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Article

Innovating smart cities in Latin America: Addressing regional urban challenges and opportunities

Andres Escobar*, Jorge Luna, Alexander Caraballo

School of Economic Sciences, Universidad de Cartagena, Cartagena 130001, Colombia
*** Corresponding author:** Andres Escobar, aescobare@unicartagena.edu.co

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Abstract: This study analyzes the role of innovation in the development of smart cities in Latin America. It focuses on how emerging technologies and sustainable strategies are being integrated into urban planning and urban development. In this sense, this study seeks to contribute to the smart city literature by answering the following research questions: (i) To what extent smart city innovative initiatives have been addressed in Latin America? and (ii) To what extent scholars have addressed sustainable innovation strategies in the smart city literature? To this end, this is the first comprehensive bibliometric analysis of smart city research in Latin America, with a structured and systematized review of the available literature. This methodological approach allows cluster visualization and detailed analysis of inter-node relationships using the VOSViewer software. The research comprises 4 stages: (a) search criteria; (b) selection of documents; (c) software and data extraction; and (d) analysis of results and trends. Results indicate that studies on the Latin America region began to develop in 2012, with Brazil as a leader in this field and the tourism sector as the most relevant. Nevertheless, strong international collaboration was identified in co-authoring studies, underscoring a cooperative approach to solving common urban problems. The most active research area is technological innovation and sustainability, with focus on solutions for urban mobility, quality of life and smart governance. Finally, this work underlines the need to continue exploring the integration of technology in urban development, suggesting an agenda to guide future research to evaluate the sustainability and long-term impacts of smart city initiatives in Latin America. From the policy perspective, smart city initiatives need to be human-centered to boost smart solutions adoption and to guarantee long term local impacts.

Keywords: smart cities; innovation; sustainability; Latin America; urban development

1. Introduction

The concept of Smart Cities originated from discussions among academics and professionals in the 1980s, who reflected on the future of cities (Glasmeier and Christopherson, 2015). For example, Sheridan Tatsumo—a fellow at the Institute of Constructive Capitalism at the University of Texas—noted at the time the rise of the "era of technopolis" and the metamorphosis of traditional cities and high-tech parks (Harris, 1993). Tatsuno described a global network city of highly interactive economic nodes, connected by vast networks of airports, roads, and communications, which was an approach that introduced the idea of the smart city, characterized by advanced information and communication technologies, supported by satellites and fiber optics, inhabited by knowledge processors dedicated to rapid information exchanges (Harris, 1993). These pioneering concepts reflect a vision of the city transformed by technology, not only as a place where new technologies could be born but as receivers for the application of these technologies, pointing towards an urban transformation

focused on efficiency, competitiveness, and improvement of the quality of urban life (Glasmeier and Christopherson, 2015). In this sense, the operational logic of a smart city depends on the drivers behind the process (state-driven, corporate-driven, or citizen-driven) and their primary focus on technology, governance, citizen wellbeing, or sustainability (Mosco, 2019). Given current developments, a broad definition of smart city is "an urban environment where technology allows for an efficient relationship between data and its applications in order to provide an environment that is responsive, resilient and healthy" (James et al., 2021, p. 6).

By 2050, 66% of the world's total population is expected to be living in cities (RPI, 2018). This poses serious challenges for urban planners, who will have to rethink how they provide basic services to residents in a sustainable way. In this sense, smart city governments are seeking the convergence of technology and ecosystems, collaboration, and partnerships between stakeholders from different industries - such as energy, infrastructure, telecommunications, and government—to achieve an integrated and sustainable service delivery for the population (Glasmeier and Christopherson, 2015).

This gives relevance to the sustainability component within smart cities, which must be environmentally, socially, and economically sustainable (Toli and Murtagh, 2020). The concept of sustainability in the definitions of smart cities is a fundamental issue to understand the evolution and objectives of these cities of the future, taking into account that smart cities have emerged as a possible solution to environmental and social problems arising from rapid urbanization. In this context, sustainability is understood as the coexistence of social equity, environmental conservation, economic growth, and quality of life in the urban environment (Toli and Murtagh, 2020).

On the other hand, innovation is a fundamental pillar for smart cities due to disruptive technologies, such as renewable energies and intelligent transport systems, which are fundamental for sustainable development (Pan et al., 2021). In addition, for public policies to lead effectively to urban sustainability, it is crucial to incorporate technological innovation strategies with concrete sustainable results, demonstrating the importance of innovation not only in technological development but also in the creation of urban policy frameworks that promote comprehensive sustainability (Yigitcanlar and Kamruzzaman, 2018).

Innovation strategies is thus fundamental for smart cities to achieve a sustainable urban transformation that meets the needs of present and future generations, without compromising natural resources and social equity. However, smart cities face significant constraints related to infrastructure, human capital, governance, and financing, which challenge their implementation and effective development (Joia and Kuhl, 2019). In fact, there is a gap in the literature regarding the conceptualization, motivations, unique drivers, and barriers to the development of smart cities, especially in developing countries (Tan and Taeihagh, 2020), which reflects an academic lag in this field for such countries.

