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Research Article

Blockchain Governance Assessment Tools: A Conceptual Model from a Business Sustainability Perspective

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ABSTRACT

Purpose: This research aims to identify research trends in governance assessment tools, explore the methods used in designing and developing tools for assessing blockchain governance, and examine elements of readiness and components from a business sustainability perspective.

Design/methodology/approach: A systematic literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The search was performed on nine databases: Scopus, ScienceDirect, ACM Digital Library, Emerald Insight, ProQuest, IEEE Xplore, SpringerLink, Sage Journals, and Taylor & Francis, focusing on English-language journal articles published between 2019 and 2023. A total of 24 papers were selected for the review and bibliometric analysis using Biblioshiny. The governance assessment functionalities identified were categorized based on readiness in the STOPE framework. The conceptual model was developed and validated by experts with deep interviews.

Findings: This research identified research conducted between 2019 and 2023 that predominantly addressed natural ecosystems, natural resources, flood management, and the environment (66.67%), health and healthcare (20.83%), and information technology, e-government, and innovative governance (3%). The identified elements and components have been proposed as elements or components for blockchain governance assessment tools from a business sustainability perspective, which is crucial for learning organizations because it drives continuous development and innovation aligned with long-term objectives. Experts developed and validated the conceptual model.

Research limitations/implications: This research proposed elements and conceptual models of blockchain governance assessment tools from a business sustainability perspective to ensure blockchain systems remain transparent, secure, scalable, and compliant with regulations. These tools help identify inefficiencies, security risks, and governance gaps, leading to better blockchain performance and, ultimately, greater benefits for users and organizations adopting blockchain technology.

Practical implications: This research proposed elements and a conceptual model for blockchain governance assessment tools, paving the way for blockchain technology's more widespread and effective adoption in various industries.

Originality/value: This research proposes a unique conceptual model of blockchain governance assessment tools from the perspective of business sustainability and has been validated by experts. The research also identifies elements of blockchain governance assessment tools, a unique aspect that has not been previously reported.

Keywords: Assessment tools, Blockchain governance, Business Sustainability, Governance

INTRODUCTION

Blockchain is an emerging technology based on the principle of a distributed ledger (Mohammed et al., 2023). Its initial purpose was to eliminate the need for third-party intermediaries (Liu et al., 2022). Blockchain has become a key driver of digital transformation across various sectors and use cases, extending beyond the financial sector (Gurzhii et al., 2022).

Blockchain has been widely adopted in numerous sectors, including education, transportation, healthcare, finance, supply chain management, asset management, art and NFTs, agriculture, privacy, and security (Alnuaimi et al., 2022; Battah et al., 2022; Mohammed et al., 2023; Truong, Le, & Niyato, 2023; Gurzhii et al., 2022; Sunny et al., 2022; Ullah, 2021; Mochram et al., 2022). Its implementation leverages specific characteristics such as immutability, cryptographic features, traceability, and other attributes (Mohammed et al., 2023; Ali et al., 2023; Konin & van der Linden, 2022; Mochram et al., 2022). However, not all blockchain implementations successfully deliver added value to the organizations adopting them (Tan, Mahula, & Crompvoets, 2022). Poor governance is a significant cause of such failures (Tan, Mahula, & Crompvoets, 2022).

Governance is critical in successfully adopting blockchain technology (Tan, Mahula, & Crompvoets, 2022; Ziolkowski, Miscione, & Schwabe, 2020). Research has explored the development of blockchain governance from various perspectives. For instance, research conducted by Tan, Mahula, and Crompvoets (Tan, Mahula, & Crompvoets, 2022) proposed a blockchain framework for the public sector, while research conducted by Liu et al. (Liu et al. 2022) developed governance principles and a framework addressing essential questions related to both communities and ecosystems. Despite these studies, no practical tools have been developed to assess blockchain readiness or adoption (Liu et al., 2022). Existing governance assessment tools are unsuitable as they often fail to distinguish between governance and management aspects and lack specific instruments for determining blockchain readiness or implementation status (Ebert, Vizcaino, & Manjavacas, 2020). Moreover, these tools do not incorporate business sustainability considerations.

Blockchain governance remains an evolving research area. For example, research conducted by Laatikainen, Li, and Abrahamsson (Laatikainen, Li, & Abrahamsson, 2023) proposed an initial blockchain governance model from a systems perspective. However, systematic literature reviews and empirical studies have not explicitly addressed tools for assessing blockchain governance. The strategy for implementing effective blockchain governance is crucial to its success (Tan, Mahula, & Crompvoets, 2022). One such strategy involves the use of application tools. Therefore, this paper aims to review studies on governance assessment tools, focusing on their design, methodologies, and assessed elements.

The research aims to identify research trends in blockchain governance assessment tools, examine the methods employed in designing and developing these tools, and explore the elements or components of readiness and business sustainability assessed by these tools. This research addresses the following research questions:

RQ1: What are the research trends in the design and development methods of application tools for blockchain governance assessment?

RQ2: What methods are used to design and develop application tools to assess governance, particularly blockchain governance?

RQ3: What readiness and business sustainability elements are measured by these tools?

RELATED WORKS

Several studies are related to this research, including systematic reviews and the development of blockchain governance frameworks. Research conducted by Laatikainen, Li, and Abrahamsson involved a systematic review to develop blockchain governance using a systems approach (Laatikainen, Li, & Abrahamsson, 2023). This research conceptualizes blockchain as a cycle that includes formation or design, operation, crisis, and termination. The components of blockchain identified by Laatikainen, Li, and Abrahamsson include technological, business, and legal/regulatory aspects (Laatikainen, Li, & Abrahamsson, 2023). During its adoption cycle, blockchain may undergo hard forks, feedback mechanisms, self-renewal or forking, and equity (Laatikainen, Li, & Abrahamsson, 2023). However, this research is limited to framework design and does not propose or develop blockchain governance assessment tools. Additionally, research conducted by Laatikainen, Li, and Abrahamsson identified 22 theories that can be used to develop blockchain governance but do not recommend or implement assessment tools (Laatikainen, Li, & Abrahamsson, 2023).

Research conducted by Tan, Mahula, and Crompvoets develops blockchain governance from a public management perspective (Tan, Mahula, & Crompvoets, 2022). The proposed framework divides governance levels into micro, meso, and macro. It identifies nine types of decisions, but similar to research conducted by Maia, Kris, and Hans (Maia, Kris, & Hans, 2019), it does not provide tools for governance assessment.

Research conducted by Beck, Müller-Bloch, and King categorizes blockchain governance based on access to transactions and validation into three categories: public-permissioned, public permissions, and private-permissioned (Beck, Müller-Bloch & King, 2018). This research identifies three components of blockchain governance: decision rights, accountability, and incentives. However, like research conducted by Laatikainen, Li, and Abrahamsson (Laatikainen, Li, & Abrahamsson, 2023) and research conducted by Mohammed et al. (Mohammed et al., 2023), research conducted by Beck, Müller-Bloch, and King (Beck, Müller-Bloch, & King, 2018) does not develop governance assessment tools.

Research conducted by Liu et al. (Liu et al., 2022) highlights the lack of systematic guidance in blockchain governance. This research develops blockchain governance based on fundamental questions, resulting in six principles: decentralization, blockchain stakeholders, ecosystem-level blockchain governance, legal compliance, and ethical responsibility. Nevertheless, similar to several research (Laatikainen, Li, & Abrahamsson, 2023; Mohammed et al., 2023; Liu et al.; Beck, Müller-Bloch, & King, 2018), this research does not provide tools for governance assessment.

Apart from research on blockchain governance, several studies discuss the use of blockchain in various sectors and use cases. These include research conducted by Alnuaimi et al. on the use of blockchain for sending jewelry (Alnuaimi et al., 2022); research conducted by Battah et al. on its application in NFTs (Battah et al., 2022); research conducted by Mohammed et al. on blockchain in supply chain management (Mohammed et al., 2023); research conducted by Truong, Le, & Niyato on the metaverse (Truong, Le, & Niyato, 2023); and research conducted by Ullah on smart agriculture (Ullah, 2021). The diversity of blockchain use cases suggests a growing trend in blockchain implementation.

