastructure

Poverty and hunger

Air pollution

Negative health impacts

Deforestation

Environmental hazards

Waste accumulation

Biodiversity loss

The 2030 Agenda for Sustainable Development

The potential for exacerbation of the problems affecting cities makes them significant vectors for actions to tackle urgent challenges such as poverty, inequality, pollution, mitigation and adaption to climate change.

The **Sustainable Development Goals (SDGs)** of the United Nations aim to address these challenges – particularly SDG 11, which aims to make cities and human settlements inclusive, safe, resilient and sustainable.

SDG 11: Sustainable Cities and Communities

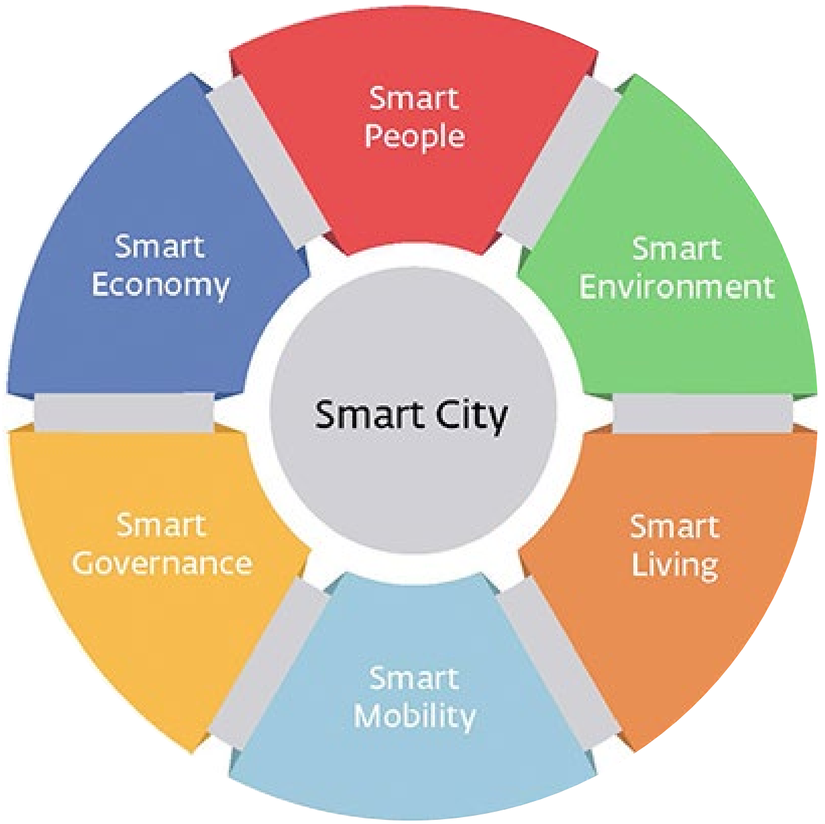
Smart Sustainable Cities

Concentrated efforts to reach SDG 11 are imperative to make our cities more sustainable through better utilization of technology. Within the concept of smart cities, solutions to make cities and communities more efficient, technologically advanced, greener, and socially inclusive are to be implemented. In this context, one of the key definitions for Smart sustainable cities (SSC) developed by the International Telecommunication Union (ITU) is as follows.

"A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects."

Recommendation ITU-T Y.4900

Smart Sustainable Cities



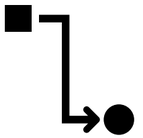
Six dimensions of smart cities

Smart city implementation challenges

However, there are also challenges associated with the implementation of a smart city, such as:

Security

Communication, social and regulatory



Data sharing, transparency, privacy and traceability

Trust

Financing

Blockchain as a solution

Blockchain technology is increasingly seen as a tool for boosting data transparency and traceability in smart cities. As a decentralized IT infrastructure, blockchain technology can serve as a suitable means to manage the growing networks emanating from smart sustainable cities. Blockchain can help:

