

Article

Emerging Trends and Knowledge Structures of Smart Urban Governance

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Abstract: The concept of smart cities peaked in 2015, bringing an increased influx of ‘smart’ devices in the form of the Internet of Things (IoT) and sensors in cities. As a result, interest in smart urban governance has become more prevalent in administrative, organisational, and political circles. This is sustained by both local and global demands for an increased contribution to the goals of sustainability through urban governance processes in response to climate change urgencies. Cities generate up to 70% of global emissions, and in light of societal pressures for more inclusivity and democratic processes, the need for sound urban governance is merited. Further knowledge on the theme of smart urban governance is required to better understand the trends and knowledge structures and better assist policy design. Therefore, this study was undertaken to understand and map the evolution of the concept of smart urban governance through a bibliometric analysis and science mapping techniques using VOSviewer. In total, 1897 articles were retrieved from the Web of Science database over 5 decades, from 1968 to 2021, and divided into three subperiods, namely 1978 to 2015, 2016 to 2019, and 2020 to early 2022. Results indicate that the overall emerging themes across the three periods highlight the need for citizen participation in urban policies, especially in relation to smart cities, and for sustained innovation for e-participation, e-governance, and policy frameworks. The results of this study can aid both researchers exploring the concept of urban governance and policy makers rendering more inclusive urban policies, especially those hosting technological and digital domains.

Keywords: smart cities; urban governance; smart governance; ICT; IoT; big data analytics; inclusivity; citizen participation; innovation; institutions; democracy



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1. Introduction

Cities across the globe have been confronted by several challenges in the past century, including climate change, rapid population growth, and exponential urbanization, amongst others. After the end of World War Two (WW2), it was reported that the economic welfare of many global residents started to grow, especially in urban areas, courtesy of sound urban governance approaches that were adopted [1]. This was prompted by an increase in opportunities for economic growth, education, socialization, and recreation in cities, thereby attracting a sizeable number of people, businesses, and government operations.

This prompted further growth of cities in terms of population, size, and Gross Domestic Products (GDP), as well as opening opportunities for the emergence of new urban areas [2]. Currently, as a result of increased activities in cities, they are home to more than 55% of the global population; by the year 2050, it is projected that they will host more than 68% of the global population [3]. Furthermore, their contribution to the global economy is expected to continue as more frontiers and opportunities continue to emerge, especially prompted by the adoption of new technologies. Additionally, the commitment of those governing cities would be very critical in spurring more growth by ensuring they seal loopholes and leakages prompted by the endemic urban challenges. Currently, cities have been argued to contribute approximately 70% of the global GDP, and this is expected to grow to more than 80% by 2050 [4]. However, it has been observed that cities also prompt numerous governance challenges at varying scales, both at local and national levels (see Bibri [5] for a detailed account and discussion).

Such challenges include provision of services, investments in capital infrastructures, collection of revenues, and financing of different projects and initiatives, among others. The adoption of technology in cities has been observed to help ease many challenges, especially with an increase in efficiency and performance of cities [6,7]. This has been made possible by the emergence of technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Cloud computing, and others that have increased the potential to render various aspects of cities 'smart', a concept that cements the decades-long appeal of technology use in urban areas [8–10]. In this strand of smart urbanism, governance denotes the capacity of employing technology and innovation as a set of intelligent and adaptive acts for facilitating decision making, implementing policies and tracking their effects, developing advanced organisational structures, and dealing with substantive challenges. Smart urban governance is about utilising and harnessing the innovative potential and significant role of advanced Information and Communication Technology (ICT) in the functioning of smart cities (e.g., [5,11–14]) in terms of their planning and management. Its emergence has made local governments in many cities rethink their functions in regard to the use of smart technologies in upgrading administrative systems, improving institutional structures, and optimising organisational processes. This involves streamlining urban operations by seamlessly integrating them into manageable networks instead of maintaining disjointed systems, enhancing stakeholders' collaboration capabilities, increasing the capacity to handle urban challenges, and enhancing decision making based on evidence-based approaches. This has become possible due to the flowing-torrent of data produced from different urban frontiers, coupled with its analytical power. This in turn aids in extracting deep insights for a wide range of uses pertaining to urban management and urban policy.

While the adoption of smart technologies in urban governance is not ultimately perfect, as there have been pitfalls and risks reported in different cities in relation to a variety of areas, it nevertheless has numerous advantages and benefits that are accrued. For instance, it was recorded that smart urban governance has the potential to help save each urban resident approximately 100 h per year, which when monetized, could translate to approximately \$1377 per person per year in America, or £904 in the United Kingdom [15]. This, however, is much less significant than other direct benefits such as improved liveability status [16–18], improved emergency preparedness and response [19], and improved infrastructural development [20] thanks to emerging technologies. Smart urban governance is further seen to be instrumental in the achievement of urban sustainable agendas, as captured in the Sustainable Development Goal 11 [21]. Regarding this, Tomor et al. [22] note that different smart technologies have made it possible for local governments to partner with citizens in finding solutions to endemic environmental challenges. This includes participation in making housing projects smarter, adoption of smart grids, smart parking, responsive waste management, regeneration of urban green spaces, and others.

With the diverse potential that smart urban governance has unlocked, many cities across the globe are now turning toward the adoption of different technologies to enhance various urban dimensions. However, this has opened a plethora of issues relating to

privacy [23–26], data security [24,27], data ownership [28], and personal security [24], amongst others. From a wide range of data, those concerns are legitimate and have capacities to influence the success of smart technologies' deployment in cities.

In light of the above information, this study seeks to explore, through a bibliometric analysis, the various publications that have been made concerning adoption of smart technologies, especially in the governance of cities. While several bibliometric studies touching on smart cities exist, only one [29] has been identified that directly touches on the subject matter of urban governance, being key in the smart city discourse [30–32]; hence, this study seeks to increase the knowledge on this topic by incorporating works that arose immediately after and during the height of COVID-19. The rationale is that it is possible that the number of publications continues to increase as more attention is focused on adoption of smart technologies in cities, and specifically to the need to further ponder and include societal factors [16,33]. Furthermore, with concerns such as monetization of data by third party corporations and start-ups contracted by local governments to manage the massive data being generated in cities, it becomes paramount to analyse the research interests and terminologies that are emerging. This way, the analysis will help guide researchers and other stakeholders seeking to understand the dynamics in the academic realm concerning the emergence and widespread acceptability and appeal of the smart city concept in respect to urban governance. This can ultimately lead to better-informed decisions and enhanced urban policies. In addition, there is still a lack of research on the knowledge structure and trends of smart urban governance over different time periods. The performance of this analysis is the main novelty of this study, and provides interested stakeholders with a better understanding of the evolution of this field. Therefore, the main objectives of this study were to:

- Understand the major thematic focus areas of smart urban governance;
- Discuss how they have evolved over time; and
- Highlight authors, sources, and publications that have been notably influential.

Throughout the course of addressing the objectives set in this study, several observations were made on:

- The time periods in which research on smart urban governance gained maximum attention and the possible reasons as to why;
- How the field of smart urban governance evolved thematically over time; and
- Some of the contributing factors to the growth of this field.

In order to respond to the above objectives, this article is structured as follows. Section 1 covers the Introduction and background information. It is followed by Section 3, which entails a detailed Materials and Methodology section that comprehensively highlights all the approaches, materials, tools, and steps that were adopted to attain observations satisfying the objectives. Section 3 subsequently covers the literature review related to this study. The methodology section is followed by a detailed *Result* section (Section 4) that captures and presents all the results obtained after running the available data in VOSviewers software. The results are presented in the form of graphs, tables, and relationship diagrams. The analysis of the results and their implications is presented in the Discussion section, which is succeeded by a Conclusion section.

2. Background

Smart city governance is a new approach to urban policy, planning, and management that is able to solve the emerging challenges of urban areas while ensuring sustainability. It has emerged as a result of the innovative potential and growing role of advanced ICT in the functioning of smart cities (e.g., [10,32–35]). Several literature reviews have been carried out on the topic of smart urban governance, approaching the subject from a variety of perspectives. In one of the early literature reviews conducted on the topic, Meijer and Bolívar [34] attempted to fill the gap pertaining to the conceptual understanding of smart urban governance. Accordingly, the authors explored the concept of smart urban

governance both theoretically and empirically to build a research model. Inductively, they identified various categories within the key dimensions of smart urban governance: defining elements, aspired outcomes, and implementation strategies. The categories were then refined based on an empirical investigation on the dominant perceptions of practitioners of these dimensions. Using a slightly different approach to the topic to fill the gap of a rather systematic understanding of the different components of smart urban governance and their measurement metrics, envisaged outcomes, and influencing contextual factors, Ruhlandt [36] proposed conceptual insights and generated a research scheme, and then used this for an extensive discussion of the literature instead. The author revealed substantial variances in contextual factors, measurement techniques, and outcomes among the concepts of smart city governance, in addition to the differences in its definitions. To expand their previous work, Meijer and Bolívar [34] offered another review on the topic. In this light, the authors endeavoured to bring some structure to the debate by analysing a corpus of 51 publications and mapping their variation. The authors demonstrate key differences in the emphasis of these publications with respect to the key dimensions addressed in their previous paper, namely (1) smart technology, smart people, or smart collaboration; (2) better outcomes or a more open process as the legitimacy claim for smart city governance; and (3) a transformative or incremental perspective on changes in urban governance. They provide several arguments, highlights, suggestions, and contributions involving conceptual, practical, research, and policy implications. The two studies by the same authors complete each other in terms of analysis and findings with the aim to enhance the conceptual and practical foundations of smart urban governance.