Blockchain and business sustainability

Overview of blockchain technology

Blockchain is an emerging technology with the potential to transform businesses and industries. It revolutionizes data storage by enhancing security, traceability, and trustworthiness (Paik et al., 2022). Blockchain's application spans sectors such as healthcare, finance, data quality assurance (including data transparency, consistency, and privacy), and sustainable energy systems (Sood et al., 2023). Its widespread adoption is driven by features such as faster settlements, immutability, security, and transparency.

Blockchain data storage can occur either on-chain or off-chain (Paik et al., 2022). On-chain storage is directly involved in the consensus process, whereas off-chain storage is used for temporary data, which is subsequently updated to on-chain storage (Paik et al., 2022). Blockchain distinguishes itself from conventional database storage through features such as cryptographic hashes and decentralized control. Hashes, a form of applied mathematics, enhance information security. Unlike conventional databases, which are centrally controlled, blockchain operates on a decentralized model.

Blockchain technology has several strengths, including trust, anonymity, consensus driven operations, and digitization, distributed and decentralized systems, auditability, robustness, immutability, chronological order, and time-stamping (Komalavalli et al., 2020). However, despite its strengths, blockchain also faces significant challenges (Komalavalli et al., 2020). These challenges include scalability, high initial costs, energy consumption, integration with legacy systems, security and privacy concerns, legal and regulatory issues, public perception, and a lack of skilled professionals (Komalavalli et al., 2020).

Blockchain employs various consensus algorithms, which continue to be developed to meet business needs. As summarized by Komalavalli (Komalavalli et al., 2020), these algorithms include:

1) *Proof of Work* (PoW)

This algorithm is widely used for mining, requiring participants to solve puzzles to add blocks. The participant who solves the puzzle receives a reward. However, it demands high computational power and substantial hardware.

2) *Proof of Stake* (PoS)

This algorithm validates blocks based on participants' stakes. Unlike PoW, it lacks a reward mechanism, with validation determined by the value of the currency.

3) *Practical Byzantine Fault Tolerance* (PBFT)

Based on the Byzantine Generals' Problem, this algorithm focuses on achieving consensus by considering both faulty and functional nodes. Fault tolerance is achieved by taking correct values from functional nodes and assigning a default vote to faulty nodes.

4) *Proof of Activity* (PoA)

This algorithm combines PoW and PoS. PoW is used to identify a new block, and once a block is found, PoS is used for validation.

5) *Proof of Burn Time* (PoBT)

This algorithm involves destroying or "burning" coins held by miners. It uses PoW, allowing miners to proportionally write blocks based on the burned coins.

6) *Proof of Capacity* (PoC)

This algorithm utilizes hard disk space, allowing nodes to store possible solutions before mining. This approach reduces the likelihood of quick changes to the header value.

7) *Proof of Importance* (PoI)

Developed from PoS, this algorithm introduces concepts of harvesting and vesting. Harvesting determines a node's eligibility to add a block, while the node alternately assigns transaction fees within that block

Blockchain users can be categorized into end-users, developers, regulators, network operators, certificate authorities, and application interfaces:

1) *End-user*

All participants or members who can access and transact on the blockchain network are considered users or end- users.

2) *Developer*

Developers are responsible for building and maintaining the blockchain network.

3) *Regulators*

Regulators oversee the network and establish rules for transactions.

4) *Network operators*

Network operators manage the blockchain network and define permissions for participants.

5) *Certificate authorities*

Certificate authorities handle the management and issuance of certificates for permissioned blockchains.

6) *Application interfaces*

Blockchain interfaces include HTTP APIs and WebSockets.

Blockchain for Business Sustainability

Sustainability refers to meeting present needs without compromising the ability of future generations to meet their own needs. Sustainable business practices consider environmental, social, and economic aspects to enhance profits while protecting society and the environment (Moroojo et al., 2024). Examples of sustainability in emerging technologies include resource and energy efficiency, e-waste management, stakeholder participation, and ethical sourcing (Moroojo et al., 2024). In some cases, business sustainability serves as a critical indicator of long-term resilience and financial success for investors (Moroojo et al., 2024).

Business sustainability is a comprehensive approach that integrates economic, social, and environmental aspects to ensure long-term success and positive impacts on society and the environment [22]. The three key elements of business sustainability are:

1) *Economic sustainability*

Ensuring profitability and efficiency in business activities by minimizing costs and optimizing resource use.

2) *Social sustainability*

Operating in ways that benefit society, addressing social and ethical concerns through corporate social responsibility (CSR) initiatives.

3) *Environmental sustainability*

Reducing environmental harm by adopting sustainable practices, such as improving resource efficiency, minimizing waste, and using renewable energy.

The focus on business sustainability provides clear direction and motivation for learning organizations to continue developing and innovating in ways that support long-term goals (Moroojo et al., 2024). Through continuous learning, innovation, and flexible adaptation to change, learning organizations can ensure they remain relevant, competitive, and capable of thriving in the future. The focus on sustainability also helps create a culture that supports creativity, collaboration, and sustainable problem-solving, all of which are essential for maintaining the survival and growth of the organization in an ever-changing business environment (Moroojo et al., 2024). The emphasis on business sustainability is crucial for learning organizations, as it drives continuous development and innovation aligned with long-term objectives (Moroojo et al., 2024). By fostering a culture of adaptability and creativity, these organizations can maintain relevance and competitiveness in a dynamic business environment. The following sections elaborate on key aspects of this relationship (Moroojo et al., 2024).

Blockchain possesses features that can drive business sustainability, including shared ledgers, permissions, smart contracts, and consensus mechanisms (Komalavalli, Saxena, & Laroiya, 2020). A shared ledger provides an immutable record of all transactions, recorded once and shared with network members through replication (Komalavalli, Saxena, & Laroiya, 2020). Permissions define participant access to transactions, while smart contracts establish transaction rules embedded within the blockchain (Komalavalli, Saxena, & Laroiya, 2020). Consensus ensures stakeholder agreement to validate transactions (Komalavalli, Saxena, & Laroiya, 2020). The distributed nature of blockchain supports business sustainability by offering several benefits, such as preventing single points of failure, enhancing transparency, increasing transaction speed, reducing fraud, lowering costs, promoting collaboration, and improving security (Komalavalli, Saxena, & Laroiya, 2020). Blockchain enables participants to transact directly, eliminating the need for third parties, and its immutable and irreversible nature helps mitigate fraud (Komalavalli, Saxena, & Laroiya, 2020).

METHODS

This research employed several methods: (1) systematic literature review (SLR), (2) bibliometric analysis, (3) identification of methods, features, or functionalities of blockchain governance assessment tools, and (4) validation of the model developed from the identified features or functionalities by experts and practitioners. The systematic literature review and literature selection procedure followed the PRISMA methodology (Page et al., 2021), chosen for its ability to ensure transparency and ease in documenting the systematic review process. Bibliometric analysis was conducted using Biblioshiny (Aria & Cuccurullo, 2017), which focuses on data processing and analysis, including citation, publication, and author analysis (Aria & Cuccurullo, 2017).

Search Strategy

The systematic literature review was conducted across nine databases: Scopus, ScienceDirect, ACM Digital Library, Emerald Insight, ProQuest, IEEE Xplore, SpringerLink, Sage Journals, and Taylor & Francis. The search terms or keywords used were “governance assessment” AND “tool”. These general terms were chosen to maintain the essence of the research question while accommodating the relatively new and limited body of research on blockchain governance. The search targeted journal articles published between 2019 and 2023 to ensure the inclusion of the most recent data and information, given the rapid development of blockchain applications across various sectors and use cases.

Eligibility Criteria

The inclusion criteria (IC) for the Systematic Literature Review (SLR) were defined based on the PRISMA methodology (Page et al., 2021), to guide the research selection process:

1. IC1: The literature must be accessible in full text and written in English.
2. IC2: The literature must consist of research results published in reputable journals.
3. IC3: The literature must focus on governance assessment tools or blockchain governance assessment tools.

