Spatial Data Infrastructure Trends in Urban Context: A Bibliometric Analysis

DMSLB Dissanayake, Manjula Ranagalage, JMSB Jayasundara, PSK Rajapakshe, NSK Herath, Samali Ayoma Marasinghe, WMSB Wanninayake, HUK Dilanjani, ALWM Perera, and HMYLP Herath

Department of Environmental Management, Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka, Mihintale, Sri Lanka. dissanayakedmslb@gmail.com

1. Introduction

The urban areas are complex and dynamic, offering considerable socio-economic advantages. In the last couple of decades, urban areas have extensive development in many aspects. By development of urban areas, it is meant the transformation of rural areas into an urban setup through the socio-economic process, which is very complicated, and people move from rural to urban areas.(UN Department of Economic and Social Affairs, 2018). The rapid urbanization globally, going on over the last couple of decades. Rapid urbanization, technological changes, and a growing shift towards sustainability mark the growth of urban cities in recent decades. The driving force is population growth: more people have increased the number living in urban areas and placed the quality of life at the heart of these areas. (Mouratidis, 2021). Essentially, it can be observed that cities have experienced significant development since the turn of the past century through various waves of development, from industrialization that accelerated growth and expansion to the newer concept of a smart city. A smart city incorporates an integrated network of interrelated environments that adapt autonomously to changes in behavior through learning from daily activity patterns.(Kandt & Batty, 2021). Spatial Data Infrastructure (SDI) is a very important core part of the smart city framework since it allows integration, management, and dissemination of geospatial data. SDI plays a critical role in supporting sustainable development by enabling effective data sharing and spatial analysis for decision-making in urban and environmental planning. Although the some challenges such as integrating diverse data sources, achieving interoperability across platforms, and implementing real-time data applications have turned out to be recent challenges for the full realization of SDI potentials. Therefore, addressing these issues is essential and search for appropriate solutions to to create resilient and adaptable systems that support sustainability efforts within dynamic and complex urban settings.

Understanding research trends in SDI will be important to guide future studies in both SDI and urban development, since it helps indicate gaps, new emerging technologies, and challenges of integration in urban settings. Bibliometric analysis is very critical in uncovering such gaps, monitoring emerging concepts, and giving shape to future research directions. With systematic analysis of publication patterns, keywords, citations, and influential studies, it lays the foundation for informed and targeted research in the field. It helps to ensure that research has a solid background derived from prior knowledge.(Donthu et al., 2021). The following are the objectives that have been addressed in this study. (I). To identify the most influential research publications in contributing to knowledge growth in SDI, their trends, and application in urban areas.(II)To examine the development of author key words over time. (III).To identify the main research propose, future research directions and suggest new approaches to applying SDI in urban planning and smart city management.

2. Materials and Methods

This Bibliometric analysis targets publications on SDI systems and related urban research. The review has only included empirical and review articles, while excluding those studies published in languages other than English during the Scopus database data collection process.

Commonly, a bibliometric analysis comprises five major steps, namely research design, data collection, analysis, visualization, and interpretation.(Župič & Cater, 2015). In this study, we focus on the three main stages.

Data were downloaded from the Scopus database on 28 June 2024, considering the literature related to the keywords "Spatial Data Infrastructure" and "City." The study analyzed data from 156 publications published in English, from the years 2003 through 2023, by using Scopus, since the database provides broad coverage of peer-reviewed literature. The obtained records were analyzed using bibliometric tools comprising publication trends, author keywords, and visualizations like trend charts, thematic maps, and author productivity charts, using the Biblioshiny software in order to ensure efficient synthesis. The results have been visualized using figures, and statistics that were subjected to further evaluation so as to make the necessary conclusions. This bibliometric analysis is limited to not considering non-English publications. This may result in a biased presentation of the SDI system and urban research emarging from various linguistic contexts.

3. Results and Discussion

3.1. Trend Analysis

The annual growth trend in papers related to "Spatial Data Infrastructure system of a City" research has grown quite high from the years 2005 to 2023. There were only a few papers from the year 2000 to 2012, showing very less interest in the topic. There has, however, been increased interest from the year 2013 to 2019, whereby a peak was reached in 2019 with 19 publications. This rising trend continued sharply from the year 2020 up to 2023 to underline emergence as a hot research area. The mean average annual growth in publications was 8.72%, with 4229 references to documents averaging at 12.79 citations per document.

The publication trends of the study "Spatial Data Infrastructure System of a City" shows an increasing tendency between 2005 and 2023. In recent years, since 2020, there has been consistent growth in the level of research being pursued, reflecting that greater importance is being vested in sustainable and green city development.(Javidroozi et al., 2023). The publication trends of "Spatial Data Infrastructure System of a City" shows an increasing tendency between 2005 and 2023. In contrast, the output is low from the year 2000 onwards to the year 2012 because at that time the discipline was in an infant state. Three stages are formed, with peaks in the years 2010 and 2013, and the highest in the year 2019, as the interest would have surged amidst technological development and increased complexity in managing urban areas.

3.2. Keywords

Keywords serve as a summary of literature content. In this study there are 1194 keywords in the literature on SDI and City from 2003 to 2023.

