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Global Research Development on Smart Village and Rural Digital Transformation: A Bibliometric Study

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ABSTRACT

The concepts of Smart Village and rural digital transformation have gained increasing attention as strategic approaches to promoting sustainable rural development, reducing the digital divide, and enhancing community resilience in the digital era. Over the past decade, governments, international organizations, and researchers have increasingly emphasized the role of digital technologies in improving public services, economic opportunities, social inclusion, and governance in rural areas. This study aims to analyze the global development of research on Smart Village and rural digital transformation through a bibliometric approach. Data were collected from internationally indexed scientific publications and analyzed using performance analysis and science mapping techniques. The study examines publication trends, influential authors, countries, institutions, journals, citation structures, collaboration networks, and thematic evolution within the field. The findings reveal a significant increase in scholarly interest, particularly after 2018, driven by advances in digital technologies and growing policy attention to rural innovation. Major research themes include digital infrastructure, smart governance, rural sustainability, digital inclusion, community empowerment, smart agriculture, and rural entrepreneurship. Emerging topics such as artificial intelligence, Internet of Things (IoT), smart ecosystems, and data-driven rural development indicate the evolving nature of the field. The study contributes to the literature by providing a comprehensive overview of the intellectual structure and research trends related to Smart Village and rural digital transformation, while identifying future research opportunities to support sustainable and inclusive rural development.

Keywords
Smart Village, Rural Digital Transformation, Rural Development, Digital Governance, Bibliometric Analysis, Sustainability.

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INTRODUCTION

The rapid advancement of digital technologies has fundamentally transformed economic, social, and governance systems across the globe. While urban regions have benefited significantly from technological innovation, rural communities often continue to face challenges associated with inadequate

infrastructure, limited access to digital services, and persistent socioeconomic disparities. These challenges have encouraged policymakers and researchers to explore innovative approaches that leverage digital technologies to promote inclusive and sustainable rural development. One such approach is the concept of the Smart Village**,** which integrates technological innovation, community participation, and local resource optimization to improve the quality of life in rural areas. According to the European Commission (2017), Smart Villages are communities that use innovative solutions and digital technologies to enhance resilience, strengthen local services, and create new opportunities for sustainable development.

The Smart Village concept emerged as an extension of the Smart City paradigm, adapted to the specific needs and characteristics of rural environments. Unlike Smart Cities, which often emphasize urban infrastructure and technological sophistication, Smart Villages focus on community empowerment, local participation, and context-sensitive development strategies. The objective is not merely technological modernization but also the creation of sustainable economic, social, and environmental benefits for rural populations. Visvizi and Lytras (2018) argue that Smart Villages represent an innovative framework that combines digital technologies with local knowledge and community engagement to address rural development challenges effectively.

Digital transformation has become a key driver of rural development in the twenty-first century. Rural digital transformation refers to the integration of digital technologies into governance, agriculture, education, healthcare, entrepreneurship, and public service delivery. Advances in information and communication technologies (ICTs), broadband connectivity, cloud computing, and mobile applications have expanded opportunities for rural communities to access information, markets, and public services. According to Philip and Williams (2019), digital technologies can significantly reduce geographical barriers and improve social and economic connectivity in remote areas. Consequently, digital transformation has become a strategic priority for governments seeking to bridge the urban-rural divide and foster equitable development.

The role of digital technologies in agriculture and rural economies has gained increasing attention in recent years. Emerging technologies such as artificial intelligence, the Internet of Things (IoT), remote sensing, and big data analytics are transforming traditional agricultural practices into more efficient and sustainable systems. The Food and Agriculture Organization of the United Nations (2022) emphasizes that digital innovations can improve productivity,

optimize resource utilization, enhance food security, and strengthen rural resilience. These developments have reinforced the importance of Smart Village initiatives as mechanisms for accelerating rural modernization while maintaining environmental sustainability.

