Understanding Digital Governance in Smart Cities: In-Depth Study Utilizing VOSviewer and CiteSpace

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Abstract. Rapid technological advances have led to the emergence of smart cities, where digital systems and technologies are integrated to improve urban life. The research aims to provide a comprehensive understanding of digital governance in smart cities by conducting in-depth studies using VOSviewer and CiteSpace. The study used a meta-analysis approach to analyze various literature from the Scopus database related to digital governance in smart cities. VOSviewer is used for visualizing and mapping keyword coexistence, while CiteSpace is used to identify influential authors, seminal works, and emerging trends in the field of research. The findings reveal key themes and concepts surrounding digital governance, including policy frameworks, citizen participation, data privacy, and cybersecurity. In addition, the analysis highlights the nature of the development of digital governance in smart cities, with a shift towards a more inclusive and participatory approach. It identifies significant research gaps and opportunities for future studies, such as integrating artificial intelligence, blockchain, and Internet of Things (IoT) technologies into the digital governance framework. The research contributes to existing knowledge by providing a comprehensive overview of digital governance in smart cities, identifying key research areas, and suggesting potential paths for further exploration.
Keyword: Smart Cities, Digital Governance, Inclusive Governance, VOSviewer, CiteSpace

1 Introduction

Smart city digital governance is critical for sustainable urban government, which includes minimizing traffic-related pollution, promoting social fairness, supporting healthy market competition, and allowing easy multi-modal mobility. The complexity of urban systems makes decision-making processes difficult when creating and implementing ecologically sustainable, commercially successful, and socially acceptable urban transportation systems [1]. Adopting improved smart city technology can identify the changes required to enhance

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the living environment in smart cities. Governments, particularly municipal governments, may utilize them as a policy feedback mechanism [2], [3].

Digital governance in smart cities depends on digital infrastructure, data, and software design to efficiently administer cities. Decision-makers, academics, urbanists, and technologists come together on urban data platforms to examine the possibilities and problems of data-driven methods. The information gathered pertains to data quality and privacy, raw data ownership, and data surveillance ethics [4]–[6]. Data-based policies are the foundation of smart city initiatives and influence policy design and data management [7]. Perfect central law can offer a secure and stable environment for smart cities, and the number of local standards has a good association with the growth of the digital economy [8].

Smart cities speed the adaption of current urban services while creating new socializing, accumulation, and regulation areas. The Living Facility Index, which ranks cities based on innovation, quality of life, sustainability, digital communities, and smart city projects, must be improved in gauging such scenarios [9]–[11]. Smart cities are being established to solve urban difficulties via sustainable development initiatives. Shenzhen's digital infrastructure results in data centralization, which can alter low-level government organizations. To underline IBM's involvement, International Business Machines (IBM) positions municipal governments as significant actors in promoting the smart city concept [12]–[14].

The gap in the analysis of digital governance in smart cities is evident in the need for better decision-making processes and policies in designing and implementing sustainable urban mobility systems. Using smart city technologies as feedback tools for government policies is crucial but requires further exploration. Data quality, privacy, ownership, and ethics on urban data platforms still need to be studied. The influence of data-based policies on smart city initiatives and their impact on policy design and data management requires deeper investigation. Furthermore, the deficiencies of current indices, such as the Living Facility Index, in quantifying the effect of smart city projects on innovation, quality of life, sustainability, and digital communities need a more thorough examination. Finally, the role of municipal governments as significant players in promoting the smart city paradigm and the possible ramifications of data centralization need to be investigated further.

The research aims to fill gaps in digital governance analysis in smart cities by investigating the issues surrounding data quality, privacy, ownership, and ethics in urban data platforms via VOSviewer and CiteSpace analysis to understand digital governance in smart cities better. Furthermore, the research intends to investigate the influence of data-driven policy on smart city projects, policy formulation, and data management. Finally, it highlights municipal governments' roles as significant players in supporting smart city ideas and investigating the possible ramifications of data centralization.

2 Research Method

The research uses in-depth studies to explain and understand research related to digital governance in smart cities indexed by Scopus. The research used two analytical methods: evaluating and analyzing Scopus database search results using VOSviewer and CiteSpace tools. The study is based on a review of literature using the Scopus database, a leading global journal database that provides scientific and academic information [15], [16]. This literature evaluation uses articles from 272 documents obtained from the Scopus database. Early searches find papers with titles, abstracts, and keywords related via an API call: TITLE-ABS-KEY ("digital governance smart cities" OR "digital governance smart city") AND PUBYEAR > 2012 AND PUBYEAR < 2023 AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")).

