

Bibliometric Analysis of Geographic Information System Impact on Urban Areas Management.

Maxwell Amponsah¹, Enok Maryani²

¹PhD Student, Universitas Pendidikan

²Professor, Universitas Pendidikan

Abstract

Geographic Information System is a global phenomenon that has revolutionized technology and is receiving much attention currently. To objectively conceptualize the research context of Geographic Information System (GIS) impact on human settlement, bibliometric and biblioshiny software packages were applied to conduct data mining and qualitative analysis. Research papers including journals and articles in the fields of GIS and Urban Areas management spanning from 2000 to 2023 were extracted. This scientific data was extracted on 8TH January 2023 in the Publish or Perish core collection database. The results indicated that: publications fell from 2000 to 2001, however, they increased a bit in 2002. There was no significant change until 2007 when there was a slight increase in publications up to 2008. Geographic Information Systems, flood-prone areas, urban areas, suitable areas, rural areas and maps are the most frequently used keywords in the field of GIS and urban areas management in recent years. Consequently, the paper concludes that the research directions on GIS impact on human settlement management in future include the following processes and mechanisms: the application of state-of-the-art GIS technologies, the introduction of GIS crime monitoring innovations for urban centers, robust GIS simulation innovations to enhance urban resilience and digitization of human settlements for promotion of sustainable, Smart and Blue Cities. Finally, research into the creation of geo-spatial database platforms and data infrastructure for human or urban centers should be promoted. This paper aims to review the literature on the significance of GIS as a powerful tool in addressing the complexities and challenges inherent in urban environments.

Keywords: Bibliometric; Geographic Information System; Urban Areas; Geospatial database; data infrastructure; Co-Authorship network:

1. Introduction

Geographic Information Systems (GIS) is Information and Communication Technology (ICT) software which has brought modernisation and prominently enhanced planning and management of urban areas in the 21st century and industrial revolution era. The computerization of the processes involved in the preparation of spatial plans has significantly reduced the drudgery and difficulties involved in spatial data capture, storage, retrieval and analysis. Geographic Information System has made all these processes much easier for Spatial Planners, Surveyors and Geographers in the dispensation of their routine functions. Collaboration through geospatial data platforms enhances data sharing for analysis, local revenue generation, crime surveillance and inferences that promote scientific decision-making.

GIS is a system designed to capture, store, analyse, manage, and present spatial or geographic data (Maliene et al., 2011). At its core, GIS integrates various types of data, such as maps, satellite images, aerial photographs, and tabular data (like demographics or land use), to create a layered visual representation of the Earth's surface and its features. GIS has emerged as a transformative technology in the realm of urban management, significantly impacting the planning and development of human settlements. As urbanization intensifies globally, the effective management of human settlements becomes paramount. GIS, with its ability to capture, analyse, and visualize spatial data, plays a pivotal role in facilitating informed decision-making processes within urban environments.

Literature reviews play an essential role in academic research to gather existing knowledge and examine the state of a field (Kunisch et al., 2018). Researchers typically collect available evidence on a topic or issue before conducting new research to assess the state of the already available evidence. However, a literature review that only offers an arbitrary selection of evidence is often not fully representative of the state of existing knowledge, and the selection of some studies over others ultimately leads to what is known in statistical analysis as a sample selection bias – a type of bias caused by choosing a non-random sample of data for further analysis. Consequently, narrative reviews often offer no comprehensive background for theory development and testing (Linnenluecke et al., 2020).

Since the 1990s, the range of Public Participation GIS (PPGIS) applications has been extensive, from community and neighbourhood planning to mapping traditional ecological knowledge (Brown et al., 2014). Concerning urban parks, PPGIS has been used in urban planning to identify potential green spaces and walking trails of importance to the public (Rall et al., 2019) and to identify the type and location of values people have for urban parks (Brown, 2008). In this article, we detail methodological steps for how researchers can conduct systematic literature reviews and offer examples of bibliometric approaches to visualise results.

This article's objectives are: how to apply the bibliometric literature review to provide a rigorous and thorough assessment of literature published in Geographic Information System impact on urban areas management. Identification of research gaps in the existing body of knowledge and specify future research directions. This paper aims to explore the profound impact of GIS on the management of urban areas, focusing on its applications in urban planning, infrastructure development, and resource allocation. By elucidating the synergies between GIS technology and urban areas management. The following sections will delve into specific applications, analysis, and researchers' publications implications on Geographic Information System in the context of urban areas management.

2. Methodology

Scientific research requires empirical data for analysis which informs the triangulation of results and findings for future direction of research. The Publish or Perish software is one of the world's largest and most comprehensive collections of scientific research resources. The search for data was conducted on 8TH January 2024. The search engine applied in the Publish or Perish interface was Google Search. The search was done using the document Title Terms button. The search terms were: Geographic Information System OR Urban Areas. The development of the search terms was conducted in line with the Boolean Operatives (Linnenluecke et al., 2020). The sample size limit adopted was 1000 publications. The duration for the search was set at 2000 to 2023. During the search, only 366 publications were obtained. The application of the inclusion and exclusion criteria, resulted as follows: 5 of the publications were books,

10 as conference papers and 1 in a different language apart from English. The final results obtained were 350 publications in articles and journals.