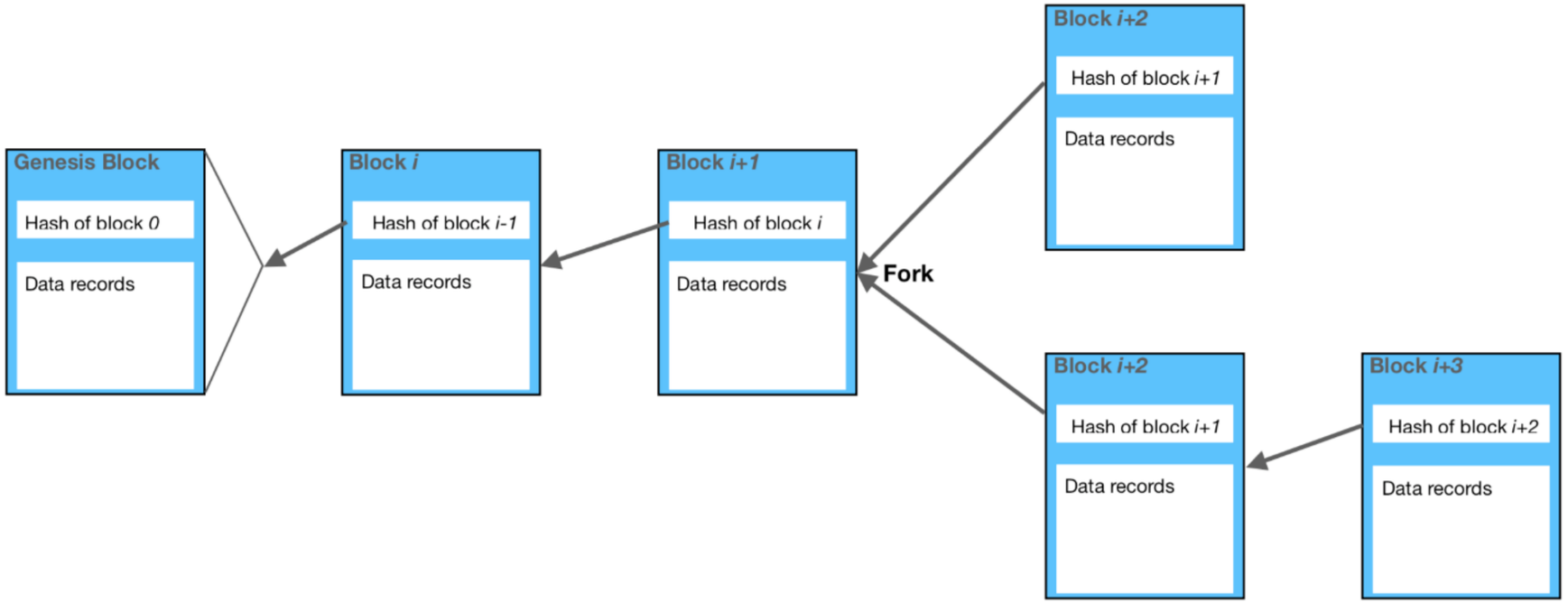
Monitor supply chains

Execute and validate data trails

Ensure authenticity and integrity of data

Unlocking the Blockchain concept

Blockchain is a sequence of blocks, which holds a complete list of transaction records like a conventional public ledger. These transactions or contracts are enclosed in code and stored in transparent and shared databases where they are protected from deletion or change.



Simplified data structure and main elements of blockchain

Blockchain explained

There are five principles related to blockchain functioning:

Each party on a blockchain has access to the entire distributed database.

Communications occur directly between peers without the intervention of a third party or a central entity.

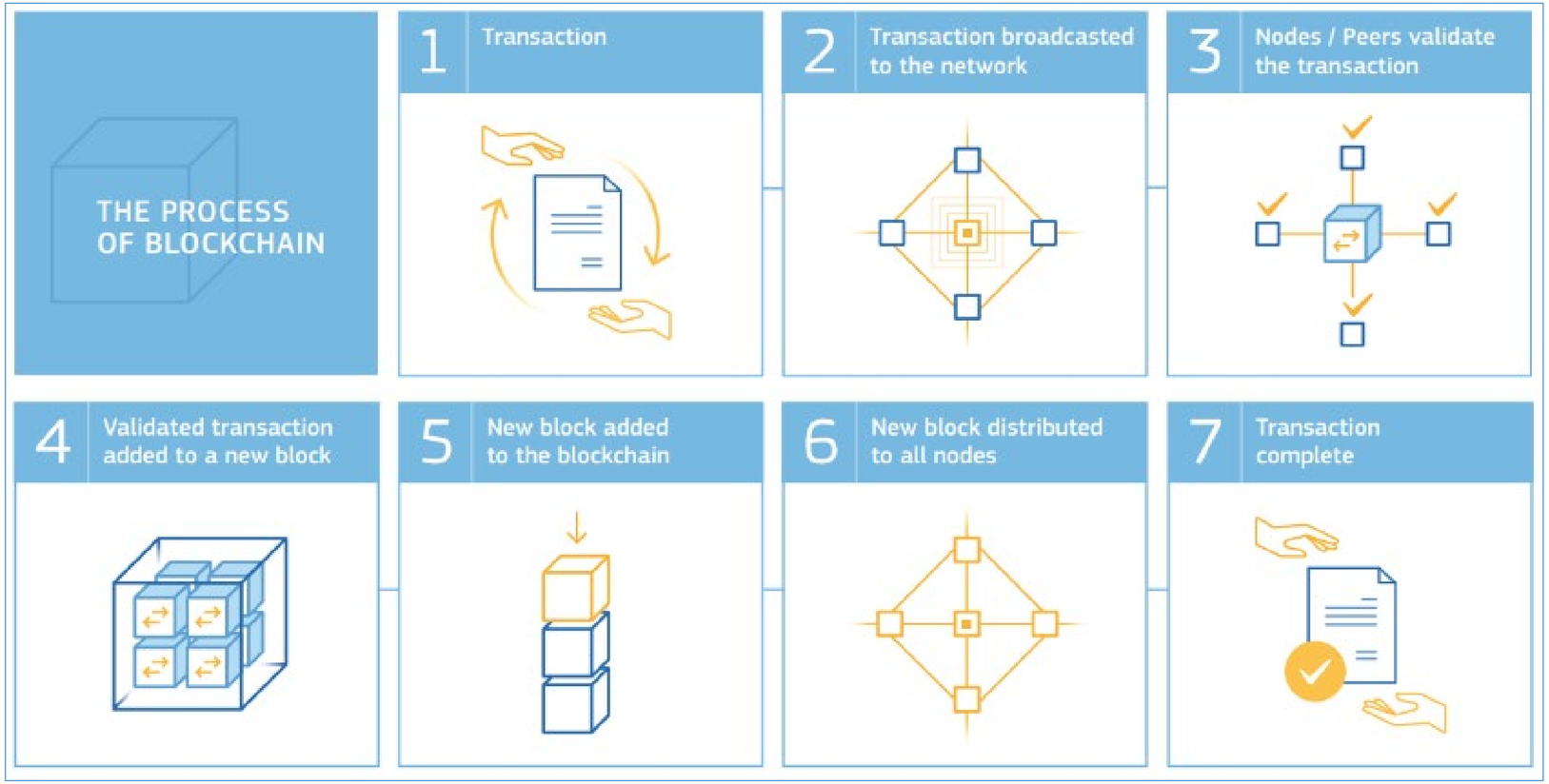
Information about the transactions and the associated value is provided to all the participants with access to the network. Actors can choose to remain anonymous or reveal their identity.