The growing importance of Smart Villages is also closely linked to the achievement of the Sustainable Development Goals (SDGs). Digital technologies can contribute to multiple SDGs by promoting quality education, reducing inequalities, improving healthcare access, strengthening economic opportunities, and enhancing institutional effectiveness. According to the United Nations (2015), technological innovation and inclusive infrastructure are essential components of sustainable development. In this regard, Smart Villages provide a practical framework for implementing digital solutions that support long-term rural sustainability and social inclusion.

Academic interest in Smart Villages and rural digital transformation has expanded considerably over the last decade. Researchers have explored diverse themes such as digital governance, smart agriculture, community empowerment, rural entrepreneurship, renewable energy, digital inclusion, and social innovation. Bosworth et al. (2020) argue that successful Smart Village initiatives depend on strong stakeholder collaboration, local leadership, and the active participation of rural communities. Similarly, Zavratnik et al. (2018) highlight that Smart Villages should be viewed as holistic ecosystems that integrate technological, social, and economic dimensions of development rather than merely technological projects.

Recent studies have further emphasized the role of digital governance in enhancing public service delivery and institutional performance in rural areas. Digital governance platforms facilitate communication between governments and citizens, improve transparency, and support evidence-based decision-making processes. Komninos et al. (2022) suggest that digital governance systems can strengthen local development planning by enabling data-driven policy formulation and more efficient resource allocation. These developments indicate that digital transformation extends beyond technological adoption and encompasses broader institutional and governance reforms.

Despite the growing body of literature, research on Smart Villages and rural digital transformation remains fragmented across disciplines and geographical contexts. Existing studies often focus on specific technologies, individual case studies, or regional development programs, resulting in limited understanding of the overall evolution of the field. Furthermore, the interdisciplinary nature of Smart Village research creates challenges in identifying dominant themes, influential contributors, and emerging research

directions. Therefore, a comprehensive synthesis of the literature is necessary to provide a clearer understanding of the intellectual structure and development of this research area.

Bibliometric analysis has emerged as a powerful method for systematically evaluating scientific literature and identifying research trends. By examining publication outputs, citation patterns, collaboration networks, and thematic evolution, bibliometric studies provide valuable insights into the development of academic disciplines. Donthu et al. (2021) emphasize that bibliometric techniques are particularly useful for mapping knowledge structures and identifying future research opportunities. Similarly, Aria and Cuccurullo (2017) highlight the effectiveness of science mapping tools in visualizing relationships among authors, institutions, and research themes.

The increasing application of bibliometric methods in rural development studies has facilitated a deeper understanding of how scientific knowledge evolves over time. Through co-citation analysis, keyword co-occurrence mapping, and collaboration network analysis, researchers can identify influential studies and emerging research clusters. According to Cobo et al. (2011), science mapping techniques enable scholars to track thematic evolution and uncover conceptual relationships within a field. Such analyses are particularly valuable in rapidly evolving domains such as Smart Villages and digital transformation, where new technologies continuously reshape research priorities.

Furthermore, international organizations have increasingly recognized the strategic importance of digitalization for rural development. The Organisation for Economic Co-operation and Development (2020) emphasizes that digital connectivity and innovation are essential for enhancing rural competitiveness, improving public services, and supporting regional development. This growing policy attention has contributed to the expansion of research activities focused on rural digital ecosystems, smart communities, and technology-enabled development strategies.

Given the increasing significance of Smart Villages and rural digital transformation in addressing contemporary development challenges, a comprehensive assessment of global research trends is both timely and necessary. Therefore, this study aims to map the global development of research on Smart Village and rural digital transformation through a bibliometric analysis. Specifically, the study seeks to identify publication trends, influential authors, institutions, countries, collaboration networks, citation structures, and thematic evolution within the field. By providing a systematic overview of the literature, this study contributes to a deeper understanding of

the intellectual foundations and emerging directions of Smart Village research while offering valuable insights for policymakers, practitioners, and future researchers.