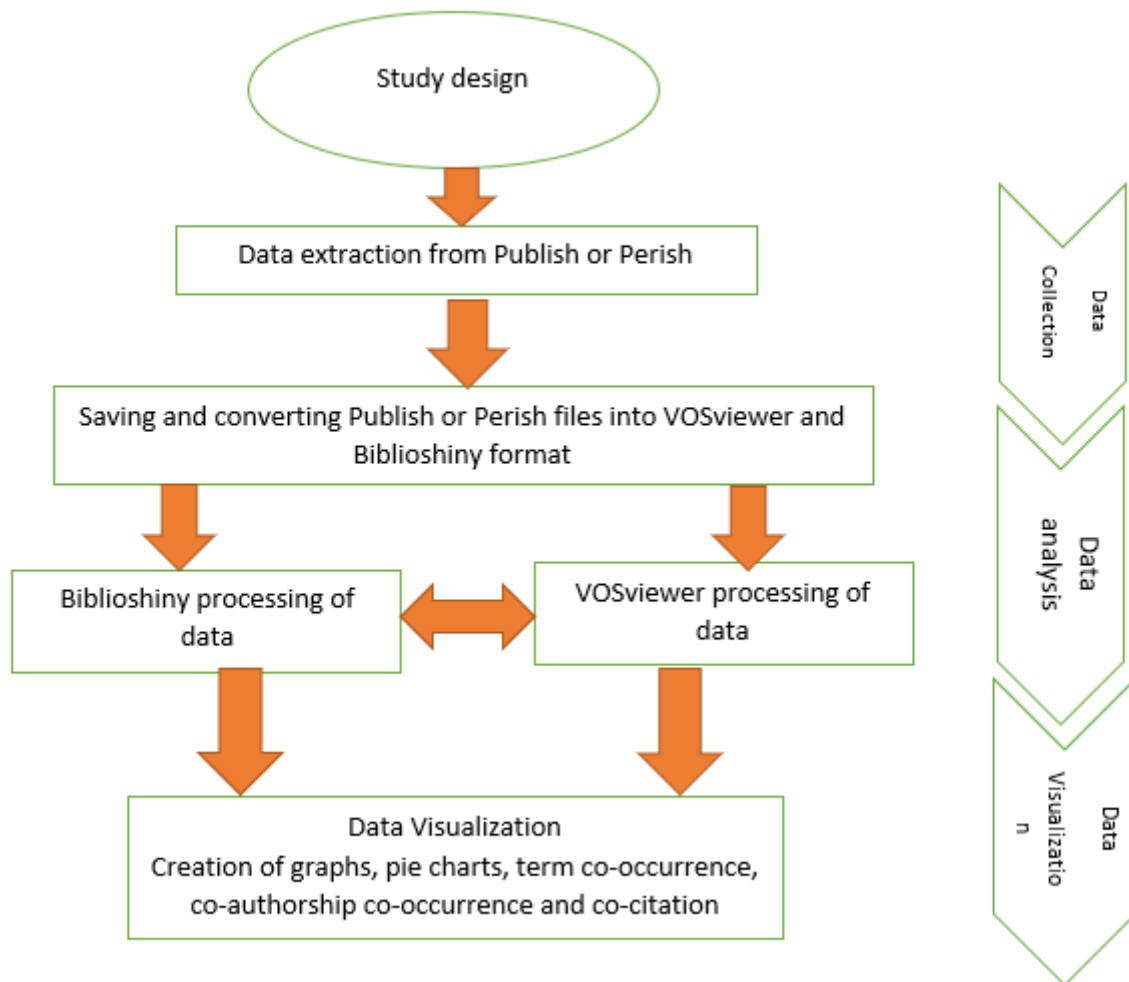


Figure 1: Bibliometrix Science Mapping Workflow.
Source: (Aria & Cuccurullo, 2017)

The standard bibliometric analysis process involves specific guidelines (Mukherjee et al., 2022): The research design, study data collection, data screening, data analysis and synthesis and, data visualization. These stages are outlined in Figure 1. Software dubbed R and Rstudio which utilizes add-ons such as library(bibliometrics) and biblioshiny() to run Biblioshiny was installed and applied. Also, VOSviewer software was installed to process data for visualization. The data extracted from the Publish or Perish website (Karakaya et al., 2014) was saved in the file format of BiB, CSV, RIS and EndNote to enable migration to biblioshiny and VOSviewer for data processing analysis and synthesis.

3. Results

The output from the processed data is presented in the following findings, discussions and conclusions to inform the future direction of research. The purpose of this research is to identify research gaps in existing literature on Geographic Information System impact on urban area management.

