

# Blockchain and Smart Cities for Inclusive and Sustainable Communities: a Review

Biasin, M., Delle Foglie, A.

Corresponding author: [a.dellefoglie1@unimc.it](mailto:a.dellefoglie1@unimc.it)

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# Agenda

- Background
- Research Motivations and Contribution
- Research Design
- Results of the Bibliometric Analysis
- Results of the Systematic Analysis
- Conclusions and Research Agenda



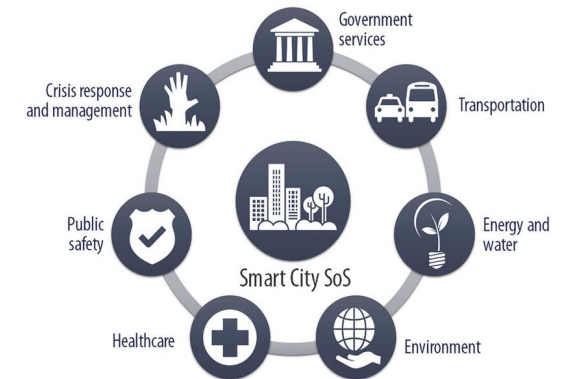
# Background

A Collection of real estate assets  
(building and infrastructures)



**Cities**

A set of governance structures and services  
(transportation, security, waste management,



- **Quality of life** → almost 75% of EU people live in cities
- **Sustainability and climate change** → almost 75% of total GHG emissions come from metropolitan areas
- **Use of spaces** → Urban areas represent between 3-6% of the total geographic land use but roughly 90% of the overall land/real estate values in financial terms where, in turn, real estate represents almost 55-57% of the overall wealth of households' portfolios



# Research Motivations and Contribution

- **Lack of literature** → lack of a systematic comprehension of the existing literature of the field and the fact that, despite the **research efforts by scholars, crucial knowledge about smart cities remains scattered and fragmented** on several fronts, leading to limited contributions also in terms of potential policy indications.
- **Scarcity of studies referring specifically to applications of blockchain technology** to urban activities and phenomena that allow, as a whole, an integrated vision of their impacts on the overall urban system. This is to the benefit of both economic operators and governance authorities in charge of the regulatory choices on the subject and for managing the urban contexts.



# Research Motivations and Contribution

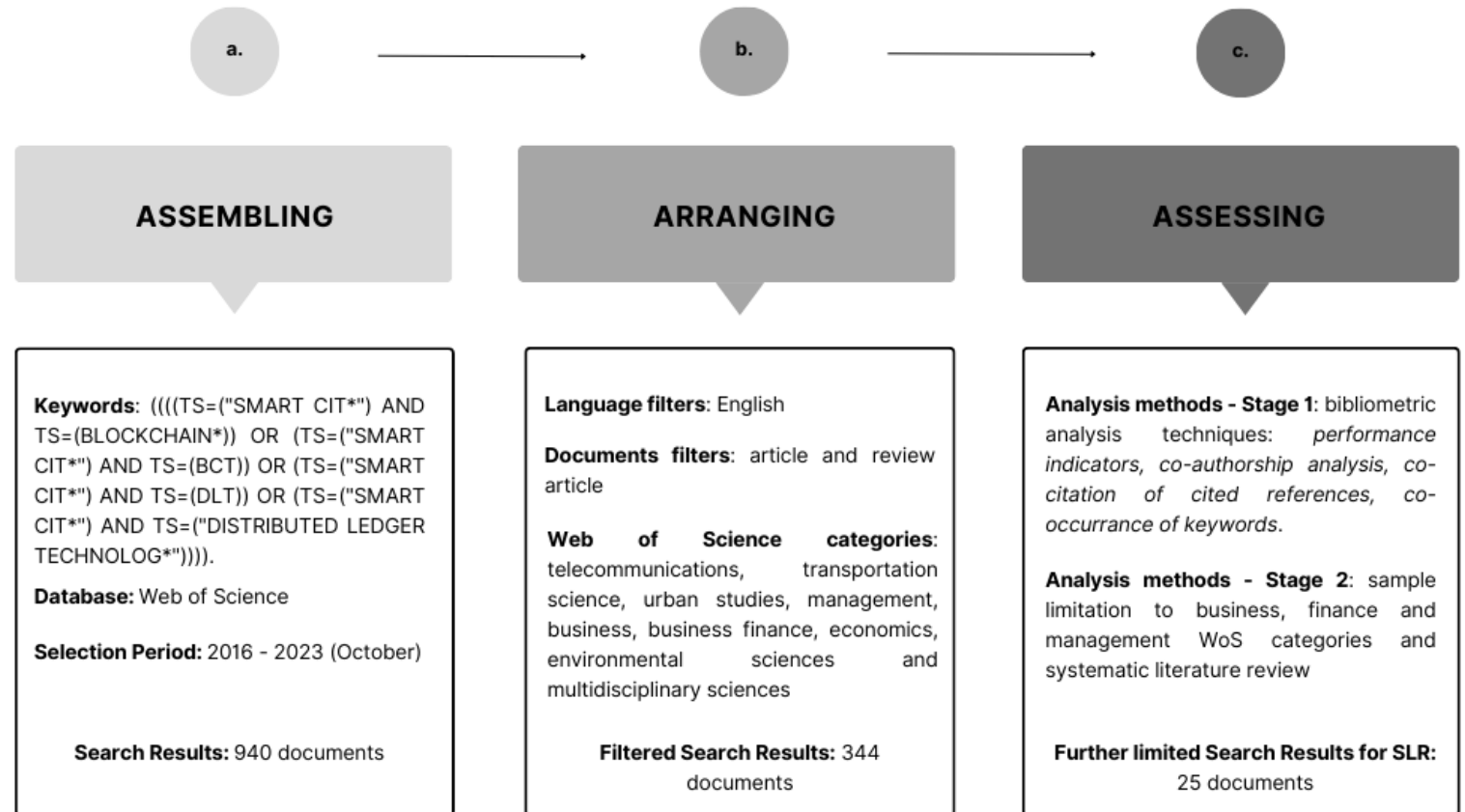
Blockchain as a Distributed Ledger Technology (DLT) has immense potential for urban settings → **perfectly suited to conveying secure and trusted information spread across sites and market participants**