The literature review performed by Pereira et al. [31] focuses on smart governance as an emerging domain of study and provides further insights into the definition and conceptualisation of smart governance and its relationships with e-government. The authors show that smart government can be a basis for developing smart governance using ICT for governing purposes to improve decision-making through better collaboration among different stakeholders. They also highlight the role of ICT-based tools in increasing citizen engagement and participation and supporting the development of new governance models for smart government, among others. Expanding on this work, Tomor et al. [22] provide a systematic review on smart governance as technology-enabled collaboration between citizens and local governments to advance sustainable development. The authors focus on the relationships between ICT-enabled citizen–government collaboration and sustainable urban development and how contextual circumstances influence these related elements. The latter connects well with the review conducted by Ruhlandt [36], but from a smart governing perspective. However, the authors show that empirical evidence for the alleged sustainability benefits is sparse, and the emerging picture is ambiguous, as it reports both positive and negative effects as it regards the social sustainability achievements of smart governance. This review is part of a large research project that assesses the value of ICT for engaging citizens in the governance of sustainable cities. One of the conclusions drawn in this review is that smart governance, in the sense of ICT-enabled government–citizen collaboration to advance urban sustainability, is still rare. Despite the increasing variety of collaboration-based digital instruments, a one-way information supply in citizen–government interactions tends to dominate. Moreover, although governments promote online and offline citizen engagement and civic empowerment, in practice they do not encourage deliberation or any broad-based public–civil interactions. Therefore, ICT-supported government–citizen cooperation for collectively shaping public matters seldom occurs. Rather, as concluded in a review carried out by Bibri [12] on smart sustainable cities, what smart governance entails and the way it functions raises several critical questions, including whether the policy and governance of smart sustainable cities of the future will become too technocentric and technocratic, respectively, and also with regard to other aspects of social and environmental sustainability. In their recent review paper, however, Przebylłowicz and Cunha [37] put an emphasis on government characteristics to achieve smart urban governance from internal to external transformation. Therefore,

the authors provide a systematic literature review based on 36 publications and merge this with the existing e-government literature on critical success factors for adopting IT in the public sector. In contrast to the two previous reviews, the authors shed light on the key organizational attributes that can pave the way for the transition from government to smart urban governance. They identify three main characteristics: (1) local governance related to the nature of the relationship among key stakeholders; (2) government assets as to funding, technology, and human capital; and (3) local government management and strategy and local public administration positioning. As a conclusion, unlike e-government, which focuses on transforming the social organization internally, smart governance focuses on transforming the social organisation internally and externally.

Overall, while new ICT-based solutions are constantly emerging to help city governments improve their institutional and organisational structures, processes, and practices, these solutions are largely associated with smart cities and their strategies and objectives. Moreover, review studies tend to address either conceptual or practical issues while espousing different approaches to the topic of smart urban governance. However, there is a lack of the theoretical basis and empirical evidence required to holistically evaluate the potential effects of the transformative processes within smart governance in connection with the practices, operations, and institutions of smart cities. Furthermore, the topic of sustainability is still underexplored, both theoretically and empirically, with regard to its social and environment dimensions, as well as to the integration of these with the economic dimension of sustainability. Notably, existing literature reviews on smart urban governance are associated with some limitations in terms of exploring and analysing only a limited number of publications on the topic. This bibliometric analysis involves large volumes of scientific data and allows us to unpack the evolutionary nuances of the field of smart urban governance in regard to its emergence, insertion, functioning, and evolvment as a discourse facilitated by politics. These aspects, the driving forces behind the expansion and prevalence of smart urban governance, and other nuances are missing from the previously overviewed review papers. In addition, this bibliometric analysis sheds light on the emerging areas in the domain of smart governance beyond its own. More explicitly, it fills the gap pertaining to the knowledge structure and trends of smart urban governance over different periods in order to enhance the understanding of the evolution of the field.

3. Materials and Methods

This research was conducted in two major steps. The first step involved scope definition (development of search string) and literature search and selection. The second step was conducting bibliometric analysis using VOSviewer and interpreting the outputs of the bibliometric analysis. These are shown in Figure 1 and will be further explained below.

Input data for bibliometric analysis are the bibliographic details of academic publications that were obtained from the Web of Science (WoS) [38,39]. Among different databases that archive academic research (e.g., Scopus [40,41] and Dimensions [39,42]), WoS was selected due to its reputation for indexing quality research related to the topic of this study and since it provides detailed bibliographic information necessary for accurate analysis using the bibliometric software (i.e., VOSviewer [43–45]). We acknowledge that this is a limitation of this study, as a more comprehensive analysis would require including literature from other databases as well as grey literature. However, as we have analysed a large number of articles, we believe the results are sufficiently reasonable and representative. We designed a broad-based search string to include as many articles as possible relevant to smart urban governance in the analysis. The search string (see the Appendix A) is a combination of different terms related to smartness, governance, and cities. We searched for the relevant articles in all citation indexes of the WoS (i.e., A&HCI, ESCI, SCI-EXPANDED, SSCI) on 15 January 2022. The search period was unlimited (i.e., all research published until 15 January 2022), but we only searched for articles, review articles, proceeding papers, book chapters, editorial materials, and data papers. This literature search returned 2001 articles. After screening titles and abstracts of these documents, 1897 articles that were related to

smart urban governance were selected and their associated data (i.e., 'Full Record and Cited References') were downloaded for bibliometric analysis.

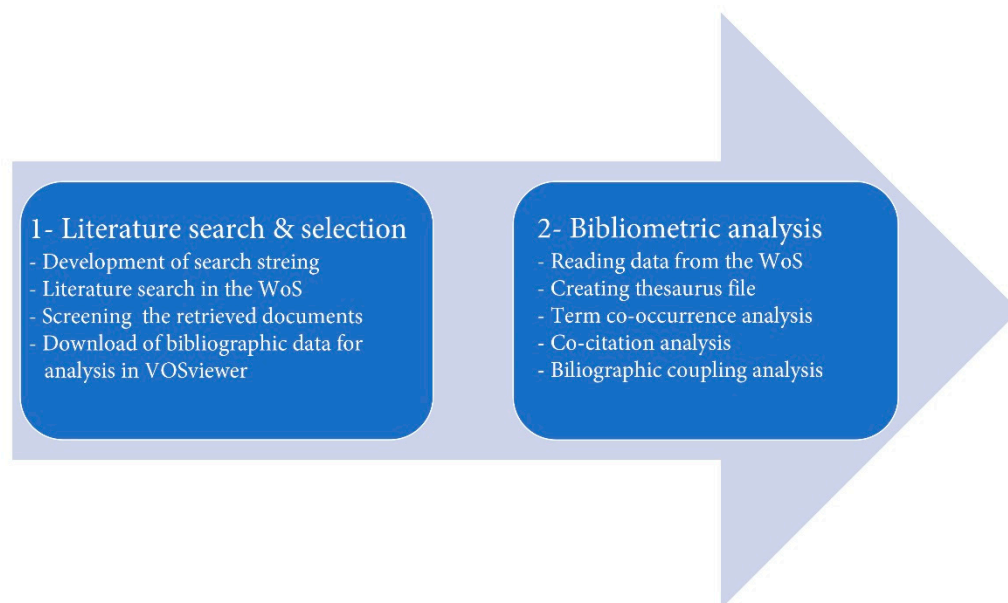


Figure 1. Major steps taken for the purpose of this study.

Over the past two decades, several software tools for bibliometric analysis have been developed [44]. These include VOSviewer, SciMAT, and CiteSpace. Despite their differences, all these tools provide means to understand the overall structure of a research field and the complex interactions between different variables related to academic papers (e.g., keywords, references, authors, journals, etc.). Here we used VOSviewer, as its interface is more user friendly and its graphic outputs are more suitable for interpretation [45–48]. VOSviewer is a freely available Java application (<https://www.vosviewer.com>, (accessed on the 1 December 2021)). Free access to user manuals and demo projects is provided by the developers and interested readers are referred to the tool manual for step-by-step description of the different steps for analysis. We used VOSviewer to conduct term co-occurrence analysis (using the 'full counting' counting method and setting 'all keywords' as the unit of analysis), citation (setting 'documents' as the unit of analysis), co-citation (using the 'full counting' counting method, and setting 'cited references', 'cited sources', and 'cited authors' as units of analysis), and bibliographic coupling (using the 'full counting' counting method, and setting 'organizations' and 'countries' as units of analysis) [28]. It should be noted that 'fractional counting' can also be used to create the maps using VOSviewer. We have used 'full counting', as its outputs are easier to interpret [48]. We suggest that a similar analysis using fractional counting could also be done in the future to compare the outputs. The term co-occurrence analysis was used to identify the most dominant terms and understand how they are linked to other terms related to smart urban governance. Also, terms that co-occur frequently provide information about major thematic research clusters. It should be mentioned that, as different variants of a term may exist (e.g., Information and Communication Technologies and ICT), before conducting the term co-occurrence analysis, a thesaurus file was created and added to the VOSviewer database to avoid separate counting of synonyms.

In Section 4, outputs of the analyses are shown in a graph format. In each case, the node size is proportional to the frequency and link width is proportional to the strength of connection between two nodes. For instance, in the case of term co-occurrence analysis, the node size is proportional to the number of times a term has co-occurred with other terms and the link width indicates the strength of connection between two terms. The frequently co-occurred terms establish clusters that represent different thematic research areas.

As one of the objectives of this study was to find out how the field has evolved thematically over time, we divided the study period into three sub-periods. This was based on important milestones that could have influenced the evolution of the field. As different international policy frameworks related to cities (e.g., Agenda 2030 and the New Urban Agenda) were adopted in 2015, it was selected as one of the milestones. Additionally, given the significant impacts of the COVID-19 pandemic on cities and its effects on the acceleration of digitalization, the post-pandemic period was considered as a separate sub-period. More sub-periods could have been considered before 2015; however, as can be seen in Section 3, the pace of publications was slow until then, not warranting further sub-periods. Accordingly, the following sub-periods were considered: until 2015, 2016 to 2019, and 2020 until now. Term co-occurrence analyses were conducted for each sub-period to understand their thematic research focus and see how it has evolved over time.

To find out what authors, journals, and references have made more contribution to the development of the field, we used co-citation analysis. Co-citation refers to the link between two documents that are both simultaneously cited by another document [28]. Based on this definition, cited references of the selected articles are also considered in the co-citation analysis. Bibliographic coupling is another analysis that can be used to understand countries and institutions that have made more contributions to the development of the field. “A bibliographic coupling link is a link between two items that both cite the same document” [47].

4. Results

This section presents the results obtained after running the data in VosViewer. The results are ordered in different thematic areas, including publication trends, most influential journals and authors, and the overall thematic focus for each of the three periods under which the publication years were categorized.

4.1. Publications Trends

From the literature, the quest to transform cities with the use of data came into light since the 1970s, when Los Angeles (first data used in 1974) became the first urban centre to experiment with this [49]. However, it was not until the emergence of the fourth industrial revolution that the concept started to attract substantial attention. This is confirmed in Figure 2 below, showcasing that between 1978 and 2015, only 220 publications touching on smart urban governance had been published. Even during this first phase of publications, it is evident that researchers’ attention to smart technologies in cities was drawn as from 2004 and grew steadily until 2015, when substantial interest was clearly noticed. The drive to investigate, research, and publish on smart urban governance during the 2000s was being influenced by activities by large IT corporations such as Cisco and IBM, which were the main pioneers in concentrating on the usage of information technology in cities [30]. For instance, in 2005, Cisco became the first corporation to invest in research and development (R&D), committing \$25 million [50]. In 2009, IBM committed \$50 million to the Smarter Cities campaign, aimed at influencing cities to embrace technology in their planning to increase urban efficiency and performance [51]. By 2015, the concept had become almost mainstream in most countries, with cities slowly embracing different aspects of smart cities.