The irreversibility of records bestows the permanent character of the transaction recorded in the database, their chronological order and their availability.

The digital nature of the ledger of the blockchain transaction can be programmed automatically through the set-up of algorithms and rules.

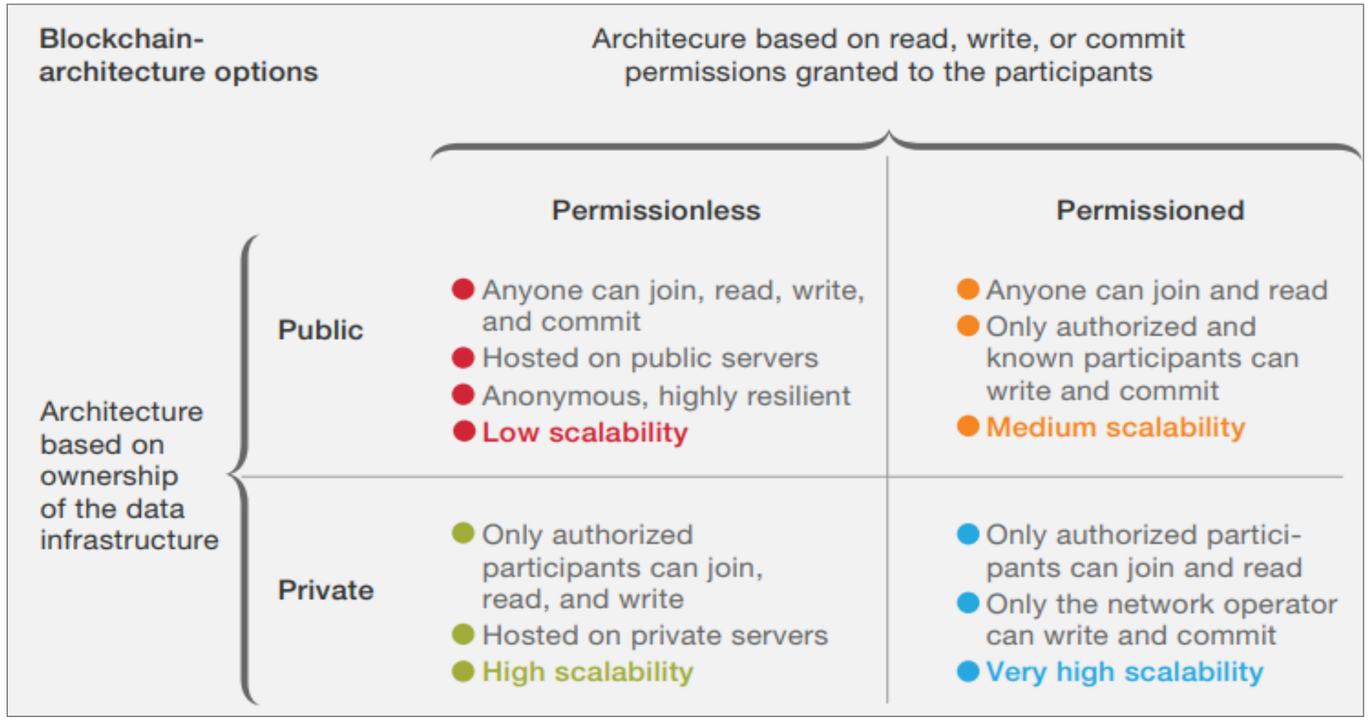
Blockchain explained

The process carried out by the blockchain to validate a transaction and to add it to the network is presented in this Figure.



Blockchain explained

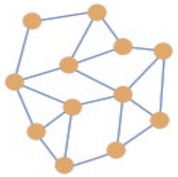
Blockchain can be classified into two categories public vs. private and permissionless vs. permissioned. A combination of the different types of blockchain solutions is composed of blockchain architecture options.



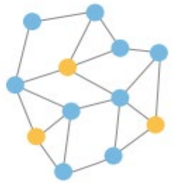
Blockchain architecture options and differences

Blockchain explained

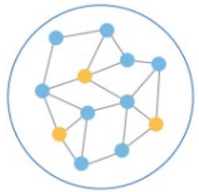
Four blockchain architecture options are based on the type of ownership of the data infrastructure, public or private and the level of “read, write and commit” permission granted to the participants of the networks. These options are often presented as new hybrid blockchains that combines different aspects of the technology



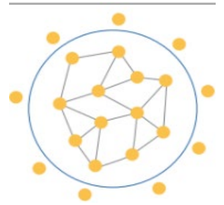
Public permissionless blockchains



Public permissioned blockchain



Private permissioned blockchain



Private permissionless Blockchain

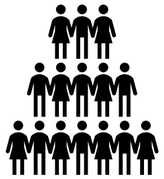
Examples of blockchain types

Blockchain explained

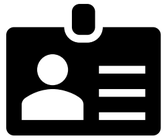
Categories	Opportunities and Benefits of Blockchain technology
Strategic	Transparency, Avoiding Fraud and Manipulation, Reducing corruption
Organisational	Increased trust, Transparency and accountability, Predictive capability, Increased control
Economical	Clear ownerships, Reduced costs
Informational	Increased resilience to attack, Data integrity and high quality, Reducing human errors, Information access, Privacy, Reliability
Technological	Resilience, security, Persistency and immutability (irreversibility)

