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Increased Attention to Smart Development in Rural Areas: A Scientometric Analysis of Smart Village Research

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Abstract: As the research on smart cities matures and thrives, research focusing on smart rural development has also emerged into the spotlight in recent years. An increasing number of scholars have called for extending the discussion of smart development in the rural context. In response, this paper aims to conduct a comprehensive scientometric review of the current academic literature in the discussion of smart development in rural areas, centering on the concept of the smart village, which is the most recognized concept in the existing literature and practices. The contributions of this study are threefold. First, an overview of the current implementation and understanding of smart village initiatives and conceptual frameworks provides practical and theoretical insights as prerequisites for comprehending the concept. Second, to the best of our knowledge, this is the first complete scientometric study in the smart village field and will establish baseline data for future analysis and comparison. It describes the status of the scientific landscape based on quantitative analysis and an intuitive visualization, identifying patterns, hotspots, trends, and gaps. Finally, we find that the current trend puts a relatively narrow focus on the technology-driven approaches, while the dimensions of society, services, and culture have been largely neglected. Therefore, a dynamic conceptual model is proposed to call for more human-driven perspectives. We believe that a knowledge-based, community-led, and human-centric rural society is the core of a smart village ecosystem.

Keywords: smart village; smart rural development; scientometric; science mapping; model

Citation: Wang, Q.; Luo, S.; Zhang, J.; Furuya, K. Increased Attention to Smart Development in Rural Areas: A Scientometric Analysis of Smart Village Research. *Land* **2022**, *11*, 1362. https://doi.org/10.3390/land11081362

Academic Editors: Marco Locurcio, Francesco Tajani and Debora Anelli

Received: 31 July 2022
Accepted: 18 August 2022
Published: 21 August 2022

1. Introduction

In the 2030 Agenda for Sustainable Development, the United Nations committed to 17 sustainable development goals (SDGs), highlighting the question of how we can make communities and their settlements more sustainable [1]. Within existing initiatives and practices, one of the most promising answers towards achieving higher levels of sustainability and meeting SDGs is to make communities "smart(er)" [2–4]. Many global, national, and regional agendas have adopted the notion of "smart" as a central debate in the vision of the future [5–7]. Although the term "smart" appears to be a malleable concept in response to the realities of divergent agendas, the broad conceptual definitions appear to be convergent [8–10]. The label of "smart", in general, can be regarded as a growing concept that involves fostering digital technology, intelligence, innovation, resilience, and sustainability in community development.

Recently, research on smart cities has gained a significant amount of momentum and still continues unabated, attracting diverse debates that contribute to interdisciplinary approaches and reflections [11–14]. However, a common theme in smart city research is its focus on large urban areas with a high population density and easy access to technology, resources, and infrastructure [15]. Rural areas, on the other hand, have been neglected in this wave of development.

Rural areas, compared with metropolitan areas, are significantly restricted by negative constraints such as depopulation, a low degree of accessibility, digital illiteracy, and inadequate infrastructure [16–19]. It has been pointed out that rural areas risk being left even further behind and marginalized during the next stage of technological innovation, since technologies are framed within an urban and neo-liberal approach to development [20,21]. Although technologies such as AI and blockchain are opening up new frontiers of productivity and opportunities [22,23], they can also exacerbate the exclusion of underdeveloped regions with lower levels of technology adoption and usage. The digital divide, as warned by the UN deputy chief, might become "the new face of inequality" [24].

To overcome the digital divide and reduce inequalities, more attention has been focused on smart rural development. Some researchers believe that smart city research can be seen as a scalable approach to be applied equally to the study of social phenomena unfolding at the level of villages as well as cities [25]. Some argue that rural regions form a typology of regions whose identity and composition are distinct from most urbanized regions [16]; hence, the solutions proposed should also be different [26]. Although existing smart city research paradigms and approaches have paved the way for smart rural development, rural areas still need more targeted responses. Smart rural development initiatives and approaches, commonly termed "smart villages", are regarded as a vital solution that combats the rural decline due to remoteness and depopulation. As the research on smart cities matures and thrives, research focusing on rural areas has emerged into the spotlight in recent years [27,28]. Thus, an increasing number of scholars have called for extending the discussion of smart development in rural areas [21,29,30].

With the increase in the number of academic publications, it is critical to synthesize the existing knowledge and provide evidence-based insights for future studies. Previous scholars have reviewed this field from different perspectives using several approaches. Zavratnik et al. [7] conducted a comprehensive qualitative review of the initiatives and practices focusing on the smart village concept and the importance of digital transformation in rural areas. Stojanova et al. [31] provided a thorough review and synthesis of rural development policies closely related to the concept of smart villages through a literature review and online surveys. Although traditional reviews play an important role in providing up-to-date knowledge, they also have limitations, such as being prone to subjective bias and having no explicit structure for gathering and presenting evidence [32,33]. Systematic reviews have emerged as an alternative to traditional reviews for more scientific and transparent reporting of research in an evidence-based, structured, and pre-defined protocol that requires rigorous methods [34,35]. Mishbah et al. [36] constructed a conceptual model of a smart village through a systematic review and meta-analysis based on 56 articles. Mukti et al. [37] conducted a thorough systematic literature review in order to formulate a theoretical model that explains the causal mechanisms of rural smartness and its impact based on 119 articles. Gerli et al. [38] conducted a systematic review of 79 documents and emphasized the definition and characterization of a smart village. However, most of the existing systematic reviews are based on a limited number of articles and were conducted using a simplified process. Bibliometrics, as a wider term for scientometrics, provides more objective and reliable analyses of the "big picture" view of existing research based on quantifiable and observable data [39–41]. However, bibliometric or scientometric studies of smart villages are scarce. We are only aware of one study that used bibliometric analysis to identify the limited interventions of smart villages in Greece, which restricted the document publication year to the time period from 2010 to 2021 and focused only on the global trends of conceptual and planning approaches to smart villages [17].

To summarize, the existing reviews of smart village research mainly focus on the following themes: initiatives, practices, and policies; conceptual or theoretical components, frameworks, and models; measures and indicators for evaluation or assessment; and, finally, research trends and topics. Thus, the current reviews do not provide a quantitative, in-depth, and comprehensive overview of smart village research.

In response, this paper aims to conduct a comprehensive scientometric review to fill the gaps in previous literature reviews. We focus on the current academic literature in the discussion of smart development in rural areas, centering on the concept of the smart village, which is the most recognized concept in the existing literature and practice. This paper provides a detailed overview of smart villages based on the following research goals:

1. Review current understandings and implementations related to smart village initiatives and outline a classification system for smart village research topics;
2. Describe the historical and geographic distributions of publications related to smart village research;
3. Identify the influential contributors and collaboration patterns between differently sized communities;
4. Visualize the knowledge base of this field and depict conceptual and intellectual structures;
5. Reveal the research evolution trend to identify research hotspots and frontiers;
6. Propose a conceptual model capable of displaying an overview of the structure of a smart village ecosystem.

The remainder of this paper is structured as follows. Section 2 describes the methodology of this study. Section 3 presents the results. Section 4 discusses some of the findings. Section 5 provides our conclusions and states the limitations of this study and prospects for further research.

2. Methodology

In recent decades, scientometrics [42] has been broadly adopted as a quantitative approach for evaluating existing scientific activities and impacts, identifying transformative patterns, depicting knowledge landscapes, and predicting emerging trends in various scientific fields [43–46].

2.1. Study Design

The scientometric analysis involved a six-step procedure adapted from the general workflow proposed by Zupic and Čater [47], which is a recommended standard workflow for science mapping research using bibliometric methods [48]. The overall workflow is described in Figure 1.