- At the micro-level for incorporating legal, ESG, technical, and financial data on urban real estate assets and development projects
- At the macro-level for integrating reliable and certified information in traditional metropolitan services and cities' overall planning and renewal

1. Perimeter the reference literature investigating **smart cities and blockchain technology**
2. Outline the knowledge in the field in terms of research topics and results → **map emerging trends and intellectual structures in smart cities research**
3. Highlight the directions for potential future research with a **pioneer research agenda**



# Research Design



- ✓ Firstly combine qualitative and quantitative methods in the field → systematics and bibliometrics methodologies (Paul and Criado, 2020);
- ✓ Firstly adopt SPAR-4-SLR protocol in the field (Kumar et al., 2022; Paul et al., 2021, He et al., 2022);
- ✓ Review softwares → VOSviewer (Van Eck and Waltman, 2020) and Bibliometrix (Aria and cuccurullo, 2017)
- ✓ Original dataset 1950 - 2023



# Results of the Bibliometric Analysis

## Information about the sample and performance analysis

Table 2. Top Influential Sources by TC

Source	H Index	G Index	M Index	TC	N. of Articles published	PY_start	Impact Factor**
IEEE Access	17	33	3	1470	33	2018	3.9
IEEE Internet of Things Journal	16	32	3	1072	35	2019	10.6
Sustainable Cities and Society	11	13	1.833	984	13	2018	11.7
IEEE Communications Surveys and Tutorials	6	6	1	862	6	2019	35.6
Cities	4	4	1	445	4	2019	6.7

Figure 1. Times cited and published over time.

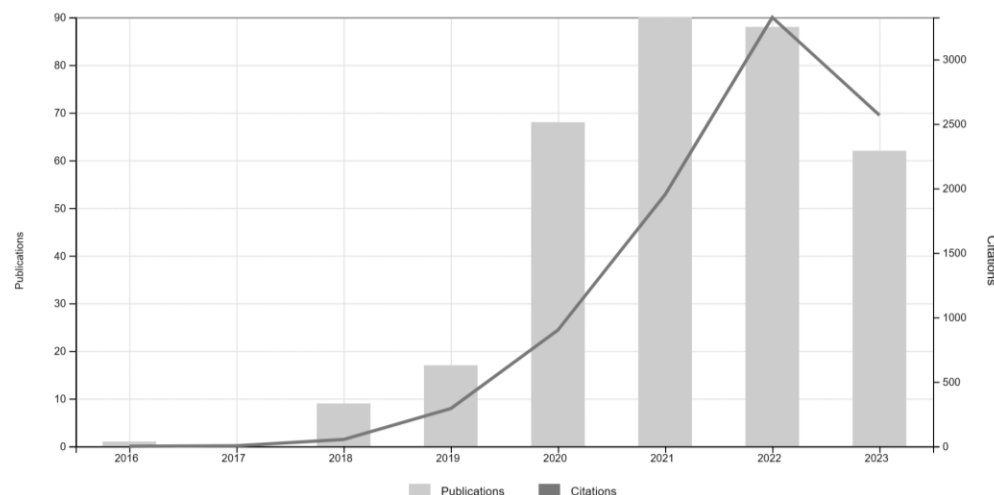


Table 1. Sample Details

Description	Results
Sources (Journals)	87
Authors	1181
Documents	334
References	18654
Average years from publication	1.7
Average citations per document	26.83
Average citations per year per doc	8
Documents per author	0.283
Authors per document	3.54
Co-authors per documents	4.25
Collaboration index	3.72