In the Latin American region, important challenges emerge due to rural-urban migration. In fact, local governments need to identify innovative solutions in a scenario of limited infrastructure, the lack of basic services, increasing insecurity, and pollution, in order to overcome unsustainable patterns of growth (Marchetti et al., 2019). In this sense, there are some customized local efforts aligned with smart city

concepts. Most of the local initiatives are related to urban mobility such as car sharing, bike sharing, and Bus Rapid Transit Systems (Santiago de Chile, Bogota, Buenos Aires. Rio de Janeiro, Mexico City). Examples of non-pollutant solutions are the initiative of the electric vehicle taxi fleet in Bogota, and the electric staircase system in Medellin (both in Colombia). More ambitious initiatives are related to smart, and green buildings (Mexico City), urban renovation (Buenos Aires), technological programs (Montevideo), smart urban planning and green spaces (Curitiba). Another important initiative is the Green City Index to assess the urban environmental sustainability of cities in Latin America which highlights Curitiba, Belo Horizonte, Brasilia, Sao Paulo, and Bogota as benchmark in the region (Siemens, 2012).

In this sense, given the complexities of Latin American societies the implementation of smart city initiatives represents outstanding challenges for policy makers. Nevertheless, innovative sustainable solutions that consider potential beneficiaries and citizens can contribute more efficiently to solve persistent social inequalities and foster development processes at local levels. In fact, the involvement of citizens from the beginning through the process can enhance substantially the sustainability of the proposed solutions (Augusto, 2021; Gil-Garcia et al., 2023; Giorka et al., 2020).

In this region, some gaps are also identified in the development and implementation of "Smart Cities initiatives", highlighting the need for the development of this type of initiatives with approaches adapted to local needs and differential realities of the region (Irazábal and Jirón, 2020) and how these initiatives may be sustained over time. These critical gaps indicate the need for a systematic and comprehensive analysis of the connections between smart cities and innovation to enhance sustainable dynamics (Gil-Garcia et al., 2023). This creates the ideal scenario for rigorous analysis of the literature in this field in order to find common and relevant aspects about smart cities in Latin America.

This research examines the role of innovation strategies in smart cities across Latin America through a comprehensive review of the relevant literature. The methodology is detailed in the next section. Subsequently, the results and main discussions are presented. Finally, the conclusions, limitations and future research agenda are presented.

2. Materials and methods

This research aims to analyze the role of innovation in smart cities in Latin America. For this, a structured approach, based on PRISMA, is used that includes the identification, selection, and systematization of data (Moher et al., 2009). The PRISMA guidelines provide a structured approach to the review process, ensuring the identification of all relevant studies, as well as an accurate and transparent report of their data (Sarkis-Onofre et al., 2021).

The search for information was conducted in April 2024 using the SCOPUS database, recognized by its repository of high academic and scientific impact (Abdullah, 2021; Jacso, 2011; Matela et al., 2019). For the purposes of replicability of this research, the search equation used in Scopus advanced search option is provided:

TITLE-ABS-KEY (“Smart City*”) AND (innov*) AND (latam OR “Latin America” OR Argentina OR Bolivia OR Brazil OR Chile OR Colombia OR “Costa Rica” OR Cuba OR “Dominican Republic” OR Ecuador OR “El Salvador” OR Guatemala OR Honduras OR Mexico OR Nicaragua OR Panama OR Paraguay OR Peru OR “Puerto Rico” OR Uruguay OR Venezuela)

For logical operators, the “TITLE-ABS-KEY” was used to refine the search in the metadata corresponding to title, abstracts and keywords; the quotation marks to search for exact phrases composed of several words; the asterisk symbol (*) allowed words with different suffixes to be included; the parentheses are used to group terms; the logical operator “AND” to combine search terms; and the operator “OR” to broaden the search when retrieving documents containing any of the keywords separated by this operator (Escobar et al., 2023; Yadav and Chakrabarti, 2022).

It is important to note that conference papers and books were included in the search criteria because these types of documents can also enrich the review and bibliometric analysis by providing perspectives and relevant findings in the field of study (Fang, 2021). In this regard, it should be mentioned that due to the initial state of the literature on the topic (Tan and Taeihagh, 2020), important research is presented at international conferences to obtain feedback before publishing in a scientific journal (Adeli et al., 2008; Zhang and Jia, 2013). The remaining inclusion and exclusion criteria are presented in **Table 1**.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion criteria
• Databases: Scopus • Types of documents: scientific articles, books and conference papers. • Language: English, Spanish and Portuguese • Orientation: Innovation in Latin America’s Smart Cities	• Any information that does not come from Scopus. • All types of documents other than scientific articles, books and conference papers. • Documents written in languages other than english, spanish and portuguese • Documents that do not deal with innovation in smart cities in Latin America.

The initial search identified in total 134 documents, 23 documents were excluded for not meeting the inclusion criteria (1 document did not meet the required document types, 9 documents did not meet the language criteria and 13 documents did not meet the required thematic orientation). By this, 111 documents were identified at the first selection stage. Subsequently, an in-depth evaluation of the remaining documents led to the exclusion of 19 documents that did not focus on innovation in Latin American smart cities, which was the final exclusion criterion. Finally, the final sample of 92 documents that met the selection criteria were included for the review and analysis (**Figure 1**).

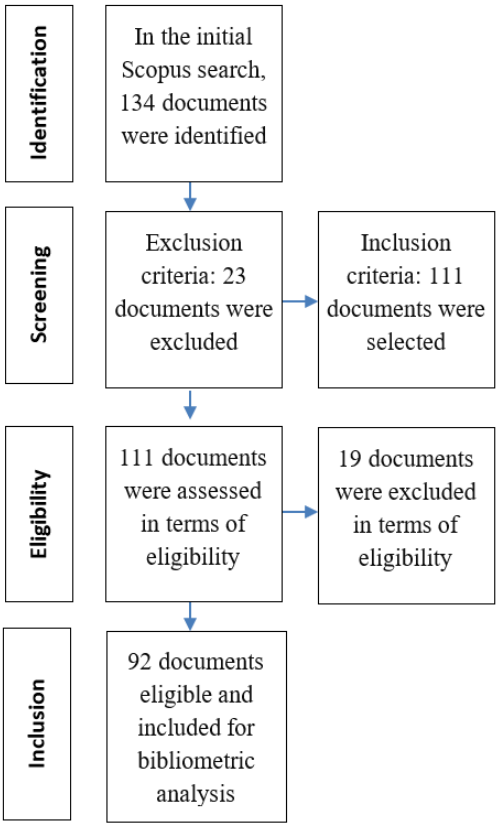

Figure 1. Document selection strategy and search protocol.