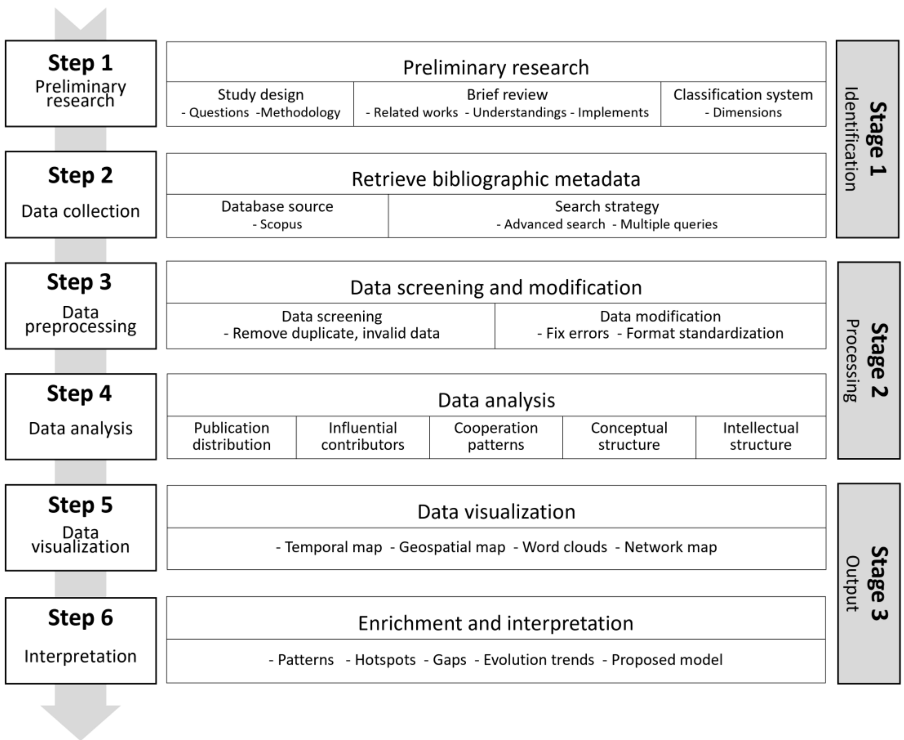


Figure 1. Workflow of the research.

2.2. Data Collection and Preprocessing

In terms of data sources, we chose Scopus as the database for data collection in this research for the following reasons. First, Scopus is one of the largest and most reliable global databases with broad, comprehensive, and high-quality research coverage [49]. Second, considering the two most widely used and important bibliographic databases (Web of Science and Scopus), Scopus provides better coverage of the social sciences [50,51] and delivers fewer inconsistencies regarding content verification and content quality [52]. Third, other scholars have used Scopus to perform scientometric analysis in related areas [53–55].

The performance of the search strategy largely influences the results of the analysis. As the field has a multidisciplinary nature, except for "smart village", there are similar or related concepts regarding smart rural development (e.g., smart rural areas, smart countrysides, and smart rural communities). In this case, we adopted several search queries with multiple terms and refined the results within those mainly targeting rural areas with the Boolean operators "OR" and "AND". The search strategy adopted a fuzzy search denoted by the asterisk (*), which allows for heterogeneous enders or starters of the adopted terms to be found to capture relevant variations of a word. Regarding document type, we included articles, reviews, and conference papers for more comprehensive coverage and confined the language to English documents. The final search was conducted on 6 November 2021 (for details, see Table A1).

Although the majority of bibliographic records retrieved from queries are reliable, they inevitably contain errors, such as duplicate records, misspellings, inconsistent formats, and missing information [48,56], and, in our case, irrelevant documents resulting from the fuzzy search. During the data collection phase, we manually screened the records according to their titles and abstracts to expel irrelevant documents for the first round. We then aggregated the data obtained from multiple queries and removed duplicates, finally reducing the sample to 425 documents published between 1998 and 2021. For data preprocessing, we used a combination of R and Excel, and further data cleaning was performed to standardize formats, fix detectable errors, and add missing information.

2.3. Techniques and Tools

Bibliometrics, or contemporary scientometrics, incorporates two main approaches: performance analysis and science mapping [57–59]. Performance analysis concentrates on assessing the activity of scientific actors (e.g., authors, institutions, countries, and journals) and the impacts based on publications, citations, and collaborations. The most common metrics are total publications (TP) and total citations (TC), where TP is a proxy for productivity and TC measures impact and influence. Other metrics, such as citations per publication (TC/TP) and the h-index [60], combine both citations and publications to measure the performance of research constituents. Science mapping, or bibliometric mapping, explores the intellectual structures and dynamic patterns of scientific research [42,61]. The most commonly used techniques are co-citation analysis [62], co-word analysis [63], and co-authorship analysis [64]. Co-citation analysis assumes that frequently co-cited publications are thematically similar and is used to analyze the knowledge base constructed by academic communities. Co-word analysis studies the co-occurrence relationships of phases or words extracted from keywords, titles, or abstracts to reveal the conceptual structure of a research field. Co-authorship analysis examines the interactions among authors and their affiliations to study social structure and collaboration networks. When combined with network analysis and clustering, such techniques are instrumental in presenting the patterns and structures of the research field [65].

Cobo et al. [66] compared nine bibliometric analysis tools and concluded that no single tool could provide a fully complete suite of bibliometric analyses. Therefore, we performed a scientometric analysis through the combined use of two powerful and pragmatic bibliometric tools, namely the bibliometrix R-tool and VOSviewer. Bibliometrix was developed by Aria and Cuccurullo [48] based on the R language and is an open-source tool for performing comprehensive science mapping analysis that can be integrated well with other statistical R-packages and bibliometric software. VOSviewer, developed by Van Eck and Waltman [67], is a professional program for constructing and visualizing bibliometric maps. Bibliometrix contains a more extensive set of analytical techniques and provides a user-friendly interface (called "Biblioshiny") for practitioners, whereas VOSviewer provides a better visualization of networks.

3. Results

3.1. Preliminary Study

In this step, we conducted a preliminary study to obtain a better understanding of the subsequent interpretation of the results of the scientometric analysis, mainly addressing two questions. First, what are the current understandings and implementations of smart villages? Second, assuming that a smart village is an integrated system, what are its basic dimensions based on existing studies?

3.1.1. Current Understandings and Implementations

In the late 1990s, the smart growth movement, which initially targeted urban spawl issues in the United States, inspired a widespread discussion about and the implementation of the notion of "smart" [68–70]. Meanwhile, the widespread and rapid evolution of information and communication technologies (ICTs) provided new opportunities and instruments [71,72]. More inter-related concepts emerged in public discussions and social science conferences. Earlier concepts included smart communities and smart communities in urban areas, that is, smart cities. Soon, they entered social and political initiatives on multiple levels, from the local to the supranational [5]. The switch in attention towards rural communities only occurred during the last decade.

Similar to the smart city concept, there is a lack of a consensus on the origin, definition, and conceptualization of the 'smart village'. In EU countries, the implementation of the Europe 2020 strategy in 2010 is regarded as the beginning of the smart village movement [4]. The Europe 2020 strategy indicated three inter-related priorities: smart, sustainable, and inclusive growth leading to greater rural development [73]. In the EU policy framework, smart growth is applied in a knowledge context, including policies for innovation, education, and research [27]. In South and Southeast Asia, since India was one of the first countries to apply the smart village concept within national missions, some researchers [74,75] believe that the smart village concept was first introduced by Indian scholars in a book entitled "Design of Smart Village" [76]. This book mapped out an integrated design procedure for building a smart village ecosystem to deal with the demographic deficit and achieve the goal of inclusive growth.