RESEARCH METHOD

This study employed a bibliometric research design to systematically analyze the global development of scholarly publications on Smart Village and rural digital transformation. Bibliometric analysis is a quantitative method used to evaluate scientific literature through publication patterns, citation structures, collaboration networks, and thematic evolution within a specific research field. This approach enables researchers to identify the intellectual structure of a discipline, influential publications, leading authors, institutions, countries, and emerging research trends. According to Donthu et al. (2021), bibliometric analysis provides a comprehensive framework for mapping scientific knowledge and understanding the evolution of academic research over time. Therefore, this method was considered appropriate for examining the development and dynamics of Smart Village and rural digital transformation studies at the global level.

The data for this study were collected from the Scopus database, one of the largest and most reputable international scientific indexing databases. The search process was conducted using the keywords "Smart Village" OR "Rural Digital Transformation" in article titles, abstracts, and keywords. Only peer-reviewed journal articles published in English were included in the dataset to ensure the quality and consistency of the analysis. After applying the inclusion and exclusion criteria, the bibliographic data were exported in CSV format and screened to remove duplicate records and irrelevant publications. The extracted information included publication year, authors, affiliations, countries, source titles, citations, abstracts, and author keywords. These data provided the basis for performance analysis and science mapping to identify publication trends and research developments in the field.

The data were analyzed using Bibliometrix in R Studio and VOSviewer software. Bibliometrix was utilized to conduct descriptive bibliometric analyses, including annual publication growth, most productive authors, institutions, countries, journals, and citation performance. Meanwhile, VOSviewer was employed to visualize co-authorship networks, co-citation relationships, bibliographic coupling, and keyword co-occurrence patterns. Furthermore, thematic evolution and cluster analyses were conducted to identify dominant and emerging research themes related to Smart Village and rural digital transformation. The findings were interpreted using performance analysis and

science mapping techniques to provide a comprehensive overview of the intellectual structure and future research directions within the field. This methodological approach offers valuable insights into the development of Smart Village research and its contribution to sustainable rural development in the digital era.

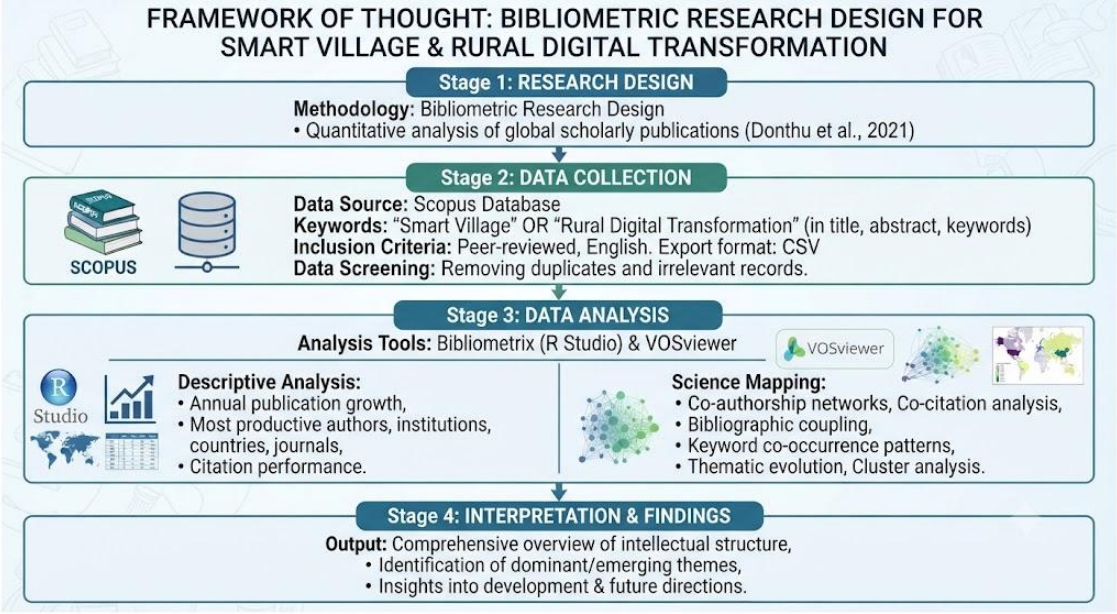

Figure 1.
Comprehensive Bibliometric Research Workflow for Smart Village and Rural Digital Transformation