This research employs VOSviewer analysis to elucidate the topics focused on studying digital governance in smart cities [17], [18]. Additionally, CiteSpace is utilized for network analysis to explore further the interconnectedness and relationships among the research publications in this field. By combining these two powerful tools, we aim to provide a comprehensive and in-depth understanding of the intricate dynamics and emerging trends [19], in the realm of digital governance within smart cities. This methodological approach allows us to unravel the key themes, patterns, and influential works that shape the discourse on digital governance in the context of urban development.

3 Results and Discussion

3.1 Focus Research on Digital Governance in Smart Cities

Based on analysis using VOSviewer, nine topics focused on the study of digital governance in smart cities have been identified, as shown in Table 1. This information provides a strong foundation for understanding and analyzing the role of digital governance in developing smart cities. We can gain in-depth insights into current research trends and focus on these fields by analyzing repeatedly emerging research topics. Thus, the table becomes a valuable guide to understanding the key themes researchers emphasize in exploring digital governance in the context of smart cities.

Fig. 1. Digital governance in smart cities subject areas network visualization

Table 1. Frequently occurring research themes in publications on digital governance in smart cities.

Themes	Number of Theme	Percentage of Theme (%)
Digital infrastructure smart city initiative	42	18,9
Adoption artificial intelligence in smart urbanism	33	14,9
ICT and citizen participation in smart city	32	14,4
Model application and digital technologies in smart city development	31	14
Big data transportation sustainable development	20	9
Transformation blockchain infrastructure	18	8,1
Digital platform urbanism service	18	8,1
Capacity e-government in local government	14	6,3
Sensor smart sustainable city	14	6,3

Table 1 gives an overview of the research topics often appearing in digital governance publications in smart cities. The most frequently appearing theme in this table is "digital infrastructure smart city initiative," with a frequency of 42. This shows that digital infrastructure initiatives in developing smart cities are a significant concern for researchers. This reflects efforts to build a strong, efficient technological infrastructure to support smart city life.

Next, the second most frequently emerging theme is "Adoption of artificial intelligence in smart urbanism," with frequency 33. This shows that the application of artificial intelligence (AI) in developing smart cities is a significant research focus. Researchers seek to understand how to integrate AI into various aspects of smart cities, such as traffic management, public services, or energy efficiency.

The third common theme is "ICT and citizen participation in smart cities," with a frequency of 32. It highlights the role of information and communication technologies (ICT) in facilitating citizen participation in developing smart cities. Research on this topic includes using digital platforms to support public participation, improve accessibility of information, and enhance interaction between government and society.

The following themes listed in the table are "Model application and digital technologies in smart city development" (frequency 31), "Big data transportation sustainable development" (20 frequency), "Transformation blockchain infrastructure" (18 frequency), "Digital platform urbanism service" (frequency 18), "Capacity e-government in local government" (frequency 14), and "Sensor smart sustainable city" (frequency 14).

Table 1 shows some topics that dominate research in digital governance in smart cities. It reflects researchers' interest in building robust digital infrastructures, adopting artificial intelligence, leveraging information and communication technologies, and implementing digital technologies such as big data and blockchain to support smart city development. In addition, citizen participation is also a significant concern in the development of smart cities. Table 1 provides an essential overview of research trends and focuses on digital governance in smart cities.