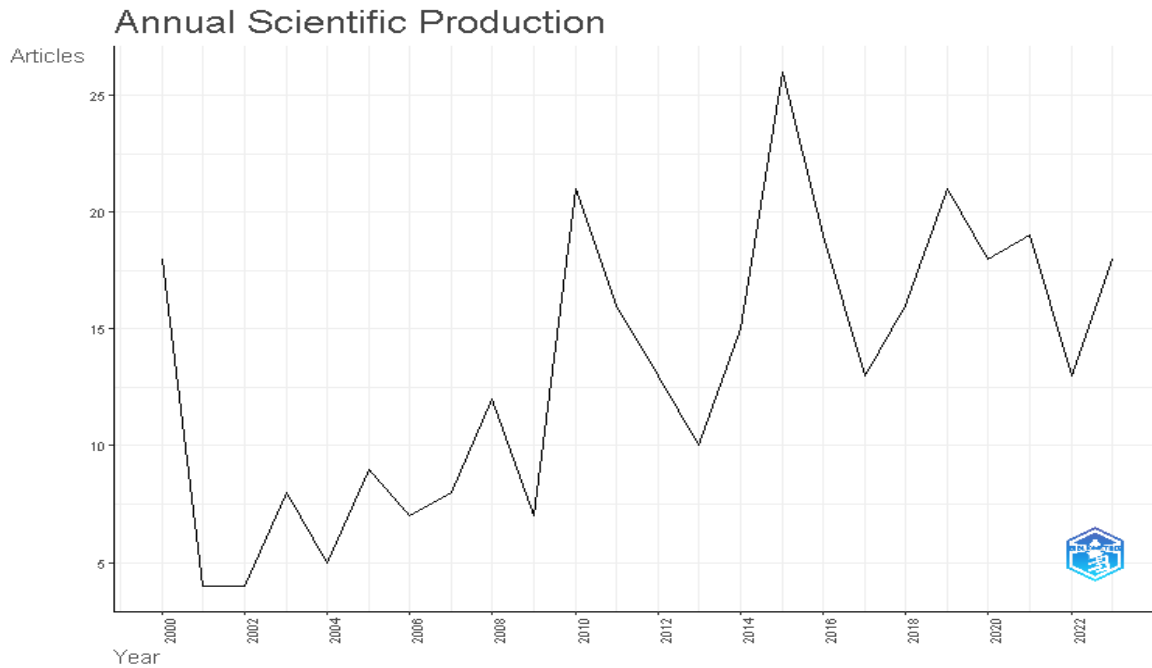


Figure 2: Annual scientific production
Source: Authors' construct, 2023

The BiB file saved from Publish or Perish on the 350 publications extracted generated a line graph indicated in Figure 2. The analysis of the data in the biblioshiny software results in a line graph indicated that: publications fell from 2000 to 2001, however, it increased a bit in 2002. There was no significant change until 2007 when there was a slight increase in publications up to 2008. However, there was a massive increase in 2015 and fell up to 2017 since then there were no significant changes until 2022 as identified in figure 2.

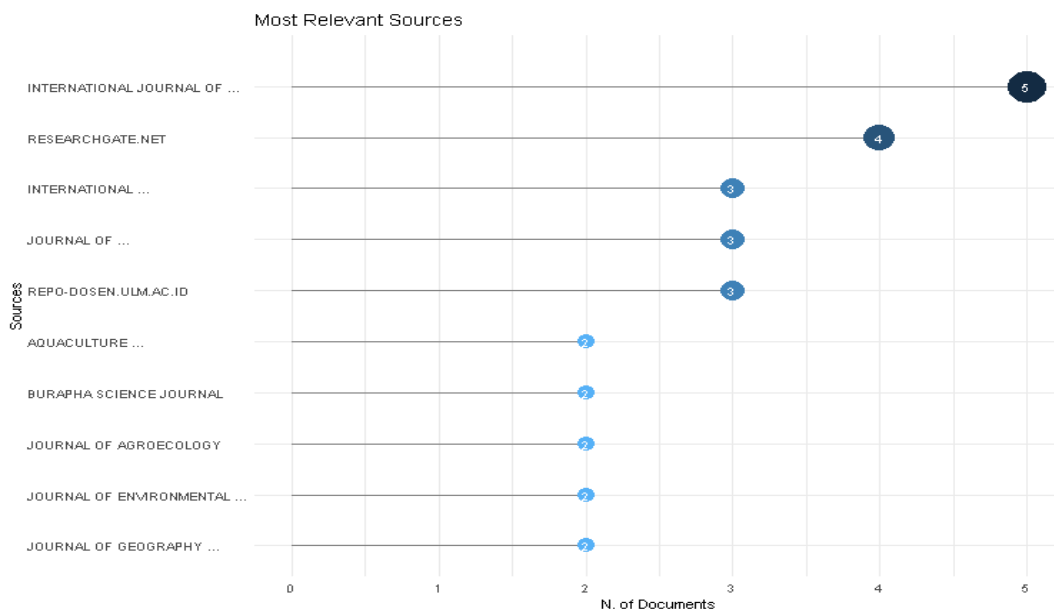
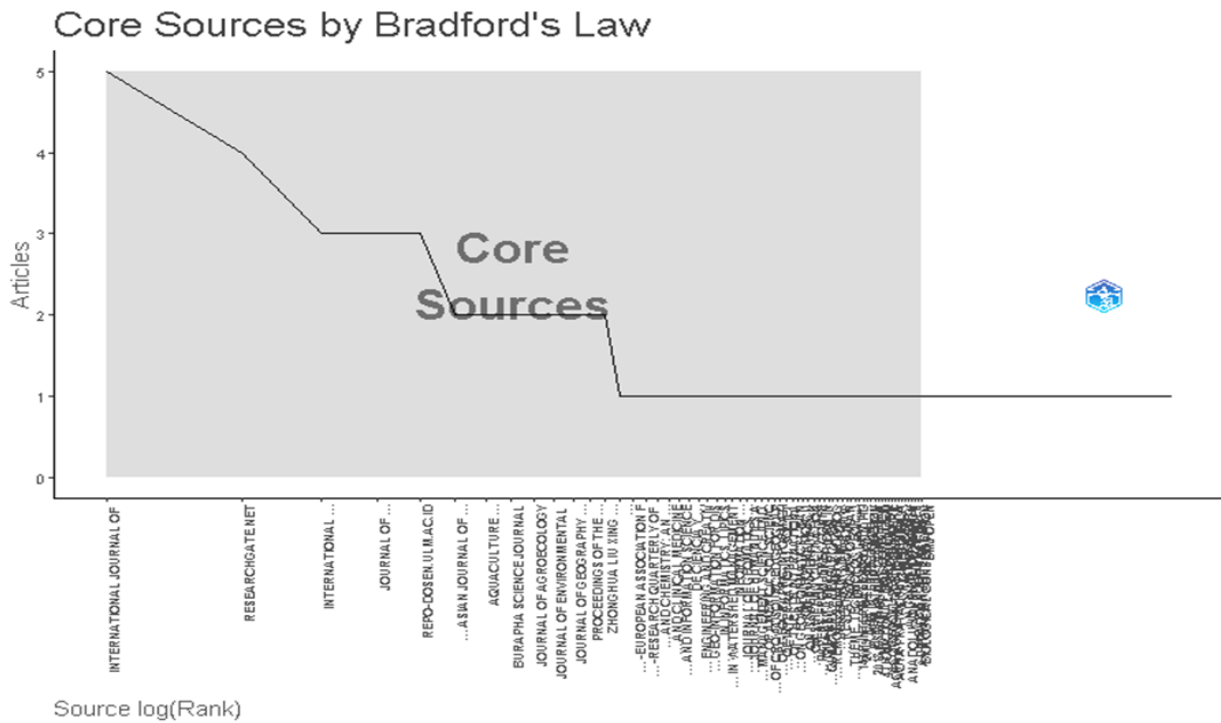