# Results of the Bibliometric Analysis

## Information about the sample and performance analysis

**Table 3. Top Global Cited Documents**

Author (s) (Year)	Title	Journal	Local Citation	Total Citations	TC per Year	LC/TC Ratio (%)	Normalized TC
Fuller et al. (2020)	Digital Twin: Enabling Technologies, Challenges and Open Research	IEEE Access	0	442	111	0	10
Allam and Dhunny (2019)	On big data, artificial intelligence, and smart cities	Cities	11	329	66	3.34	3
Dagher et al. (2018)	Ancile: Privacy-preserving framework for access control and interoperability of electronic health records using blockchain technology	Sustainable Cities and Society	7	329	55	2.13	3
Xie et al. (2019)	A Survey of Blockchain Technology Applied to Smart Cities: Research Issues and Challenges	IEEE Communications Surveys & Tutorials	38	298	60	12.75	3
Stoyanova et al. (2020)	A Survey on the Internet of Things (IoT) Forensics: Challenges, Approaches, and Open Issues	IEEE Communications Surveys & Tutorials	5	261	65	1.92	6
Sun et al. (2016)	Blockchain-based sharing services: What blockchain technology can contribute to smart cities	Financial Innovation	28	253	32	11.07	1

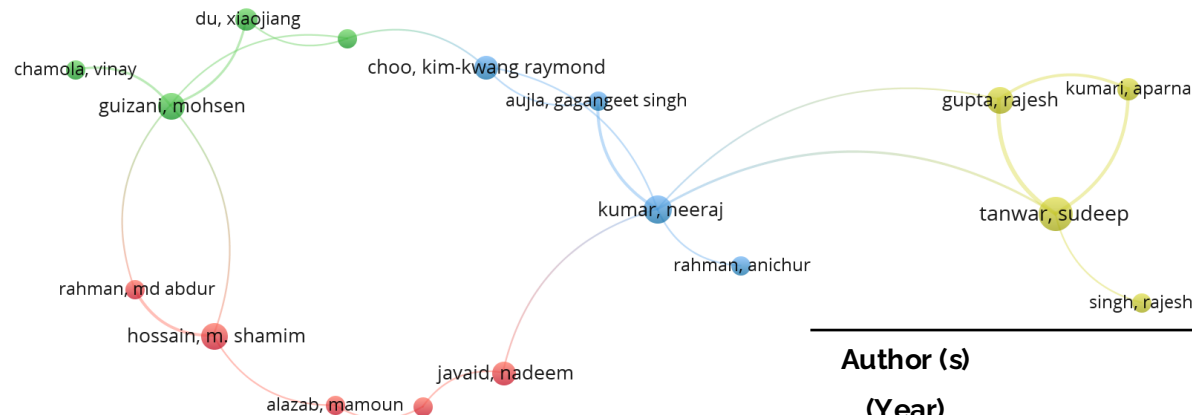




# Results of the Bibliometric Analysis

## Co-authorship Analysis

Co-authorship analysis, also named social network analysis, has become a common practice in literature reviews. It helps identify relationships between authors, which in turn helps scholars in their future research projects (Bahoo et al., 2020; Olawumi and Chan, 2018; Hajek et al., 2022).



VOSviewer

Author (s) (Year)	Title	Journal	TC	TCpY	Cluster
Yu F. Richard	A survey of blockchain technology applied to smart cities: research issues and challenges	IEEE Communications Surveys & Tutorials	298	60	-
Choo Kim-Kwang Raymond	A blockchain future for internet of things security: a position paper	Digital Communications and Networks	222	37	3
Guizani Mohsen	Privacy-preserving support vector machine training over blockchain-based encrypted IoT data in smart cities	IEEE Internet of Things Journal	210	42	2