3.2 Cluster Analysis on Digital Governance in Smart Cities

In this study, cluster analysis was conducted to understand digital governance in smart cities. This cluster analysis aims to identify patterns and characteristics in related literature and differences and similarities in digital governance approaches and implementation in smart cities. This cluster analysis is expected to gain an in-depth insight into the concepts, strategies, and practices used in building effective digital governance in smart cities. As for visualizations using CiteSpace based on the Scopus database, they can be seen in the following figure:
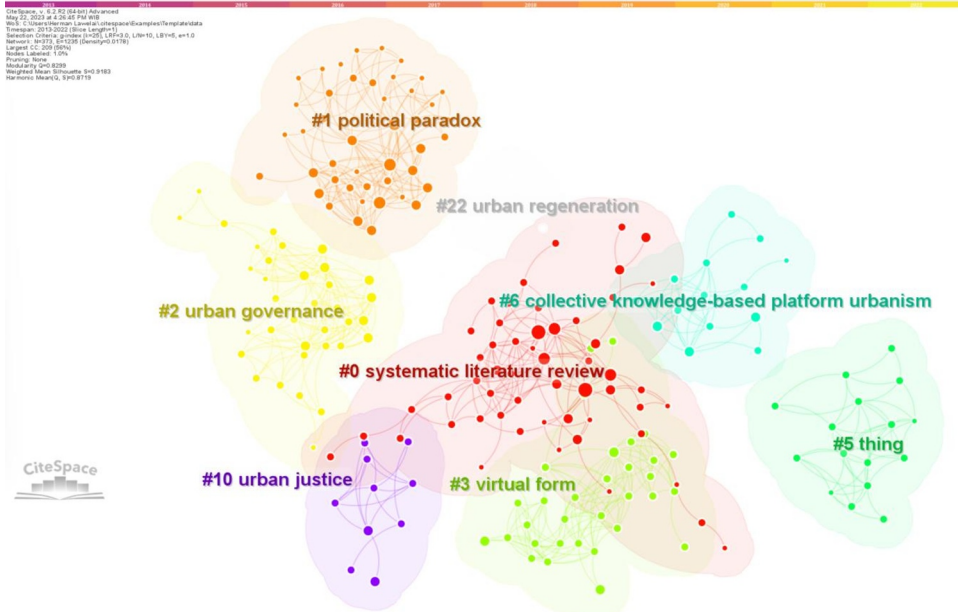
Fig. 2. The results of our cluster analysis are based on literature co-citations.

3.2.1 Cluster systematic literature review

Cluster #0 in this analysis represents the largest group, with 54 members and a silhouette value of 0.875. It has been categorized as a "systematic literature review" according to Local Literature References (LLR), "smart cities" according to Latent Semantic Indexing (LSI), and "smart city concept" with a score of 1.94 according to Modularity Index (MI).

The most frequently cited article within this cluster is the work by Allam, Z. (2022), titled "Emerging Trends and knowledge structures of smart urban governance." Smart technology implementation in urban contexts requires critical study and active citizen participation to ensure inclusiveness, stakeholder needs, and environmental sustainability. By involving citizens in planning and design processes, smart technology can empower citizens to play a role in designing their cities' future, addressing paradoxes and socio-political impacts [20].

Several members with the highest citation count in this cluster include Ahvenniemi H (14 citations), Ruhlandt RWS (12 citations), and Silva BN (10 citations). Ahvenniemi [21] in their article titled "What are the differences between sustainable and smart cities?" discusses the distinctions between the concepts of sustainable and smart cities [21]. Ruhlandt (2018), in their work titled "The Governance of Smart Cities," delves into the topic of governance in the context of smart cities [22]. Meanwhile, Silva (2018), in their article "Towards Sustainable Smart Cities," explores the steps towards achieving sustainable smart cities [23].

This cluster demonstrates a considerable interest in undertaking systematic literature studies to understand smart city ideas and governance better. This cluster's research focuses on comprehending the smart city idea, distinguishing between sustainable and smart cities, and solving governance concerns in the context of smart cities. Within this cluster, the article by Allam, Z. (2022) acts as the essential reference, and the highly cited members give an in-depth comprehension of these themes [20].

As a result, this cluster gives insights into contemporary trends and knowledge structures in smart city digital governance. This cluster provides a complete grasp of smart city principles and governance practices and their differences from sustainable cities as well as their differences from sustainable cities, by emphasizing rigorous literature evaluations.

3.2.2 Cluster political paradox

Cluster #1 in the analysis represents the second-largest group, with 44 members and a silhouette value of 0.954. It is characterized as a "political paradox" according to LLR, "smart cities" according to LSI, and an "open challenge" with a score of 1.04 according to MI.

The major citing article within this cluster is the work by Kong, L. (2018), titled "The Ideological Alignment of Smart Urbanism in Singapore: Critical Reflections on a Political Paradox," This article is highly cited and serves as a significant reference within this cluster.