This infographic presents a structured four-stage bibliometric research design tailored for analyzing scholarly publications on "Smart Village" and "Rural Digital Transformation." The workflow begins at Stage 1 with the overall Research Design, emphasizing a quantitative methodology to map the intellectual landscape of the field based on foundational literature (Donthu et al., 2021). Stage 2 details the rigorous Data Collection process, specifying the use of the Scopus database, precise keyword combinations, language and publication-type restrictions (peer-reviewed English articles), and a thorough screening process to ensure the dataset's quality and relevance by removing duplicates and irrelevant records.

Moving into the core analysis phase, Stage 3 illustrates how the cleaned bibliographic data is processed using specialized tools. The workflow bifurcates into two primary analytical streams: "Descriptive Analysis," performed with Bibliometrix in R Studio to evaluate publication performance metrics like annual growth and key contributors, and "Science Mapping," executed in VOSviewer to visualize complex relationships such as co-authorship networks, bibliographic coupling, and thematic clusters. Finally, Stage 4 consolidates these

analyses into "Interpretation & Findings," where the results are synthesized to provide a comprehensive overview of the intellectual structure, identify dominant and emerging research themes, and offer critical insights into future research directions.

RESULTS AND DISCUSSION

Results

The network visualization generated using VOSviewer in the study entitled *"Global Research Development on Smart Village and Rural Digital Transformation: A Bibliometric Study"* reveals a structured pattern of relationships among keywords within the global literature on rural digitalization and smart rural development. The analysis identifies two dominant clusters interconnected through several bridging keywords, particularly "smart village," "rural development**,"** and "digital transformation," which function as central nodes linking traditional rural development concepts with emerging digital innovation themes. On the left side of the network, a red cluster is observed, consisting of keywords such as "rural development," "community empowerment," "sustainability," "local development," "social innovation," and "rural governance.**"** These nodes are closely interconnected, indicating strong co-occurrence relationships and reflecting the traditional focus of rural development studies on community participation, local capacity building, sustainable livelihoods, and territorial development. The density and proximity of these keywords suggest a mature and well-established body of literature emphasizing rural resilience and sustainable community development as the foundation of rural transformation.

Conversely, the right side of the network is dominated by a green cluster that includes keywords such as "smart village," "digital transformation," "ICT," "smart agriculture," "Internet of Things (IoT)," "digital governance," and "digital inclusion." This cluster reflects the increasing scholarly interest in the integration of digital technologies into rural development strategies. Compared to the traditional rural development cluster, the nodes within this group appear more dispersed, indicating relatively newer but rapidly evolving research areas. The connections between the red and green clusters are moderately strong, suggesting an increasing convergence between conventional rural development approaches and technology-driven innovation. This pattern demonstrates that contemporary Smart Village research is evolving beyond traditional community development frameworks toward digitally enabled ecosystems that promote innovation, connectivity, and sustainable growth. Overall, the network visualization illustrates a significant transition from

conventional rural development paradigms toward integrated models of digital transformation and smart rural governance.