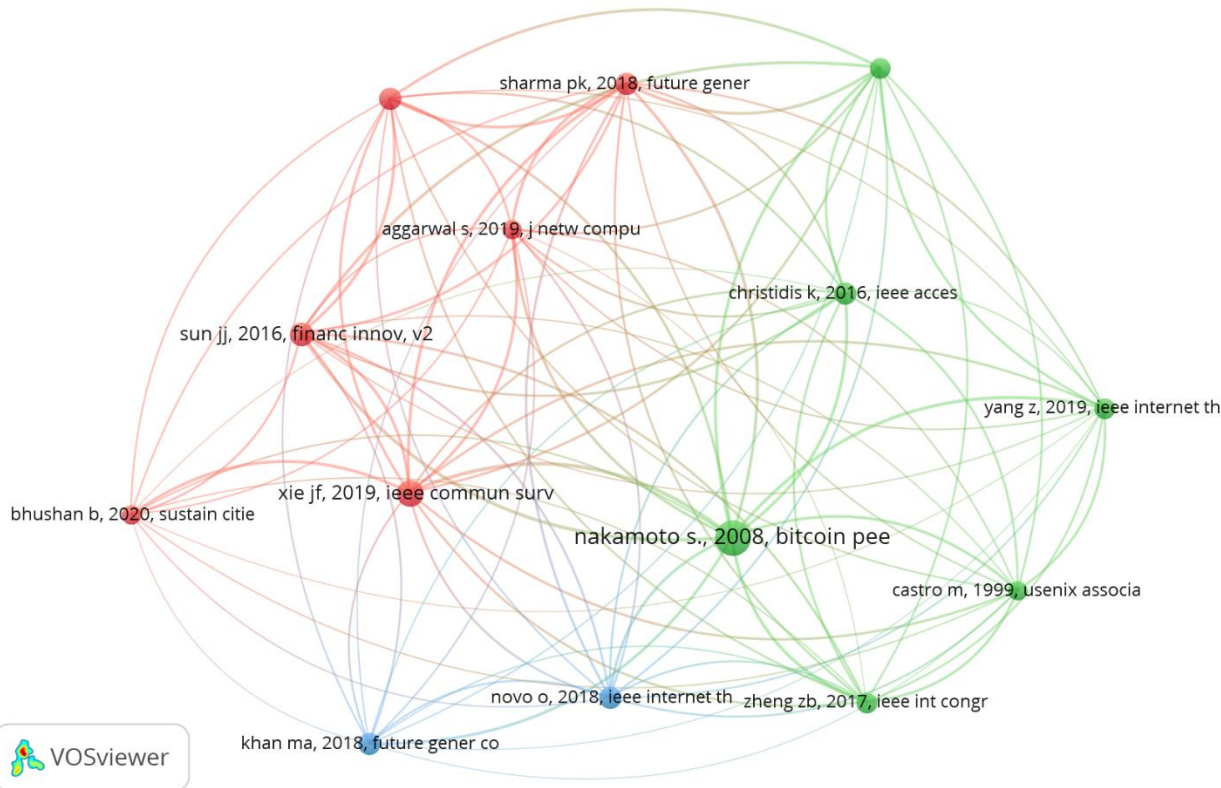


# Results of the Bibliometric Analysis

## Co-citation analysis

Three clusters...

This bibliometric method allows for identifying the articles that cite each other on the same concept or topic. This method provides valuable insights into the commonalities and research streams or clusters in the literature, thereby aiding in the identification of emerging trends and areas of interest (Panetta et al., 2023; Paltrinieri et al., 2019; Patel et al., 2022; Hajel et al., 2022).



Author/s (Year)	Citations	Total Link Strength	Cluster
Nakamoto (2008)	65	113	2
Xie et al. (2019)	38	92	1
Sun et al. (2016)	28	77	1
Sharma and Park (2018)	27	78	-
Biswas et al. (2016)	26	67	1
Khan and Salah (2018)	26	37	3
Christidis and Devetsikiotis (2016)	25	60	2
Novo et al. (2018)	25	56	3
Sharma et al. (2017)	22	72	2
Yang et al. (2018)	22	50	2

**Co-occurrence Analysis** Cartographic analysis aims to map the keywords that identify different research streams by grouping them into clusters that represent content areas. The relatedness of these areas is evaluated by considering the total link strength and the number of occurrences of the keywords in the sample (Khan et al., 2022; Migliavacca et al., 2023; Bahoo et al., 2020; Sgambati and Gargiulo, 2022).