Data Items and Synthesis

Data collection for the systematic literature review in this research was performed manually using a spreadsheet. The extracted information included design and development methods, elements of readiness measured, types of governance measured, assessment concepts, and main features or functionalities.

The authors categorized the functionalities and elements of readiness for (blockchain) governance using the STOPE framework (Bin Abbas & Bakry, 2014). For each function category, the authors detailed the sub functions or data elements implemented or recommended in the selected articles. Additionally, the authors described the methods, development processes, and readiness elements measured by the tools (if any) in the reviewed articles.

Expert Validation

The conceptual model for blockchain governance assessment tools developed in this research incorporates a business sustainability perspective. This model was validated by three experts or practitioners, including two from the industry and one from a government organization, all with over five years of professional experience. The validation process aimed to ensure the model's applicability in both industry and government contexts. Two criteria were used to evaluate the conceptual model: functionality and innovation/uniqueness (Whitten & Bentley, 2007).

The validation was conducted via Zoom and WhatsApp applications. The validation process was conducted by three experts as follows:

1. A goods/services procurement manager from a government agency, with 16 years of work experience.
2. A practitioner and consultant in governance and information security, with 35 years of work experience.
3. The Chief Executive Officer of an emerging technology provider company, with 10 years of experience in innovation related to emerging technology.

The experts are practitioners with a minimum of 10 years of experience in areas such as information technology governance, corporate governance, information security, communications and informatics policy, or emerging technologies.

RESULTS AND DISCUSSION

Research selection

The research selection process followed the PRISMA methodology (Page et al., 2021), encompassing identification, screening, and inclusion stages. The steps are illustrated in Figure 1 below.

Keyword or search string queries in each online database yielded the following results: 222 records from Scopus, 79 from ScienceDirect, 4 from ACM Digital Library, 23 from Emerald Insight, 172 from ProQuest, 0 from IEEE Xplore, 36 from SpringerLink, 0 from Sage Journals, and 19 from Taylor & Francis, resulting in a total of 555 records. After removing duplicates, 10 duplicate records were excluded, leaving 545 records for the abstract, title, and keyword selection process. Based on eligibility criteria, 520 records were excluded as their abstracts, titles, and keywords did not match the search terms, leaving 25 records. These 25 records underwent further evaluation based on the eligibility criteria, resulting in 24 full text papers that were included for extraction and synthesis.

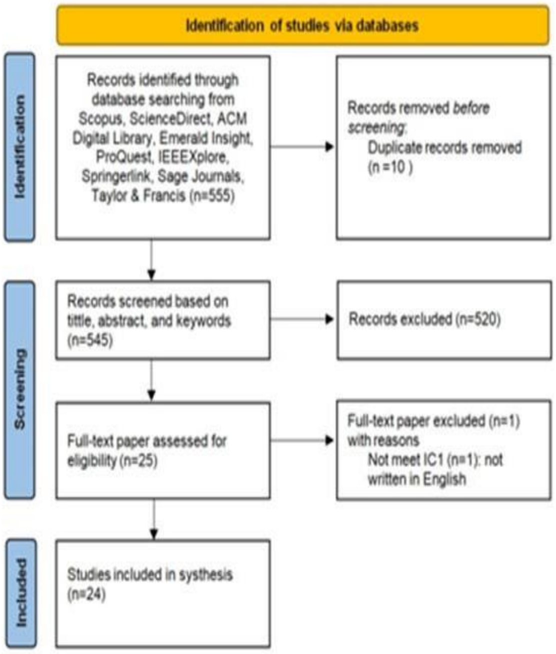

Figure 1. Flow diagram for search results.

Research Characteristics

The 24 selected papers reveal that case studies were conducted across five continents: Europe (9 papers), Asia (6 papers), Africa (7 papers), and America (2 papers). The distribution of case studies by continent is depicted in Figure 2.

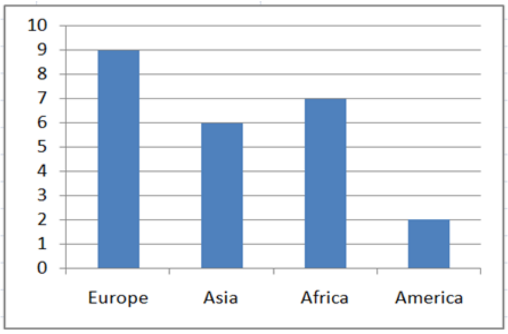

Figure 2. Continents involved in governance assessment tools studies.

The selected studies were published over five years. Specifically, 6 studies were published in 2019, 8 in 2020, 3 in 2021, and 7 in 2023. The distribution of publications by year is shown in Figure 3.

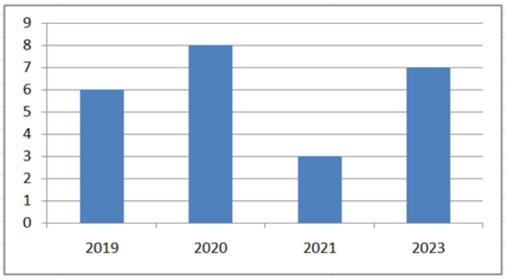

Figure 3. Publication years of governance assessment tools studies.

In addition to year and location, the subsequent section explores governance topics and objects of interest in these studies.

Research trends

Based on the results of the Systematic Literature Review (SLR) with 24 papers extracted and synthesized, the following key findings were identified:

1. Governance assessments using tools are predominantly conducted within the scope of environmental governance, such as national parks, biological ecosystems, natural water resources, water levels, and flood prevention and mitigation, particularly in urban areas (66.67%).
2. A smaller portion of the research focuses on governance assessments in the health sector (20.83%) and computer science or information technology (3%).
3. Tools utilized in these studies include ALTUS, GAT (Governance Assessment Tool), and combinations or developments of GAT.
4. Governance assessment concepts are often based on specific frameworks or theories, sometimes combining multiple frameworks or theories.
5. The assessments measure various elements and types of governance-related components.
6. The main features or functions of the tools or applications developed or used are highlighted, though not all research provides detailed information about these functionalities.
7. Methods for designing and developing tools are discussed in studies that focus on tool development.

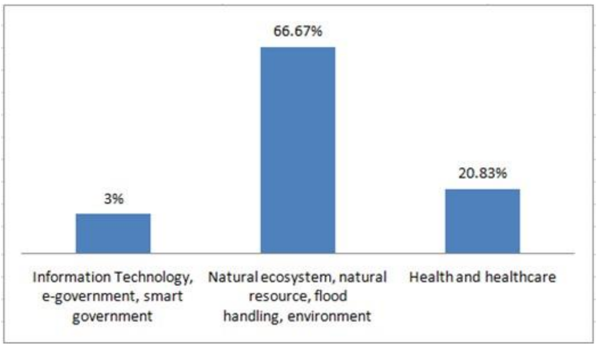

Figure 4. Governance objects involved in governance assessment tools studies.

Figure 4 illustrates the governance objects addressed in these studies. Most of the research on governance assessment focuses on themes related to natural ecosystems, natural resources, flood management, and environmental governance (66.67%). This is followed by health and healthcare (20.83%) and information technology, including e-government and smart government (3%). These trends suggest that governance assessments in information technology receive comparatively less attention from researchers than those in environmental governance.

Bibliometric analysis

The bibliometric analysis in this research was conducted using the Biblioshiny tool (Aria & Cuccurullo, 2017). The analysis focused on several aspects, including sources, authors, documents, conceptual structure, intellectual structure, and social structure. Key information derived from the references of the Systematic Literature Review (SLR), which consisted of 24 documents, is presented in Figure 5.