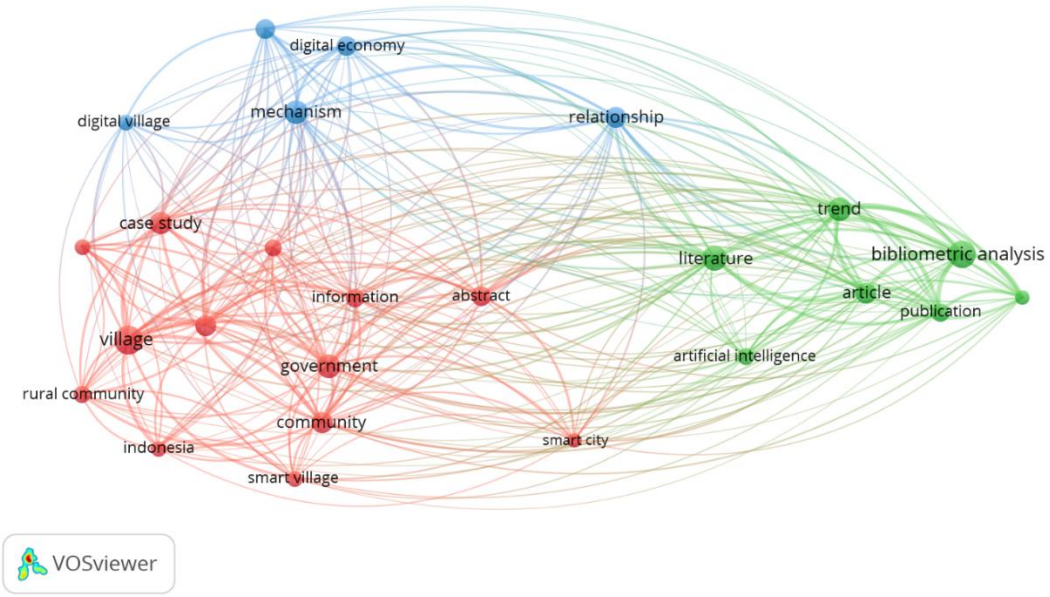

Figure 2.
Network Visualization of Research Themes on Smart Village and Digital Rural Development Using VOSviewer

Figure 1 presents the network visualization generated using VOSviewer, illustrating the relationships among the most frequently occurring keywords in the literature on smart villages and digital rural development. The visualization identifies three major thematic clusters that represent the conceptual structure of this research field. The red cluster is centered on keywords such as *village*, *government*, *community*, *smart village*, *Indonesia*, *rural community*, and *case study*, indicating that many studies focus on village governance, community empowerment, and rural development practices. The blue cluster includes keywords such as *digital economy*, *digital village*, *mechanism*, and *relationship*, highlighting the growing emphasis on digital transformation, technological innovation, and the mechanisms that support sustainable rural development. Meanwhile, the green cluster consists of keywords including *bibliometric analysis*, *trend*, *literature*, *publication*, *article*, and *artificial intelligence*, reflecting the increasing use of bibliometric methods to evaluate scientific development and identify emerging research trends within the smart village domain.

The network structure also demonstrates that several keywords function as central nodes connecting different research themes. The keyword *village* appears as one of the largest and most interconnected nodes, indicating that it

serves as the primary focus of the literature. Strong relationships between *village*, *government*, *community*, and *smart village* suggest that rural development is widely examined through the perspectives of governance, community participation, and local institutional capacity. Similarly, the close connections among *digital village*, *digital economy*, and *mechanism* indicate that researchers increasingly investigate the role of digital technologies in promoting economic growth, improving public services, and strengthening rural governance. The dense linkages across clusters illustrate that smart village research has evolved into a multidisciplinary field integrating public administration, rural development, digital innovation, information systems, and economic development.

Furthermore, the visualization reveals that bibliometric studies have become an important component of contemporary smart village research. The prominence of keywords such as *bibliometric analysis*, *trend*, *literature*, and *publication* demonstrates a growing academic interest in mapping scientific knowledge, identifying influential research themes, and exploring future research directions. At the same time, the presence of emerging keywords such as *artificial intelligence*, *digital economy*, and *digital village* suggests that the research landscape is gradually shifting toward technology-driven rural transformation. These findings indicate that future studies should place greater emphasis on integrating digital technologies, artificial intelligence, sustainable governance, and community participation to accelerate rural innovation and improve the quality of life in rural areas. Consequently, Figure 1 provides a comprehensive overview of the intellectual structure of smart village research while highlighting both established themes and emerging opportunities for future scholarly investigation.