Figure 3: Most relevant sources of production
Source: Authors' construct, 2023

The major relevant sources of production of the 350 publications over the selected period are International Journal of Literature, Researchgate.NET, Burapha Science Journal, Journal of Agroecology, Journal of Environmental, Journal of Geography, and REPO-Dosen.ULM.AC.ID. These are the major sources that published these journals as generated by the biblioshiny software. The annual sources of production in Figure 3 inform the trend of publications over the years to motivate future research publications to promote state-of-the-art publications on GIS.



Source: Log (rank), 2023
Figure 4: Core sources by Bradford’s Law

Bradford's Law is a principle in library and information science that describes the distribution of journal articles within a field (Viju & Ganesh, 2013). It helps identify the core sources or journals that contribute significantly to the literature in a specific subject area.

According to Bradford's Law: Core: A small number of journals (or sources) will contribute a significant portion of the published articles in a particular field. Concentration: These core journals will be concentrated in the first few titles (or journal titles), with subsequent groups contributing fewer articles.

In Figure 4 the law is often represented graphically in three zones known as Bradford zones: Zone 1 (Core): Contains a few highly productive journals that publish a significant number of articles on the subject. Zone 2 (Near-Core): Contains more journals than Zone 1 but with fewer articles than the core journals. Zone 3 (Peripheral): Contains a larger number of journals with fewer articles than Zones 1 and 2.

In practical terms, Bradford's Law assists researchers, librarians, and information scientists in Identifying the most influential journals or sources in a specific field. Efficiently managing and selecting sources for literature reviews or research. Understanding the distribution of articles and focusing efforts on the most relevant journals.

Instead of reviewing all the 350 literature on the research topic, only these 9 most impactful publications are reviewed for identification of the research gap and direction of future research.

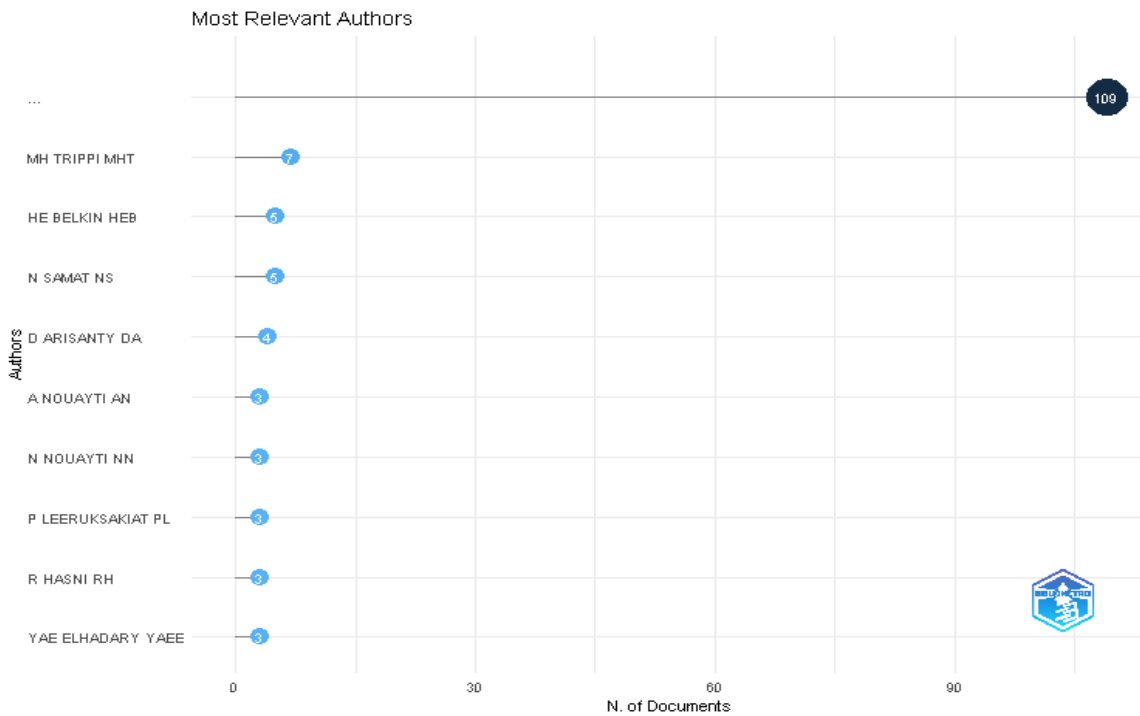


Figure 5: Most Relevant Authors
Source: Authors' construct, 2023

Determining the most relevant authors in a field like GIS involves considering those who have made significant and impactful contributions through research, publications, and innovations. Here are several influential authors known for their contributions to GIS and related fields:

Michael F. Goodchild: Known for Pioneering work in Geographic Information Science (GIScience) and spatial analysis (Longley et al., 2015). Contributions: Research on spatial data modelling, uncertainty in GIS, and spatial statistics (Goodchild, 2022). Roger Tomlinson, is often referred to as the "Father of GIS" for his pioneering work in developing the first GIS in the 1960s. Instrumental in the creation and application of GIS technology for land-use planning and resource management (AABEYIR & TUU). Helen Couclelis: Known for: Research on geographic information systems, spatial analysis, and the social implications of GIS. Work focusing on human interactions with GIS, urban planning, and behavioural geography (Couclelis, 2010).

Karen Kemp: Known for Extensive work in GIS education, remote sensing, and environmental monitoring (Kemp, 2008). Author of numerous GIS textbooks and publications, particularly in spatial analysis and environmental applications. Mark Monmonier: Known for: Contributions to cartography, geospatial intelligence, and critical analysis of GIS. Monmonier et al. (2015) Author of influential books on cartographic ethics, GIS-based surveillance, and map design. David M. Mark: Known for: Work in GIScience, spatial cognition, and geographic ontology. Contributions (Mark, 2003): Research on conceptual modelling, semantics in GIS, and geographic information modelling. Waldo Tobler: Known for: Tobler's First Law of Geography ("Everything is related to everything else, but near things are more related than distant things") (Miller, 2004). Pioneering work in spatial analysis, cartography, and geographic information science. Sarah Williams: Known for: Research on spatial analysis, urban informatics, and the intersection of technology and urban planning (Milusheva et al., 2021). Work on urban data analytics, geospatial technologies for urban planning, and civic technology.

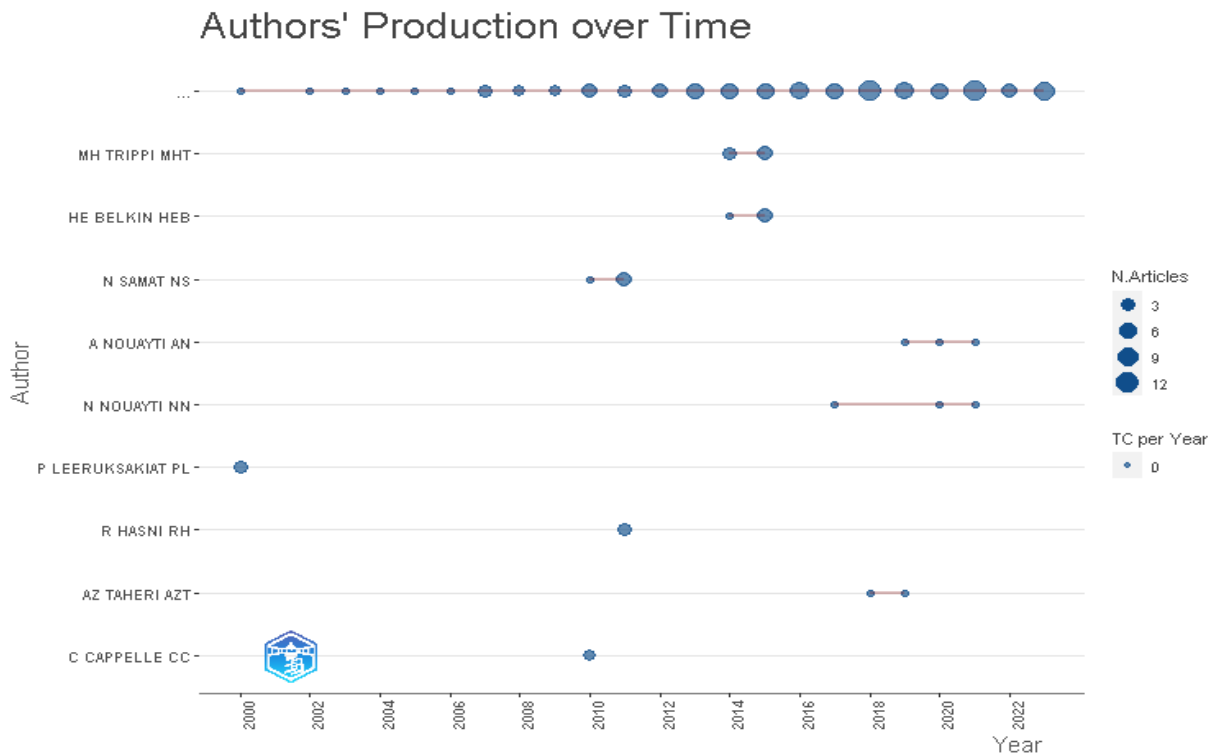


Figure: 6 Authors' production over time.