Between 2015 and 2019, the number of publications increased substantially, and this could be attributed to the increased acceptance of the smart city concept in different urban fabrics. Furthermore, during this period, many technologies such as AI, IoT, Machine Learning, and others started to gain traction in cities, as smart components such as sensors, cameras, smart mobile devices (smartphones), wearables, and others continued to increase globally, thereby prompting an increase in data generation and its subsequent analysis [32]. With the diversification of smart components, numerous terminologies, areas of research interest, and demand for publications on this topic increased, prompting an increase in research works published.

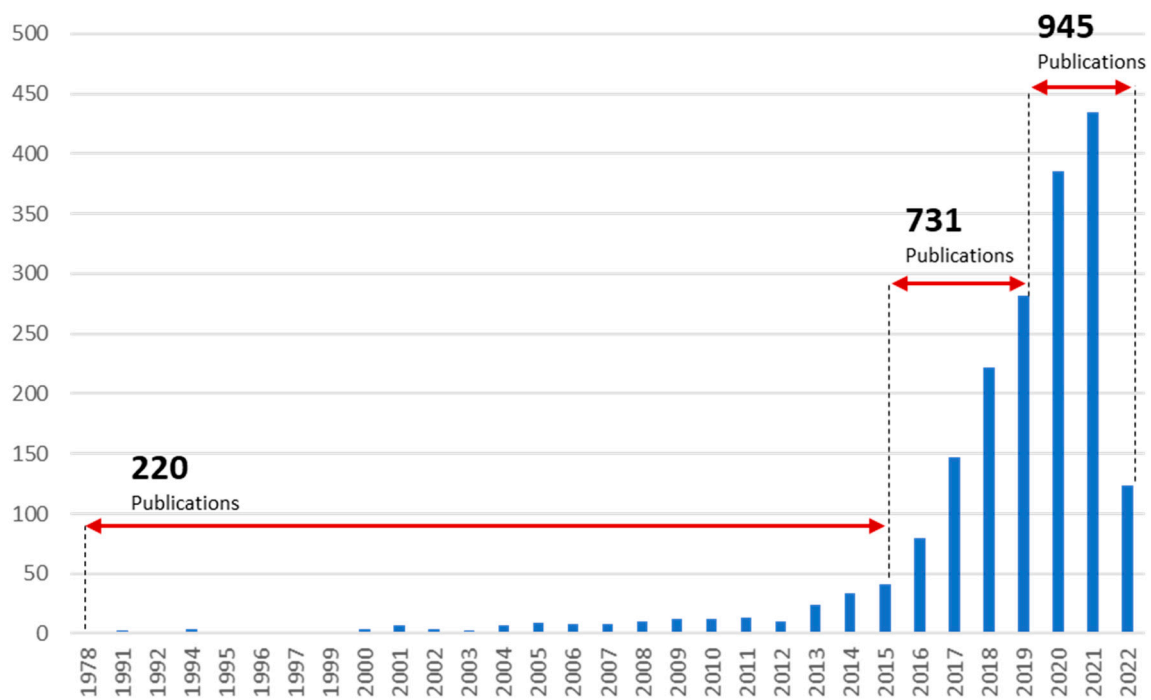


Figure 2. Number of publications on ‘Smart Urban Governance’ between 1978 and early 2022.

Between 2020 and 2022, despite the outbreak of COVID-19 that brought about an unprecedented change in normal activities globally, the number of publications increased even further. This could be attributed to the role technology played in helping urban residents, governments, and stakeholders in the health sector to identify the coronavirus and craft strategies to combat its spread. During this period, despite the lockdowns, controlled movement of people, and other health measures instituted, people continued to undertake some activities, especially through the work-from-home clarion. Such influence of technology may have prompted even more interest among researchers, including how technology could further be deployed in the future to help overcome similar pandemics in urban fabrics while still allowing cities to engage in their primary activities. This is part of a prevailing narrative, but there are other studies and perspectives on the topic of COVID-19 that have criticised the use of surveillance technologies in terms of their negative implications on society and civic values in the context of smart urbanism (see, e.g., [52–55]).

4.2. Influential Journals

Between the period in relevance to this study (1978–2022), a wide range of journals and publications have emerged focusing on different aspects of smart urban governance, as depicted in Table 1 below. While the table only captures 20 of the most influential journals and publications, that does not suppress the fact that there are other numerous publishing companies concentrating on research works touching on the ‘smartness’ of governance features. In Figure 3 below, the two most influential journals are *Cities* and *Government Information Quarterly*, with total link strengths of almost 29,900 and 21,297, respectively. Of interest is that journals with the highest Impact Factor are not necessarily the most influential, as some publish research particularly on issues of cities and governance, with their scope including some of the most influential research areas that have emerged over the entire period of study.

Table 1. Top 40 Most Influential Journals.

Title	Publication	Year	Authors
A Ladder of Citizen Participation	Journal of the American Institute of Planners	1969	Arnstein [56]
Internet of Things for Smart Cities	IEEE Internet of Things Journal	2014	Zanella et al. [57]
Smart Cities in Europe	Journal of Urban Technology	2011	Caragliu et al. [58]
Will the real smart city please stand up?	City	2008	Hollands [59]
Smart city as urban innovation: Focusing on management, policy, and context	International conference on theory and practice of electronic governance	2011	Nam and Pardo [60]
Understanding Smart Cities: An Integrative Framework	Hawaii International Conference on System Sciences	2012	Chourabi et al. [61]
Smart cities: Ranking of European medium-sized cities	Smart cities: Ranking of European medium-sized cities	2007	Giffinger and Pichler-Milanović [62]
Smart cities: Big data, civic hackers, and the quest for a new utopia	WW Norton & Company	2013	Townsend [63]
Smart Cities of the Future	The European Physical Journal Special Topics	2012	Batty et al. [64]
Current trends in Smart City initiatives: Some stylised facts	Cities	2014	Neirotti et al. [65]
Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation	The Future Internets	2011	Schaffers et al. [66]
From e-government to we-government: Defining a typology for citizen coproduction in the age of social media	Government Information Quarterly	2012	Linders [67]
Foundations for Smart Cities	IBM Journal of Research and Development	2010	Harrison et al. [68]
Is there anybody out there? The place and role of citizens in tomorrow's smart cities	Futures	2014	Vanolo [69]
A Smart City Initiative: the Case of Barcelona	Journal of the Knowledge Economy	2013	Bakıcı et al. [70]
Governing the smart city: a review of the literature on smart urban governance	International Review of Administrative Sciences	2016	Meijer and Bolivar [34]
Modelling the smart city performance	Innovation: The European Journal of Social Science Research	2012	Lombardi et al. [71]
What are the differences between sustainable and smart cities?	Cities	2017	Ahvenniemi et al. [72]
Big data, smart cities and city planning	Dialogue in Human Geography	2013	Batty [73]
Smart and Digital City: A Systematic Literature Review	Springer	2014	Coccia [74]
Conceptualizing smart city with dimensions of technology, people, and institutions	International Digital Government Research Conference: Digital Government Innovation in Challenging Times	2011	Nam and Pardo [75]
Smart cities as corporate storytelling	Cities	2014	Söderström et al. [76]
The role of big data in smart city	International Journal of Information Management	2016	Hashem et al. [77]
Smart city policies: A spatial approach	Cities	2014	Angelidou [78]
Smart sustainable cities of the future: An extensive interdisciplinary literature review	Sustainable Cities and Society	2017	Bibri and Krogstie [10]
Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco	Technological Forecasting and Social Change	2014	Lee et al. [79]
Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart	Cities	2018	Silva et al. [80]
The 'actually existing smart city'	Cambridge Journal of Regions, Economy and Society	2015	Shelton et al. [81]
Critical interventions into the corporate smart city	Cambridge Journal of Regions, Economy and Society	2015	Hollands [82]
Smart cities: A conjuncture of four forces	Cities	2015	Angelidou [6]
Making sense of smart cities: addressing present shortcomings	Cambridge Journal of Regions, Economy and Society	2014	Kitchin [83]
Programming Environments: Environmentalty and Citizen Sensing in the Smart City	Environment and Planning D: Society and Space	2014	Gabrys [84]
New urban utopias of postcolonial India: 'Entrepreneurial urbanization' in Dholera smart city, Gujarat	Dialogues in Human Geography	2015	Datta [85]
Being a 'citizen' in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland	Geo Journal	2019	Cardullo and Kitchin [86]
The governance of smart cities: A systematic literature review	Cities	2018	Ruhlandt [36]

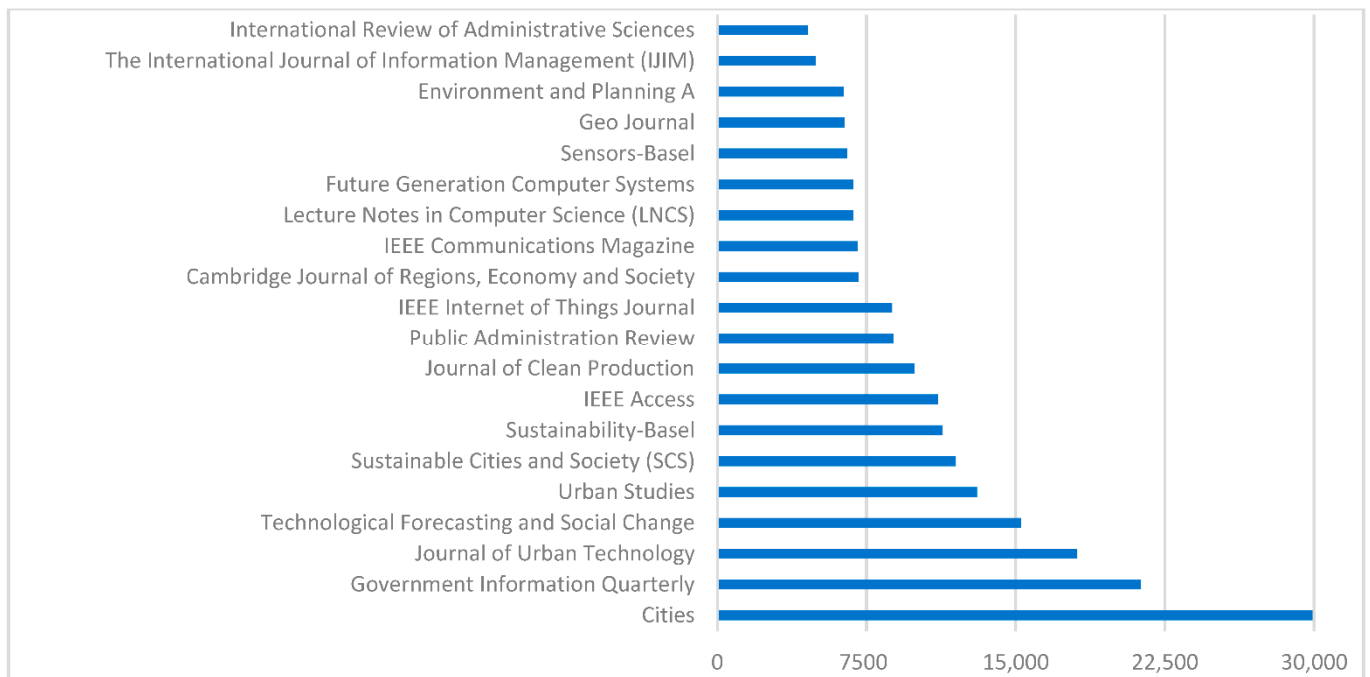


Figure 3. Top 20 most influential journals, where the x-axis shows the link strength.