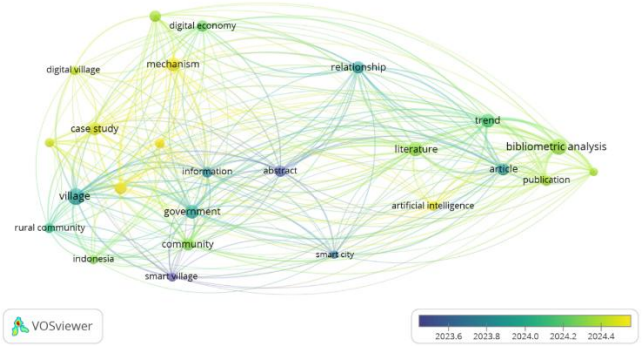

Figure 3.
Overlay Visualization of Research Trends on Smart Village and Digital Rural Development.

Figure 2 presents the overlay visualization generated using VOSviewer, illustrating the temporal evolution of research themes related to smart villages and digital rural development during the period 2023–2024. The overlay map applies a color gradient to indicate the average publication year of each keyword, where dark blue represents earlier publications, green indicates intermediate periods, and yellow denotes the most recent research topics. The visualization reveals that the research field has gradually shifted from emphasizing foundational concepts such as *smart village*, *government*, *relationship*, *abstract*, and *smart city* toward more practical and technology-oriented issues. At the center of the visualization, the keyword *village* maintains strong connections with numerous related concepts, confirming its role as the core theme in the smart village literature. The dense network of relationships further indicates that rural development research increasingly integrates governance, technology, digital transformation, and community development within a comprehensive interdisciplinary framework.

The overlay visualization also demonstrates that several keywords have emerged as recent research hotspots. Keywords such as *mechanism*, *case study*, *digital village*, *artificial intelligence*, and *information* appear in yellow, indicating that these topics have received increasing scholarly attention during 2024. This trend reflects a growing interest in understanding how digital technologies, artificial intelligence, and innovative governance mechanisms can accelerate rural transformation and improve the quality of public services. In addition, the increasing prominence of *digital village* and *digital economy* suggests that researchers are focusing more extensively on the economic and technological dimensions of rural development. Meanwhile, keywords such as *relationship*, *government*, *village*, and *smart village*, which appear in blue and green shades, represent well-established research themes that continue to provide the conceptual foundation for contemporary smart village studies.

Furthermore, the visualization highlights the dynamic evolution of smart village research toward evidence-based and innovation-driven rural development. The close relationships among *bibliometric analysis*, *trend*, *publication*, *literature*, and *article* indicate that bibliometric methods have become increasingly important for evaluating scientific productivity, identifying influential research themes, and mapping future research directions. At the same time, the integration of emerging topics such as *artificial intelligence*, *digital economy*, and *digital village* demonstrates that technological innovation is becoming a strategic component of sustainable rural governance. These findings suggest that future studies should place greater emphasis on interdisciplinary approaches that combine digital technology, artificial

intelligence, public governance, and community participation to strengthen rural resilience, promote inclusive economic growth, and support the successful implementation of smart village initiatives in both developing and developed countries.