Figure 5. Main information

As shown in Figure 5, the timespan of the articles is from 2019 to 2023. The research includes 20 sources and 24 documents, with an annual growth rate of 3.93%. The 24 documents were authored by a total of 83 contributors, with no single author papers. The international co-authorship rate is 66.67%, and the average number of co-authors per document is 4.04. A total of 102 keywords were identified across the 24 documents, which collectively cited 1,473 references. The average document age is 3.25 years, and the average citations per document is 8.875. Further bibliometric analyses of sources, authors, documents, conceptual structure, intellectual structure, and social structure are illustrated in Figure 6 through Figure 15.

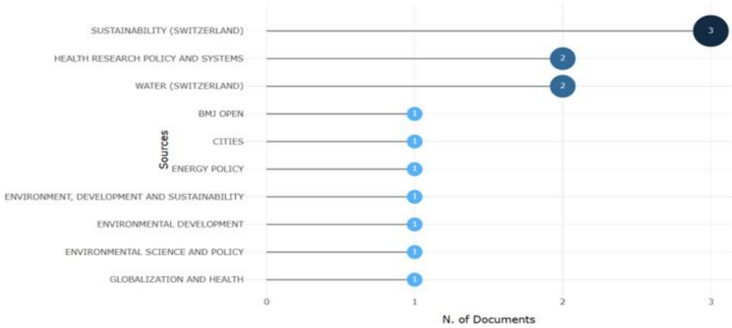

Figure 6. Most relevant sources

Figure 6 highlights the most relevant sources in this research. The top three sources are Sustainability (Switzerland) with three documents, followed by Health Research Policy and Systems and Water (Switzerland), each contributing two papers. These journals are reputable and internationally indexed.

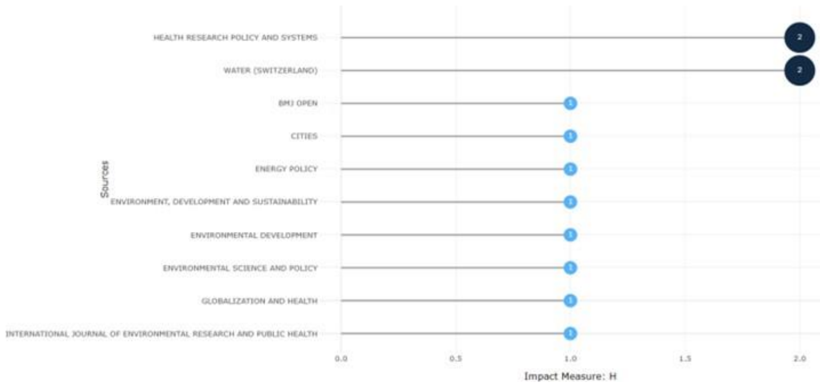

Figure 7. Sources' local impact

Figure 7 the local impact of the most relevant sources. The top two sources with the highest local impact are Health Research Policy and Systems and Water (Switzerland). Other notable sources include BMJ Open, Cities, Energy Policy, Environment, Development and Sustainability, Environmental Science and Policy, Globalization and Health, and the International Journal of Environmental Research and Public Health. All are reputable, internationally indexed journals.

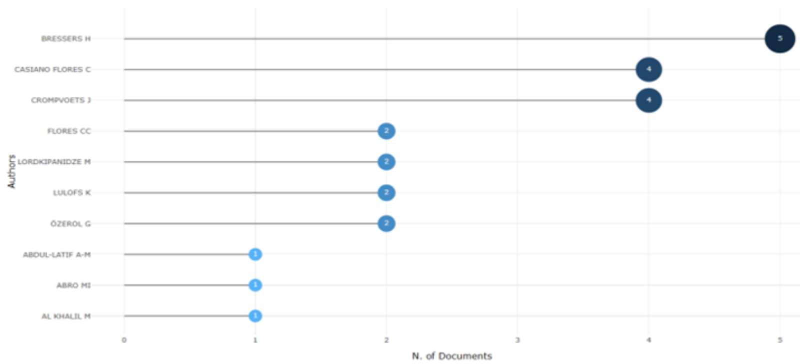

Figure 8. Most relevant authors

Figure 8 shows the most relevant authors of included articles in this research. The most relevant authors are Bressers H with a total of five documents. Then followed by Casiano Flores C with a total of four documents, and Crompvoets J with a total of four documents.

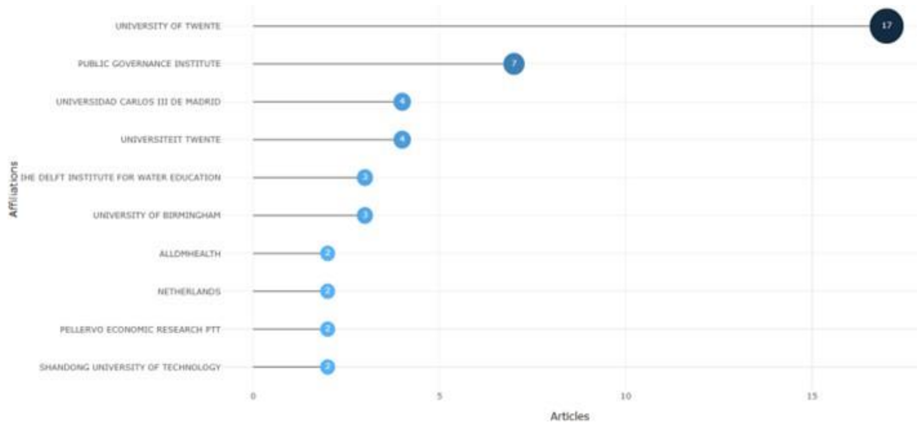

Figure 9. Most relevant affiliations

Figure 9 highlights the most relevant author affiliations in this research. The top affiliation is the University of Twente, contributing a total of 17 articles. This is followed by the Public Governance Institute with seven articles, Universidad Carlos III De Madrid with four articles, and Universiteit Twente with four articles.

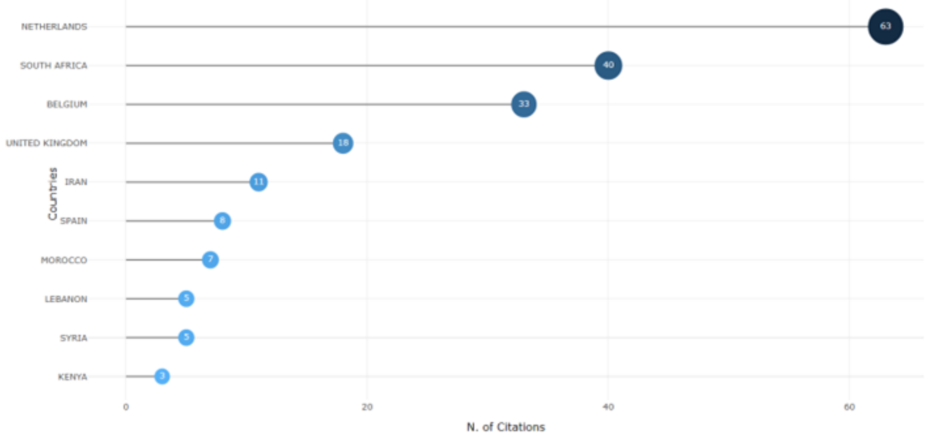

Figure 10. Most cited countries

Figure 10 presents the most cited countries in this research. The Netherlands leads with a total of 63 citations, followed by South Africa with 40 citations and Belgium with 33 citations. Countries with fewer than 20 citations include the United Kingdom (18 citations), Iran (11 citations), Spain (8 citations), Morocco (7 citations), Lebanon (5 citations), Syria (5 citations), and Kenya (3 citations).