Among the most frequently cited members in this cluster are Albino V (10 citations), Kitchin R (8 citations), and Vanolo A (8 citations). Albino (2015), in their article "Smart Cities," explores the concept of smart cities, while Kitchin (2015), in "Making Sense of Smart Cities," provides insights into the understanding of smart cities. Vanolo (2014) discusses the concept of "smart mentality" in their article.

This cluster sheds light on the political paradox associated with smart cities. It indicates that while smart cities are often seen as a promising solution to urban challenges, they also present political dilemmas and tensions. The research within this cluster delves into the complexities and contradictions arising from implementing smart urbanism. The work by Kong, L. (2018) stands as a notable reference, offering critical reflections on the ideological alignment of smart urbanism in the context of Singapore.

Thus, this cluster contributes to understanding the political dimensions and challenges inherent in smart cities. It emphasizes the need to critically analyze and navigate the political paradoxes that arise from integrating smart technologies and governance in urban contexts. The cited members' research provides valuable insights into the concept of smart cities and contributes to the discourse on the political implications of their implementation.

3.2.3 Cluster urban governance

Cluster #2 in the analysis represents the third largest group, with 35 members and a silhouette value of 0.912. It is identified as "urban governance" by both LLR and LSI and as "data sovereignty" with a score of 0.4 according to MI.

The major citing article within this cluster is the work by León, LFA (2020), titled "Technology as Ideology in Urban Governance," published in the journal Annals of the American Association of Geographers, volume 110, page 10, with the DOI 10.1080/24694452.2019.1660139. This article is a significant reference within the cluster, highlighting the role of technology as an ideological factor in urban governance.

Among the most frequently cited members in this cluster are Joss S (7 citations), Barns S (6 citations), and Joss S (5 citations). Joss (2019), in their article "The Smart City as Global Discourse," examines the smart city concept as a global discourse. Barns (2016), in "Mine Your Data," discusses the importance of data mining in urban governance. Joss (2017) contributes to the cluster with their work on "Smart Cities," providing insights into the concept of smart cities.

This cluster focuses on urban governance and highlights the significance of data sovereignty in urban development. It underscores the importance of understanding how technology and data influence city governance processes and decision-making. The cited members' research contributes to the global discourse on smart cities and emphasizes the role of data mining and the challenges of data sovereignty in urban governance.

Thus, this cluster provides insights into the complexities and dynamics of urban governance in the era of technology and data-driven decision-making. It emphasizes the need for critical analysis and understanding of the role of technology and data sovereignty in shaping urban governance practices. The principal cited article by León, LFA (2020) adds depth to the cluster, offering valuable perspectives on the ideological aspects of technology in urban governance.

3.2.4 Cluster virtual form

Cluster #3 in the analysis represents the fourth largest group with 33 members and a silhouette value of 0.863. It is identified as a "virtual form" by both LLR and LSI and as an "environmental justice research agenda" with a score of 0.61, according to MI.

The major citing article within this cluster is the same as in Cluster #0: the work by Allam, Z. (2022), titled "Emerging trends and knowledge structures of smart urban governance," published in the journal Sustainability (Switzerland) with the DOI 10.3390/su14095275. This article is a significant reference within the cluster, indicating its relevance to understanding virtual form and environmental justice in smart cities.

Among the most frequently cited members in this cluster are Zuboff S (6 citations), Allam Z (5 citations), and Angelidou M (4 citations). Zuboff (2019), in their work "The Age of Surveillance Capitalism," explores the implications of surveillance capitalism in the digital age. Allam (2021) contributes to the cluster with their article "Future (Post-COVID) Digital, Smart, and Sustainable Cities in the Wake of 6G," which discusses the potential of 6G technology in shaping future cities. In her research, Angelidou (2018) focuses on enhancing sustainable urban development through smart city applications.

This cluster highlights the concept of virtual form and its intersection with environmental justice research. It signifies the importance of understanding how virtual forms, such as surveillance capitalism and emerging technologies, impact cities' social and ecological aspects. The cited members' research contributes to the discussion on the implications of virtual form and explores the potential of smart city applications in achieving sustainable urban development.

Thus, this cluster provides insights into the role of virtual form and its implications in the context of smart cities. It emphasizes the need to consider environmental justice and sustainability when incorporating virtual technologies and applications into urban development. The principal cited article by Allam, Z. (2022) further strengthens the cluster's focus on smart urban governance and its relationship with virtual form.