The diffusion initiatives and practices in countries with different needs and contextual conditions make it difficult to identify shared opinions and common trends on a global scale [77]. A brief review of current worldwide initiatives may provide more insights for understanding smart villages from a pragmatic perspective. We list some of the most representative practices in Table 1.

In 2017, the European Commission launched the EU Action for Smart Villages, which was aimed at villages that were in decline due to remoteness and depopulation. The plan contained a pragmatic definition of smart villages as "rural areas and communities that build on their existing strengths and assets as well as develop new opportunities" [83]. To be more specific, in the EU framework, smart villages are local rural communities that use digital technologies and innovations in their daily life, thus improving their quality of life and the standard of public services and ensuring better use of local resources. This is the first official and most often repeated definition of a smart village [26].

Table 1. Current global initiatives and regional or national agendas related to smart villages.

Year	Project or Program	1. Worldwide Initiatives Objectives	Affiliation	Source
2011	Climate-Smart Villages (CSVs)	To help farmers adapt to climate change	CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS)	[78]
2014	Smart Village Initiative (SVI)	To look at technical, entrepreneurial, and policy solutions to provide sustainable energy for off-grid rural community development	Smart Villages Research Group	[79]
2014	IEEE Smart Village (ISV)	To support the world's energy-impoverished communities with renewable energy, community-based education, and entrepreneurial opportunities	IEEE Inc.	[80]
Year	**Region or Nation**	**2. Regional or National Agendas Representative Strategic Agendas**	**Vision**	**Source**
2010	Malaysia	In 2010, the idea of Smart City Smart Village (SCSV) was presented and approved by Malaysia's Global Science and Innovation Advisory Council (GSIAC).	To improve everything from energy use to healthcare, education, traffic, and shopping by doing it "smart" with the help of ICT and green technology.	[81]
2016	India	The Government of India has proposed the Shyama Prasad Mukherji Rurban Mission (SPMRM), or the so-called Smart Village program, aimed at developing such rural areas by the provision of economic, social, and physical infrastructure facilities.	To make villages smart and the growth centers of the nation. To develop a cluster of villages that preserve and nurture the essence of rural community life with a focus on equity and inclusiveness, without compromising the facilities perceived to be essentially urban in nature.	[82]
2017	European regions	In 2017, the European Commission launched the EU Action for Smart Villages, which aimed to prevent villages from declining due to remoteness and depopulation.	To initiate some reflections on the villages of the future based on a shared vision of balanced development in European regions and the need to provide rural areas and villages with opportunities for growth.	[83]
2019	China	The Chinese government issued the "Smart (Digital) Village Development Strategy Outline" in order to realize the sustainable development of rural areas through the construction of Smart Villages.	To revitalize rural areas in an all-round way, with a strong agricultural sector, a beautiful countryside, and full realization of farmers' wealth by 2050.	[84,85]

Note: Compiled by the authors.

In conclusion, in underdeveloped and developing areas, smart village initiatives mainly focus on revitalizing rural areas through the agriculture sector or addressing the lack of resources, basic infrastructure, and services (e.g., energy, water, education, food, and employment). In developed regions such as Europe, initiatives are implemented in areas already equipped with basic infrastructure and, hence, target different challenges such as the lack of productivity, knowledge innovation, and specialization. Thus, 'smart village' is a fluid concept with different priorities depending on realistic situations, and the central idea is to stimulate the endogenous development potential of rural areas.

3.1.2. Dimensions of a Smart Village

A village is a complex system composed of various dimensions and components. We aimed to identify the basic dimensions of a smart village and use them in a classification system to better understand the corresponding results of the scientometric analysis and develop a conceptual model.

Table 2 outlines the key dimensions of a smart village as proposed in various studies. Some researchers have constructed theoretical models to help us understand the concept and provide pragmatic guidance. Others have identified smart village dimensions for the assessment and evaluation of the performance of an implementation. In the studies listed below, Adamowicz and Zwolińska-Ligaj [4] evaluated the potential for the smart growth of rural areas in Poland based on a rating system that includes six dimensions and is consistent with the smart city framework defined by Giffinger et al. [86]: (1) smart mobility, (2) smart environment, (3) smart living, (4) smart people, (5) smart economy, and (6) smart governance. According to Bibri and Krogstie [87], Giffinger et al.'s framework is the most widely quoted, used, and applied classification system in the smart city field. It seems that this framework, initially developed for urban communities, has also been adapted to the study of rural communities.

Table 2. Current global initiatives and regional or national agendas related to smart villages.

Key Dimensions of a Smart Village			**Source**	**Key Dimensions of a Smart Village**		**Source**
1. Smart Village Ecosystem				5. Smart Village Digital Ecosystem		
a	Institutions			a	Society	
b	Resources		[76]	b	Digital service	[88]
c	Service delivery technologies and mechanisms			c	Technical platform	
d	Service chains			d	Infrastructure	
2. Smart Village Conceptual Model				e	Organizational ecosystem	
a	Energy			6. Smart Village Model		
b	Economy			a	Governance	
c	ICT		[36]	b	Technology	
d	People			c	Resources	[75]
e	Governance			d	Village services	
f	Environment			e	Living	
g	Living			f	Tourism	
3. Framework of a Smart Village				7. Theoretical Framework for a Smart Village System		
a	Resources			a	The strategic subsystem	
b	Technology		[74]	b	The social subsystem	[85]
c	Service chains			c	The economic subsystem	
d	Institutions			d	The information subsystem	
e	Sustainability			e	The resource and environmental subsystem	
4. Smart Village model				8. Dimensions of the Smart Village Concept		
	Process	Enabler		a	Management	
a	Smart economy	Smart management		b	Quality of life	
b	Smart technology	Smart industry	[89]	c	Economy	[4,90]
c	Smart society	Smart infrastructure		d	Society	
d	Smart ecology	Smart people		e	Natural environment	
e	Smart administration	Smart environment		f	Mobility	

Note: Compiled by the authors.

In this regard, it is obvious that the key dimensions of a smart village are not fixed. Smart villages manifest themselves in several forms based on different objectives, challenges, and realistic situations, a finding that is consistent with Albino et al.'s [91] findings on the smart city literature. In our case, we aimed to create a classification system that could be used for the identification and delineation of keywords and themes in the academic literature during the subsequent analysis. Thus, referring to the discussion of the smart village dimensions above, we preliminarily proposed a general theoretical framework with the broadest possible coverage (as shown in Table 3).

Table 3. Proposed conceptual classification system for smart village research.

	Dimensions	Elements		Dimensions	Elements
1	Society	Human capital, cultural capital, institutions, knowledge, information, innovation, etc.	5	Governance	Decision making, planning, monitoring, assessment, e-governance, branding, etc.
2	Resources	Energy, land, water, soil, air, etc.	6	Service	Sanitation, employment, health care, education, food supply, safety, housing, training, etc.
3	Infrastructure	Architecture, transportation, waste and water management, power grid, telecommunication, etc.	7	Technology	IoT, AI, cloud, blockchain, GIS, computing, smart grid, 5G, ICTs, etc.
4	Economy	Agriculture, farming, tourism, e-commerce, creative industry, etc.	8	Others	Strategies, objectives, challenges, conditions, etc.

Note: Compiled by the authors.

3.2. Scientometric Analysis

3.2.1. Publication Distributions

Annual Distribution

Figure 2 shows the historical development of smart village research from 1998 to 2020. According to the findings of bibliometric studies on smart cities, smart city publications showed a dramatic increase during the 2010s [92] and at an even earlier date (in 2008) [71,93]. The overall development trend is similar to that of smart city research, lagging by at least five years. Moreover, the volume of smart village publications is still small compared with that of smart city research. Thus, there is still a great deal of potential for smart development in the rural context. Taking 2015 as a dividing line, we separated the period into two phases based on the annual growth rate of publications.