All documents included for the analysis were exported as a CSV—"Comma-Separated Values" dataset file. Then, the data visualization was organized and a network and cluster analysis was carried out with the support of the VOSViewer program. This program contains a data visualization tool with special capabilities focused on improving the visual elements of maps, allowing a fully detailed examination of specific data (Alvarez-Sosa and Abbas, 2021; Van Eck and Waltman, 2019).

An analysis of co-authorship of countries, co-citations of authors, and co-occurrences of keywords was performed. The number of co-citations of authors selected for the network was at least 10. In the case of the co-authoring network, a minimum of 5 documents per country. For the co-occurrence analysis, a minimum of 5 keywords were used. This type of analysis allows to capture a significant number of nodes with their corresponding interconnections to fulfill the research purpose.

3. Results

3.1. Growth pattern in publications

Innovation and smart cities in Latin America are an emerging topic in the literature. **Figure 2** shows that published evidence started in 2012. In this sense, the works of Schuurman et al. (2012) on innovative ICT ideas in the context of smart cities, Schaffers et al. (2012) on smart applications for smart cities, and Sauer (2012) on entrepreneurs in smart cities can be considered pioneering studies in Latin America, which were developed in Chile, specifically by researchers from the University of

Talca. **Figure 2** also shows a downward trend in the number of documents published between 2012 and 2014. However, between 2015 and 2019 the number of published documents increased significantly. In this sense, the work of Angelidou (2017) explores the main characteristics of smart cities and their presence in the development plans of 15 cities including Rio de Janeiro. In more recent years, the number of published documents decreased (11 documents in 2020, 14 documents in 2021, 8 documents in 2022 and 8 documents in 2023), but this trend remained the average which is 7.5 per year. In 2024, a couple of documents have been published on human rights in smart cities in Brazil (Souza et al., 2024) and on the implications of the concept of smart cities for urban planning in Chile (Ulriksen, 2024).

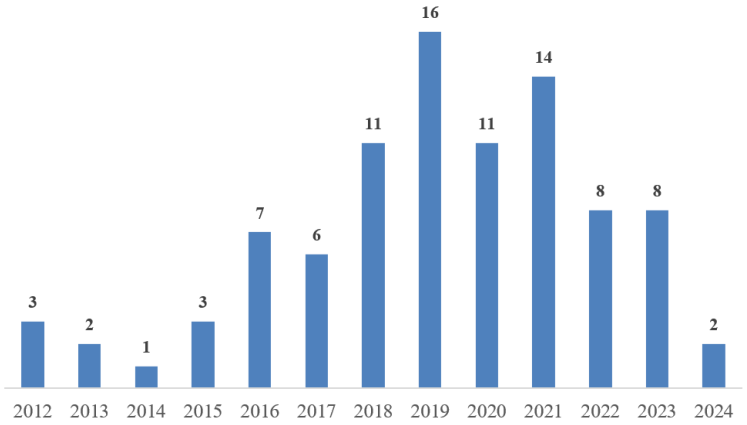

Figure 2. Number of published documents (Scopus), 2012–2024.

3.2. Contributions and co-citations by authors

Table 2 shows the authors with the highest number of publications on this topic. Victor Larios is highlighted first with research in smart health, smart governance, and innovation indices for smart cities (Alba et al., 2016; Avalos et al., 2016; Helder et al., 2019; Larios et al., 2019; Limon-Ruiz et al., 2019). Next, Janina Macke focused her research on innovative proposals for the improvement of quality of life in smart cities (Cerutti et al., 2019; Macke et al., 2018; Moreira and Macke, 2023). On the other hand, Tan Yigitcanlar and Jamile Sabatini-Marques collaborate on innovative strategies to achieve smart urbanity in cities and tourist islands in Brazil (Fachinelli et al., 2023; Sabatini-Marques et al., 2020; Yigitcanlar et al., 2018).

Table 2. Top authors by number of publications.

Authors	No. of Publications
Larios V.M.	5
Yigitcanlar T.	3
Sabatini-Marques J.	3
Macke J.	3

Co-citations mapping between authors (**Figure 3**) it is found that Yigitcanlar and Sabatini-Marques (**Table 2**) are cited together with their work on innovative strategies to achieve smart urbanity (Cerutti et al., 2019; Macke et al., 2018; Moreira and Macke, 2023). In addition, three other clusters of co-citations emerge, mainly Nicos Kmninos

on issues related to digital transformation and ecosystems in smart cities (Komninos et al., 2021), Ramon Gil-García on accessibility to information as a fundamental dimension of smart cities (Gil-Garcia et al., 2021), and Keiko Fonseca on innovation and its importance in urban mobility of smart cities (Rosa et al., 2021).