Source: Authors construct, 2023

The most relevant Authors are those who have made impactful publications so far as the research topic is concerned. Figure 6 shows that MH Trippi MHT published 7 articles as compared to other authors in the GIS discipline. In reviewing the literature on the research topic, attention will be focused on their latest publications to review their research work as they are outstanding in this field of research.

The most relevant Authors' production over time as shown in Figure 6 indicates their research publications from 2000 to 2023. Within this timeframe; the following most relevant Authors were able to publish articles and journals indicated against their names: MH Trippi MHT 7, HE Belkin HEB 5, N Samat NS 5, A Nouayti AN 3, N Nouayti NN 3, P Leeruksakiat PL 3, R Hasni RH 3, AZ Taheri AZT 2 and C Cappelle CC 2. All these are presented in Figure 6.

Table 1: Most relevant Authors research focus

NO.	Author	Title	Abstract	Research Focus	Relation to Topic
1	(Trippi & Belkin, 2015)	USGS compilation of Geographic Information System (GIS) Data of Coal Mines And Coal-Bearing Areas In Mongolia	A brief report summarizes the methodology used for the creation of the shapefiles and the chemical analyses run on the samples.	Coal Mines and Coal-Bearing Areas	Moderately related.

2	(Trippi & Belkin, 2015)	COMPS. 2015. USGS compilation of Geographic Information System (GIS) data representing Coal Mines and Coal-Bearing Areas of Mongolia	A brief report summarizes the methodology used for the creation of the shapefiles and the chemical analyses run on the samples.	Coal Mines and Coal-Bearing Areas	Moderately related.
3	(Samat et al., 2011)	Modelling land use changes at the peri-urban areas using geographic information systems and cellular automata model	The findings provide invaluable information for planners and decision-makers in managing and planning urban growth.	Urban planning.	Highly related.
4	(Saadi et al., 2021)	Application of remote sensing data and geographic information system for identifying potential areas of groundwater storage in the middle Moulouya basin of Morocco	Five thematic maps of lithology, rainfall, drainage, lineaments, and slope; were respectively categorized as they were weighed. Capaciously, they have been used to generate the map of potential groundwater storage zones.	Potential groundwater zones.	Highly related.
5	(Saadi et al., 2021)	Application of remote sensing data and geographic information system for identifying potential areas of groundwater storage in the middle Moulouya basin of Morocco	Five thematic maps of lithology, rainfall, drainage, lineaments, and slope; were respectively categorized as they were weighed. Capaciously, they have been used to generate the map of potential groundwater storage zones.	Potential groundwater zones.	Highly related.
6	(Kung, 2000)	Application of geographic information system for the estimation of shrimp farm and mangrove forest areas	Chachoengsao and Chonburi Provinces are on the east coast of Thailand and were increasingly developed for various human needs without proper	Resources planning and management.	Highly related.

		in Chachoengsao and Chonburi Provinces	coastal resources planning and management		
7	(Samat et al., 2011)	Modelling land use changes at the peri-urban areas using geographic information systems and cellular automata model	The findings provide invaluable information for planners and decision-makers in managing and planning urban growth.	Urban planning.	Highly related.
8	(Piri et al., 2019)	Areas for medicinal species of Astragalus (Astragalus Hypsogeton Bunge) using the analytic hierarchy process (AHP) and Geographic Information System 2019	The study could ultimately show that it can be obtained an optimal locality to identify medicinal plants in different areas using modern technology GIS and AHP with minimal cost and time.	Medicinal species.	Lowly related
9	(Cappelle et al., 2010)	Charpillat f. Intelligent geolocalization in urban areas using global positioning systems, three-dimensional geographic information systems and vision	Experimental results using data from an odometer, a gyroscope, a GPS receiver, a camera, and an accurate geographical 3D model of the environment illustrate the developed approach.	Geolocalization of Urban Areas	Highly related

Source: Authors' construct, 2023

The relevant Authors' articles' titles, abstracts, research focus and how they relate to the chosen topic for review are captured in Table 1. This clearly shows their research themes and focus. Out of the 9 most relevant Authors, two of them focused on developing the identification of groundwater using GIS. The other two also focused on the application of GIS in managing coal mining areas. One of them also focused on the application of GIS in the identification of medicinal species. The rest of the constituting four, focused on urban planning or settlement planning issues such as urban planning and urban development. None of these 9 Authors wrote directly on the research topic and other searches conducted outside the Publish or Perish platform, such as Google Scholar have proven that the research topic for conducting this study does not exist in the available literature.

Considering the relationship of the research topic with the focus of the 9 relevant Authors, it indicates that, 6 of their research focuses were highly related to the chosen research topic except the other three that were moderately related. The implications are that: there was limited bias in the search for literature on the

research topic. Also, the reliability of the outcome of the 350 selected literature is very high for triangulation that, the research topic is non-existent in the available literature. Conclusively, the Geographic Information System impact on Urban area management is confirmed as a research gap for researchers to explore for further research in the quest to enhance sustainable cities.