Categories	Challenges and barriers of blockchain technology
Technological	Immature technology, security, Scalability, flexibility, data privacy, cost and performance, energy consumption, interoperability, complexity, limited technical skills
Organisational	Feasibility, acceptability governance model, organisational readiness, leadership readiness, business model alignment
Institutional	Legal framework, regulatory uncertainty, ethical parameters, inter-organisational relationship, ecosystem readiness

Blockchain for Cities (B4C)

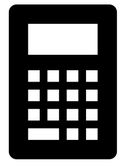


Democracy and decision making



Identity

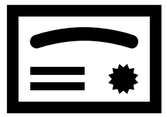
Voting



Public accounting, contracts and taxes

Law enforcement and legal systems

Title and asset registration



Certification

B4C applications in smart governance, smart people and smart community

Blockchain for Cities

Healthcare services

Education

Social care

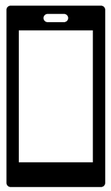
Mobility and transportation

Environment

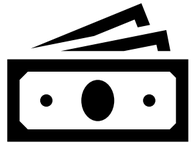
B4C applications in smart living, smart environment and smart mobility

Blockchain for Cities

Energy



Telecommunication



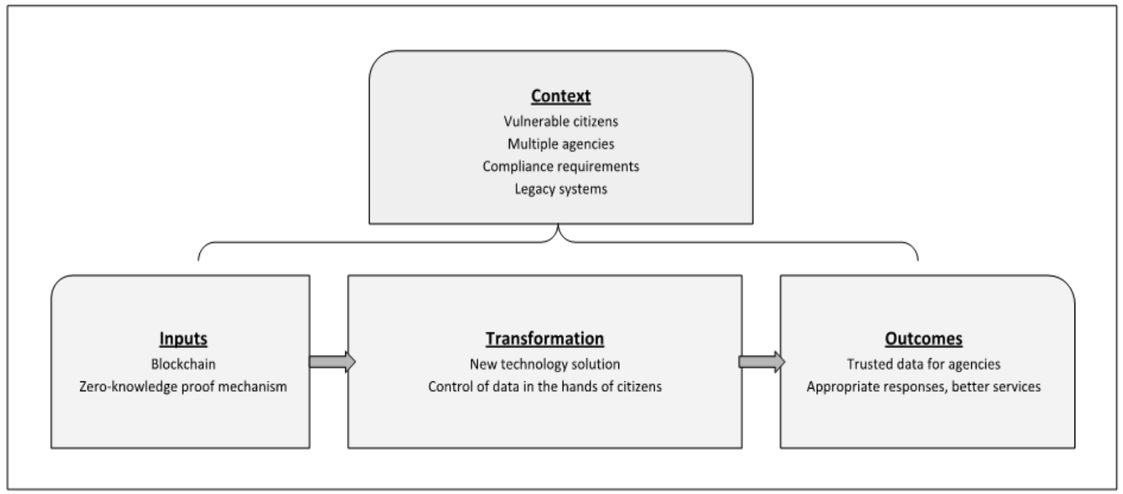
Finance

B4C applications in smart economy

Blockchain for Cities (B4C) Use Cases

Facilitating debt relief in The Hague

- Blockchain as solution to better share and analyze the information about the people in Debt between Government agencies.
- Development of a cost-efficient solution in compliance of privacy and data protection regulations.
- Use-case for situations where individuals need to make verifiable claims about themselves on a network of related, but sparsely connected actors that, by law, cannot share personal information.

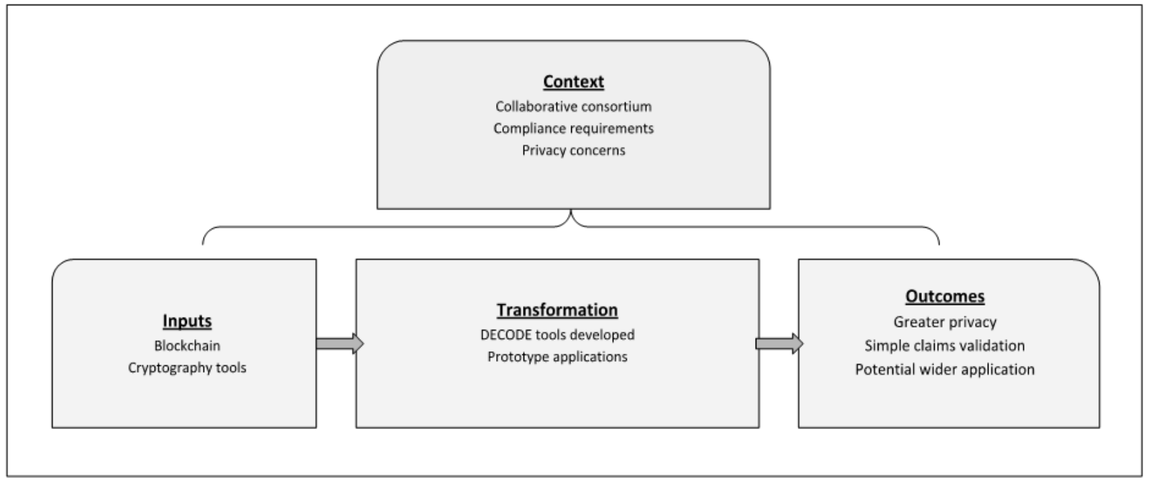


City of the future in The Hague

- The Dutch Central Judicial Debt Collection Agency (CJIB) looked into solutions for better sharing and analysing data about people in debt among government agencies, without compromising their privacy.
- Blockchain technology allows for self-sovereign identity management and verification of owner-shared data without compromising privacy.
- There appear to be promising technical solutions that can give individuals control of their personal data, comply with privacy laws and allow for data sharing that will improve government services.