Figure 1. Word Cloud Map

The word cloud underlines the central role of Spatial Data and Geographic Information Systems in the domain, pointing out their role as cornerstones for the building of urban infrastructure. The terms urban planning, smart city,three dimensional computer graphics ensure strong base to urban applications supported by advanced technological tools. This is evidenced by the inclusion of keywords such as"Information Management","Interoperability", and"Decision Making" that reflect the increasing focus on integrated data systems and application in assisting informed urban development. Further evidence is the inclusion of sustainable development and urban growth, reflecting commitment to the use of spatial data infrastructure for solving some of the key challenges being faced by urban areas today. The figure 1 as a whole might be taken to indicate that research is not only becoming more technically sophisticated but that it is also increasingly congruent with the demands of modern urban management in sustainable ways.

3.3. Thematic Analysis

Thematic analysis provides a visual presentation of the trending themes in this area of research (Dissanayake et al., 2022). The thematic map illustrates basic themes, namely, GIS, SDI, Spatial Data, 3D Modeling, Photogrammetry, and Urban Planning, that are core to spatial data research. These themes, especially SDI, GIS, and urban planning, are somewhat simple but significant concepts within this area of research. GIS, SDI, and 3D modeling, along with photogrammetry, and, demarcating new paths for improving urban planning through improved spatial analysis, visualization, and data integration that would lead to informed decision-making. Such technologies would ensure better land use planning, resources management, and infrastructure development that would eventually link to sustainable and resilient urban environments. Analysis offers the emergence of new roles that smart city initiatives and 3D computer graphics are playing in enhancing SDI. Moreover, the top right quadrant of the map underlines newer themes, such as location-based services and mobile navigation systems; these have a smaller importance compared to other communities' locations, but nonetheless show two areas of interest that in the future will likely grow. However, there is an emerging trend to engage various user communities, including the public and non-governmental organizations, in order to realize full benefits derived from spatial data development investments(Kelly, 2007). The most effective solution to address these spatial community issues remains the implementation of SDIs.

4. Conclusion

This study analyzes the bibliometric research development of SDI and city development, thus gives some keys to enlighten the most important development trend, and fast-growing themes such as "Spatial Data Infrastructure," "Spatial Data," and "Geographic Information System" to develop hot and key areas in which research and innovation are continuously being carried out. It also shows collaboration trends between scholars and institutions, and this can be of great value in insights, informing city planners, policymakers, and industry professionals in their search for partnership opportunities with academic and technological organizations. Urban planners and policymakers should actively engage with academic institutions and technological organizations to foster collaborative research initiative through new trends in SDI and GIS feeding into informed decision-making which can inform decision-making in urban development and lead to sustainability and resilience in the urban environment amidst changing regulatory and societal dynamics.In fact, such indications have become imperative to optimize strategies for urban development and manage smart cities more effectively to render them sustainable and resilient. This requires continuous analysis of trends emerging in development, technological changes, and changing regulatory situations to accomplish informed decisions and improved collaboration across agencies both in urban planning and smart city management.

5. Acknowledgment

6. Keywords:

Bibliometric Analysis, Geo Spatial Technologies, Spatial Data Infra-structure, Urban Area

7. References

- Dissanayake, H., Iddagoda, A., & Popescu, C. (2022). Entrepreneurial Education at Universities: A Bibliometric Analysis. *Administrative Sciences*, *12*(4). https://doi.org/10.3390/admsci12040185
- Dissanayake, H., Popescu, C., & Iddagoda, A. (2023). A Bibliometric Analysis of Financial Technology: Unveiling the Research Landscape. *FinTech*, *2*(3), 527–542. https://doi.org/10.3390/fintech2030030
- Hualin Xie , Yanwei Zhang, Z. W. and T. L. (2020). *A Bibliometric Analysis on Land Degradation :*
- Id, Y. Z., Zhao, L., Zhao, H., & Gao, X. (2021). *Urban development trend analysis and spatial simulation based on time series remote sensing data : A case study of Jinan , China.* 1–22. https://doi.org/10.1371/journal. pone.0257776
- Javidroozi, V., Carter, C., & Grace, M. (2023). *Smart , Sustainable , Green Cities : A State-of-the-Art Review.*
- Kandt, J., & Batty, M. (2021). Smart cities, big data and urban policy: Towards urban analytics for the long run. *Cities*, *109*(October 2020), 102992. https://doi.org/10.1016/j.cities.2020.102992
- Kelly, P. (2007). Role of Spatial Data Infrastructures in Managing Our Cities. *Proceedings of the FIG Commission*, *May 2007*, 1–11. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Role+of+Spatial+Data+Infrastructures+in+Managing+Our+Cities#2
- Mouratidis, K. (2021). Urban planning and quality of life: A review of pathways linking the built environment to subjective well-being. *Cities*, *115*, 103229. https://doi.org/ https://doi.org/10.1016/j.cities.2021.103229
- UN Department of Economic and Social Affairs. (2018). World Urbanization Prospects. In *Demographic Research* (Vol. 12). https://population.un.org/wup/Publications /Files/WUP2018-Report.pdf
- Župič, I., & Cater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods*, *18*(3), 429–472. https://research.gold.ac.uk/ id/eprint/26859/