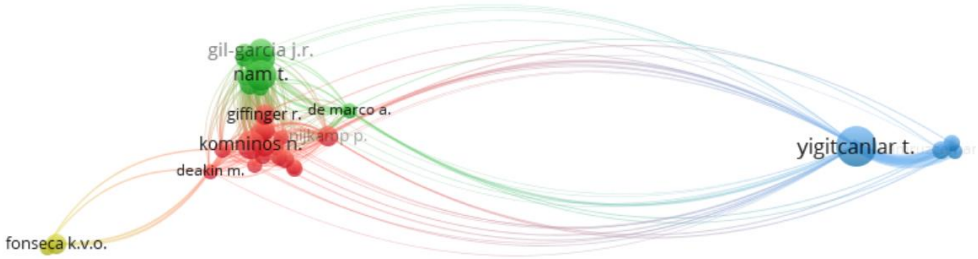

Figure 3. Visualization map of co-citations (authors).

3.3. Contributions and co-authorship by country

The country-based co-authorship mapping (**Figure 4**) allows us to visualize in which countries research networks are being consolidated around this topic. It shows the central role of Brazil where more research is carried out (**Table 3**) highlighting the work done by Pereira et al. (2017) on innovative open governance initiatives in the context of smart cities. In addition, **Table 3** also shows that, although Portugal and the United States are not part of Latin America, research done in these countries has focused on cities in the Latin American region and most of these studies have been co-authored with researchers from LAC region which denotes international collaboration in this topic. **Figure 4** shows important connections: between the US and Brazil, with studies on the importance of open data in smart cities (Iano et al., 2015; Tavares et al., 2016); between Brazil and Portugal on sustainability research in smart cities (de Bem Machado et al., 2021; Saraiva et al., 2018); between the US and Mexico on innovative initiatives for smart cities of the future (Gil-Garcia and Aldama-Nalda, 2013; Mendez et al., 2021); and between Ecuador and Portugal on how to measure performance in smart cities.

Table 3. Countries with the highest number of publications (Scopus).

Country	Number of documents
Brazil	37
Mexico	17
Colombia	9
Portugal	6
United States	6

Figure 4. Co-authorship visualization map by country.

Table 4 shows the affiliations of the top authors based on the number of publications. As in **Table 3**, four of the top five institutions are from Brazil and one from Mexico. University of Sao Paulo stands out as the institution with the highest number of publications, some of them related to the importance of the Internet of Things (IoT) in smart cities (De Souza et al., 2019; Fantinato et al., 2018; Zuffo et al., 2022) and smart city models/strategies for urban development (Bergermann et al., 2022; Fachinelli et al., 2023; Sabatini-Marques et al., 2020). The university that stands out in Mexico is the University of Guadalajara, with research focused on different sectors such as tourism (Ortega and Malcolm, 2020), health (Avalos et al., 2016) and energy (Helder et al., 2019), among others.

Table 4. Authors' most relevant affiliations (Scopus).

Country	Number of documents
Universidade de Sao Paulo	8
Universidad de Guadalajara	6
Universidade Federale de Santa Catarina	6
Universidade de Caxias do Sul	5
Universidade Federale do Rio de Janeiro	3

3.4. Contributions by type of documents

Figure 5 shows the distribution of documents by source type. Scientific articles and conference papers represent the largest portions, each accounting for 41% of the total documents. On the other hand, research books comprise 17% of the overall sample.

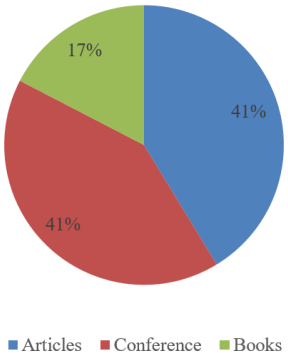

Figure 5. Percentual distribution by type of document.

As mentioned above, due to the current state of innovation research on Latin American smart cities, an important amount of research is being presented at international conferences. In fact, in the final sample of documents included, there are 38 research articles, 38 conference papers, and a book. For this reason, it is important to identify the main conferences and scientific journals in which this topic is discussed.

Concerning international conferences **Table 5** shows that the "ACM International Conference Proceeding Series" stands out with 7 documents. The Association for Computer Machinery (ACM) publishes research related to technological innovation in the field of computing and computing mainly, hence it publishes research related to innovation for digital transformation and open data in the

context of smart cities (Bernardes et al., 2018; Macadar et al., 2016; Weiss et al., 2023). On the other hand, the "International Smart Cities Conference" published 6 documents. This is a scientific event specialized in smart cities with important scientific impact such as Cacho et al. (2016) with 21 citations and Alba et al. (2016) with 18 citations in Scopus.

Regarding scientific journals, **Table 6** shows those with the highest scientific impact based on the number of citations done by the scientific community (first quartile according to "Scimago Journal Ranking"). The journal with the highest number of publications is "Sustainability", in which is worth highlighting the works of Ortega and Malcolm (2020) on smart tourist cities in Mexico, and that of Sabatini-Marques et al. (2020) on innovative strategies for smart cities in Brazil. In the "Journal of Theoretical and Applied Electronic Commerce" is published the pioneering works of Schuuman et al. (2012), Schaffers et al. (2012) and Sauer (2012) mentioned above.

Table 5. International conferences and publications.

International Conference	No. Documents
ACM International Conference Proceeding Series	7
IEEE International Smart Cities Conference	6
Advances in Intelligent Systems and Computing	2
Proceedings of the International Astronautical Congress (IAC)	2

Table 6. Scientific journals and number of research documents.