Verifying eligibility age in Amsterdam

- Blockchain as solution to allow young people to verify their age in Amsterdam.
- Development of a useful solution that helps improve understanding of the user experience and journey, giving people control over their personal data.
- Use-case for situations where individuals need to prove that they are over 18 years old, without revealing their other personal information, in order to, for example, gain access to a club or to buy alcohol.

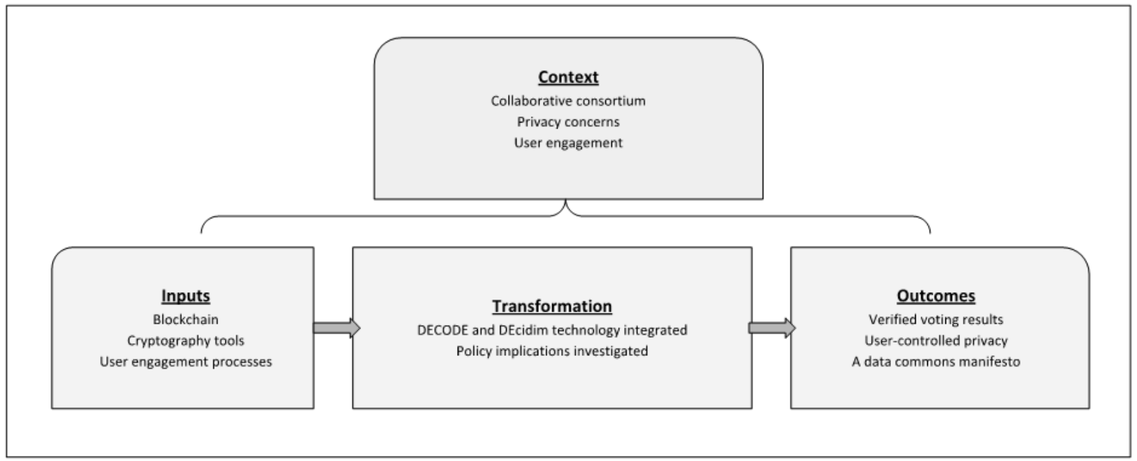


Amsterdam canal

- The city of Amsterdam has decided to develop an app called ‘Stadspas’ (city pass) to facilitate access to city services as part of the "Open City” program.
- The Claim Verification 18+ is a prototype application, based on the technologies developed by the DEcentralised Citizens Owned Data Ecosystem (DECODE) project, that enables people to prove that they are over 18 years old, without revealing their name, date of birth or other information.
- It is possible to use blockchain with zero-knowledge proof and attributes-based credentials to prove claims with limited exposure of personal data.

Digital democracy and data commons, Barcelona

- Blockchain as solution to for managing personal data that is used for governance purposes.
- Development of a viable solution that accepts and counts votes on petitions anonymously, while ensuring voter eligibility.
- Use-case for situations where individuals want to choose to share anonymized data such as the age range or neighborhood of residence.



Decidim. Barcelona webpage

- The Decidim system is a participatory democracy platform in use in Barcelona. It needed to accept and count votes on petitions anonymously, while ensuring that the people voting were eligible to vote. Users would sign petitions with a secured Yes or No vote.
- Distributed ledgers (blockchain) can be used to make public voting (petitions) systems that are auditable, fast and secure.
- Such systems allow users to choose which of their personal data they wish to withhold and which they would like to share, in order to allow platform managers to understand their user base. Any attributes to be shared are cryptographically combined with a unique identifier related to the petition and submitted to a blockchain ledger as a transaction.
- The process is also considered to be GDPR (General Data Protection Regulation) compliant.

Energy system in South Holland

- Blockchain as solution to enable wide participation in the energy system without costly upgrades to the current grid.
- Development of low-cost investment solutions to help balance supply and demand in the energy system, and to ensure the stability, reliability and safety of energy grids with a decentralized influx of renewable energy sources.
- Use-case for eco-friendly houses that are well isolated and use solar power to be, for example, 90% independent of the grid – in essence, neighborhoods of the near future which could produce their own renewable power.