1. Incubation phase (1998–2014).
   In the exploration phase, there were 41 relevant documents. Since we adopted a broad search with multiple related terms, most studies in this phase discussed smart rural areas under the framework of smart growth, smart community, and smart city discourse. The earliest document available in Scopus dates back to 1998 and is titled "Communities left behind: Can nonviable places become smart?" [94]. In this paper, the author noticed the recent attention to "growth from within" strategies, emphasized rural endogenous development, and suggested quantitative measures for more pragmatic decision-making. It is noteworthy that the author provided some clues for how nonviable communities could become "smart", as "smart communities have empowered individuals, skilled leadership, innovative institutions, cultural capital, and social capital". Although there have been practical implementations, such as Climate-Smart Villages (2011), the Smart Village Initiative (2014), and the IEEE Smart Village (2014), as stated earlier, their influence seems to show a period of lag in the academic literature.
2. Initial development (2015–present).

During this phase, the distribution of annual publications witnessed a period of rapid growth. There are 384 relevant documents, including data from 2021. We defined this phase as the initial development phase because the volume of annual publications related to smart villages is small compared with smart city research. In 2015, the SDGs of the UN General Assembly, known as the 2030 Agenda, were issued, which might have been an important motivation for the significant increase in academic concern towards rural smart development. Among the retrieved journal articles and conference papers, Azizul et al. [81] first mentioned the "smart village" concept as a rural development initiative in a conference paper aiming to support the Smart City Smart Village (SCSV) project within the Digital Malaysia initiative through computing technology. Like Malaysia, during this period, many global, regional, and national agendas adopted the smart village concept and applied it in policy-making and implementations, as concluded in the previous section (Table 2). The dramatic surge in publications shows how public policy agendas, pragmatic practices, and scientific activities influence each other.

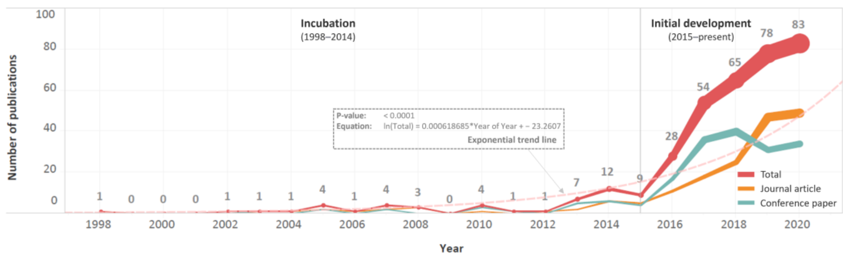


Figure 2. Annual distribution of publications, 1998–2020.

Geographic Distribution

A total of 77 countries have contributed to the smart village research field, as depicted in the world map in Figure 3. When counting the total number of publications, we identified all authors and found 867 valid nationality records. The number of citations was counted according to the affiliation of the first author.

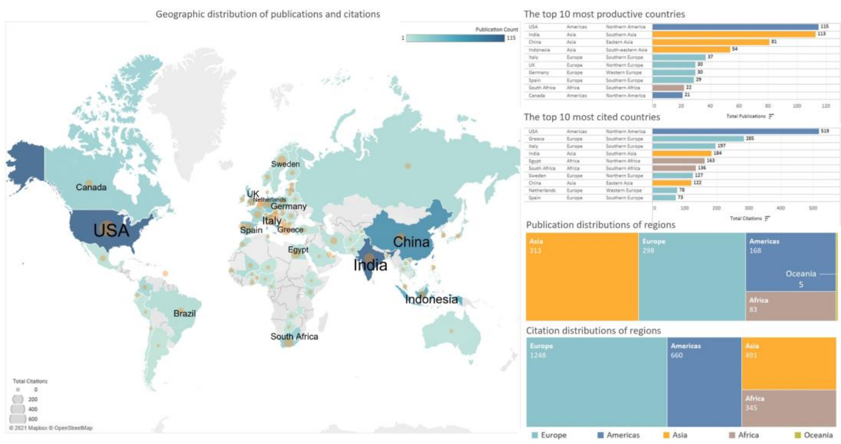


Figure 3. Geographic distribution of publications and citations.

Among all countries, the United States is the most productive and most cited, playing an important role in this field. Asia is the most productive region, with India ranking second, followed by China and Indonesia. Most studies in Asia are distributed in the southern, eastern, and southeastern areas. The EU regions are also productive and influential, with most of the European countries participating in the discussion and having the largest number of total citations. In Africa, studies occurred mainly in peripheral coastal areas where many practical projects have been carried out. Egypt and South Africa are the leading countries in Africa.

3.2.2. Relevant Contributors and Collaboration Patterns

Authors

We used frequency analysis to identify the most relevant contributors in terms of authors and sources. Table 4 reveals the top 15 most relevant authors ranked according to total publications, together with their affiliation information and bibliometric indicators. The most prolific author was RB Zougmore, a member of the CGIAR Research Program on CCAFS, which initiated the Climate-Smart Villages (CSVs) project to help farmers adapt to climate change. It is worth pointing out that MD Lytras and A Visvizi have an extremely high number of citations per publication (TC/TP = 115.00), indicating that their studies have had a profound influence in this field. Among the listed authors, almost half (n = 7) of the researchers belonged to affiliations in European regions.

Table 4. Top 15 most relevant authors.

No.	Author	Institution	Country (Region)	TP *	MAP	FAP	TC	TC/TP
1	Robert Zougmore	CGIAR Research Program on CCAFS	Netherlands (Europe)	7	7	1	86	12.29
2	Robert T Dobson	Stellenbosch University	South Africa (Africa)	6	6	0	111	18.5
3	Gerro J Prinsloo	Stellenbosch University	South Africa (Africa)	6	6	6	111	18.5
4	Alan Mickelson	University of Colorado	USA (Americas)	6	6	1	7	1.17
5	Andrea Mammoli	University of New Mexico	USA (Americas)	5	5	0	87	17.4
6	Emilija Stojmenova Duh	University of Ljubljana	Slovenia (Europe)	5	5	0	72	14.4
7	Francesc Girbau-Llistuella	Polytechnic University of Catalonia	Spain (Europe)	5	5	4	34	6.8
8	Andreas Sumper	Polytechnic University of Catalonia	Spain (Europe)	5	5	0	34	6.8
9	Andrej Kos	University of Ljubljana	Slovenia (Europe)	4	4	0	64	16
10	Francisco Díaz-González	Polytechnic University of Catalonia	Spain (Europe)	4	4	0	30	7.5
11	Bennett Miller	University of Colorado	USA (Americas)	4	4	1	1	0.25
12	Miltiadis D. Lytras	Effat University	Saudi Arabia (Asia)	3	3	1	345	115
13	Anna Visvizi	Effat University	Saudi Arabia (Asia)	3	3	1	345	115
14	Nada A. Nabeeh	Mansoura University	Egypt (Africa)	3	3	3	159	53
15	Veronika Zavratnik	University of Ljubljana	Slovenia (Europe)	3	3	3	61	20.33

Note: * means ranking by TP. Abbreviations: TP, Total Publications; TC, Total Citations; TC/TP, Citations per Publication; MAP, Multi-authored Publications; FAP, First-authored Publications. Data Source: Scopus.

Sources

We calculated the number of journal articles (n = 217) and identified the 10 most prolific journals out of the 151 sources. Table 5 summarizes the details of the top ten journals. In terms of total publications, Sustainability is the leading journal with a high number of articles (n = 21), followed by Energies (n = 9) and European Countryside (n = 8). The top 10 source journals accounted for 27.6% (60/217) of the smart village papers.