3.2.5 Cluster thing

Cluster #5 in the analysis represents the fifth largest group with 16 members and a high silhouette value of 0.99, indicating a strong coherence within the cluster. It is labeled as a "thing" by both LLR and LSI and as "datafied urban governance" with a score of 0.04 according to MI.

The major citing article within this cluster is the work by Sheller, T. (2019), titled "Datafied Urban Governance: Real-Time Data Sustainability, Smart Digital Technologies, and the Citizen-Driven Internet of Things," published in the journal Geopolitics, History, and International Relations with the DOI 10.22381/GHIR11220192. This article is a significant reference within the cluster, focusing on data-driven urban governance and its connection to real-time data sustainability and the citizen-driven Internet of Things (IoT).

Among the most frequently cited members in this cluster are Bibri SE (3 citations), Popescu Ljungholm D (3 citations), and Rădulescu A (3 citations). Bibri (2018) contributes to the cluster with their article "The IoT for Smart Sustainable Cities of the Future," discussing the potential of the Internet of Things in enabling smart and sustainable cities. Popescu Ljungholm (2018) explores the regulation of automated individual decision-making and artificially intelligent algorithmic systems. Rădulescu (2018) focuses on users' social trust in sharing data with companies, shedding light on the implications of data sharing in urban governance.

This cluster highlights the concept of "thing" in the context of smart cities and urban governance. It signifies the importance of understanding the role of interconnected devices, the Internet of Things, and real-time data in shaping urban governance processes and sustainability. The cited members' research contributes to the discourse on the potential of IoT in enabling smart cities, the regulatory

challenges surrounding automated decision-making, and the implications of data sharing on user trust and privacy.

Thus, this cluster provides insights into the role of "things" or interconnected devices in urban governance and the implications of datafication in smart cities. It emphasizes the need to understand the complexities and ethical considerations of using data-driven technologies in urban governance processes. The major citing article by Sheller, T. (2019) strengthens the cluster's focus on data-driven urban governance and its relationship with real-time data sustainability and citizen-driven IoT.

3.2.6 Cluster collective knowledge-based platform urbanism

Cluster #6 in the analysis represents the sixth largest group with 14 members and a high silhouette value of 0.979, indicating a strong coherence within the cluster. According to MI, it is labeled as "collective knowledge-based platform urbanism" by both LLR and LSI and as a "royal borough" with a score of 0.12.

The major citing article within this cluster is the work by Repette, P. (2021), titled "The Evolution of City-as-a-Platform: Smart Urban Development Governance with Collective Knowledge-Based Platform Urbanism," published in the journal Land with the DOI 10.3390/land10010033. This article serves as a significant reference within the cluster, focusing on the evolution of the city-as-a-platform concept and its governance in smart urban development, specifically highlighting the role of collective knowledge-based platform urbanism.

Among the most frequently cited members in this cluster are Ismagilova E (6 citations), Appio FP (4 citations), and D'Amico G (4 citations). Ismagilova (2019) contributes to the cluster with their work on smart cities, providing insights into the characteristics and components of smart cities. Appio (2019) focuses on understanding smart cities discussing the multidimensional nature of these urban environments. D'Amico (2020) delves into the understanding of sensor cities, exploring the role of sensor technologies in urban contexts.

This cluster sheds light on the concept of collective knowledge-based platform urbanism in the context of smart cities. It emphasizes the importance of leveraging collective knowledge and digital platforms to enhance urban development processes. The cited members' research contributes to the discourse on smart cities, providing insights into their understanding of the role of sensors and the multidimensional nature of urban environments.

Thus, this cluster provides insights into the concept of collective knowledge-based platform urbanism and its relevance in smart urban development governance. It highlights the need to leverage digital platforms and collective knowledge to foster sustainable and efficient urban environments. The major citing article by Repette, P. (2021) strengthens the cluster's focus on collaborative knowledge-based platform urbanism and its relationship with the evolution of the city-as-a-platform concept in smart urban development.

3.2.7 Cluster urban justice

Cluster #10 in the analysis represents the seventh largest group with ten members and a high silhouette value of 0.981, indicating a strong coherence within the cluster. According to MI, it is labeled as "urban justice" by both LLR and LSI and as a "Chinese smart city" with a score of 0.08.