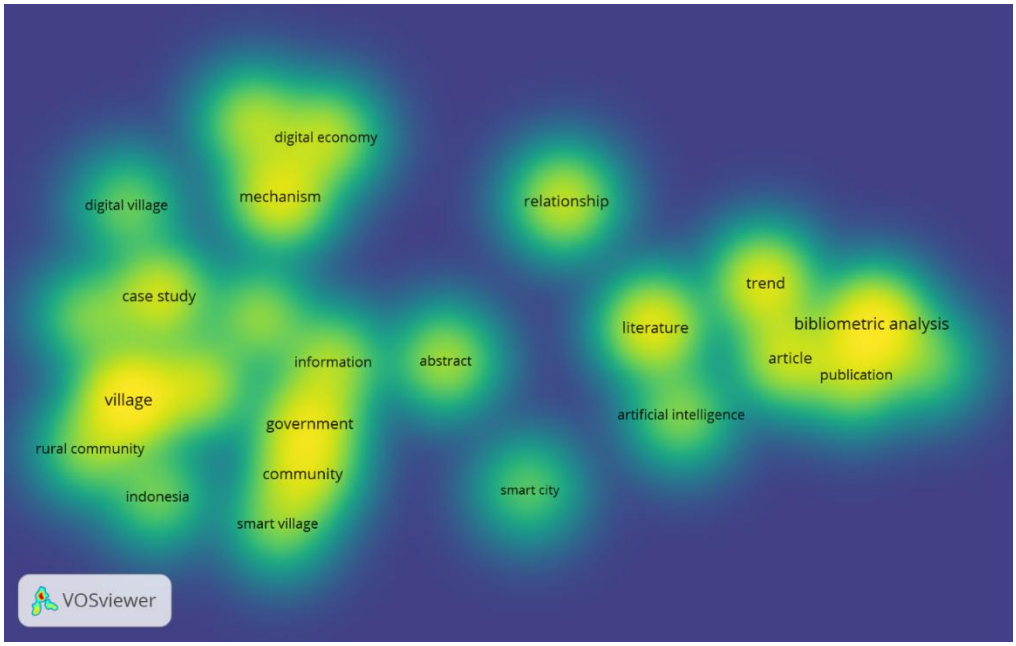

Figure 4.
Density Visualization of Research Keywords on Smart Village, Digital Economy, and Bibliometric Analysis

Figure 3 presents the density visualization generated using VOSviewer, illustrating the concentration and frequency of keyword occurrences within the selected literature. In this visualization, brighter yellow areas indicate keywords with higher occurrence frequencies and stronger relationships with other terms, whereas green and blue areas represent keywords that appear less frequently or have weaker associations. The figure reveals that the most prominent hotspots are concentrated around the keywords village, government, mechanism, bibliometric analysis, publication, literature, and trend, suggesting that these topics constitute the dominant research focus within the Smart Village and digital governance literature. Their high density indicates that these concepts have been extensively investigated and frequently co-occur across numerous scholarly publications.

The visualization also demonstrates that research concerning village development is closely integrated with governance and community-related concepts. Keywords such as government, community, smart village, information, and rural community form an interconnected density region, highlighting the emphasis of previous studies on rural digital transformation,

local governance, and community participation. Likewise, the concentration surrounding digital economy and mechanism suggests that scholars increasingly examine the institutional processes, policy frameworks, and technological mechanisms that facilitate digital economic development in rural areas. These dense thematic areas indicate the maturity of research addressing governance transformation and digital innovation within village administration.

Conversely, several keywords remain located in lower-density regions, including artificial intelligence, smart city, relationship, digital village, and abstract. Their relatively lower intensity suggests that these topics have not yet received the same level of scholarly attention as the dominant governance-related themes. In particular, artificial intelligence appears as an emerging research direction with considerable potential for future investigation, especially regarding its application in supporting Smart Village governance, public service delivery, decision-making systems, and sustainable rural development. Therefore, the density visualization not only identifies well-established research domains but also highlights existing knowledge gaps, providing valuable guidance for future studies seeking to expand the theoretical and practical development of Smart Village research through interdisciplinary and technology-driven approaches.

Discussion

The density visualization provides a comprehensive overview of the intellectual structure of Smart Village research by identifying the most intensively studied themes within the scientific literature. The brightest areas are concentrated around the keywords village, government, mechanism, bibliometric analysis, publication, literature, and trend, indicating that these concepts have become the primary foundation of contemporary Smart Village studies. This finding suggests that the development of Smart Villages is predominantly examined from governance and institutional perspectives, where government intervention, policy mechanisms, and community development play central roles. The prominence of these keywords reflects the growing recognition that successful rural digital transformation depends not only on technological innovation but also on effective governance structures and institutional capacity capable of supporting sustainable rural development.