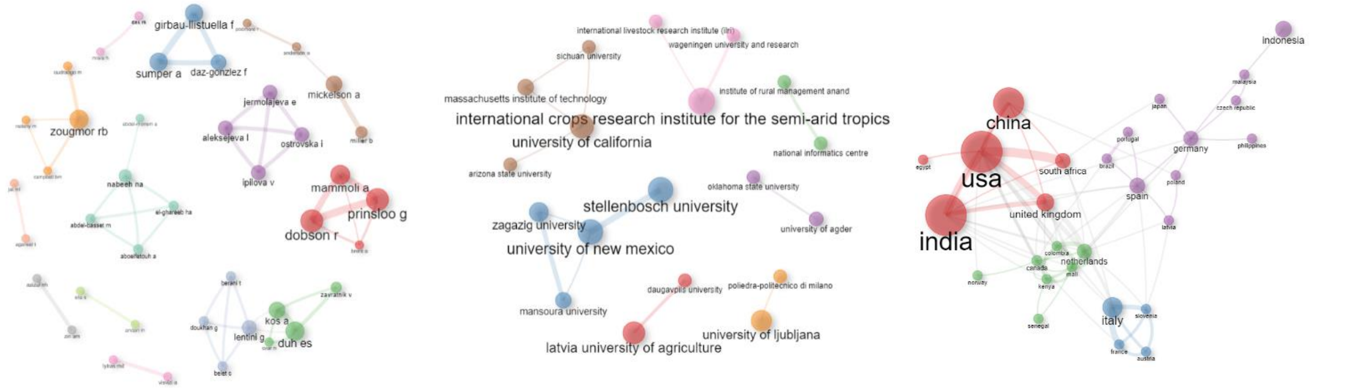
Table 5. Top 10 most relevant sources.

No.	Journal	TP *	TC	TC/TP	h-Index	CS	JCR Category
1	Sustainability	21	365	17.38	8	3.9	• Social Sciences • Environmental Science • Energy
2	Energies	9	113	12.56	5	4.7	• Mathematics • Engineering • Energy
3	European Countryside	8	29	3.63	4	2.1	• Social Sciences • Environmental Science
4	Journal of Rural Studies	4	167	41.75	4	6.4	• Social Sciences
5	IEEE Access	3	156	52.00	3	4.8	• Engineering • Computer Science • Materials Science
6	Journal of the American Planning Association	3	87	29.00	3	6.6	• Social Sciences
7	Sensors	3	19	6.33	3	5.8	• Physics and Astronomy • Engineering • Computer Science • Physics and Astronomy • Chemistry • Biochemistry, Genetics, and Molecular Biology
8	IEEE Consumer Electronics Magazine	3	13	4.33	2	6.4	• Engineering • Computer Science
9	Water	3	7	2.33	1	3.7	• Social Sciences • Agricultural and Biological Sciences • Environmental Science • Biochemistry, Genetics, and Molecular Biology
10	Sustainable Cities and Society	3	6	2.00	2	10.7	• Social Sciences • Engineering • Energy

Note: * means ranking by TP. Abbreviations: TP, Total Publications; TC, Total Citations; TC/TP, Citations per Publication; CS, CiteScore2020. Data Source: Scopus.

Co-Author Relationships

The identification of the co-author relationships in terms of scholars and their affiliations clarifies the research collaboration status quo [95–97]. We present the collaborative network between authors, institutions, and countries in Figure 4 from the micro-, meso-, and macro-perspectives, respectively. In this case, we limited the number of nodes to 50 based on publications and removed isolated ones to prune the network so that the graph would not be too complicated to comprehend.



(**a**) (**b**) (**c**)

Figure 4. Collaboration networks between authors, institutions, and countries. (**a**) Authors; (**b**) Institutions; (**c**) Countries.

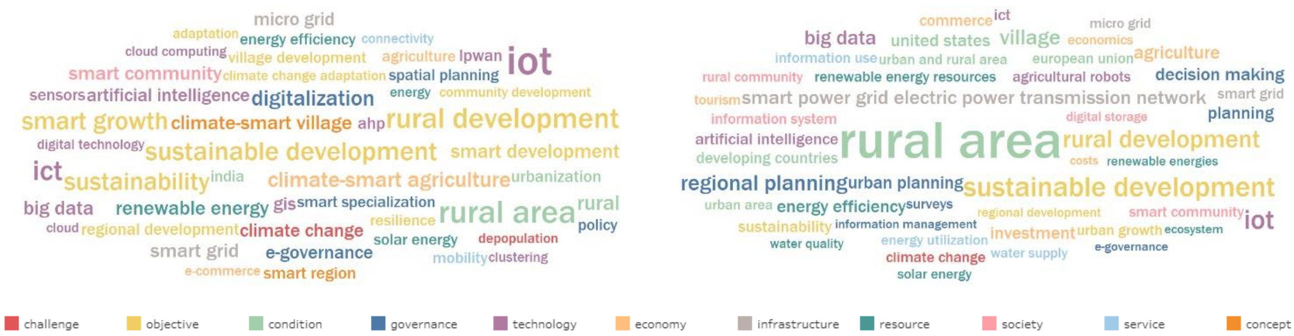
At both the author level and the institution level (Figure 4a,b), there were several closed-loop circuits. This indicated that prolific authors and institutions have established strong, closed collaborative groups. However, the lack of an interconnection between clusters implies that there is still enough room to broaden authorial and institutional cooperation. At the country level (Figure 4c), there were four distinct clusters consisting of 28 nodes (total link strength, 279; links, 77). The United States has the broadest range and largest number of collaborations (total link strength, 116; links, 12). The strongest cooperation occurred between the United States and South Africa (link strength, 36). The United States also has a close relationship with India, the United Kingdom, and China, with link strengths of 25, 16, and 9, respectively. In European countries, the Netherlands has the most extensive range and highest number of international collaborations (total link strength, 60; links, 12). However, highly productive countries such as China and Indonesia seem to participate in a relatively limited range of international projects considering the number of publications produced. Overall, academic collaboration in the field of smart villages is carried out worldwide and has a great deal of potential.

3.2.3. Hotspots, Structures, and Trends

According to the Scopus subject area count, among the 425 retrieved documents, the top five most common subject areas were computer science (n = 190), social sciences (n = 150), engineering (n = 141), energy (n = 96), and environmental science (n = 96) along with 18 other subject areas. This indicates that rural smart development involves multidisciplinary knowledge. In this section, we are interested in hotspots, conceptual and intellectual structures, and the evolution of trends in the smart village field.

Most Frequent Keywords

Keywords are important terms and phrases highlighting the themes and focus of the research content [98]. In Scopus, a document usually has two types of keywords: author keywords and indexed keywords. Author keywords were chosen by the author(s), while indexed keywords were chosen by content suppliers [99]. In this case, we performed a statistical analysis on both types of keywords. It is worth clarifying that, to reduce the confusion caused by multiple variations of terms, we conducted a standardization procedure to merge frequently used keywords considering synonyms, various spellings, and plurals. The word clouds shown in Figure 5 intuitively illustrate the top 50 most frequent keywords. The keywords were colored in accordance with the classification system we developed earlier. In addition, according to the classification system, we conducted a classification procedure to categorize these keywords into relevant dimensions, as shown in Table A2.