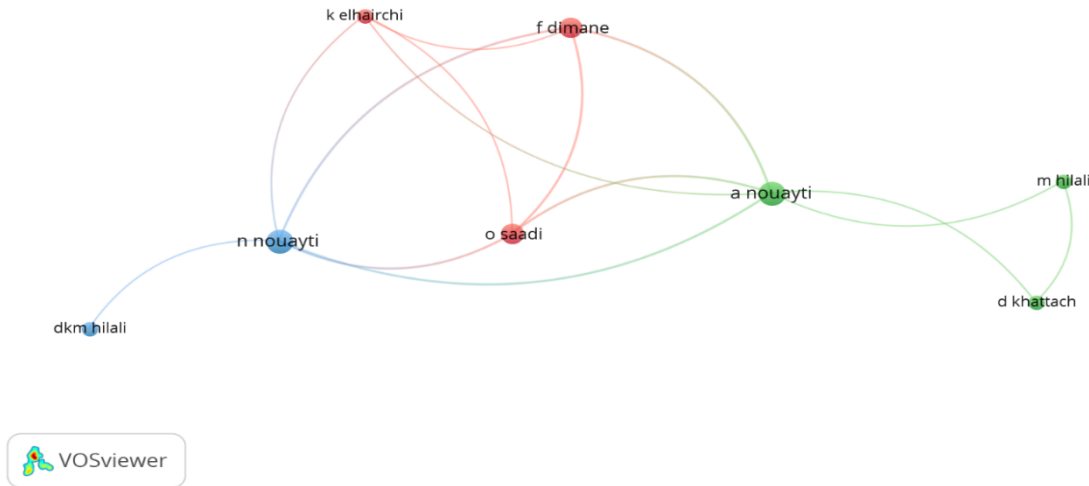


Figure 7: Co-Authorship network
Source: Authors’ construct, 2023

A co-authorship network refers to a network of collaboration among researchers or authors who have jointly authored academic papers, articles, or publications (Fagan et al., 2018). It visualizes the relationships between authors based on their collaborations within academic or research endeavours. Figure 7 indicates Co-Authorship after analysing the data through VOSviewer. It indicated that 8 of the Authors were working together which implies that they were strongly connected and collaborated in publishing some of the 350 articles journals under consideration. In the VOSviewer platform, when the cursor is placed on a particular circle or point it shows the linkages or the network of authors that teamed up with that particular author on the circle. Since the production of academic papers needs efforts and inputs from other professionals in that discipline it requires a concerted effort to publish impactful papers that are high-quality materials to add to the body of knowledge.



Figure 8: Co-Authorship co-occurrence
Source: Authors’ construct, 2023

Co-authorship co-occurrence refers to the occurrence or frequency of collaboration between authors across multiple publications or research projects within a specific field or topic (Qiu et al., 2014). It represents instances where two or more authors collaborate or co-author papers together, indicating shared contributions to scholarly work.

In Figure 8, the Co-Author Co-occurrence of the 350 articles indicates that 780 Authors were cited in this study. 309 clusters and 779 links. The link strength is 828. This implies that in this study, 780 authors contributed to the production of the articles and the journals involved. However, 309 clusters of them were in separate groups working together. 779 links across them and having a strength of 829.