Figure 4 below depicts the different influential journals and publications, including the clusters under which they fall. The publications are clustered into four distinct categories highlighted by blue, red, green and yellow colours. The red cluster comprises journals focusing more on urban sustainability, and it is evident that these subjects are very popular with most researchers, as most journals in this cluster have high linkages with the rest of the categories. The blue cluster comprises journals focusing more on public management and administration in cities. It is evident that the journals publishing works on governments and public administration are very popular, with high linkages to journals with a scope touching on cities and their sustainability agendas. The green cluster comprises journals focusing more on different aspects of Information Technology (IT) and their applicability in different facets of cities. Finally, the yellow cluster encompasses journals focusing on geographical aspects of cities.

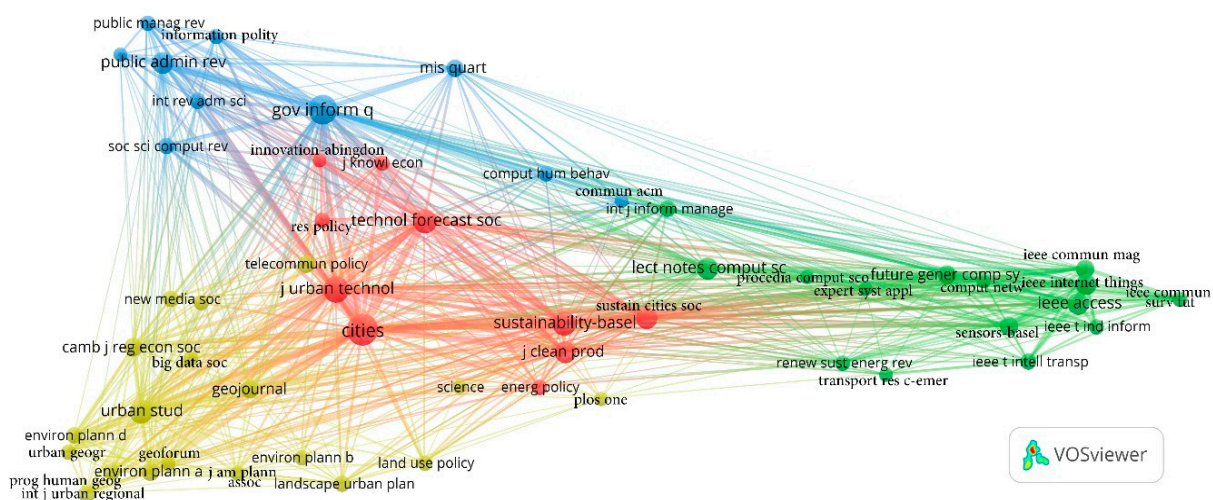


Figure 4. Most influential journals and publications. Illustration by authors.

The different clusters showcase the progress that has been made in publications focusing on smart cities. As highlighted in Figure 2 above, research works and research interests on technology use in urban areas has been progressive, with substantial momentum observed in 2015, and an exponential growth in 2020 and 2021. From the literature, it is observed that the aspect of ‘smartness’ in cities was focused on specific components of cities; that is, the administration aspect with the aim being to increase efficiency and performance. However, as more smart-based technologies emerged, the ‘smartness’ aspect gained traction in other urban dimensions such as urban mobility, energy production and consumption, sustainability, socioeconomic dimensions, and others. As a result, research works and publications expanded their scopes from administration to include these other aspects; hence, affirming why more influential publications are emerging, as attention on the smart city concept continues to grow.

4.3. Influential References

From the literature, it was highlighted that the quest to have smart cities began in the 1970s, and this quest materialized in a notable way in 2005, when large ICT corporations, driven by profit-making agendas [26], began to increase their attention and commitment toward the realization of this objective. The growth and interest amongst academics and researchers have likewise been increasing, as highlighted in Figure 2, capturing the number of publications between 1970 and 2022. At the heart of these publications are dedicated authors and researchers whom, as depicted in Table 2 below, have published ground-breaking works which emerge as the most cited compared to others.

As highlighted in Figure 5 below, those different influential references can be clustered into two categories characterised by the colours red and yellow. The red category encompasses all the references focusing on general contributions to sustainability, including aspects such as air pollution and economic growth. References in the yellow category, however, focused on aspects relating to urban planning and urban studies. From the figure, it is noticeable that most of the influential authors were more interested and focused on issues pertaining to sustainability, and this could be attributed to the fact that most cities, as noted from the literature, have been cited to have the potential to contribute substantially discourses perpetuating a bid to address the challenges of climate change.

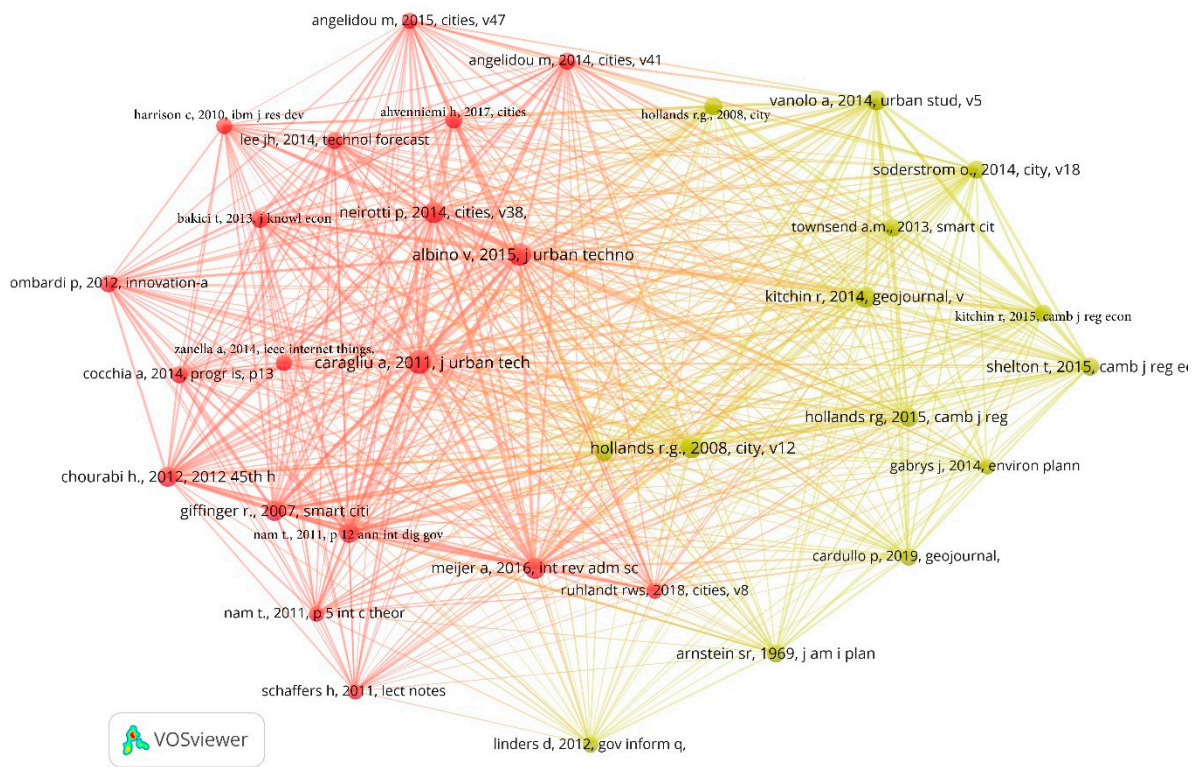


Figure 5. Most influential references. Illustration by authors.

Table 2. Top 40 Most Influential References.

Title	Publication	Year	Citations	Authors
A Ladder of Citizen Participation	Journal of the American Institute of Planners	1969	26,258	Arnstein [56]
Internet of Things for Smart Cities	IEEE Internet of Things Journal	2014	5564	Zanella, Bui, Castellani, Vangelista and Zorzi [57]
Smart Cities in Europe	Journal of Urban Technology	2011	4791	Caragliu, Del Bo and Nijkamp [58]
Will the real smart city please stand up?	City	2008	3494	Hollands [59]
Smart city as urban innovation: Focusing on management, policy, and context	International conference on theory and practice of electronic governance	2011	2979	Nam and Pardo [60]
Understanding Smart Cities: An Integrative Framework	Hawaii International Conference on System Sciences	2012	2939	Chourabi, Nam, Walker, Gil-Garcia, Mellouli, Nahon, Pardo and Scholl [61]
Smart cities: Ranking of European medium-sized cities	Smart cities: Ranking of European medium-sized cities	2007	2791	Giffinger and Pichler-Milanović [62]
Smart cities: Big data, civic hackers, and the quest for a new utopia	WW Norton & Company	2013	2702	Townsend [63]
Smart Cities of the Future	The European Physical Journal Special Topics	2012	2543	Batty, Axhausen, Giannotti, Pozdnoukhov, Bazzani, Wachowicz, Ouzounis and Portugali [64]
Current trends in Smart City initiatives: Some stylised facts	Cities	2014	2273	Neirotti, De Marco, Cagliano, Mangano and Scorrano [65]
Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation	The Future Internets	2011	2184	Schaffers, Komninos, Pallot, Trousse, Nilsson and Oliveira [66]
From e-government to we-government: Defining a typology for citizen coproduction in the age of social media	Government Information Quarterly	2012	2092	Linders [67]
Foundations for Smart Cities	IBM Journal of Research and Development	2010	1527	Harrison, Eckman, Hamilton, Hartswick, Kalagnanam, Paraszcak and Williams [68]
Is there anybody out there? The place and role of citizens in tomorrow's smart cities	Futures	2014	1390	Vanolo [69]
A Smart City Initiative: the Case of Barcelona	Journal of the Knowledge Economy	2013	1355	Bakıcı, Almirall and Wareham [70]
Governing the smart city: a review of the literature on smart urban governance	International Review of Administrative Sciences	2016	1308	Meijer and Bolívar [34]
Modelling the smart city performance	Innovation: The European Journal of Social Science Research	2012	1201	Lombardi, Giordano, Farouh and Yousef [71]
What are the differences between sustainable and smart cities?	Cities	2017	1130	Ahvenniemi, Huovila, Pinto-Seppä and Airaksinen [72]
Big data, smart cities and city planning	Dialogue in Human Geography	2013	1036	Batty [73]
Smart and Digital City: A Systematic Literature Review	Springer	2014	975	Coccia [74]
Conceptualizing smart city with dimensions of technology, people, and institutions	International Digital Government Research Conference: Digital Government Innovation in Challenging Times	2011	965	Nam and Pardo [75]
Smart cities as corporate storytelling	Cities	2014	949	Söderström, Paasche and Klausner [72]
The role of big data in smart city	International Journal of Information Management	2016	928	Hashem, Chang, Anuar, Adewole, Yaqoob, Gani, Ahmed and Chiroma [77]
Smart city policies: A spatial approach	Cities	2014	910	Angelidou [78]
Smart sustainable cities of the future: An extensive interdisciplinary literature review	Sustainable Cities and Society	2017	895	Bibri and Krogstie [10]
Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco	Technological Forecasting and Social Change	2014	882	Lee, Hancock and Hu [79]
Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart	Cities	2018	831	Silva, Khan and Han [80]
The 'actually existing smart city'	Cambridge Journal of Regions, Economy and Society	2015	780	Shelton, Zook and Wiig [81]
Critical interventions into the corporate smart city	Cambridge Journal of Regions, Economy and Society	2015	776	Hollands [82]
Smart cities: A conjuncture of four forces	Cities	2015	744	Angelidou [6]
Making sense of smart cities: addressing present shortcomings	Cambridge Journal of Regions, Economy and Society	2014	743	Kitchin [83]
Programming Environments: Environmentality and Citizen Sensing in the Smart City	Environment and Planning D: Society and Space	2014	731	Gabrys [84]
New urban utopias of postcolonial India: 'Entrepreneurial urbanization' in Dholera smart city, Gujarat	Dialogues in Human Geography	2015	682	Datta [85]
Being a 'citizen' in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland	Geo Journal	2019	638	Cardullo and Kitchin [86]
The governance of smart cities: A systematic literature review	Cities	2018	496	Ruhlandt [36]