(**a**) (**b**)

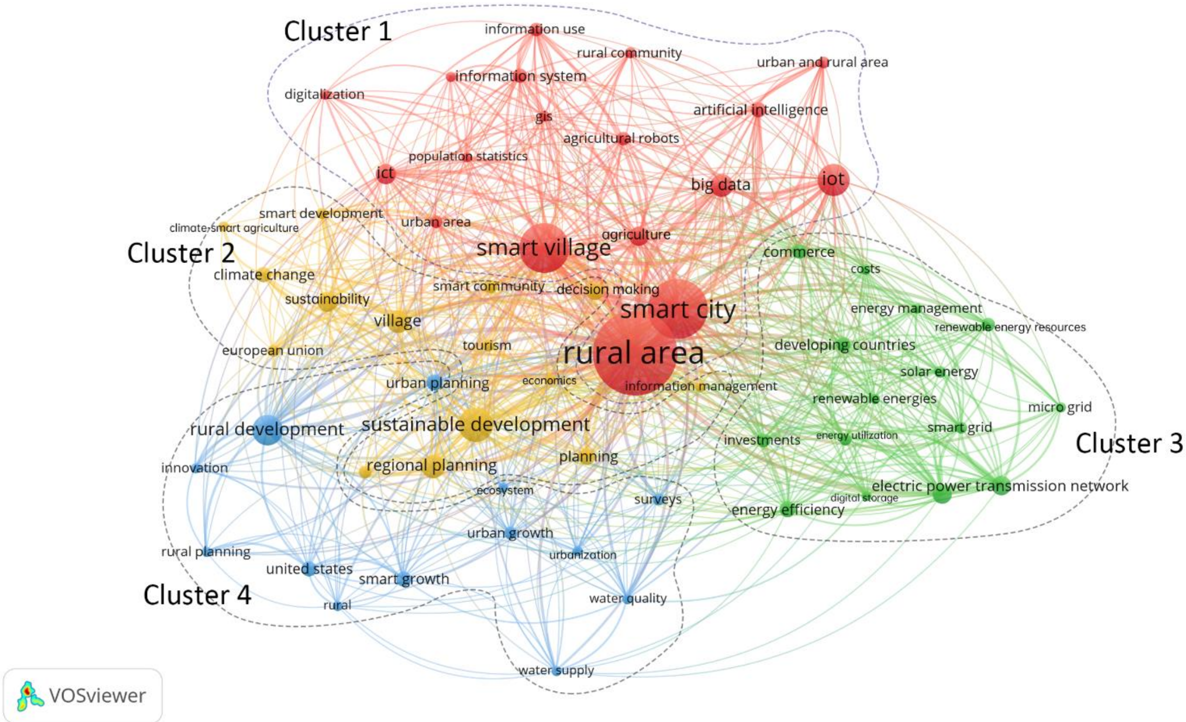
Figure 5. Top 50 most frequent keywords in author keywords and indexed keywords. (**a**) Author keywords; (**b**) Indexed keywords. The basic terms "smart village" and "smart city" were omitted in the word clouds.

The keyword frequency analysis shows that, considering both author keywords and indexed keywords, the dimension of technology has received a tremendous amount of attention. Authors tend to choose keywords related to the objective dimension. In the indexed keywords, phrases relevant to conditions and governance also accounted for a large share. However, the total frequency related to social and service topics is relatively low, indicating that there is still much space for discussion in these two dimensions.

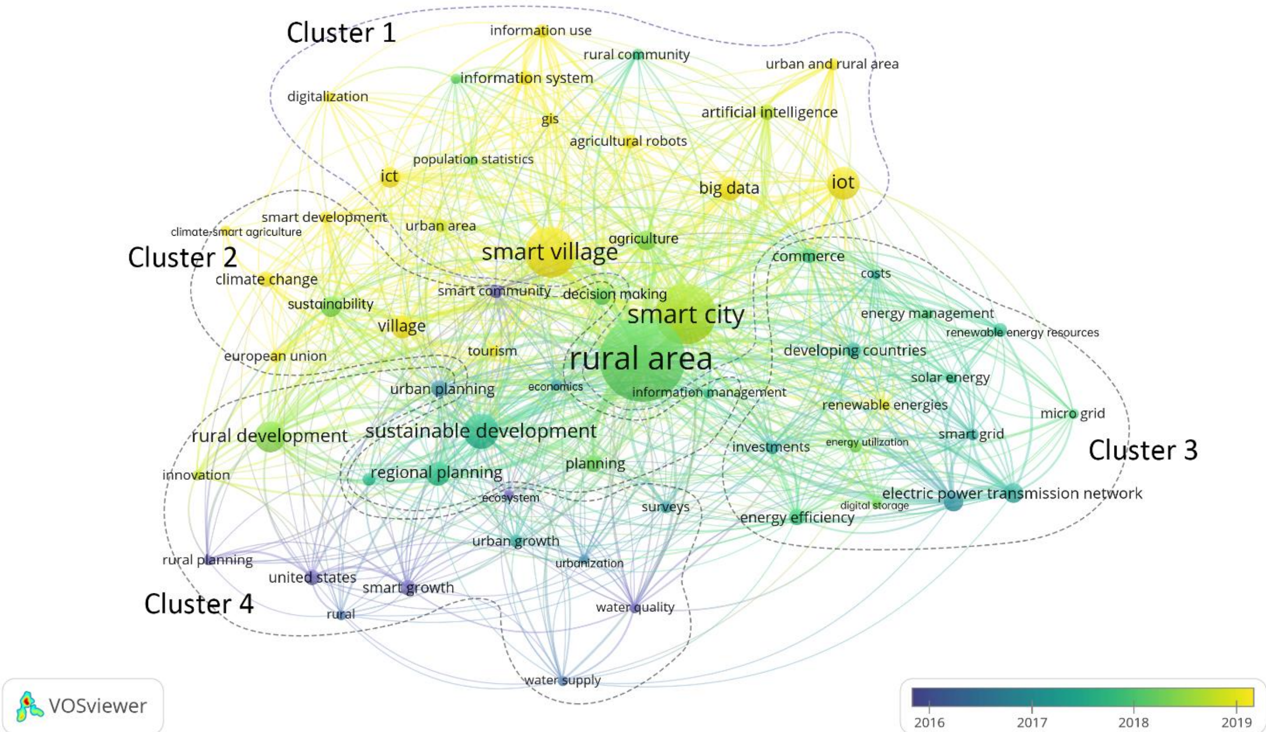
Keyword Co-Occurrence Analysis: Conceptual Structure

Since keywords are typically viewed as brief and clear descriptions of research subjects, it is reasonable to use keywords as units of analysis and extract a co-occurrence network of keywords to identify the conceptual structures of the field. Here, we constructed networks of all keywords (author keywords and index keywords) based on co-occurrence data. We set the minimum occurrence frequency to 8, and, of the 3430 identified keywords, 61 met the threshold. In the network visualization view (Figure 6a), each keyword was assigned to a cluster based on the computational algorithm in VOSviewer. In the overlay visualization view (Figure 6b), the color of each keyword represents the keyword's average publication year, which was determined by taking the average of the publication years of all the documents containing the keywords.

Four overarching themes became apparent through the clustering analysis. Cluster 1 is the largest cluster and comprises the most recently used keywords reflecting the high degree of relevance of smart rural development and ICTs. Many technology-based approaches (e.g., IoT, big data, robotics, and AI) are rescaled and applied in rural contexts. Agriculture is a promising area of application. In Cluster 2, the vision of sustainability is emphasized and often discussed in connection with planning, decision-making, tourism, and communities. The EU has a strong relationship with this topic. Cluster 3 embodies the significance of energy use, especially in developing countries. Renewable energy is a relatively new topic in this group. Cluster 4 comprises keywords that were adopted in earlier studies that discuss rural planning under the smart growth discourse that initially took place in the United States. The negative impacts of unlimited urbanization have drawn attention to ecology, the environment, and rural conservation. Innovation is regarded as an important new idea related to this perspective.