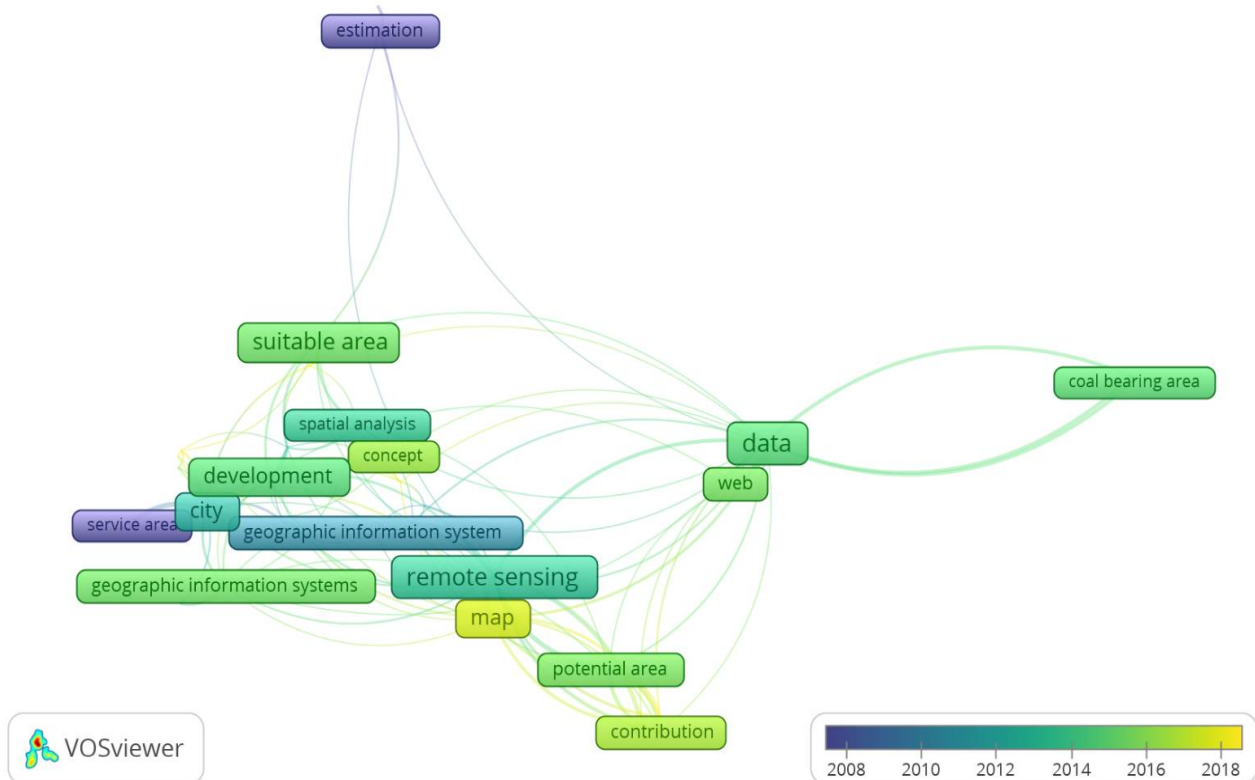


Figure 9: Term Co-occurrence
Source: Authors' Construct, 2023

Term co-occurrence refers to the appearance or frequency of two or more terms appearing together within a specific context, document, or corpus. It is a measure used in text analysis and natural language processing to identify the simultaneous appearance of words or phrases within a certain proximity of each other (Sun et al., 2017). Term co-occurrence shows the most frequently used terms in the journals and articles selected for the review.

As indicated in Figure 9, in the VOSviewer platform, there were 33 items, 6 clusters, 113 links and a total link strength of 309 as indicated in Figure 8. This shows the most frequently used terms in the journals and articles selected for the review on the research topic; geographic information system OR urban areas. A careful study of Figure 8 shows that Geographic Information System has been used frequently, however, urban areas management is completely missing on this diagram. The implication is that all the 350 publications did not focus much attention on the application of GIS in urban area management.

4. Discussion

Existing literature indicates that GIS impact on urban areas management research is still evolving and future research needs to be further expanded in the following aspects: Research on the application of GIS tools for managing urban areas is limited. Urban areas are growing rapidly which requires the application of GIS processes and mechanisms in dealing with this emerging challenge. One of the features of smart cities is the rigorous application of GIS in all spheres of the urban environment. Research on the evaluation of GIS impact on urban areas is paramount in the 21st century to inform future interventions to promote patronage in GIS applications in managing human settlements to enhance navigation, tracking and monitoring of human activities.

The relevant Authors' articles' titles and abstracts captured in Table 1 indicate their research focus. Out of the 9 most relevant Authors, 4 of them focused on developing spatial plans using GIS. The rest of them focused on different urban or settlement planning issues such as coal mining, exploring the potential of groundwater and identification of medicine species. None of these 9 Authors wrote directly on the research topic. Consequently, the most relevant Authors' research themes can be categorized into four main themes: the implementation of GIS for Urban Planning, the application of GIS for monitoring coal mining, using GIS for the identification of medicinal species and the application of GIS for the identification of groundwater potential.

The development of geospatial platforms is a novel GIS management tool for urban areas management that needs to be explored to promote sustainable cities. Publications on the research topic achieved their peak in 2021 decreased sharply in 2022 and started increasing in 2023. This implies that there is a need to reverse this trend to strengthen the application of GIS in managing human settlements and urban areas. Almost all sectors in urban areas are applying GIS in managing and controlling challenges such as big data and the application of remote sensing for proactive approaches in dealing with complex urban problems.

The dominant finding identified is the fact that none of the 350 publications focused attention on the impact of GIS on urban area management especially evaluation of GIS applications on the management of urban areas. Conceptualizing the application of GIS in managing urban areas is paramount as integration of all sectors on the GIS platform is indispensable. The core research objective for formulating this review of Geographic Information System impact on Urban Areas is accomplished for future research attention and focus on the enforcement of the GIS era in managing urban areas.

5. Conclusion

Scientific research requires empirical data for analysis and synthesis which informs the triangulation of results and findings for future direction of research. The Publish or Perish software is one the world's largest and most comprehensive collection of information resources. The search for data was conducted on 8TH January 2024. The search engine applied in the Publish or Perish interface was Google Search. The search was done using document Title Terms. The search terms were: Geographic Information System OR Urban Areas. The development of the search terms was conducted in line with the Boolean operators. The most frequent keywords in the field of Geographic information system OR Urban Areas management are geographic information system, suitable area, city, potential area, spatial analysis, remote sensing, data, web, map, development, and service area among others. Every spectrum of human life is in one way or another affected by geographic information systems. The digital revolution discourse is an intervention to promote navigation, tracking and surveillance of human activities. Leveraging on geospatial database

encompasses the composite unit of all sectors in the urban areas. Researching in specific sectors is a challenge in identifying the impact of Geographic Information Systems. In the urban certain, the entities involved in governing their jurisdiction should be for instance overarching Authorities, Regional Coordinating Councils, and Metropolitan, Municipal and District Assemblies should be evaluated to know the impact of Geographic Information Systems on their performance in policy formulation to direct GIS affairs.

The research topic remains a research gap in the existing literature as none of the 350 available literature has been published on it. All the Authors focused on specific sectors such as health, and spatial planning. Disaster resilience, urban resilience and transportation. However, there is a need to rigorously evaluate and appraise these sectors in human settlements through scientific research. Consequently, future research direction should be geared towards geographic information system impact on human settlement to propose recommendations for strengthening the GIS era.

Consequently, the paper concludes that the research directions on GIS impact on urban area management in future should include the following processes and mechanisms: the application of the state of art GIS technologies, introduction of GIS crime monitoring innovations for urban centres, robust GIS simulation innovations to enhance urban resilience and digitization of human settlements for promotion of sustainable, smart and blue cities. Finally, research into the creation of geo-spatial database platforms and data infrastructure for human or urban centres should be promoted.

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