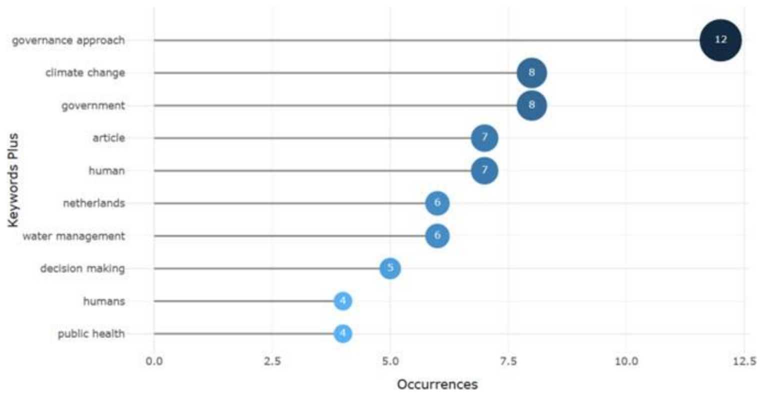

Figure 11. Most frequent words

Figure 11 presents the most frequent words in this research. The most frequently mentioned term is "governance approach," with 12 occurrences, followed by "climate change" and "government" with 8 occurrences each. Other frequently appearing terms include "article" (7 occurrences), "human" (7 occurrences), "Netherlands" (6 occurrences), "water management" (6 occurrences), "decision making" (5 occurrences), "humans" (4 occurrences), and "public health" (4 occurrences).

Figure 12. Word cloud

Figure 12 provides a visual representation of the most frequent words, reinforcing the significant emphasis on governance approaches and related themes in the selected articles. The prominence of "governance approach" indicates the primary focus of the research in the selected articles. This approach is frequently applied to address climate change issues and involves both local and national governments in decision making processes while considering human factors, as demonstrated across the reviewed studies.

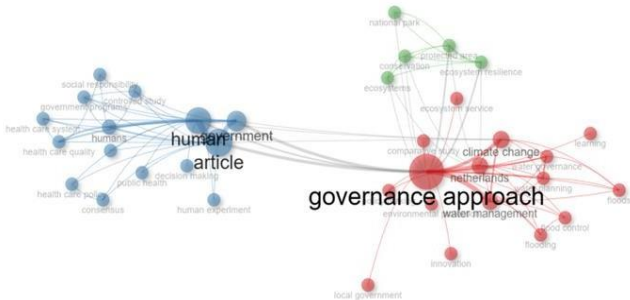

Figure 13. Conceptual structure

Figure 13 illustrates the conceptual structure in this research. The visualization reveals three concept clusters: red, blue, and green. The red cluster pertains to governance approaches and their application in addressing issues related to climate change, flooding, water management, and environmental concerns, with an emphasis on the government's role. The blue cluster focuses on government, decision-making, policies, and service quality, highlighting the involvement of humans as a key aspect. The green cluster encompasses topics related to ecosystems, protected areas, and resilience.

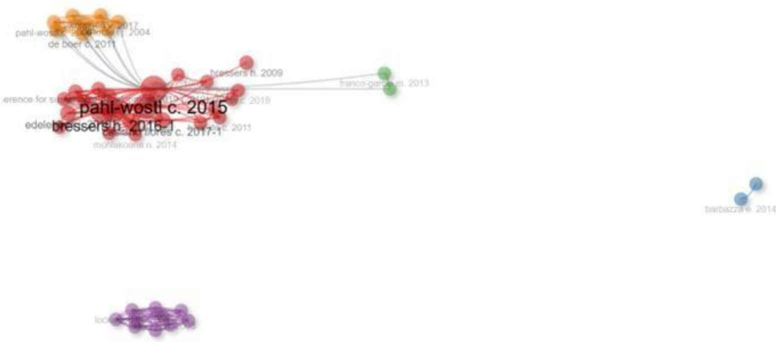

Figure 14. Co-citation Network

Figure 14 depicts the co-citation network, illustrating the relationships among publications. The visualization identifies five co-citation clusters: red, orange, green, purple, and blue. The red, orange, and green clusters are interconnected, indicating that the governance-related topics in these clusters are closely associated and frequently cited together. In contrast, the purple and blue clusters are not interconnected, nor are they linked to the red, orange, and green clusters. This suggests that the governance-related topics within the purple and blue clusters are less closely associated with those in the other clusters.

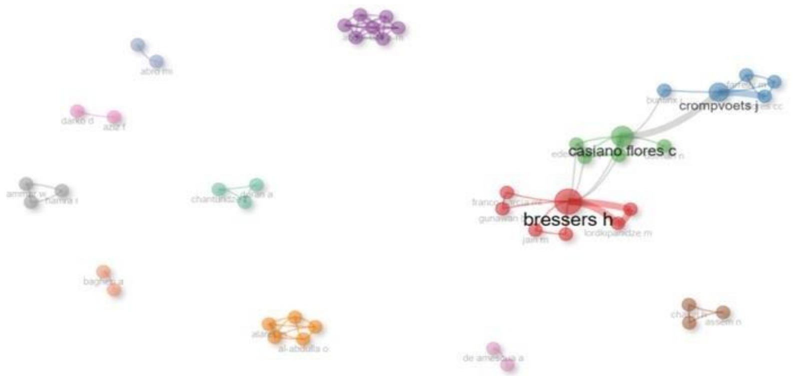

Figure 15. Collaboration Network

Figure 15 presents the collaboration network in this research, showing 12 clusters representing author collaborations. Three clusters red, green, and blue are interconnected, indicating collaboration both within and across these clusters. In contrast, the remaining nine clusters are isolated, reflecting a lack or absence of collaboration among authors in these clusters.

Method to Develop and Design

Among the 24 selected paper titles, only three studies developed or utilized tools in the form of websites (Chakiri & El Mohajir, 2020; Sajeva, Maidell, & Kotta, 2020; Flores & Crompvoets, 2020). Research conducted by Chakiri and El Mohajir, employed a hybrid data warehouse design driven by supply and demand, automated processes, and contextual modeling (Chakiri & El Mohajir, 2020). The primary features of the application developed in this research include data extraction, data matching, and reconciliation (Chakiri & El Mohajir, 2020).

Research conducted by (ajeva, Maidell, and Kotta, implemented a bottom up approach to eco-GAME within geospatial decision support system (DSS) applications (Sajeva, Maidell, & Kotta, 2020). Its key functionalities include analysis, systematic geospatial representation, and behavior synthesis. Research conducted by Flores & Crompvoets (Flores & Crompvoets, 2020), does not detail the development method or design of the software. However, through snowballing, a web-based application such as Webtool for Municipalities and Citizens (A Webtool for Municipalities and Citizens, 2024) was identified, built using the Governance Assessment Tool (GAT). Its main features include assessment, strategy adaptation, community building, best practices, and supporting information. An overview of the design and development methods, along with the main features or functionalities, is provided in Table 1 below.

Table 1. Method to develop and design

Design and Development Method	Main Features/Function	References
Hybrid design of data warehouse, based on supply and demand driven, automatic, and using contextual modeling.	Data extraction, data matching, and reconciliation (using algorithm and WordNet).	(Chakiri & El Mohajir, 2020)
Bottom-up approach to eco-GAME in geospatial DSS application.	Analysis, systematic geospatial representation, and synthesis of behavior.	(Sajeva, Maidell, & Kotta, 2020)
N/A	Assessment, strategy adaptation, community building, good practice, and supporting information.	(Flores & Crompvoets, 2020; A Webtool for Municipalities and Citizens, 2024).

Considering the numerous governance assessment tools referenced, such as Governance Assessment Tools or GAT (Flores & Crompvoets, 2020; Lordkipanidze, Bressers, & Lulofs, 2020; Casiano, Vikolainen, & Crompvoets, 2021; Lordkipanidze, Bressers, & Lulofs, 2019; Latanna et al., 2023; Flores et al., 2019; Mirnezami, De Boer, & Bagheri, 2020; Wambua et al., 2023) the main functions or features in this analysis are mapped using the STOPE framework (Bin-Abbas & Bakry, 2014). The STOPE method for evaluating an organization's readiness to adopt or implement technology. This research adopts the readiness concept from the STOPE framework, accounting for blockchain's immutable nature and its reliance on community-based approvals (Mohammed et al., 2023), in public permissionless blockchain contexts. This approach ensures readiness and feasibility (Whitten & Bentley, 2007). The STOPE framework was selected as it provides structured guidelines for deriving, selecting, and clustering appropriate factors and indicators. The mapping results are presented in Table 2 below.