(**a**)



(**b**)

Figure 6. Keyword co-occurrence network. (**a**) Network visualization view; (**b**) Overlay visualization view. Minimum occurrence frequency, 8; nodes, 61; clusters, 4; links, 795; total link strength, 2352.

To conclude, the conceptual structure reveals three pillar themes in the existing literature that cover the four dimensions mentioned in the discussion of the classification system: regional planning and decision-making for sustainable development (the dimension of governance), renewable, efficient energy and off-grid infrastructure (the dimensions of resources and infrastructure), and ICT-enhanced technological applications (the dimension of technology).

Co-Citation Analysis: Intellectual Structure

Co-citation analysis can help us identify the most influential documents in a given field and reveal the relationships between them established by academic communities [100]. In measuring the co-citation strength, we measure the degree of the relationship or association between documents as perceived by the population of citing authors [62]. In other words, a co-citation network describes the intellectual structure of a research field whose pattern evolves as the interests and intellectual patterns of the field change over time. As the co-citation network shown in Figure 7 illustrates, we retained 100 highly cited documents, removed isolated ones, and generated a network with 59 nodes.

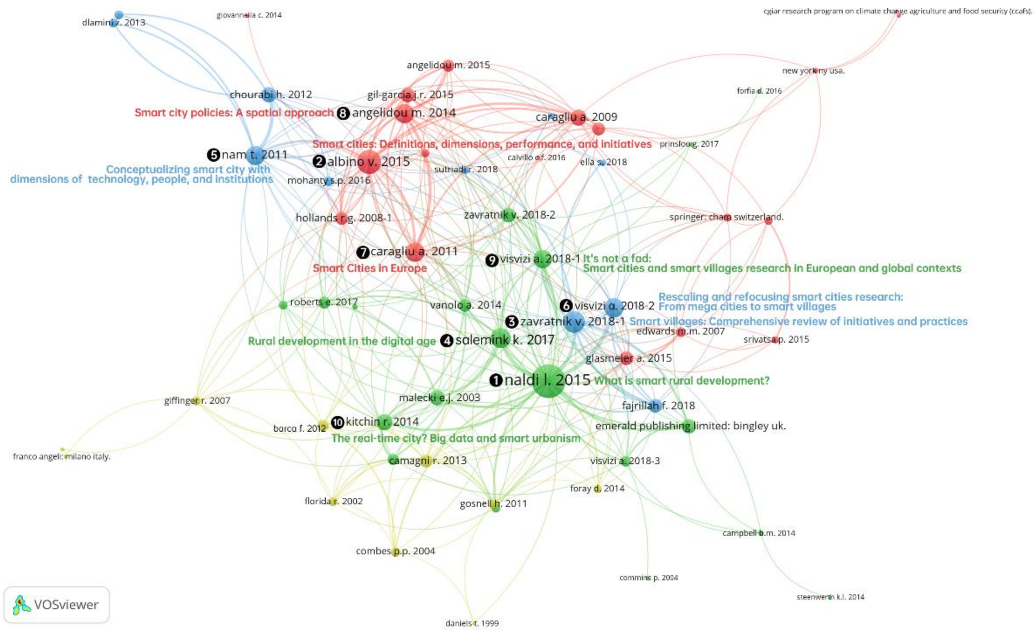


Figure 7. Co-citation network. n = 100 (isolated nodes removed). Minimum edges, 2; nodes, 59; clusters, 4; links, 315; total link strength, 710.

Table 6 lists the top 10 documents with the highest total link strengths in the network. It is apparent that the theoretical and practical studies on smart cities are valuable references for smart village research [91,101–103]. In 2015, Naldi et al. [27] highlighted an essential issue by discussing what smart rural development is. They conceptually analyzed and integrated the ideas that underlie the logic behind policies for smart growth in the EU context. The authors pointed out that there remains a question as to how we can translate smart growth policies to fit a diverse set of rural regions. The issue discussed in this paper inspired a widespread discussion of smart rural development that can be regarded as a turning point for smart rural development. After 2015, articles on rural digital development [104], reviews on initiatives and practices [7], and comparative studies between smart cities and smart villages [25] became significant references in the field.

Table 6. Top 10 most relevant sources.

No.	Title	Source	Author, Year
1	What is smart rural development?	Journal of Rural Studies	[27]
2	Smart cities: Definitions, dimensions, performance, and initiatives	Journal of Urban Technology	[91]
3	Smart villages: Comprehensive review of initiatives and practices	Sustainability	[7]
4	Rural development in the digital age: A systematic literature review on unequal ICT availability, adoption, and use in rural areas	Journal of Rural Studies	[104]
5	Conceptualizing smart cities with the dimensions of technology, people, and institutions	Proceedings of the 12th Annual International Digital Government Research Conference	[102]
6	Rescaling and refocusing smart cities research: From mega cities to smart villages	Journal of Science and Technology Policy Management	[25]
7	Smart Cities in Europe	Journal of Urban Technology	[101]
8	Smart city policies: A spatial approach	Cities	[103]
9	It's not a fad: Smart cities and smart villages research in European and global contexts	Sustainability	[28]
10	The real-time city? Big data and smart urbanism	GeoJournal	[105]

Thematic Evolution

When keyword co-occurrence analysis is employed for mapping science, clusters of keywords representing different themes are obtained [106]. According to Cobo et al. [58], if the raw data are divided into different consecutive groups of years (i.e., subperiods), the evolution of the research field under study can be analyzed. We divided the research period (1998–2021) into four subperiods (subperiod A, 1998–2014; subperiod B, 2015–2017; subperiod C, 2018–2019; subperiod D, 2020–2021). Then, we developed four strategic diagrams and a Sankey diagram based on index keywords to illustrate the thematic evolution (as shown in Figures 8 and 9).