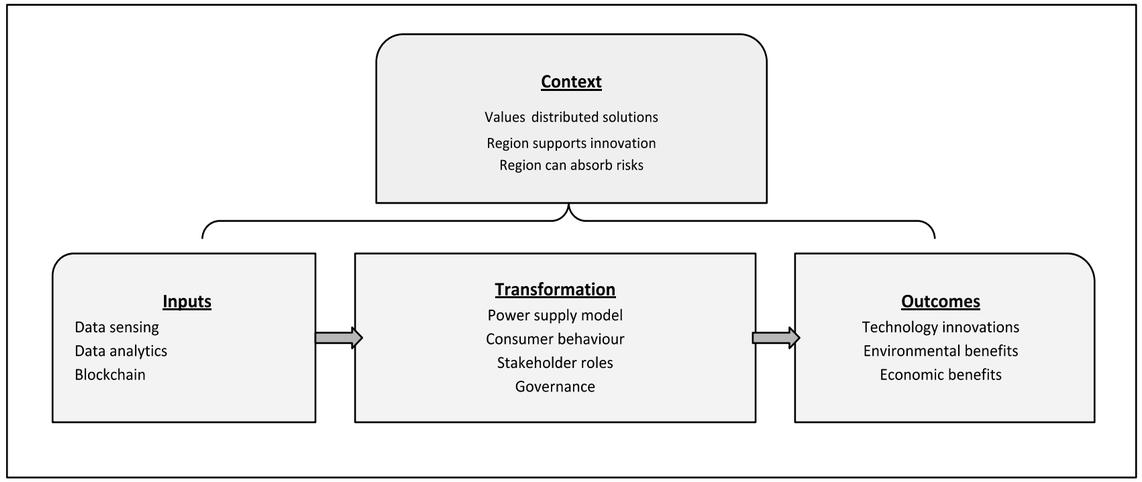
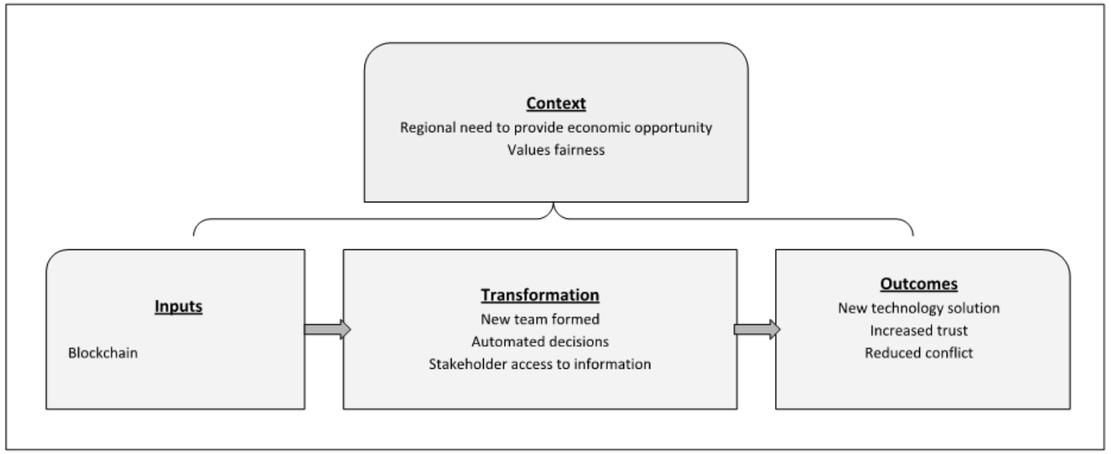


Illustration of a micro- grid community in the Netherlands

- South Holland is investigating how blockchain-based energy systems (among other innovations) can be deployed to enable wide participation in the energy system without costly upgrades to the current grid.
- Blockchain introduces the opportunity for using smart contracts to trade in energy at the level of a household, community, or city.
- Because of the experimental nature of the project, results will only emerge in the long-term and the project requires ongoing support and commitment to reach that point. This project also depends on the buy-in of the community and their willingness to share data.

Moscow weekend fairs

- Blockchain as solution to make the everyday life of residents easier and more comfortable by providing high-quality food and agricultural products to city residents, while supporting local producers and entrepreneurs.
- Development of a reliable solution to increase the transparency in the allocation of trading sites at the fairs.
- Use-case for situations where the users are known, the city needs to control the system, there is no specific need to remove the intermediaries, and the city wants to convince people that processes in government are being applied fairly.