Table 2. Dimensions and function in terms of readiness

Dimension	**Main Features/Function**
Strategy	Strategy adaptation, supporting information.
Technology	Supporting information.
Organization	Assessment and supporting information.
People	Good practice and supporting information.
Environment	Community building

Strategy adaptation and supporting information are categorized under the strategy dimension, while assessment and supporting information fall under the organization dimension (Bin-Abbas & Bakry, 2014; A Webtool for Municipalities and Citizens, 2024). Good practice and supporting information are grouped under the people dimension (Bin-Abbas & Bakry, 2014; A Webtool for Municipalities and Citizens, 2024). Finally, community building is aligned with the environment dimension, as it most closely relates to the environmental domain within the five domains of the STOPE framework (Bin-Abbas & Bakry, 2014; A Webtool for Municipalities and Citizens, 2024).

Table 2 presents the dimensions and functions of governance assessment tools in terms of readiness, categorized using the STOPE framework, which includes Strategy, Technology, Organization, People, and Environment. Strategy adaptation and supporting information fall under the **Strategy** dimension, ensuring governance tools align with long-term objectives and business sustainability. **Technology** focuses on supporting information, highlighting the need for technological infrastructure in governance assessments. The **Organization** dimension incorporates assessment mechanisms, ensuring structured governance evaluation. **People** involve best practices and knowledge sharing, reinforcing governance capacity-building. Lastly, **Environment** includes community building, emphasizing stakeholder collaboration for effective governance implementation. This structured approach enhances blockchain governance assessment, ensuring comprehensive and sustainable evaluation.

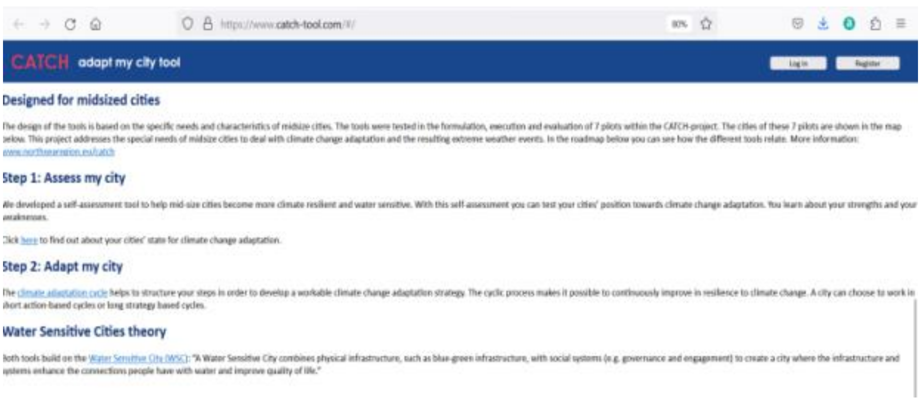

Figure 16. CATCH webpage for governance assessment (A Webtool for Municipalities and Citizens, 2024)

One online tool implementing the Governance Assessment Tool (GAT) is CATCH, or "Water Sensitive Cities: the Answer to Challenges of Extreme Weather Events" (A Webtool for Municipalities and Citizens, 2024). This tool is grounded in the theory of water-sensitive cities [31] and is designed to enhance climate resilience in urban areas, ensuring livability and long-term benefits (A Webtool for Municipalities and Citizens, 2024). CATCH can be accessed at www.catch-tool.com (A Webtool for Municipalities and Citizens, 2024). Figure 16 illustrates a sample page from CATCH, showcasing its main features: assessment, strategy adaptation, community building, good practice, and supporting information.

Elements Measured

The most widely utilized tool in the 24 studies selected for this research was the Governance Assessment Tool (GAT). GAT evaluates four quality parameters: area, coherence, flexibility, and intensity. Additionally, it measures five components: responsibility and resources, actors and networks, strategy and instruments, level and scale, and problem perspective and goal ambition.

Research conducted by Jain et al. (Jain et al., 2020), enhanced GAT by integrating it with the Sectoral Systems Innovation Assessment framework (SSIAf). The modified elements measured in their research (Jain et al., 2020) were structured into four components: the shaping of expectations, actor-network formation, institutional alignment and learning processes, and market and demand stimulation. The components and their assessment concepts are outlined in Table 3 below.

Table 3. Elements measured and assessment concepts

Element Measured	Assessment Concept	Source
Effectiveness and efficiency, rule of law, equity, transparency, participation, responsiveness, accountability, strategic vision, and consensus orientation.	Framework for automated data warehouse design and development to ensure assessment data quality.	(Chakiri & El Mohajir, 2020)
Nature, economic, social, and human.	Framework for eco-GAME (Governance Assessment Matrix Exercise) integrated in a geospatial DSS application.	(Sajeva, Maidell, & Kotta, 2020)
Quality: extent, coherence, flexibility, and intensity. Component: shaping of expectations, actor-network formation, institutions, learning process, and market demand stimulation.	Combination of Governance Assessment Tool (GAT) and Sectoral Systems Innovation Assessment framework (SSIAf).	(Jain et al., 2020)
Quality: extent, coherence, flexibility, and intensity. Component: responsibilities and resources, actors and networks, strategies and instruments, levels and scales, problem perspectives, and goal ambitions.	Governance Assessment Tool (GAT).	(Flores & Crompvoets, 2020; Lordkipanidze, Bressers, & Lulofs, 2020; Casiano, Vikolainen, & Crompvoets, 2021; Lordkipanidze, Bressers, & Lulofs, 2019; Latanna et al., 2023; Flores et al., 2019; Mirnezami, De Boer, & Bagheri, 2020; Wambua et al., 2023).
Participation, transparency, accountability, use of information, and responsiveness.	Development of a practical assessment tool: Health Policymaking Governance Guidance Tool (HP-GGT), enhanced from Siddiqi's framework.	(Hamra et al., 2020)

Element Measured	**Assessment Concept**	**Source**
Quality: extent, coherence, flexibility, and intensity. Component: responsibilities and resources, actors and networks, strategies and instruments, levels and scales, problem perspectives, and goal ambitions.	Combined GAT with three enabling factors of leapfrogging (Urban Water Management Transitions Framework - UWMTF).	(Flores & Müller, 2023)
Domain (of arrangement/assessment): institutional, financing, accountability, correspondence between responsibility and decision-making capacity.	Based on OECD healthcare quality indicators and hospital performance measurements from previous research.	(Duran et al., 2019)
Environmental governance objective impact between provincial and city levels on corporate behavior in innovation.	Empirical framework, econometric model, and measurement model developed through theoretical analysis. Uses tool variable model and fixed effect model.	(Wang et al., 2023)
Governance Capacity Framework: awareness, useful knowledge, continuous learning, stakeholder engagement, management ambition, agents of change, multi-level network potential, financial viability, and implementing capacity.	City Blueprint Approach (CBA)	(Town et al., 2019)
Quality: flexible, inclusive, participatory, affordable, reliable, attainable, and upgradeable. Component: responsibilities and resources, actors and networks, strategies and instruments, levels and scales, problem perspectives, and goal ambitions.	Fit-for-purpose governance assessment framework (FGAF).	(Casiano, 2020)
Quality: strategic vision, participation and consensus orientation, rule of law, transparency, responsiveness, equity and inclusiveness, effectiveness and efficiency, accountability, intelligence and information, ethics.	Extended Siddiqi's framework.	(Odland et al., 2023)
Normative, organizational, and procedural factors.	Analyzes success factors and indicators from WEF/IEG literature, applied to assess WEF nexus governance strategies.	(Oulu et al., 2023)
Legitimacy, accountability and transparency, effectiveness and efficiency, strategic vision.	Adopted a governance assessment framework based on literature review and group discussions.	(Alaref et al., 2023)
Architectural level.	ALTUS model.	(Sanchez-Segura et al., 2020)
Financial resources, policy, resource planning, design frameworks.	Ostrom's IAD framework.	(Maia, Kris, & Hans, 2019)

Element Measured	Assessment Concept	Source
Program Strategy - Cross-cutting: Regulation.		
Program Strategy - Alignment: Direct government support, provision of strategies and policies, provision of data.		
Program Strategy - Harmonization: Mechanisms for information sharing among partners.		
Program Strategy - Ownership and Stakeholder Involvement: Structures for stakeholder engagement.	Based on the Paris Declaration for Aid Effectiveness (agreement).	(Bünder, Karekezi, & Wirtz, 2021)
Program Implementation - Cross-cutting: Regulation.		
Program Implementation - Managing by Results: Results framework.		
Program Implementation - Accountability: Reporting structures, government oversight, review meetings.		