Journal	SJR	No. Documents
Sustainability (Switzerland)	Q1	6
Journal of Theoretical and Applied Electronic Commerce Research	Q1	3
Sustainable Cities and Society	Q1	2
Journal of Cleaner Production	Q1	2
Journal of Urban Technology	Q1	2

3.5. Co-ocurrence visualization and analysis

In **Figure 6**, the nodes closer to the center of the map tend to be the most important or influential in the network, due to their higher number of connections with other nodes or their links to other key nodes (Van Eck and Waltman, 2019). In this case, the "Smart Cities" node (52 occurrences) is established as the central node because it is the main subject of the research and because of its high connectivity with the other clusters. The nodes "Smart Cities" (42 occurrences) and "Innovation" (21 occurrences), which are implicit in the search equation, are also constituted as central nodes (see **Table 7**).

Next, we can highlight other nodes that were not part of the search equation, such as "sustainable development" (15 occurrences), "sustainability" (15 occurrences), "urban planning" (12 occurrences), "Brazil" (11 occurrences) and "quality of life" (10 occurrences). This suggests that research trends in smart city innovation in Latin America are focused on these themes, which is confirmed by the cluster analysis (**Figure 6**). The following is an analysis of the clusters formed and their main thematic:

- Urban Cluster (Green): Contains the two central keywords that cut across the other clusters (Smart City and Innovation). In addition, other keywords such as planning, development and urban policy can be found in this cluster. Here is highlighted the study by Angelidou (2017) which examines urban development in 15 cities, including Rio de Janeiro (Brazil), and finds positive aspects such as the use of technology to improve urban systems, knowledge transfers and innovation systems. Other notable articles focus on the limits and possibilities of urban planning in São Paulo (Brazil) (Dos Santos et al., 2024) and collaborative approaches to public policy formulation in Brazil (Przeybilovicz and Pereira, 2022), among others.

As can be seen, most of the work in this cluster is developed in Brazil, which is the country with the largest number of publications and an important node within this cluster (11 occurrences).

- Smart Cities Cluster (Yellow): Contains one cross-cutting keyword (Smart Cities) and two additional words: Sustainable Cities and Government Data Processing with six occurrences each. There is a study that aimed to analyze the mechanism of Government Data Processing (GDP) in support of smart cities, which found three dominant areas of GDP: information management, big data, and information and communication. Information management is related to technological change, e-commerce and innovation; big data to data mining, platforms and open data; and information and communication to privacy, public administration and e-participation (Farhan and Nurmandi, 2022).

Another relevant aspect of GDP is open government data, which is fundamental for governments to improve service delivery and interaction with stakeholders through technology. In this sense, access to open data allows public organizations to become more transparent, which contributes to improving public value and promoting greater efficiency in city management (Pererira et al., 2017),

On the other hand, electronic governance (e-governance) is also relevant to the GDP in smart cities, as it enables transparency, accountability, collaboration with all stakeholders and citizen participation (Lopes, 2017).

- Sustainable and Technological Cluster (Red): Addresses the importance of using technological developments to achieve sustainable development in smart cities. In this sense, Goodspeed (2015) points out that technology should not only be used to optimize urban systems, but also to address the social and environmental challenges that cities face.

In this cluster, there are different studies that relate sustainability and technological development in the context of smart cities: Alfonso and Pardo (2019) analyze how science, technology and innovation affect sustainable development and smart cities, highlighting the importance of these fields in promoting innovative and environmentally friendly urban growth; Bem Machado et al. (2022) focus on building sustainable cities through the implementation of smart technologies, addressing the challenges and opportunities that cities face in their transition to sustainability; De Oliveira et al. (2021) propose a multidimensional framework for ranking cities according to their sustainability, using technologies and data to assess and improve urban sustainability.

- Quality of life Cluster (Blue): Highlights the importance of quality of life for urban growth. Macke et al. (2018) point out that smart cities, by integrating advanced technologies into urban management, have the potential to significantly improve the quality of life of their residents, thereby promoting urban growth. However, the article also suggests that citizen perceptions are a crucial factor in assessing the success of these initiatives.

On the other hand, Guarda et al. (2020) agree that urban performance and growth in smart cities is measured in terms of quality of life. The authors point out that it is essential to understand territorial specificities and to determine the extent to which technologies can be useful in these territories in order to achieve a sustainable transition.

Table 7. Keywords frequencies and cluster grouping.

Green Cluster		**Yellow Cluster**		**Red Cluster**		**Blue Cluster**	
Keyword	**Freq.**	**Keyword**	**Freq.**	**Keyword**	**Freq.**	**Keyword**	**Freq.**
Smart city	52	Smart cities	42	Sustainability	15	Quality of life	10
Innovation	21	Sustainable cities	6	Sustainable development	15	Urban Growth	10
Urban Planning	12	Government data processing	6	Information Management	10	Planning	5
Brazil	11			Information and Communication technologies	8		
Urban Development	8			Internet of things	6		
Mobility	6			Decision making	5		
Urban Policy	5			Governance	5		

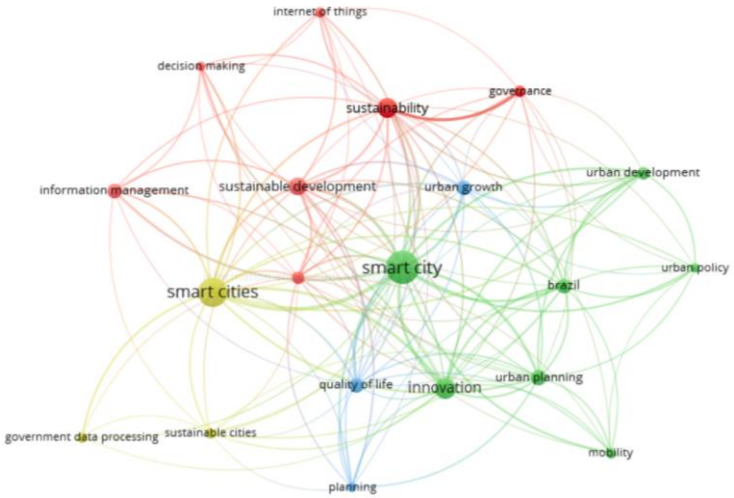

Figure 6. Keyword co-occurrence visualization map.