# Results of the Systematic Analysis

## ***Focus: WoS Business, Finance, Economics and Management***

- Examining the current status of blockchain applications in **developing financial ecosystems for smart cities**
- We have limited the database to Business, Finance, Economics, and Management WoS categories yielding **25 documents** published between 2016 and 2023.
- According to Paul et al. (2021), the process of conducting a SLR is the best option to achieve our objective since it helps to develop a comprehensive understanding of existing literature (**state of the art**) and provides new avenues for future research (**stimulating agenda**)
- The SLR process classifies the documents into **nine main themes**:
  - i) Blockchain, governance and infrastructure*
  - ii) Definitions and key components*
  - iii) Blockchain implementation and performance indicators*
  - iv) Smart City development financing*
  - v) Robotic services*
  - vi) Blockchain applications in the Smart City development*
  - vii) Transport and logistic systems*
  - vii) Big Data*
  - ix) Blockchain and sustainability of Electric Vehicle performance.*



# Results of the Systematic Analysis

## *Focus: WoS Business, Finance, Economics and Management*

- **Blockchain in Smart City Governance:** Blockchain enhances smart city governance by utilizing data computing, distributed ledger technology (DLT), visual analytics, and smart devices to engage the public, increase trust, and reduce costs through seamless data-sharing and smart contracts, leading to optimized self-governance.
- **Community-led Initiatives:** Marsal-Llacuna (2020) advocates for a People's Smart City Dashboard (PSCD) to address the top-down approach of current smart city developments by enabling community-led implementation and collaboration.
- **Technological Contributions:** Bohloul (2020) reviews challenges and trends in smart cities, highlighting the potential of technologies like blockchain, 5G, VR/AR, and quantum computing to advance smart cities, creating opportunities for research and entrepreneurship.
- **Further Research and Trends:** various authors (Migliorini et al., Sun et al., Tiwari et al.) emphasize the role of blockchain in disrupting urban networks, smart city governance, infrastructure, and financial services. Tiwari et al. (2019) also present a framework for adopting Industry 4.0 technologies like big data, cloud computing, edge computing, and IoT in smart cities.

These papers underscore the evolving nature of smart cities, driven by advanced technologies and community-led governance models.

**We found a lack of literature concerning the financial aspects of the smart city financial system...**



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# Conclusions and Research Agenda

- **Digital Technologies in Smart Cities** → promote sustainability, optimize public services, and enhance citizen well-being
- **Importance of the Financial System**
  - Crucial for development and resilience of smart cities
  - Enhances citizen participation and resource efficiency
  - Fundamental to smart city functionality
- **Role of Blockchain and DLT**
  - Increase financial inclusiveness and participation
  - Support smart city development and resilience
  - Focus of this study on their financial and economic applications in smart cities
- **Current Research Gaps**
  - Limited focus on practical financial applications of blockchain and DLT
  - Most studies emphasize other technologies (IoT, cloud computing, 5G) over blockchain's financial role
  - Need for more research on blockchain's integration into smart city financial systems



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# Conclusions and Research Agenda

## Key Areas for Future Research

- Financial ecosystem development in smart cities
- Integration of Central Bank Digital Currencies (CBDCs) in smart city payment systems
- Blockchain-based solutions for real estate (secure land registry, property transactions).
- Blockchain applications in urban services (transportation, waste management, energy services)

## Implications for Researchers and Policymakers

- Explore blockchain's impact on urban financial activities
- Focus on practical applications to improve citizen participation and resource efficiency
- Address current research gaps to support smart city financial system development.





# Conclusions and Research Agenda

Research Area	Further Research Issues
Payment services in smart city transactions	<ul style="list-style-type: none"><li>• Use of blockchain to increase transactions in smart cities without compromising performance</li><li>• Factors influencing the adoption of blockchain-based payment system</li><li>• How to increase user experience</li></ul>
Blockchain for the smart city real estate market	<ul style="list-style-type: none"><li>• How can blockchain technology be used to create secure and immutable records of title and ownership for real estate properties, thereby reducing fraud and enhancing transparency in smart cities (and reducing transaction costs)?</li><li>• Implementing smart contracts for buying, selling and renting properties</li></ul>
Smart contract and urban services	<ul style="list-style-type: none"><li>• Implementing blockchain and smart contract for automating parked reservation, waste collection, recycling systems, energy distribution, energy trading platforms, etc.</li></ul>
Blockchain and data storage, security, and privacy	<ul style="list-style-type: none"><li>• Issues of data storage solutions</li><li>• Enhancing transparency, immutability → privacy → thinking about cyber risk issues</li></ul>
Smart city governance and integration with other systems	<ul style="list-style-type: none"><li>• E-voting systems</li><li>• Automate public governance procedures</li></ul>



## Q&A

Contacts: [a.dellefoglie1@unimc.it](mailto:a.dellefoglie1@unimc.it)