Research conducted by Chakiri and El Mohajir (Chakiri & El Mohajir, 2020) developed tools to ensure data quality by automating the data warehouse design and development process. Nine elements were measured in this research: effectiveness and efficiency, rule of law, equity, transparency, participation, responsiveness, accountability, strategic vision, and consensus orientation. Additionally, the author reviewed 10 governance assessment tools and their associated elements or components.

Research conducted by Sajeva, Maidell, and Kotta (Sajeva, Maidell, & Kotta, 2020) introduced a framework and tools integrated into a geospatial decision support system (DSS) application. The framework, named eco-GAME (Governance Assessment Matrix Exercise), measured four elements: nature, economic, social, and human. Research conducted by Hamra et al. (Hamra et al., 2020) developed the HP-GGT framework and tools based on principles from Siddiqi's framework. This framework is designed for assessing health policymaking governance and measures five elements: participation, transparency, use of information, responsiveness, and accountability (Hamra et al., 2020). Research conducted by Odland et al. (Odland et al., 2023) further enhanced Siddiqi's framework.

Research conducted by Duran et al. (Duran et al., 2019) involved assessments based on OECD healthcare quality indicators and hospital performance metrics established in previous studies. The measurements in this research focused on four domains: institutional, financing, accountability, and correspondence between responsibility and decision-making capacity. Research conducted by Wang et al. (Wang et al. 2023) aimed to develop an empirical framework, econometric model, and measurement model grounded in theoretical analysis. This research utilized variable and fixed effect model tools to measure the impact of environmental governance on corporate behavior in innovation. Research conducted by Bünder, Karekezi, and Wirtz (Bünder, Karekezi, & Wirtz 2021) assessed governance using a framework based on the Paris Declaration for Aid Effectiveness (agreement), while research conducted by Maia, Kris, and Hans (Maia, Kris, & Hans, 2019), involved assessments using Ostrom's IAD framework.

Among the 24 selected studies summarized in Table 3, three focused on IT or computer science governance. These include research on e-government (Chakiri & El Mohajir, 2020), research on the adoption of UAVs to assist land administration using the Fit-for-purpose Governance Assessment Framework or FGAF (Casiano, 2020), and research on knowledge governance using the ALTUS model (Sanchez-Segura et al., 2020). Research conducted by Casiano (Casiano, 2020) modified the quality elements in the Governance Assessment Tool (GAT), introducing seven new elements: flexible, inclusive, participatory, affordable, reliable, attainable, and upgradeable.

From the analysis of the 24 selected studies, the findings suggest that the Governance Assessment Tool (GAT) is adaptable for assessing governance across various fields. Modifications can be made to either the quality elements, the component elements, or both, depending on specific needs. Additionally, GAT can be combined with other theoretical frameworks to develop higher-quality assessment tools. Table 4 summarizes the elements and components of governance assessment frameworks that could serve as references for developing blockchain governance assessment tools.

Table 4. Summary of elements and components of governance assessment framework

Elements or Components	Representative Literature
Effectiveness, equity, accountability, participation, transparency, rule of law, civic engagement, security, equity, representation, responsiveness, and consensus orientation.	(Chakiri & El Mohajir, 2020)
Quality: flexible, inclusive, participatory, affordable, reliable, attainable, and upgradeable.	(Casiano, 2020)
Component: responsibilities and resources, actors and networks, strategies and instruments, levels and scales, problem perspectives, and goal ambitions.	
Quality: extent, coherence, flexibility, and intensity.	(Flores & Crompvoets, 2020; Lordkipanidze, Bressers, & Lulofs, 2020; Casiano, Vikolainen, & Crompvoets, 2021; Lordkipanidze, Bressers, & Lulofs, 2019; Latanna et al., 2023; Flores et al., 2019)
Component: responsibilities and resources, actors and networks, strategies and instruments, levels and scales, problem perspectives, and goal ambitions.	
Awareness, useful knowledge, continuous learning, stakeholder engagement, management ambition, agents of change, multi-level network potential, financial viability, and implementing capacity.	(Town et al., 2019)
Quality: strategic vision, participation and consensus orientation, rule of law, transparency, responsiveness, equity and inclusiveness, effectiveness and efficiency, accountability, intelligence and information, ethics.	(Odland et al., 2023)
Legitimacy, accountability and transparency, effectiveness and efficiency, strategic vision.	(Alaref et al., 2023)
Financial resources, policy, resource planning, and design frameworks.	(Maia, Kris, & Hans, 2019)

By analyzing the frequency of governance assessment tools and the use of a modified GAT in UAV adoption assessments (Casiano, 2020), the elements and components of the GAT, along with those from the 10 tools reviewed in several research (Chakiri & El Mohajir, 2020; Town et al., 2019; Odland et al., 2023; Alaref et al., 2023; Maia, Kris, & Hans, 2019) could be considered as potential elements or components for blockchain governance assessment tools. This provides an avenue for further research from one or multiple perspectives.

The elements and components of governance assessment frameworks summarized in Table 4 highlight key aspects essential for evaluating governance structures across various domains, including blockchain governance. These elements broadly encompass effectiveness, equity, accountability, participation, transparency, rule of law, and strategic vision, aligning with best practices in governance theory.

The Governance Assessment Tool (GAT) is widely referenced across multiple studies, demonstrating its adaptability in evaluating governance structures. Notably, Casiano (2020) introduced modifications to GAT, integrating seven new quality elements—flexibility, inclusiveness, participation, affordability, reliability, attainability, and upgradeability—further emphasizing governance's dynamic nature. Similarly, Flores and Crompvoets (2020) expanded governance assessment to include responsibilities, resource allocation, stakeholder networks, strategic instruments, and problem-solving perspectives. Meanwhile, Odland et al. (2023) focused on governance effectiveness by assessing strategic vision, transparency, responsiveness, equity, and ethics, recognizing the critical role of governance in sustainable development. Additionally, frameworks by Alaref et al. (2023) and Maia et al. (2019) highlight financial viability and institutional planning as crucial governance dimensions. These studies collectively underscore that governance is not just about compliance but also about fostering inclusivity, efficiency, and long-term resilience. Applying these elements to blockchain governance ensures decentralized systems maintain transparency, adaptability, and ethical oversight while driving economic, social, and environmental sustainability.

Conceptual Model

A conceptual model was developed based on the elements and components of governance assessment, using a business sustainability perspective. This perspective was selected to address the global concern of climate change and its potential impact on business sustainability. By incorporating the business sustainability perspective, supported by robust planning and governance, the negative environmental impacts of adopting information technology or emerging technologies can be mitigated. Figure 17 illustrates the conceptual model of blockchain governance assessment tools from a business sustainability perspective, which has undergone expert validation.