Finally, **Figure 7** shows the evolution of research trends related to innovation in Latin American smart cities. In this sense, it is clear that the literature started to focus on merely technological issues in the context of smart cities, with keywords such as "government data processing" and "Internet of Things", which are fundamental elements of smart governance and the provision of efficient urban services to improve the quality of life (Angelidou, 2017; De Souza et al., 2019; Fantinato et al., 2018), which is another of the highlighted keywords.

Subsequently, terms such as “innovation”, “sustainable development” and “urban planning” became relevant. As Goodspeed (2015) states, technological developments should not only aim to optimize urban systems, but also to address crucial issues such as social inequality and climate change. In this timeframe, it is possible to highlight the study by Macke et al. (2018), which points out that citizen participation and perception are fundamental for urban planners seeking to develop sustainable smart city initiatives.

More recent papers make a transition from urban planning to urban policies in smart cities, where there is talk of increased management and sharing of urban information (Acuto et al., 2019), as well as urban product and service strategies through smart urban policies (Tironi, 2020). The most critical aspect within urban policies is mobility, where different innovative solutions are proposed to improve it in an efficient and sustainable way (Cerutti et al., 2019; Fryszman et al., 2019).

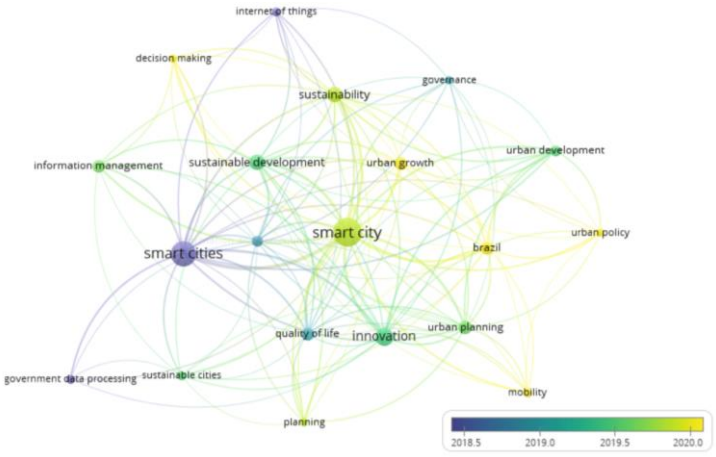

Figure 7. Keyword co-occurrence visualization by years.

4. Discussion

Based on the results of the previous section and in accordance with Glasmeier and Christopherson (2015) and Toli and Murtagh (2020), sustainability and technology are central themes in smart city research within the Latin American context. Indeed, much innovation is focused on innovative technology initiatives with sustainable approaches to smart-city issues.

Considering sustainability and technology as transversal components, the analyzed research focuses on how technological and sustainable innovations enhance the quality of life, urban service provision, and governmental functioning in smart cities (De Oliveira et al., 2021). In this context, the research identifies specific problems that can be addressed through innovative solutions to improve the social, environmental, technological, and governmental dimensions of these cities.

One of the main problems that sustainable innovative initiatives seek to address is urban mobility, which is of great importance to urban planners and authorities, as it affects other systems, especially in densely populated areas. Rosa et al. (2021) state that public transport systems are designed to move citizens efficiently to their destinations, considering variables such as user comfort, energy efficiency, minimum travel time and reduced traffic. Additionally, since existing cities already have public

transportation systems, it is also critical to assess their elements, such as the current location of bus, subway or train stops, routes and schedules. Once these measurements are obtained, models can be used to assist in the planning of both public transport systems and other urban systems (Rosa et al., 2021).

Based on the above, the concept of "Smart Mobility" becomes significant in the analyzed academic literature. It refers to technological advancements, sustainability, and user-centric considerations aimed at improving connectivity, accessibility, and efficiency within urban environments. Smart mobility is characterized by the smooth movement of people and goods, with minimal environmental impact and a focus on enhancing the quality of life for all citizens (Fryzsman et al., 2019).

Brazil is a leader in smart mobility with cities that have implemented shared transportation systems that have been well received by residents. These systems are appreciated for their positive impacts on health, the environment, and their strong social acceptance (Cerutti et al., 2019). Additionally, other cities are transitioning towards smart mobility by implementing incremental and continuous innovations in their urban transportation systems. These innovative initiatives, combined with the development of real-time control systems and the promotion of non-motorized transportation modes, are driving progress towards a more efficient, sustainable, and citizen-focused mobility model (Fryzsman et al., 2019).

Other innovative initiatives related to smart urban mobility that can be highlighted are: (1) Mobile open data applications, specialized databases, and smart subways to improve mobility, public transportation, and the quality of life (Schaffers et al., 2012); (2) Government programs that encourage the use of renewable fuels and electric vehicles in public transportation systems. The "EcoFrota" program in Sao Paulo (Brazil), seeks a transition in which CO2 emissions caused by public transport are reduced by 10% annually (Di Pasquale et al., 2016); (3) The use of bicycles as an alternative to reduce pollution and mitigate urban mobility problems (Cerutti et al., 2019; Guevara et al., 2019); (4) Other disruptive technologies for smart transportation such as artificial intelligence (autonomous vehicles, smart robots and virtual assistants) or digitalized ecosystems (Blockchain, digital hellos, IoT platforms, knowledge graphics), among others (Herrera-Quintero et al., 2019).