The major citing article within this cluster is the work by Rosol, M. (2022), titled "From the Smart City to Urban Justice in a Digital Age," published in the journal City with the DOI 10.1080/13604813.2022.2079881. This article serves as a significant reference within the cluster, focusing on the transition from the smart city paradigm to the concept of urban justice in the context of the digital age.

Among the most frequently cited members in this cluster are Grossi G (7 citations), Shelton T (5 citations), and Cardullo P (3 citations). Grossi (2017) contributes to the cluster with their work on smart cities, providing insights into the development and challenges of smart urban environments. Shelton (2019) examines the concept of "actually existing smart citizens" and explores the diverse realities of citizen participation in smart city initiatives. Cardullo (2019) investigates the intersection of smart urbanism and smart citizenship, highlighting the role of citizens in shaping and influencing smart cities.

This cluster highlights the significance of urban justice in the context of smart cities and the digital age. It emphasizes ensuring fairness, equity, and social justice in implementing smart city initiatives. The cited members' research contributes to the discourse on smart cities and urban justice, providing insights into the challenges, opportunities, and implications for citizen participation and governance.

Thus, this cluster sheds light on the concept of urban justice within the context of smart cities. It underscores the importance of addressing social and ethical considerations to ensure that the benefits of smart city technologies and initiatives are distributed equitably among all segments of society. The major citing article by Rosol, M. (2022) further strengthens the cluster's focus on urban justice in the digital age, providing a comprehensive perspective on the transition from the smart city paradigm to an approach that prioritizes fairness and social well-being.

3.2.8 Cluster urban regeneration

Cluster #22, the eighth largest cluster in the analysis, consists of three members and has a high silhouette value of 0.98, indicating a strong coherence within the cluster. It is labeled as "urban regeneration" by LLR, "digital participatory platforms for urban regeneration: a survey of Italian case studies" by LSI, and "smart cities" with a score of 0.06 according to MI.

The major citing article within this cluster is the work by de Filippi F. (2020), titled "Digital Participatory Platforms for Urban Regeneration: A Survey of Italian Case Studies," published in the International Journal of E-Planning Research with the DOI 10.4018/IJEPR.2020070103. This article serves as a significant reference within the cluster, focusing on using digital participatory platforms in the context of urban regeneration and specifically examining case studies in Italy.

The most cited members within this cluster are Falco E (2 citations), Sieber R (2 citations), and AGID (1 citation). Falco (2018) contributes to the cluster with their work on urban regeneration beyond technology, providing insights into the multifaceted aspects and considerations involved in the process. Sieber (2015) explores the role of civic open data at a crossroads, investigating the challenges and opportunities of utilizing open data in urban regeneration initiatives. AGID (2015) presents the digital growth strategy for 2014–2020 in Italy, which likely serves as a framework for the examined case studies.

This cluster focuses on the theme of urban regeneration and highlights the role of digital participatory platforms in facilitating and enhancing the process. The cited members' research contributes to understanding urban renewal beyond technology, the importance of civic open data, and the strategic planning necessary for successful implementation.

4 Conclusion

The analysis using VOSviewer identified nine research topics focused on smart city digital governance. Some topics that dominate research in digital governance in smart cities reflect researchers' interest in building robust digital infrastructures, adopting artificial intelligence, leveraging information and communication technologies, and implementing digital technologies such as big data and blockchain to support the development of smart cities. In addition, citizens' participation is also a major concern in the development of smart cities. Research focused on digital governance in smart cities provides an important overview of research trends and focuses on digital governance in smart cities.

This study analyzes digital governance in smart cities using CiteSpace, providing insights into various aspects such as concepts, political challenges, complexity, and dynamics. The first cluster explores smart city governance concepts and practices, contrasting them with sustainable cities. The second cluster examines the political dimensions and challenges associated with smart cities and the political implications of smart technology implementation. The third cluster explores the complexity and dynamics of urban governance in the era of technology and data-based decision-making. The fourth cluster emphasizes the role of virtual forms in smart cities, emphasizing environmental justice and sustainability. The fifth cluster explores the role of connected devices in urban

governance and the implications of datafication. The sixth cluster discusses the concept of a collective knowledge-based urbanism platform, the seventh discusses urban justice, and the final cluster highlights digital participatory platforms in urban regeneration. Overall, this study offers a comprehensive understanding of digital governance in smart cities, highlighting the importance of digital technology in various aspects.

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