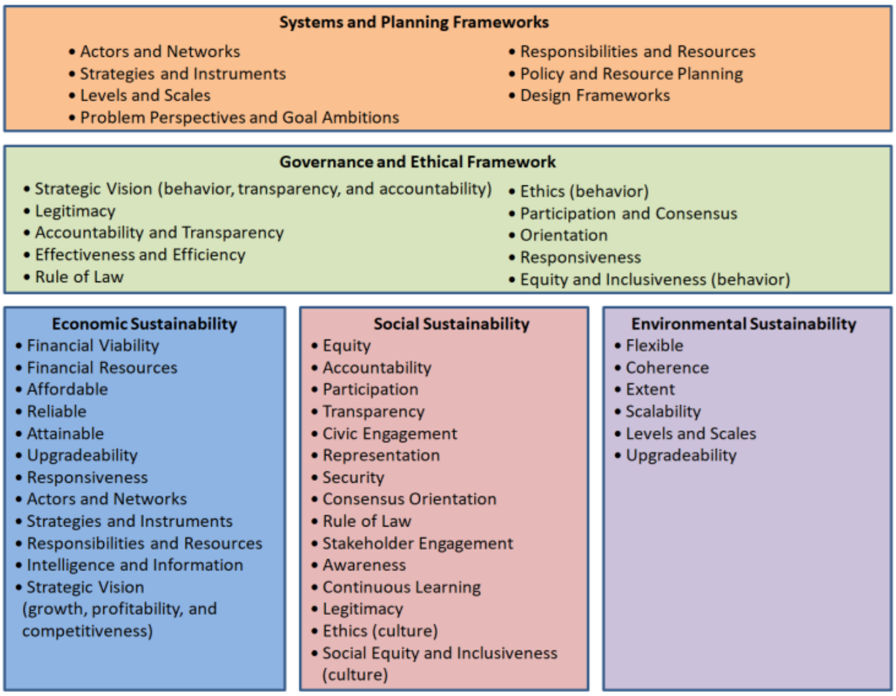

Figure 17. Conceptual model of blockchain governance assessment tools from business sustainability perspective

Figure 17 identifies five elements and components in governance assessment tools: system and planning frameworks, governance and ethical frameworks, economic sustainability, social sustainability, and environmental sustainability. Economic, social, and environmental sustainability are core elements of business sustainability. However, effective implementation and beneficial outcomes require the integration of system and planning frameworks alongside governance and ethical frameworks. The conceptual model offers an insight on governance assessment tools for promoting business sustainability. The details of each element that grouped in five main categories represent the foundational pillars of business sustainability, are explained as follows.

1. **System and planning frameworks**

The system and planning frameworks emphasize the structures, strategies, and resources that guide sustainable business practices across various levels. These frameworks include actors and networks, strategies and instruments, levels and scales, problem perspectives and goal ambitions, responsibilities and resources, policy and resource planning, and design frameworks. These components focus on the system and planning aspects. The focus of system and planning frameworks is on the foundational structures, strategies, and resources deemed essential for guiding sustainable business practices across various operational levels.

2. **Governance and ethical framework**

The governance and ethical framework encompass strategic vision (covering behavior, transparency, and accountability), legitimacy, accountability, transparency, effectiveness, efficiency, rule of law, ethics (behavior-related), participation, consensus, orientation, responsiveness, equity, and inclusiveness (also behavior-related). These components address governance and ethical aspects. Governance and ethical frameworks emphasize the framework, principles and values that govern business and stakeholder actions in realizing the goals of sustainability, transparency, fairness and accountability. The components in this category emphasize the importance of good governance and ethical behavior and its framework, to achieve business sustainability. Without adequate governance and ethics, the achievement of sustainable business goals will be hampered by, among other things, corruption, poor accountability, and unfairness in the involvement of key stakeholders.

3. Economic sustainability

Economic and sustainability category focuses on ensuring financial stability and driving long-term profits and goals by using resources efficiently and supporting environmental and social sustainability. This category emphasizes the integration of financial considerations into sustainability efforts, ensuring that businesses can achieve long-term financial success while maintaining a focus on sustainability. Economic sustainability ensures financial stability, efficient resource management, and long-term profitability. Its components include financial viability, financial resources, affordability, reliability, attainability, upgradeability, responsiveness, actors and networks, strategies and instruments, responsibilities and resources, intelligence and information, and strategic vision (growth, profitability, and competitiveness). These elements focus on the economic dimension.

4. Social sustainability

Social sustainability prioritizes fairness, accountability, participation, and inclusivity to promote social justice, engage stakeholders, and support effective governance. Its components include equity, accountability, participation, transparency, civic engagement, representation, security, consensus orientation, rule of law, stakeholder engagement, awareness, continuous learning, legitimacy, ethics (culture), and social equity and inclusiveness (culture). These elements address the social dimensions.

5. Environmental sustainability

Environmental sustainability emphasizes adaptability, scalability, and efficient resource utilization to minimize negative environmental impact and maintain ecological balance. It comprises flexibility, coherence, extent, scalability, levels and scales, and upgradeability. These components focus on environmental aspects, ensuring that emerging technologies are implemented with minimal adverse environmental effects.

Future Work

In the current systematic literature review (SLR), authors examined the empirical evidence from academia that can show current state and future research potential on blockchain governance assessment tools. Research gap and potential future work are provided in Table 5. Theme of research gap that has been identified in this research are design, development, and evaluation of blockchain governance and assessment tools, and blockchain governance assessment tools for business sustainability.

Table 5. Research gap and potential future work

Theme	Research Gap	Potential Future Work
Design and development of blockchain governance assessment tools	The lack of research on design and development of blockchain governance assessment tools	Conducting more research on design and development of blockchain governance assessment tools, not only limited to the conceptual model.
Implementation of blockchain governance assessment tools	The lack of research on implementation of blockchain governance assessment tools	Conducting more research on implementation of blockchain governance assessment tools
Evaluation of blockchain governance assessment tools	The lack of research on evaluation of blockchain governance assessment tools	Conducting more research on evaluation of blockchain governance assessment tools
Blockchain governance assessment tools for business sustainability	The lack of research on blockchain governance assessment tools for business sustainability	Conducting more research on blockchain governance assessment tools for business sustainability

Theme	Research Gap	Potential Future Work
Blockchain governance assessment	The lack of research on blockchain governance assessment	Conducting more research on blockchain governance assessment

The research gaps and potential future work identified in Table 5 underscore the need for further exploration into blockchain governance assessment tools, particularly their design, development, implementation, and evaluation. The lack of research in designing and developing blockchain governance assessment tools suggests that existing frameworks are either underdeveloped or not tailored specifically for blockchain ecosystems. While conceptual models exist, practical implementations remain scarce, limiting their applicability in real-world scenarios. Moreover, the absence of studies on implementing blockchain governance assessment tools highlights a critical gap in translating theoretical models into functional systems. Without practical application, organizations lack the necessary tools to assess governance efficiency, security, and sustainability in blockchain networks. Additionally, there is minimal research on evaluating blockchain governance tools, meaning existing solutions are rarely tested for effectiveness, usability, and long-term viability. Another significant gap is the integration of blockchain governance assessment tools with business sustainability principles. Blockchain technology offers potential benefits for economic, social, and environmental sustainability, yet research rarely explores how governance tools can enhance these dimensions. Future studies should address these gaps by developing robust assessment tools, testing their implementation in various industries, and evaluating their effectiveness in ensuring transparent, secure, and sustainable blockchain governance. This research direction is crucial for fostering trust, innovation, and regulatory compliance in blockchain applications.

LIMITATIONS

This research is limited to articles from reputable international conferences and indexed journals that have been searched using the PRISMA systematic literature review (SLR) protocol from nine databases (Scopus, ScienceDirect, ACM Digital Library, Emerald Insight, ProQuest, IEEE Xplore, SpringerLink, Sage Journals, and Taylor & Francis), focusing on English-language journal articles published between 2019 and 2023. The inclusion criteria of SLR in this research may allow some relevant articles to be missed. The SLR in this research also does not include book chapters, reports, standards, and gray literature, and is only based on evidence from academia. In addition, the review and analysis of the included articles resulting from SLR in this research only focus on the design and development process of blockchain governance assessment tools and conceptual models from a business sustainability perspective. However, this research provides a foundation for future research on blockchain governance assessment tools and their relationship to business sustainability. To address these limitations, future research should explore empirical studies that implement and evaluate blockchain governance assessment tools in different industries, such as finance, healthcare, and supply chain management. Additionally, further studies should integrate business sustainability metrics into blockchain governance assessment, ensuring governance models align with environmental, social, and economic sustainability principles. Researchers should also develop case studies that test the effectiveness of governance tools in diverse settings, providing insights into their adaptability across different regulatory and business environments.

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