As can be seen, all the innovative initiatives mentioned are sustainable from a social or environmental perspective, which reaffirms the transversality of sustainability of smart cities in the Latin American context. However, innovation before being implemented in urban areas, may have a previous experimental phase to verify its functioning and adequate implementation, usually done in universities and "Living Labs". For example, Pinto et al. (2017) used the campus of a Brazilian university to test different prototypes that aim to solve smart city problems, prior to its implementation in identified cities. In addition, "Living Labs" are created as platforms to test innovative solutions in real-life simulators, before implementing them in smart cities (Alba et al., 2016).

Urban mobility continues to pose significant challenges for decision-makers and policy experts worldwide (Dia et al., 2021). Despite substantial investments in transport infrastructure over the years, urban mobility solutions still face obstacles such as severe congestion, long travel distances, and unreliable travel times (Dia, 2017). These challenges are intensifying as populations grow, with projections

indicating that two-thirds of the global population will reside in cities by 2030 (Dobbs et al., 2012). This rapid urban growth, driven by the increasing importance of cities on the global stage, will dramatically transform urban environments and communities. Additionally, it will place immense pressure on the essential infrastructure needed to provide urban services like transportation, energy, and communications (Taylor and Derudder, 2015).

The literature also identifies other innovative solutions in the context of Smart Cities aimed at improving quality of life with respect to specific issues such as poverty, social inclusion, education, employment, among others. This is noteworthy, despite the fact that experts and urban planners indicate that the focus of smart cities tends to prioritize technologies and their solutions, often relegating residents and their well-being to the background (Macke et al., 2018).

Regarding poverty, Portugal et al. (2021) analyzed the potential of Brazilian favelas to become smart cities through branding and the creative economy. From the perspective of inclusion, research has been found indicating that integrating less privileged classes is fundamental for the development of sustainable smart cities (Bolay, 2020). Other concepts such as digital inclusion also emerge in the literature review, promoting integration and social well-being through e-inclusion, complementary education via educational software applications on the internet, e-learning, and professional development (Iano et al., 2015). All these aspects represent innovative solutions proposed in Latin American Smart Cities, which, through technological and sustainable approaches, aim to improve the quality of life for their inhabitants.

Bem Machado et al. (2021) highlight that the government must invest in the modernization of urban infrastructure, strengthening the circular economy, improving the education system to reduce school dropout rates, and increasing safety in cities. These investments are essential to transform cities into smart and sustainable spaces, which in turn improves the quality of life for their inhabitants. In this context, the importance of ESG (Environmental, Social, and Governance) lies in its ability to guide decisions toward development that balances economic growth with social justice and environmental protection (Bem Machado et al., 2021).

At this point, urban services and government functionality gain relevance, being predominant aspects in the literature on Smart City innovations in the Latin American context. Regarding smart urban services, there are studies that focus on technological infrastructure. For instance, Da Silva et al. (2020) present urban infrastructure monitoring systems as a great opportunity for smart cities development. These systems monitor and manage data related to inhabitants' behavior and lifestyle, the health and well-being of the elderly, inclusion opportunities for people with disabilities, and other public management systems. On the other hand, there is a study that presented the results of implementing a platform for tax payment, which reduced paperwork in government services, using a network of sensors (Cedillo et al., 2019).

Other significant studies have focused on intelligent public transportation systems. For instance, Montalvo et al. (2022) proposed a smart public transportation model in Mexico that takes into account factors such as passenger volume, service demand, fleet size, optimal routes, the number of stops, and waiting times. In Brazil, a sustainable approach has been implemented that offers public transportation and

food vouchers to waste collectors, effectively creating an efficient waste collection system despite limited resources (Béduneau-Wang and Galharret, 2013).

To effectively implement the innovative technological and sustainable initiatives mentioned, active government involvement is important. In this context, smart governance has emerged as a fundamental aspect of smart cities, rooted in core principles of good governance, such as transparency, accountability, stakeholder collaboration, and citizen participation, all of which are supported by e-governance (Lopes, 2017). This study by Lopes (2017) examined countries like Brazil, Colombia, and Uruguay, it was found that smart cities and e-governance share a similar evolutionary path, ultimately converging towards smart governance.

Information and Communication Technologies (ICT) are crucial to the success of smart governance, not only in delivering urban services to citizens but also in ensuring the efficient operation of government both internally and externally. Angelidou (2017) suggests that smart cities can serve as platforms for the deployment of advanced technologies, fostering cooperation among governments, businesses, and citizens, thereby improving efficiency, public service quality, and sustainable urban development. Conversely, Goodspeed (2015) argues that ICT should be leveraged not only for the optimization of urban systems but also for addressing complex challenges such as climate change, social inequality, and sustainability, with citizen participation in co-creating solutions.

From the perspective of sustainable governance, research by Sabatini-Marques et al. (2020) emphasizes the importance of sustainable governance strategies to boost cities' innovation capacities and sustainability. Using Florianópolis (Brazil) as a case study, the research underscores the necessity of inclusive governance that prioritizes the common good in urban development. However, Lopes (2017) points out that in cities like Rio de Janeiro (Brazil), the focus of the smart city agenda has often been on the economic, financial, and political benefits of technology-driven urban transformation, at the expense of other critical issues such as climate change.