From the table, the most influential reference was authored by Arnstein [56], advancing the thematic aspect of public participation, which has become a cornerstone in the pursuit of the smart city concept. According to the author, citizens' power in contributing and shaping decisions can only be realised if they are actively engaged and allowed to participate at different levels. The second most influential reference in respect to the number of citations (5564) was authored by Zanella, Bui, Castellani, Vangelista, and Zorzi [57] in 2014, and their attention was on the impacts of the 'Internet of Things for Smart Cities'. From the literature, during this period, the number of IoT devices targeted on cities were increasing (increased by 20% between 2013 and 2014) to reach 16 billion products. Further, a projection during that period was that by 2020, the number of smart things would increase to over 40 billion products [87]; hence, supporting interest in this field. Overall, despite most of the influential references, as depicted in Figure 5, being skewed toward sustainability, it is evident from the number of citations, as shown in Table 2, that most of researchers and publications were interested in understanding the different aspects of smart cities.

4.4. Influential Authors

The subject matter of smart urban governance is emotive, as it does not only touch on the political aspirations, but also influences resources allocation in cities, economic growth, and security and privacy of residents and their properties, among other issues. As a result, as showcased in Figure 6 below, over the study period (1970–2022) the number of authors with interests on the aspect of smart cities, and by extension, smart urban governance, have continued to increase. These have been pursuing different issues, as highlighted in Figure 6, where different colouration has been adopted to categorize clusters. The red cluster encompasses authors focused on sustainability and how this is being applied in smart cities. The blue cluster comprises authors whose work majors on policies, frameworks, and structures of smart cities and how this could help in achieving smart urban governance. The yellow and green clusters comprise the most influential authors, as captured in Table 2 above. Those in the yellow cluster have published most works focusing on the general aspects of smart cities, while those in the green cluster are focused more on smart urban governance and how this impacts aspects such as citizen participation and city performance. They have also focused on the possible shortcomings that could be experienced in smart cities where aspects of smart governance are fully considered.

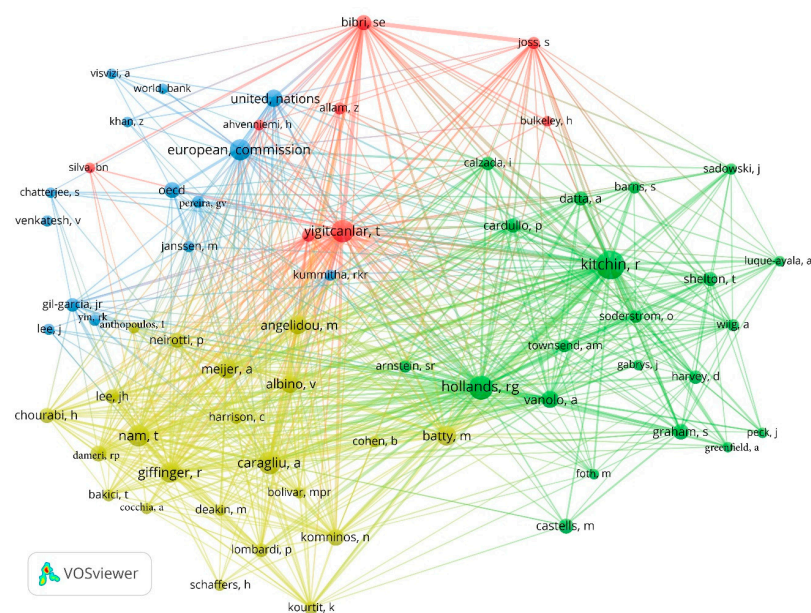


Figure 6. Most influential authors in the field of smart urban governance. Illustration by authors.

The categorization of influential authors on the subject matter of the smart city demonstrates the importance of the use of technology to enhance urban dimensions. The aspect of urban governance is critical, and this could explain why it has attracted such a sizeable interest from authors. In particular, from the different terminologies captured in the diagram, it is almost impossible to have successful smart cities if governance dimensions are not fully addressed. This is affirmed by how the different terminologies are closely linked together. From the literature, the success of smart urban governance, however, requires the cooperation of different stakeholders; hence, the need for sound policies, frameworks, and protocols. Considering this, it would be possible to pursue other related aspects such as sustainability agendas and improve and address the social and economic dimensions including areas such as liveability and others.

4.5. Thematic Focus Areas and Their Transition

This section focuses on the different themes and topics that researchers have favoured regarding aspects of urban governance within the entire period of the study. The section is ordered into different subheadings, each addressing a specific time period. An overall look at the general thematic focus is succeeded by subsections on each of the different periods.

4.5.1. Overall Thematic Focus and Structure

The quest to transform cities using data-driven approaches has been present since the 1970s; as showcased in the previous sections, the number of publications, references, and authors on different thematic issues have been on the rise. This is captured in Figure 7 (below), which highlights different dimensions that have been pursued since it became apparent that it was possible to influence urban governance, urban sustainability, urban planning, and other aspects using ICT. In Figure 7, different themes are categorized in four distinct clusters symbolized by the colours red, yellow, blue, and green. The red cluster focuses on issues related to urban governance and the subsequent benefits derived from its adoption in cities. Such issues include the sustainability agenda, economic growth, resilience, improved liveability status in cities, and others. The blue cluster captures issues related to the digital divide, political dimension, and related aspects such as policy formulation and crafting of different frameworks pertinent to the application of smart agendas in cities. The green cluster captures themes related to smart cities and smart technologies while the yellow cluster captures aspects of digitalisation, smart governance, and urban residents and their participation in smart agendas, amongst others.

The graphical representation of the different smart themes in cities illustrated in Figure 7 rightly coincides with findings from the current literature on the smart cities concept, mainly smart governance, and its influence on cities. From the literature, it is evident that smart governance plays significant roles in the global, regional, national, and local economies. It plays significant roles in influencing how cities can handle matters such as climate change, economic growth, and provision of services to residents and improve social welfare of the residents. As illustrated in Figure 7 (above), it is evident that during the entire period, the sustainability agenda has attracted substantial attention. From the literature, while policies on these emanate from global top leadership summits and transpire from agendas, it is local governments that shoulder the greatest responsibilities for their implementation. It has been established from the literature that the most successful cities in implementing projects and approaches with positive impacts on sustainability are those that have already embraced smart aspects. For instance, Singapore, which has been voted a number of times as one of the most liveable cities, is well established as being a 'smart' nation [88], with some sustainable aspects such as green spaces. While the impacts of climate change affect all cities, including those in the global north and developed economies [89–91], the aspect of smartness defines and influences the resilience and adaptability levels of different cities. That is, those with notable smart components have been argued to be more adaptable and resilient than their counterparts that have few

or no smart components installed [92–94]. This could explain why most cities, as shown in the figure above, have increased commitments towards transitioning to smart cities.

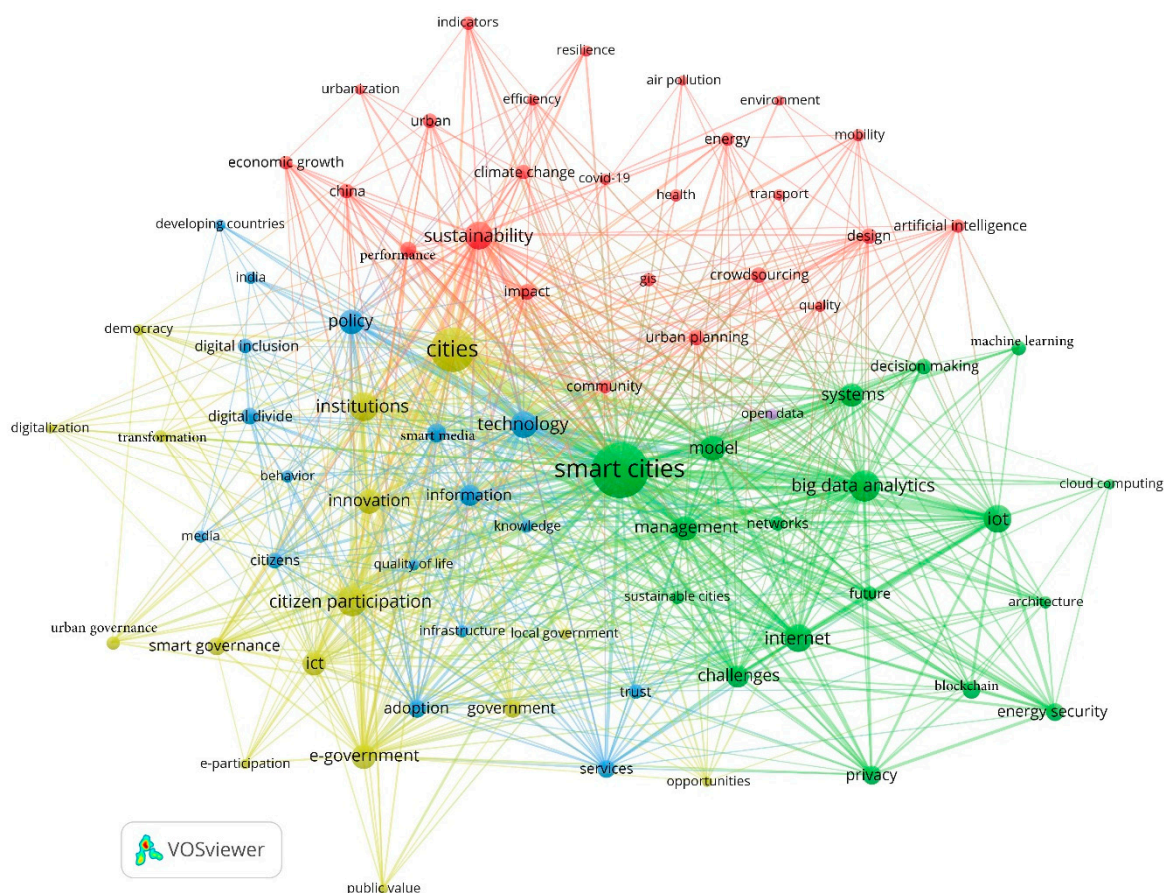


Figure 7. Overall thematic focus from 1978 to early 2022. Illustration by authors.