The visualization further demonstrates a strong relationship between governance-related concepts and rural digital transformation. The close proximity among the keywords government, community, smart village, rural community, and information indicates that researchers increasingly emphasize participatory governance, citizen engagement, and information accessibility in

the implementation of Smart Village initiatives. This pattern is consistent with the Smart Village framework, which views digital technology as an enabler of inclusive public services, economic empowerment, and social development rather than merely a technological intervention. The integration of governance and community-oriented themes suggests that successful Smart Village implementation requires collaboration among local governments, communities, academic institutions, and private stakeholders to ensure that digital innovation effectively addresses local needs and improves rural welfare.

Another important finding is the relatively high density of the keywords digital economy and mechanism, highlighting the increasing scholarly attention given to rural economic transformation through digital technologies. The digital economy has emerged as a strategic component of Smart Village development because it enables rural communities to access broader markets, strengthen local entrepreneurship, improve financial inclusion, and enhance productivity through digital platforms. The strong linkage between digital economy and governance-related concepts indicates that institutional support, regulatory frameworks, and implementation mechanisms remain essential factors influencing the success of digital transformation in rural areas. Consequently, Smart Village research increasingly recognizes that technological infrastructure alone is insufficient without appropriate governance mechanisms and policy coordination.

Conversely, several keywords such as artificial intelligence, smart city, relationship, and digital village appear in lower-density areas, suggesting that these topics remain relatively underexplored. Although artificial intelligence has attracted considerable attention in broader digital governance research, its application within Smart Village development has not yet become a dominant research theme. This finding represents a significant research opportunity, particularly considering the growing potential of artificial intelligence to support precision agriculture, intelligent public services, predictive decision-making, resource management, and data-driven village governance. Similarly, the relatively limited connection between Smart Village and Smart City concepts indicates that comparative studies examining knowledge transfer between urban and rural digital transformation remain scarce and deserve greater scholarly attention.

Overall, the density visualization reveals that Smart Village research has reached a relatively mature stage in governance, community participation, and digital economic development while simultaneously identifying several emerging research directions. Future studies should move beyond traditional governance perspectives by integrating advanced digital technologies such as

artificial intelligence, big data analytics, the Internet of Things (IoT), blockchain, and digital twins into rural development models. Such interdisciplinary approaches will not only enrich the theoretical foundation of Smart Village research but also provide practical solutions for enhancing public service quality, strengthening rural resilience, promoting sustainable economic growth, and accelerating the achievement of inclusive and sustainable rural development goals.

CONCLUSION

This bibliometric analysis demonstrates that Smart Village research has experienced significant development, with governance, village development, digital economy, community participation, and policy mechanisms emerging as the dominant themes in the literature. The VOSviewer visualizations reveal strong interconnections among these keywords, indicating that digital transformation in rural areas is primarily driven by effective governance and institutional support. At the same time, the analysis identifies several emerging topics, particularly artificial intelligence, smart city integration, and advanced digital technologies, which remain relatively underexplored despite their substantial potential to enhance rural governance and sustainable development. Overall, the findings provide a comprehensive overview of the current intellectual landscape of Smart Village research while highlighting future opportunities for expanding interdisciplinary studies that integrate technological innovation with inclusive and sustainable rural development.

Future research should broaden the scope of Smart Village studies by incorporating emerging technologies such as artificial intelligence, the Internet of Things (IoT), big data analytics, blockchain, and digital twins into rural governance and public service models. Researchers are also encouraged to conduct comparative studies across countries and regions to identify best practices and develop more comprehensive theoretical frameworks for Smart Village implementation. Furthermore, policymakers should strengthen collaboration among governments, academic institutions, local communities, and the private sector to accelerate digital transformation, improve governance quality, and ensure that Smart Village initiatives contribute effectively to sustainable rural development and long-term community welfare.

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