Moreover, smart contracts play an important role in the functioning of government systems (Bhagavan et al., 2020). These contracts are self-executing computer programs that activate automatically when specific conditions are met, eliminating the need for intermediaries. In the context of smart cities, these contracts can be employed to enhance public administration, security, energy resource management, transportation, and other aspects of urban life (Bhagavan et al., 2020).

Another major issue identified in smart cities in Latin America is related to the role that innovation can play to achieve smart and sustainable tourism. Here, tourism innovations are discussed from different perspectives. For instance, considering the perception of key actors and stakeholders (Ortega and Malcolm, 2020). Others consider the importance of innovation to turn a tourist destination into a smart city (Yigitcanlar et al., 2018). And more recently, practical applications and innovations in the management of value chains in the tourism industry supported by ICT (Gómez-Ceballos et al., 2023), and how non-technological innovative solutions are transforming tourism in emerging smart cities (Paredes et al., 2021).

As can be observed in the results of the bibliometric analysis (**Table 4** and **Figure 3**) and the discussion section, Brazil leads Latin America in the number of studies focused on innovation in Smart Cities. Within Brazil, Curitiba stands out as the

foremost city in research related to citizens' perceptions of quality of life within a smart city context (Macke et al., 2018). Furthermore, studies in this city also explore urban intelligence and the development of smart, innovative, and sustainable strategies to address contemporary urban challenges (Duran and Pérez, 2016; Fachinelli et al., 2023). Da Silva et al. (2020) point out other notable smart cities in Brazil such as Belo Horizonte, recognized for its advanced intelligence services and its partnerships with investment institutions in energy efficiency studies and management tools. Belo Horizonte also ranks third in economic sustainability due to its initiatives aimed at enhancing quality of life and preserving the environment. Sete Lagoas stands out for its "City Future Project" which is based on technologies for the generation, transmission, and distribution of energy, and includes the establishment of the first experimental photovoltaic solar energy plant in Latin America. Lastly, Uberlândia is distinguished by the development of Granja Marileusa, the city's first planned neighborhood built on Smart City principles, showcasing its progress in sustainable urban development.

Brazil serves as a model for other Latin American countries and policymakers by demonstrating how innovative public instruments can be effectively utilized to develop green, resilient cities, even when faced with limited public resources (Béduneau-Wang and Galharret, 2013). Gil-García et al. (2013), in their research on Smart Cities initiatives within the framework of public policies, highlight the need for government urban agendas to prioritize addressing issues such as economic, social, and environmental development, as well as security, public services and transportation. To achieve this, the authors point out the importance of designing smart public policies, noting that "smartness" is not limited to the automation of processes, but includes the redesign of processes, the negotiation of political support and the transformation of organizational structures and institutions, among other key factors (Gil-García et al., 2013). Additionally, Goodspeed (2015) argues that policymakers should leverage technological advancements to tackle challenges like social inequality and the climate crisis. With this approach, it is possible to design public policies for smart cities that are both technologically advanced and sustainable.

Przeybilovicz and Pereira (2022) conducted a study that used a collaborative approach to design a public policy strategy for smart cities in Brazil, based on a design policy approach. The result of this process was the Brazilian Charter for Smart Cities, a document that presents an agenda for addressing digital transformation as an opportunity for sustainable urban development. In addition, the authors highlight the importance of establishing collaborative and participatory processes in the formulation of strategies and public policies.

From the above, several key implications emerge for policymakers. Firstly, policymakers must recognize that the effectiveness of smart public policies extends beyond technological solutions and should integrate transformation of organizational structures and meet current social and environmental demands. Policymakers should therefore focus on using technology as a tool to address pressing challenges such as social inequality and the climate crisis, ensuring that smart city initiatives contribute to more inclusive and resilient urban environments. It is also important to take a collaborative approach to the design of urban public policy. This should involve the city's stakeholders.

5. Conclusion

This study on the role of innovation in smart cities in Latin America provides a comprehensive analysis of how emerging technologies and sustainable strategies are positively affecting urban planning and development in this region. Thus, technology and sustainability are considered as central themes in research on this topic.

Research results show that in Latin America, the literature is relatively recent and started to develop in 2012, with Brazil leading the generation of knowledge. Despite this, original contributions have been published in top scientific journals that have the highest scientific impact (based on the SJR Ranking). On the other hand, there is a large number of studies that are presented at international conferences.

From the policy perspective, the implementation of smart city initiatives in Latin America represents outstanding challenges for policy makers. Nevertheless, government urban agendas need to prioritize human-centered sustainable solutions, that consider potential beneficiaries and citizens, in order to contribute more efficiently to solve persistent social inequalities and foster development processes at local levels. In fact, the involvement of citizens from the beginning through the process can enhance the sustainability of the proposed solutions and contribute to more inclusive and resilient urban environments in the long run.

Finally, this research has some limitations. First, it relied on a single database, Scopus, without considering other databases such as the Web of Science. Second, it did not include document types other than research articles and conference papers. Lastly, limiting the selection to documents written in English, Spanish, and Portuguese may have excluded significant contributions in this field. Therefore, future research could expand to include additional languages, develop a comprehensive vision of the literature by considering other databases, and include another types of documents. On the other hand, it is suggested that future research should consider the following: comparative studies between Latin America and other regions of the world to understand the challenges and advances in a global scenario; longitudinal studies on smart cities intervention in the region and their sustainability; the institutional framework and public policies designed to promote innovation in cities and their urban development. In this way, it will be possible to contribute to the understanding of innovation and its impact on the transformation of smart cities in Latin America, towards sustainable urban development in the long term.

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