4.5.2. Evolution of Structure and Thematic Focus over Time

This subsection comprehensively addresses how research works and structures came about during the three periodical timeframes identified to have had significant impacts in the evolution of studies in the subject matter of urban governance. The classification of the three periods was done in respect to the timelines that a number of factors such as technological advancement, global sustainability agenda documents, the rise of the smart city concept, and the emergence of COVID-19 pandemic, among others, created, as highlighted in Figure 1 above and in the Methodology.

Period 1 (Until 2015)

Results of the study covering the first period (1978–2015) are captured in Figure 8 below. As noted from the literature, while the aspect of urban smartness may have been conceived earlier, it became vivid in 1974 in Los Angeles when the local government of the day initiated the use of data to influence certain aspects of its urban administration [5]. Later, in 1994, Amsterdam attempted to install smart government structures by adopting a ‘virtual city’ concept [95]. However, in the 2000’s, as noted in Figure 2 (above), notable possibilities of incorporating digital solutions in cities began to gain traction due to gradual growth of the ICT sector, catalysed by the fourth industrial revolution. As highlighted in Figure 8, though the collection of thematic areas being pursued was not extensive, it is evident that the aspects of smart governance, smart citizens, and smart cities were present. During this period, at the global front, high-level meetings [96–98] highlighted pressing urban challenges such as climate change, the widening socioeconomic inequality gap,

and the unprecedented urban population growth. This, as can be deduced from Figure 8, prompted debates on areas such as sustainability and how such could be achieved through changes in policies driven by global institutions. The calls for action on different urban issues originated from different quarters, such as youth movements and from the global population, which leverage social media as a tool for communication. These communication platforms were spearheaded by growth and unprecedented penetration of the internet and the gradual infiltration of smart mobile devices with capacities to help share complex information [67]. As highlighted above, during this period, the number of smart ‘things’ (powered by IoT networks) had increased to approximately 16 billion globally [87].

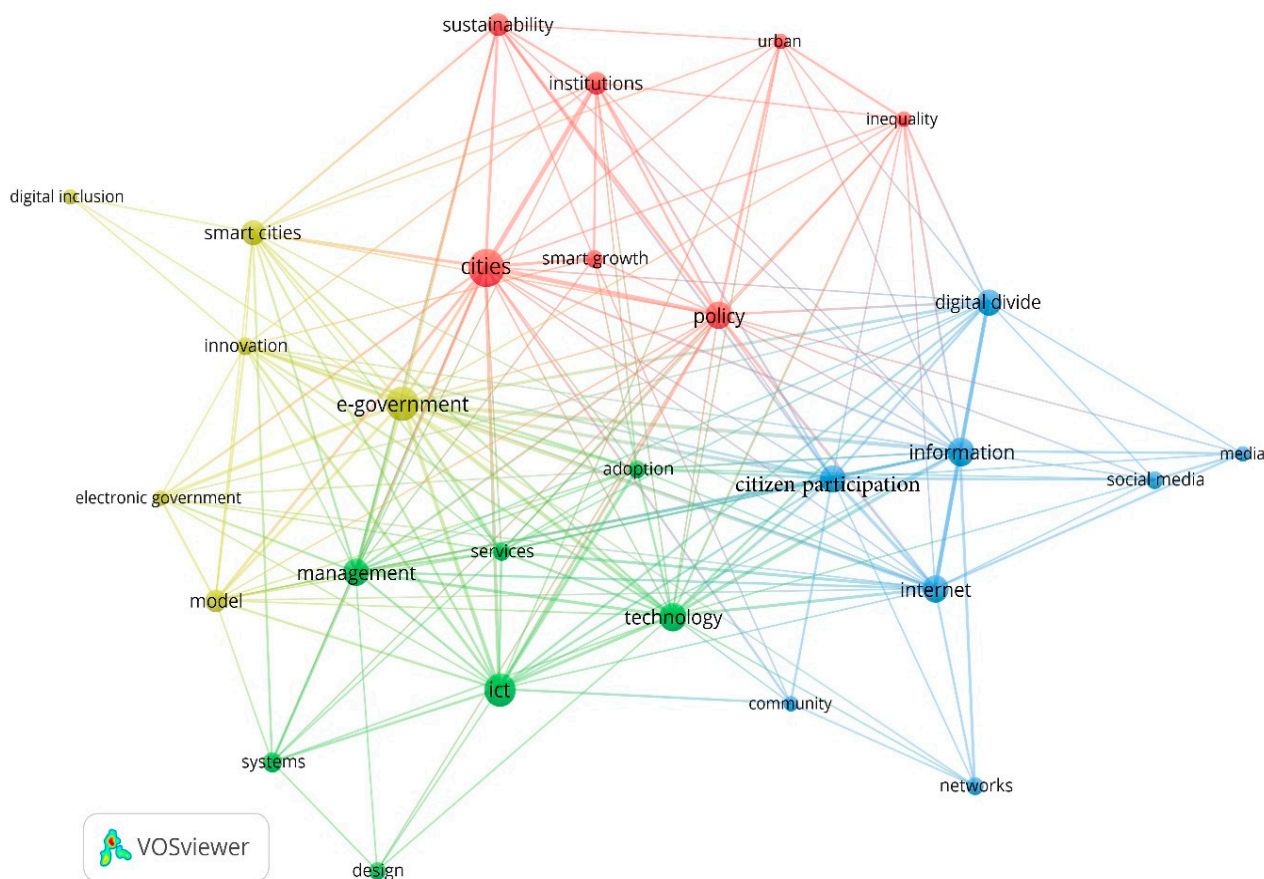


Figure 8. First period (1978–2015): illustration by authors.

In 2015, interest in different smart urban dimensions gained even more momentum, as ground-breaking documents, starting with the Paris Agreement, The Sustainable Development Goals, and the New Urban Agenda, were launched. While these captured different global aspects and themes, it is evident from the literature review that most of the solutions proposed converged on how urban areas need to be managed for increased sustainability, liveability, and resilience. Figure 7 above showcases how the full package of ‘smartness’ in cities started to gain traction during the period in question. For instance, in the question of climate change, it was appreciated in the different global accords, especially on how urban governance could help achieve low carbon, climate adaptation, and sustainable and liveable cities through adoption of innovations in varying sectors. A classic example is in the energy sector, where alternatives such as solar, wind, and hydro are becoming mainstream and require governance structures to allow for their deployment in urban areas [99]. Additionally, in the transportation and construction industries, amongst others, the role of urban governance was as critical then as it is today; already, sufficient urban challenges were originating from those sectors, as noted by Wen et al. [100]. Furthermore, it was appreciated that the achievement of those different global policies was determined by

how financial resources would be committed, and as such, the Paris Agreement proposed (Article 9) that developed economies commit at least \$100 billion to assist developing economies achieve their climate action agenda [101]. From the literature, it has been argued that smart governance is very critical in the sourcing and allocation of finances in different programs and projects that would ultimately lead to the ‘smartness’ in cities. While Figure 8 above showcases that there were limited activities happening in the academic circles in terms of publication, this period formed the backbone for cities in their quest to adopt smart technologies as tools to address the aforementioned challenges. In summary, this period outlined that:

- The global agendas of the Paris Agreement, SDGs, New Urban Agenda, and others influenced pursuits to smart growth.
- Citizen participation in urban governance started to gain traction since early in the concept.
- The technology was infancy in the beginning, outlining only a few technical dimensions, and focusing more on broad objectives.
- Some social themes such as the digital divide and inequality were already apparent then.

Period 2 (2016–2019)

The period between 2016 and 2019 experienced an increase in research interests on the subject matter of ‘smartness’, as showcased in Figure 9 below. From Figure 1, it was clearly noted that approximately 731 publications were made during this period, with research works growing gradually each year. From Figure 9, it is also evident that the number of terminologies increased substantially on each of the four thematic areas (sustainability, smart cities, smart governance, citizen participation, and policy/political Issues) categorised under red, green, yellow and blue clusters. For instance, on the thematic area of sustainability and smart cities, Bibri and Krogstie [102] provide novel insights and a number of new terminologies as a result of a synthesis of a large body of interdisciplinary and transdisciplinary literature. Additionally, there was increased attention in respect to smart governance, with new interest areas such as crowdsourcing, local governments, social media, and adaptation arising. Furthermore, regarding policies’ formulation and political influences in the achievement of ‘smartness’ in cities, it is evident from Figure 9 that this period experienced substantial interests and publications, with research works covering new grounds such as Energy, Climate Change, Economic Growth, China, India, Quality of Life, and others. Regarding smart cities, it is evident that there was increased attention, especially following emergence and popularization of new technologies such as the Internet of Things (IoT), Big Data, Artificial Intelligence, Blockchain, and others. In terms of sustainability, new innovations in areas like mobility, infrastructure development, and energy, prompted by emergence and adoption of smart technologies, further helped develop more interests (see [103,104], for illustrative case studies between 2016 and 2020).