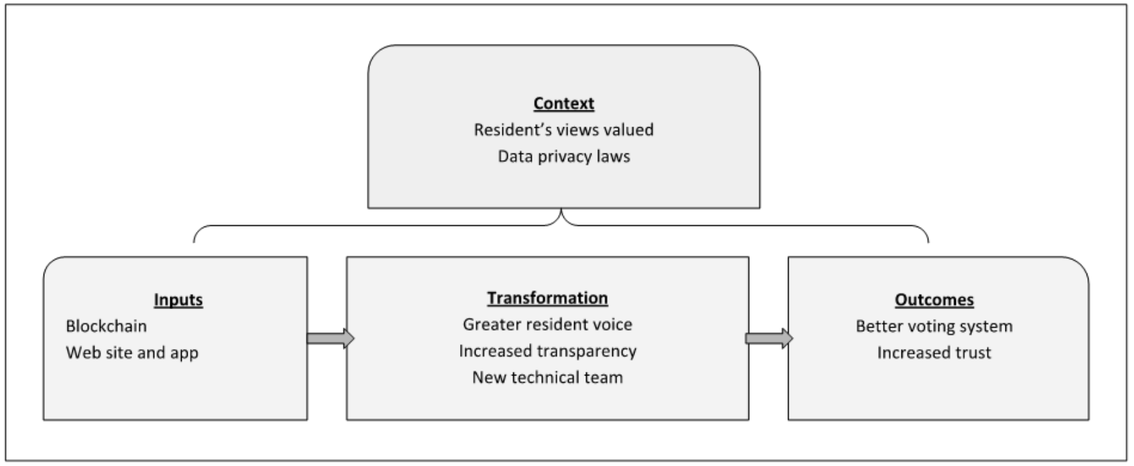


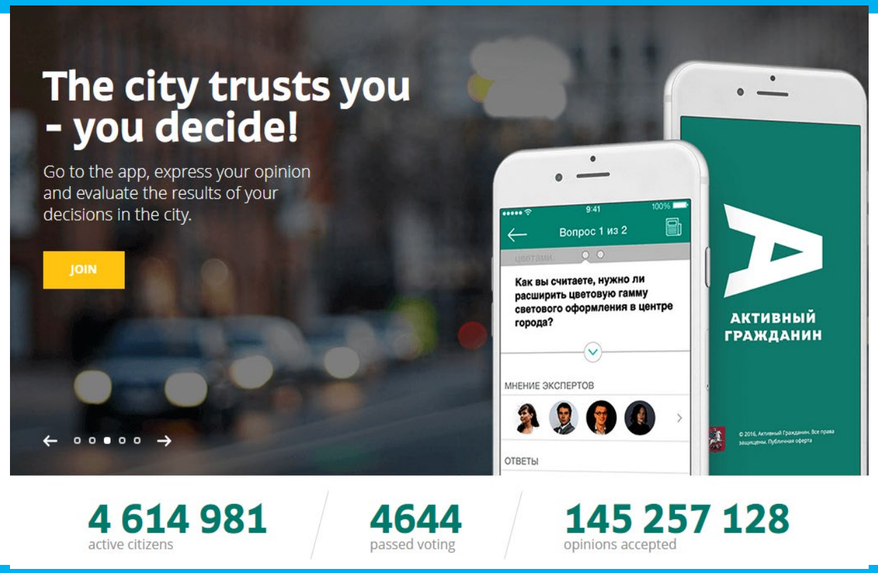
Street fair in winter, Moscow

- The Moscow government has introduced an Ethereum-based, private blockchain solution to increase the transparency in the allocation of trading sites at weekend fairs. Applications are now duplicated on the blockchain and timestamped.
- The increase in transparency relating to the processes for allotment of the trading sites will boost trust of the people in the government.
- The same principle of transparent allotments could trickle into other sectors and public tendors. But the scale of implementation of the project is limited and would need to be adapted significantly for a larger-scale implementation.

Active Citizen, Moscow

- Blockchain as solution to implement platforms for resident's participation in urban life and two-way communication with local government.
- Development of a solution to increase transparency and accountability, ensuring that every Active Citizen participant feels certain that their opinion counts.
- Use-case for situations where people believe that their city influences the citizen voting results, or residents do not understand how the votes are recorded and the results calculated.



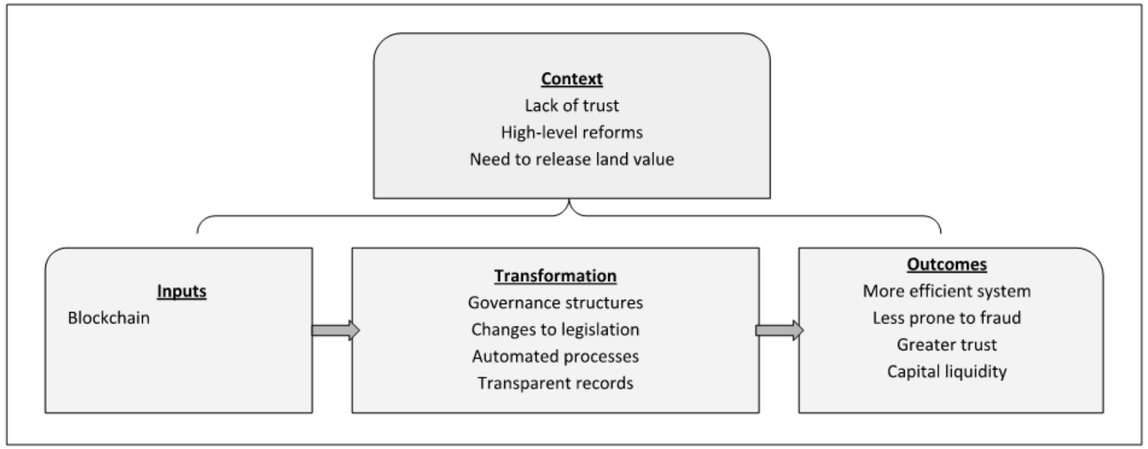


Active Citizen webpage

- In Moscow, the Active Citizen system was developed to allow people of different ages and professions to participate in the positive transformation of their constantly growing and changing city.
- Blockchain technology creates the necessary conditions for increasing confidence in public services through immutability and transparency.
- Data privacy concerns that result from the transparency of blockchain can be dealt with by using identifiers and storing personal data in a parallel system.

A land registry for Georgia

- Blockchain as solution to reduce bureaucracy and increase transparency in the land registration process.
- Development of a solution to verify and authorize the essential information about the citizen and the property, establishing proof of ownership.
- Use-case for situations where there is history of poor governance and, thereby, land disputes that directly affect the growth of smart and sustainable cities.