From the literature, this period was critical in most cities, prompted by a number of factors. First, the global accords and agreements that were launched in 2015 prompted new ways and approaches in areas of urban planning aimed at achieving different sets of objectives. For instance, in regard to addressing the challenge of climate change, which had attracted notable interests from different quarters, including calls from youth movements [105], C40 cities [106], Small Island Developing States (SIDS) [107], and others for decarbonisation, technology adoption in cities became inevitable [108,109]. Aspects of smart governance became clear, even in global summits, with participation of ‘minority groups’ such as youths, Small Island Developing States, and indigenous groups becoming apparent. The issues they raised coincided with what had already been anticipated and captured in documents such as the Paris Agreement [110]. For instance, in respect to SIDS, a report ‘Emerging Issues for Small Island Developing States’ published in by the United Nations Environment Programme (UNEP) [111] started to elicit much interest, as the details and facts contained therein mirrored what had been captured in the Paris Agreement.

During this period, attention on use of technology to alter traditions in areas such as energy production with adoption of renewable energies as a substitute to fossil fuel started to gain much traction. Indeed, as noted by the International Renewable Energy Agency (IRENA), it was during this period that costs of producing basic components such as solar panels became relatively cheaper; hence, popularity of this option increased. Overall, the aspect of ‘smartness’ advanced during this period, with numerous benefits being experienced, especially in increased efficiency and performance in cities such as Barcelona, London, Singapore, New York, and others that had embraced the aspect of smart governance. In summary, this period outlines that:

- Smart urban governance gained traction with inclusion of minority groups.
- The use of technology became more apparent, specifically in energy fields.
- Technology integration gained more ground in city administration.
- The aspect of community involvement grew more rapidly than business models for smart cities, showcasing that the model was moving from more profit-driven models to human-driven models.
- The technological cluster was expanding, underlining the need for local governments to reinforce their capacities.

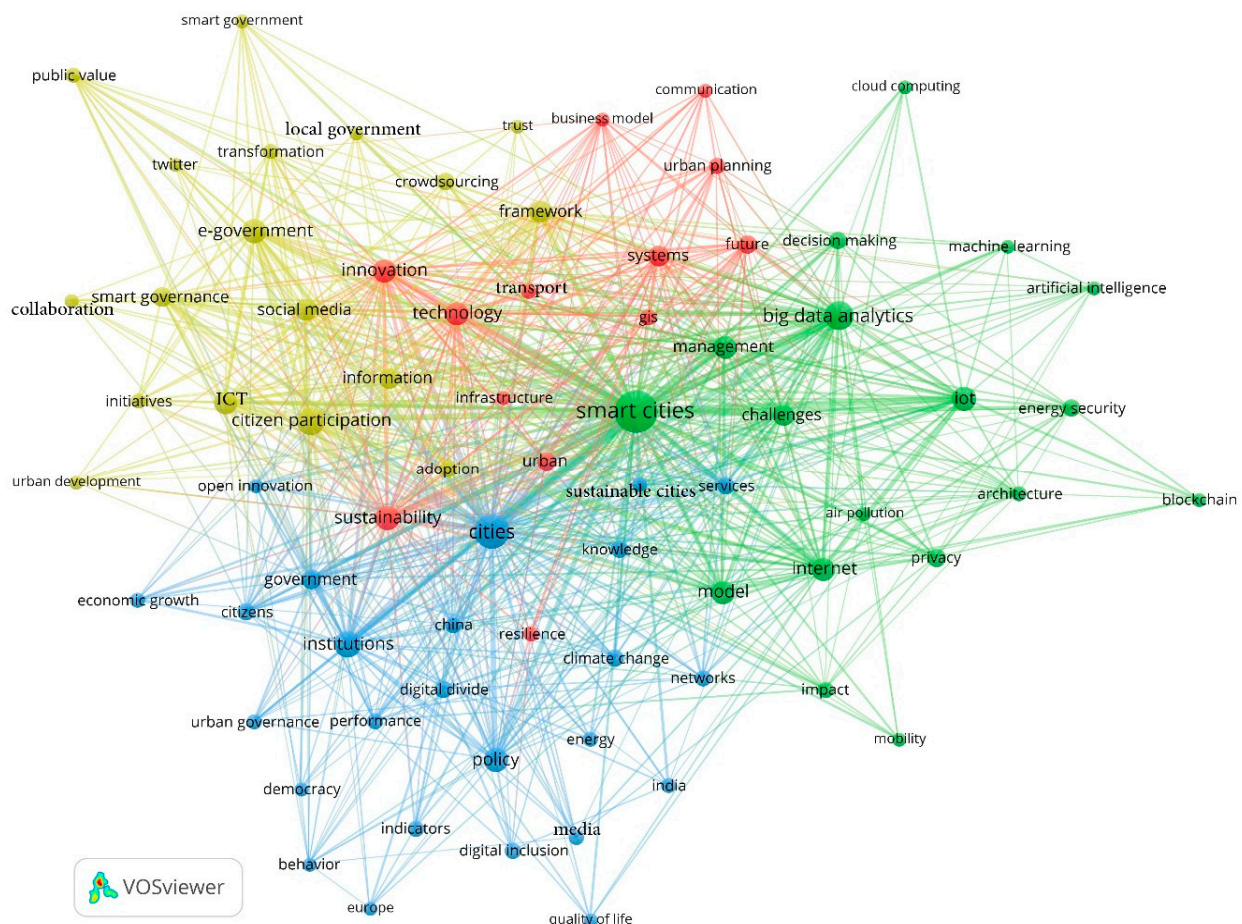


Figure 9. Second Period (2016–2019): Illustration by authors.

Period 3 (2020–Early 2022)

The period year 2020 to early 2022, which was extraordinary for the global community, was prompted by the unprecedented widespread outbreak of the COVID-19 pandemic. Unlike other recent global challenges such as climate change, COVID-19 disrupted normal activities in almost all facets of life, with urban areas and cities being the most affected, especially noting the high population density, over-reliance on transportation, and nature

of works [89]. With most countries taking drastic actions to contain the spread, delivery of services in many sectors become almost impossible (especially in the transport [112,113] and education sectors [114,115]) and others such as the health sector were, in most cities, almost overwhelmed [116]. However, it was noted in different fora [94], that cities that had embraced the smart agenda had some relief. This was especially evident in cities where the aspect of smart urban governance had gained some roots, as some services continued to be offered virtually albeit in limited scopes compared to normal [95]. Conversely, Kitchin [52] questioned the technical and practical efficacy of surveillance technologies used for contact tracing, quarantine enforcement, social distancing/movement monitoring, and symptom tracking (e.g., smartphone apps, facial recognition cameras, biometric wearables, smart helmets, drones, and predictive analytics), and examined their implications for civil liberties, governmentality, surveillance capitalism, and public health. Regardless, as depicted in Figure 10 below, despite the evident disruptions that COVID-19 posed, adoption and application of different aspects of smart city concepts continued to gain popularity even more than the previous years. There was increased attention on issues focused on digitalisation, smart governance, and citizen participation, as highlighted in the diagram using the colour yellow. Maximum research attention was focused on governance and how such would influence issues such as security and provision of services, more so in the health sector, in formulation of policies to guide emerging trends such as working from home, reduced mobility options, and adoption of smart technologies in different government departments to enhance virtual service delivery.

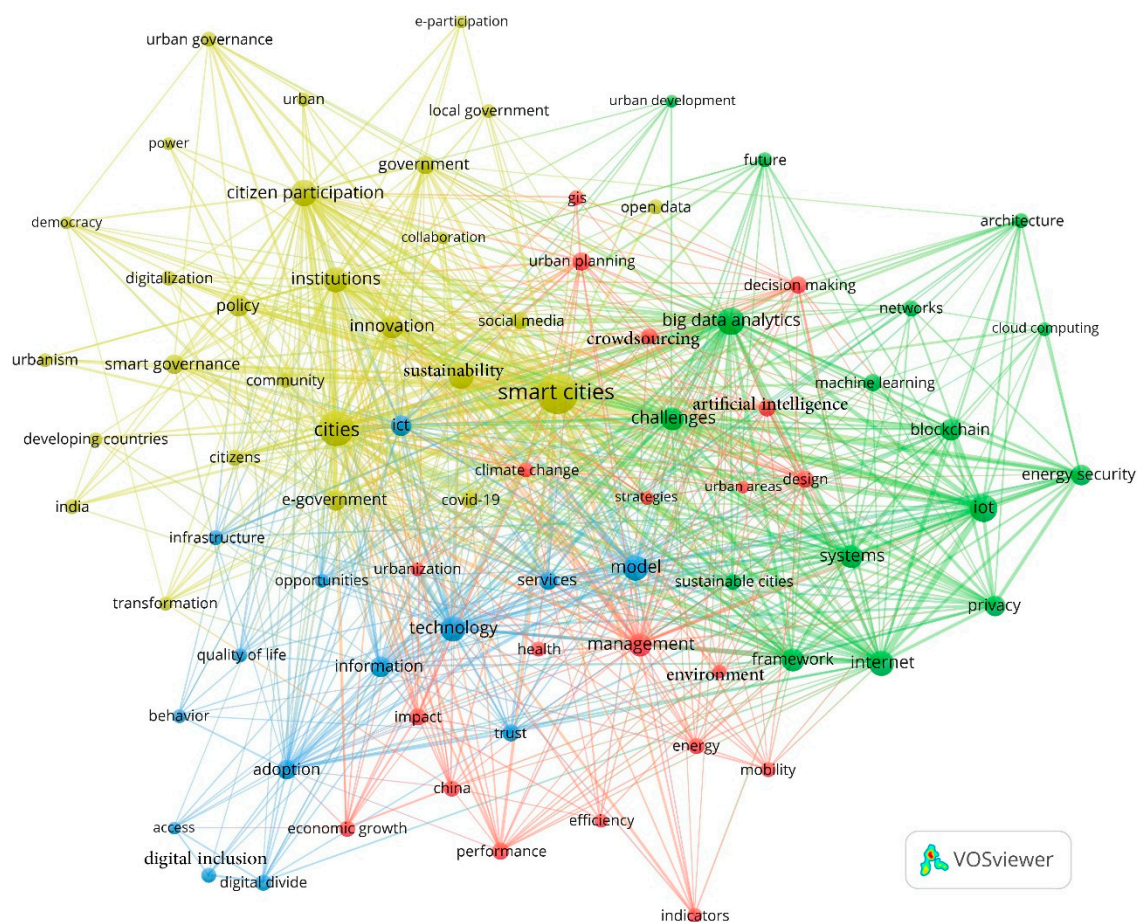


Figure 10. Period 2020: Illustration by authors.

During this period, aspects (symbolized using the colour red in Figure 10) such as sustainability, economic growth, mobility, and resilience of communities gained popularity with publishers, as the pandemic prompted mixed trends. For instance, before the

emergence of COVID-19, cities had been reported to be the greatest contributors to climate change (with of 70% of the total global GHG emissions). However, in 2020, an unprecedented decline in emissions were reported, with aspects such as urban air and water quality reported to have improved immensely [117]. Such were influenced by reduced activities in transport sectors [118,119], manufacturing sectors [120], and other energy intensive frontiers [121]. However, such reductions were seen as ‘carbon bubbles’ that would burst immediately as soon as countries started their economic recovery journey [122]. As a result, many researchers and publishers produced articles and publications highlighting the need for ‘green’ policies to be adopted during economic recovery pursuits. The adoption of modern smart technologies was identified as among potential strategies that could be used to help accelerate the ‘green’ recovery, as those had already worked in areas such as the work-from-home concept and in virtual communications, thus, helping to reduce energy consumption from non-renewable sources. In summary, this section outlines that:

- The pandemic provoked mixed trends in sustainability, economic growth, mobility, and resilience of communities.
- The human factor, showcased in yellow, grew more significantly than others.
- The need for higher quality of life emerged in this period.
- An emergence of ‘green’ policies was observed as a result of post-COVID economic pursuits.

5. Discussion

During this century, the global landscape has changed significantly following un-metered population growth and rapid urbanisation. This twin phenomenon has in turn prompted diverse critical issues such as climate change, increased resource consumption, urban congestion, and increased socioeconomic inequalities, amongst others. However, as expressed by Jiang, Geertman, and Witte [13], these different challenges greatly differ in scope and intensity in different cities, with the main underlying component being the governance structures in place. It has been established that cities that have already embraced and instituted some form of ‘smartness’ in their governance structures are relatively several steps ahead of their peers in addressing different issues in diverse urban sectors [70,123,124]. The popularity of urban smartness, as established in this study, started to draw some attention as early as the 1970s and grew steadily until 2014. The bibliometric analysis has established that within this period, most publications were centred on a limited number of issues, including how the application of smart technologies could be unpacked in cities and how such could help address emerging issues such as sustainability, e-governance, enhanced citizen participation, and the digital divide prompted by proliferation of smart devices and the rise of social media, amongst others.

On the global scene, attention during this period was focused on finding solutions for the looming urban challenges prompted by climate change [125]. This quest was particularly catalysed by the formation of the Kyoto Protocol in 1997, and from the result analysis, it is true that it was after this global agenda that an increase in related publications was observed. In cities, in the mid-2000s, the attention was on integrating information and data technology components in different dimensions to complement and enhance existing infrastructures. Large ICT corporations such as Cisco and IBM had increased their activities in research and development of smart cities, rising hope of finding digital solutions to major urban challenges, including on the governance front [126].

In the academic realm, researchers also increased their activities, and as depicted in Figure 2 above, the number of publications during this period reached a high of 220. In Table 1, displaying the most influential references, it is evident that most of those were written between 2000 and 2014, highlighting the importance of the fourth Industrial Revolution (Industry 4.0) in regard to publications on smart governance in cities. This is not surprising, as cities were on a transition path in respect to adopting new planning approaches (smart city concept) as well as in relation to adopting climate change mitigation strategies that were eventually formalized in 2015 in the Paris Agreement and the SDGs [110,127]. From

2015 to 2019, the research agrees with the argument by Angelidou [6], which expressed that cities experienced unprecedented forces; technology push and demand pulls saw an almost exponential increase in activities, particularly in the publication realm. In cities, the push was prompted by a rapid increase in digital innovations targeting different urban challenges. For instance, as noted in a report by the Statista Research Department [128], it is during this period that smart technologies increased exponentially and their applicability in different urban fabrics became more evident. This could be witnessed by the increase in the number of smart devices (IoT- based) from 16 billion products as of 2014, to a high of more than 50.1 billion devices by 2020, and a projection of reaching 75 billion devices by 2025 [129].

One of the major challenges that researchers were interested in after it became apparent that cities could benefit from the use of data in terms of efficiency and performance increase was the issue of privacy and security of data [24,130,131]. This invoked a sizeable volume of research output focusing on citizens' perception of smart cities and smart governance and their take on privacy and security of their personal information. However, the gradual potential rise and of use of different technologies such as Blockchain, as highlighted in Section 4, gradually started to help build confidence on privacy of urban residents. While the fears have not been fully arrayed, especially noting that data management in most cities is still being undertaken by third parties (with profit-making agendas), Blockchain technologies such as smart contracts, cryptocurrencies, and others have given some glimpse of hope for guaranteeing privacy (though to some extent due to invested interests).

In regard to the demand pull, it is posited that new technologies such as big data, the IoT, and AI have increased cities' capacity to offer innovative solutions to a myriad of challenges. Those technologies have enabled cities to achieve environmental sustainability, efficiency, resilience, equity, socioeconomic parity, and other qualities, thus making the smart city concept even more attractive during the second period [6,92,132]. This has created numerous research opportunities giving rise to new approaches to smart urbanism, notably data-driven cities (e.g., [133]), data-driven smart cities (e.g., [103,134–136]), sustainable smart cities (e.g., [132,137]), data-driven smart sustainable cities, and environmentally data-driven sustainable smart cities [104]. These emerging paradigm shifts to smart urbanism are seen to bring more innovative solutions to a number of complex problems and challenges pertaining to sustainability and urbanization, as well as to governance as to how to address them. This could hence explain why terminologies such as Innovation, Transportation, Environment, and Business Models increased in the publication realm during the second and third periods. Through technology, a wide range of urban solutions emerged during this period in sectors such as energy, transport, environmental monitoring, economy, health, culture and art, education, and others. For instance, in the transport sector, technology inspired new modes of mobility including the use of electric vehicles [138], car and ride sharing [139], and the use of bicycles, amongst others [140,141]. In the health sector, there has been a rise in wearables that, with the emergence of new technologies such as minimally invasive surgery [142] and the use of 3D printing technologies, have been helping address emergencies [143,144]. On the economic front, cities such as Singapore, Barcelona, and others managed to enhance their service-oriented business models, thereby increasing employment opportunities for their residents. The expansion on scope of what the smart city concept could help cities achieve consequently opened new opportunities for research and publications, thus, explaining why research works have maintained an upward trajectory since the concept gained traction in the urban planning realm.

Adoption of smart governance in cities, as showcased in Figure 9 depicting publications in 2020, sums up the influence and capacities of technologies in urban areas. From face value, the unfortunate happening during this year as prompted by the emergence of COVID-19 could have had the potential to paralyse and jeopardise activities in cities as well as in the publishing industry. This is not surprising, as during this period, activities, including in most institutions of higher learning, were almost completely halted [145]. However, courtesy of advanced technologies that allowed for remote working, virtual learning, and

collaboration [146], and continued generation of relevant data, a substantial number of publications was completed. In cities, smart governance allowed for the containment measures instituted by governments [147], and from Figure 9, it is evident that research touching on or linked to Governance, Smart Cities, and Citizen participation increased substantially. For instance, regarding social distancing, it was observed that most residents relied on technologies such as e-commerce, P2P, and others for their supplies [148]. Social media platforms became popular tools for sharing and exchanging information, while virtual communication technologies allowed for virtual meetings, virtual learning, and other activities, which all helped reduce in-person interactions [146]. While research increased the benefits accrued from adoption of smart technologies, there were some concerns on the fate of cities and economies that had not yet embraced smart technologies and the challenges they were facing. Such diverse research areas could explain why there were such extensive activities in research as depicted in Figure 9, then the rest of the periods despite the real challenge that COVID-19 had posed.

This paper presents results from the mapping of emerging trends and structures, and further research can help complement some of the findings, specifically relating to exploring the:

- Emerging factors from the COVID-19 pandemic on smart urban governance and their reasons.
- Institutional policies guiding the conceptualisations and development of smart governance solutions.
- The equality of development from cities in the global north and those in the global south, and across cities of different scales and capacities.
- The digital divide and the barriers of smart city governance implementation, and the associative solutions.
- The comprehensive mapping of 'human' dimensions emerging so as to map the needs for developers of future technologies to respond to.

6. Conclusions

Overall, from this analysis, it is evident that the aspects of smart governance and smart technologies are gaining even more attention from researchers, and in the future, with many cities focusing on embracing and implementing more dimensions of smart cities, it is expected that more research will continue to be published, with new emerging terminologies. However, smart city governance has been criticized, since it is strongly driven by government policies and the interests and agenda of high-tech companies and corporations (e.g., Hollands [82], Allam [149], Grossi et al. [150]). Many studies have focused on the potential risks and negative implications of the technocratic, corporate-led approach to smart city governance (e.g., Cardullo and Kitchin [86], Grossi, Meijer and Sargiacomo [150], Bina et al. [151], León and Rosen [152], McFarlane and Söderström [153]). Much of the criticism in this respect relates to social sustainability and the balance between the three dimensions of sustainability, especially in relation to citizen participation. Therefore, several studies have argued for the urgency and need for a transformative perspective on smart urban governance as a context-based, socio-technical way of governing cities (e.g., Jiang, Geertman and Witte [14], Pereira et al. [154], Webster and Leleux [155]), as well as new forms of human collaboration to attain the desired outcomes, including sustainable mobility to increase the quality of life in cities [156].

While the analysis has made it possible to achieve the objectives and answer the questions set in the introductory section, there are limitations that need to be addressed in future research. One key limitation is that this study is only based on peer-reviewed literature. Considering grey literature would make it possible to gain more comprehensive insights and should be prioritized in the future. Additionally, during the height of COVID-19, it became apparent that the world was braced to a 'new normal', where technology use would become mainstream and more embedded into almost every urban dimension. This would undoubtedly prompt further paradigm shifts on how urban areas are governed.

On the academic realm, such developments would prompt an increase in the number of publications focusing on the new frontiers, including on digitally infused solutions. It would therefore be interesting to have research conducted to establish the publication landscape post-pandemic to map out the influences that the coronavirus had on urban policy making and its governance features.

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Appendix A

The search string: TS = (((“smart” OR “intelligent” OR “digital” OR “digitali*ation” OR “Information and communication technolog*” OR “ict” OR “information technology” OR “internet of things” OR “iot” OR “artificial intelligence” OR “AI” OR “machine learning” OR “blockchain” OR “virtual reality” OR “VR” OR “augmented reality” OR “AR” OR “cloud computing” OR “big data” OR “5G” OR “6G” OR “industry 4*” OR “society 5*” OR “robotic*” OR “automation” OR “automated”) NEAR/5 (“governance” OR “government” OR “e-governance” OR “e-government” OR “e-planning” OR “public service” OR “participatory” OR “participation” OR “public engag*” OR “public administration” OR “public procurement” OR “democra*” OR “open innovation” OR “crowdsourcing” OR “politics” OR “political” OR “urban policy” OR “corruption” OR “accountab*” OR “trust” OR “ownership” OR “decision-making” OR “decision making” OR “transparen*” OR “citizen” OR “stakeholder” OR “inclus*” OR “institutional” OR “public sector”)) AND (“city” OR “cities” OR “urban”)).

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