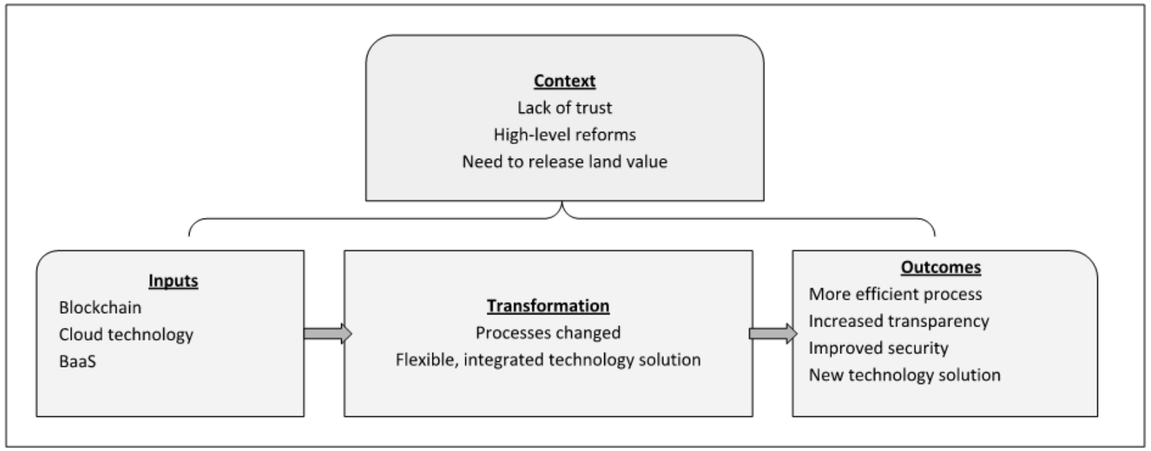


View of Tbilisi, Georgia

- The Republic of Georgia has launched a series of reforms to reduce bureaucracy and increase transparency in matters of land registry. A blockchain-based land registry has been developed. The custom-designed, private, permissioned blockchain is implemented on the Bitcoin blockchain.
- The blockchain enables transparency between the National Agency of the Public Registry and the people, thus reducing corruption. The system enables greater liquidity of hard assets like land, which has economic benefits.
- One of the main challenges is using blockchain for data verification and transparency while not storing too much data on the blockchain and not making personal data public.

Building applications for cell towers in Italy

- Blockchain as solution to better governance and administrative approaches to increase efficiency and new public accountability mechanisms.
- Development of the processes surrounding the building or modifying of cell towers, unifying the underlying technologies and allowing the community to vote on the location of cell towers. The solution would have to interface with legacy systems and be cloud-based.
- Use-case for situations where public administration struggles to offer high-quality services efficiently, resulting in lack of trust.



Alpine towers

- South Tyrol, Italy is looking to simplify bureaucratic processes, unify the underlying technologies and improve inter-agency efficiency to build trust in administration.
- The lack of trust in public administration entities and bureaucracies could be overcome by providing more transparent channels of functioning predicated on blockchain for easy determination of the success of a process as well its time-lines.
- However, local legislation and having multiple stakeholders makes it more complex to design appropriate solutions.

Blockchain for Smart Sustainable Cities

Cross-case analysis and framework proposal

The report presents a cross-case analysis highlighting the challenges, opportunities, and lessons learned from the use-cases presented previously. The findings from these analyses are summarised in the “4S framework” below.

Framework of B4C

Blockchain for Smart Sustainable Cities

Comparative analysis of the B4C use cases

Perspective	Characteristics	Weekfairs	Active Citizen	Land Titling	Energy Systems	Debt Relief	e-vote for cell towers	Digital Democracy	Claim verification	Financial Emergency	Healthy	Stadjerpass	Bling1	Bling2
Sustainability of blockchain technology	The entities and users of the system do not trust each other		✓		✓	✓		✓	Not available			✓	✓	✓
	It is not important to have a trusted third party (TTP)	✓	✓	✓						✓	✓	✓	✓	✓
	The users of the system are not known		✓					✓	✓		✓		✓	
	The control of the system by a specific entity is not required			✓				✓		✓	✓		✓	
	It is necessary to remove intermediaries			✓	✓	✓	✓	Not available	Not available		✓		✓	✓
	It is necessary to work with digital assets	✓		✓	✓	✓	✓	Not available	✓		✓		✓	✓
	It is necessary to maintain a permanent record	✓	✓	✓	✓	✓	✓	✓	Not available				✓	✓
	It is necessary to implement a contractual relationship			✓	✓		✓						✓	✓
	Its is necessary to store transaction states	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Its is not necessary to store sensitive data	✓	✓	✓	✓	✓	✓			✓		✓		
	It is not important to be able to delete records									✓	✓			✓
	The use-case requires shared write access	✓	✓		✓		✓	✓	Not available				✓	✓
	High-performance to validate transactions is not important		✓		✓		✓	Not available	Not available	✓	✓			✓
	It is not important to store large volume of non-transactional data					✓	✓	✓	Not available	✓		✓	✓	✓
Contribution to smartness	The initiative changes relationships between the stakeholders or its roles			✓	✓	✓	✓	✓	✓	✓	✓			✓
	The initiative impacts smart domains			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	The initiative is innovative	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	The initiative supports smart city values	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Contribution to sustainability	The intiative contributes to economic sustainability			✓	✓	✓				✓		✓	✓	✓
	The initiative contributes to environmental sustainability			✓	✓								✓	✓
	The initiative contributes to social and institutional sustainability	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	The initiative supports the Sustainable Development Goals	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Conclusions

The report looks to address the key considerations in implementing blockchain technologies as a part of smart sustainable city initiatives. These considerations are critical for municipal managers as well as decision- and policy-makers to reflect on and integrate when considering smart cities initiatives that involve the applications of blockchain.

1. Building a Blockchain SSC ecosystem
2. Defining a governance model
3. Prioritizing sustainability and smartness in technology and innovation adoption
4. Complying with the standards and regulation
5. Ensuring data protection and privacy
6. Acquiring knowledge and developing capabilities

Recommendations

More specifically, city administrators, policy-advisors and decision-makers should:

- **Approach** blockchain with caution.
- **Build** a blockchain for cities ecosystem in collaboration with other stakeholders in the city.
- **Develop** expert capacity and wider understanding about blockchain and smart contracts.
- **Create** a framework to address legal matters, data security and privacy, and stakeholder self-interest.
- **Focus** on planning that takes a need-driven approach.
- **Consider** the digital exclusion of parts of society and inequalities.
- **Prioritize** use cases for social and environmental sustainability.
- **Explore** innovative funding mechanisms to support innovative projects.
- **Ensure** that initiatives are closely monitored, reported on and lessons learned are shared.

For more information, contact:

u4ssc@itu.int

Website:

www.itu.int/en/ITU-T/ssc/

Access the report and other U4SSC publications **here**.

Thank you!