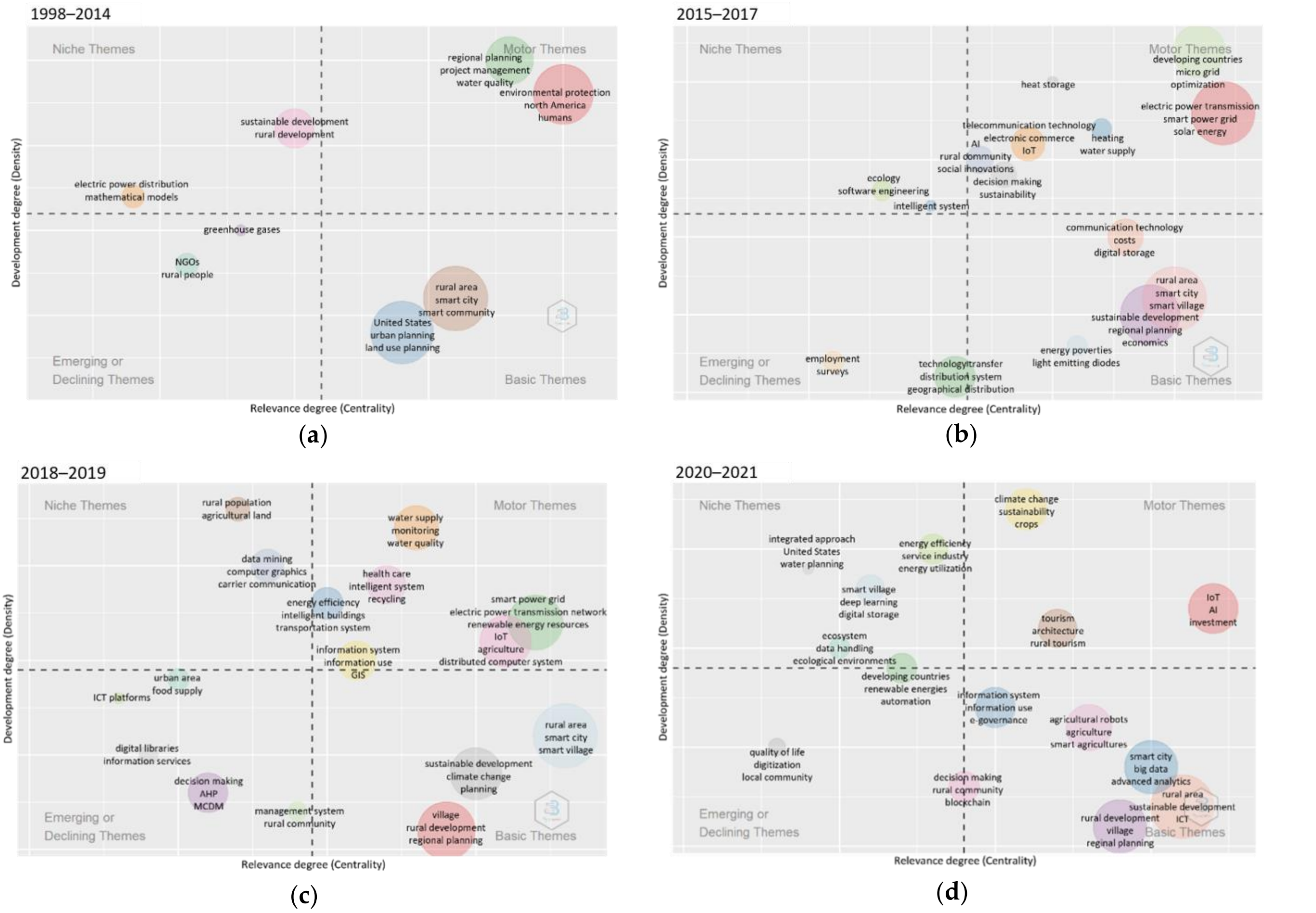


Figure 8. Strategic diagrams of smart village research (1998–2021). (**a**) 1998–2014 (41 documents); (**b**) 2015–2017 (91 documents); (**c**) 2018–2019 (143 documents); (**d**) 2020–2021 (150 documents).

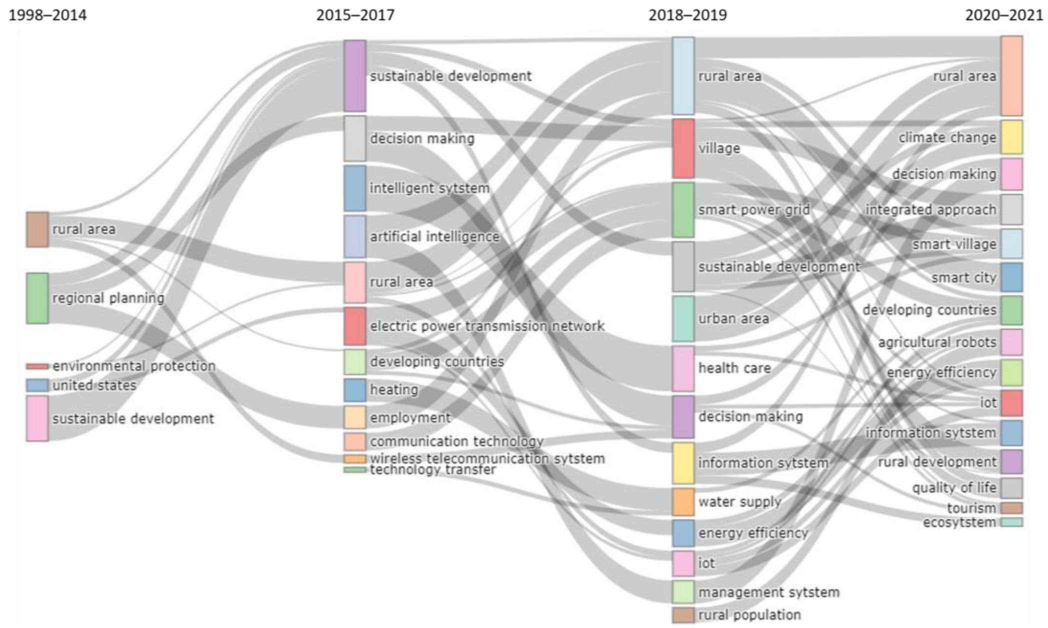


Figure 9. Sankey diagram based on the thematic evolution of keywords (1998–2021). The colors of theme clusters in the Sankey diagram are consistent with those in the strategic diagrams.

A strategic diagram (Figure 8) with four quadrants can characterize four kinds of themes according to their centrality and density: (1) motor themes (themes in the first quadrant, representing important themes with a great deal of potential), (2) niche themes (themes in the second quadrant, implying that they are very specialized but peripheral), (3) emerging or declining themes (themes in the third quadrant that are peripheral and undeveloped), and (4) basic themes (themes in the fourth quadrant, representing important but undeveloped themes that are transversal and general) [66,107–109]. In the Sankey diagram (Figure 9), each block denotes a thematic cluster labeled by the keyword used with the highest frequency. The size of the block is proportional to the number of keywords under the theme. The links and the corresponding thickness indicate the evolutionary direction and quantity [110,111]. Themes that have no linkages with other themes were omitted.

From an overall perspective, there are several enlightening findings:

1. Smart village research was initially derived from themes related to smart cities, smart communities, regional planning, and sustainable development. These themes were mainly basic themes, motor themes, and niche themes in subperiod A;
2. Sustainable development remained a significant idea throughout the thematic evolution. It was developed in 2015 and has since matured into a basic theme;
3. Technology-dimension-related themes (e.g., AI, communication technology, and the IoT) continuously evolve, transfer with a high degree of flexibility, and remain motor themes. These themes commonly merge with themes related to other dimensions (e.g., resources, governance, and the economy) and generate new themes (e.g., smart power grids, e-governance, and smart agriculture), implying a wide range of applications for these technologies;
4. Regarding subperiod D, motor themes that are well developed and have potential can be identified as subtopics in the economic dimension, such as climate-smart agriculture and rural tourism, as well as emerging technologies such as AI, the IoT, and robotics. Quality of life (i.e., smart living) and community-centered studies might become promising emerging themes in the future.

However, the continual transfer, differentiation, and regeneration among theme clusters indicates that the smart village research field is still in an initial phase and far from mature. Even in the more widely discussed dimensions, the subtopics remain untapped in terms of depth and width. Taking the dimension of resources as an example, the current focus is mainly on energy use, while an insufficient amount of attention has been paid to other aspects (e.g., land, water, and air).

3.3. Proposed Conceptual Model

Based on the results presented above, we noticed that the existing research on smart rural development has attracted a considerable amount of interest in technology-driven methods. However, there is a lack of studies on human-driven perspectives.

Therefore, to call for more human-centric perspectives, we constructed a dynamic conceptual model describing the structural relationship among the basic dimensions of a smart village. As depicted in Figure 10, the smart village model consists of three layers: an environmental layer, an activity layer, and an actor layer. The environmental layer includes natural resources, cultural resources, and the built infrastructure, providing the resources and space needed for smart activities to occur. The activity layer is composed of four active dimensions: governance, technology, services, and the economy, which facilitate smart initiatives. In the center, the actor layer is represented by the core dimension of society. We believe that the social dimension, which involves various stakeholders, is essential for realizing endogenous development. The interaction among these dimensions in different layers enables the implementation of smart environments, smart infrastructure, a smart economy, smart people, smart governance, smart living, and other future directions.

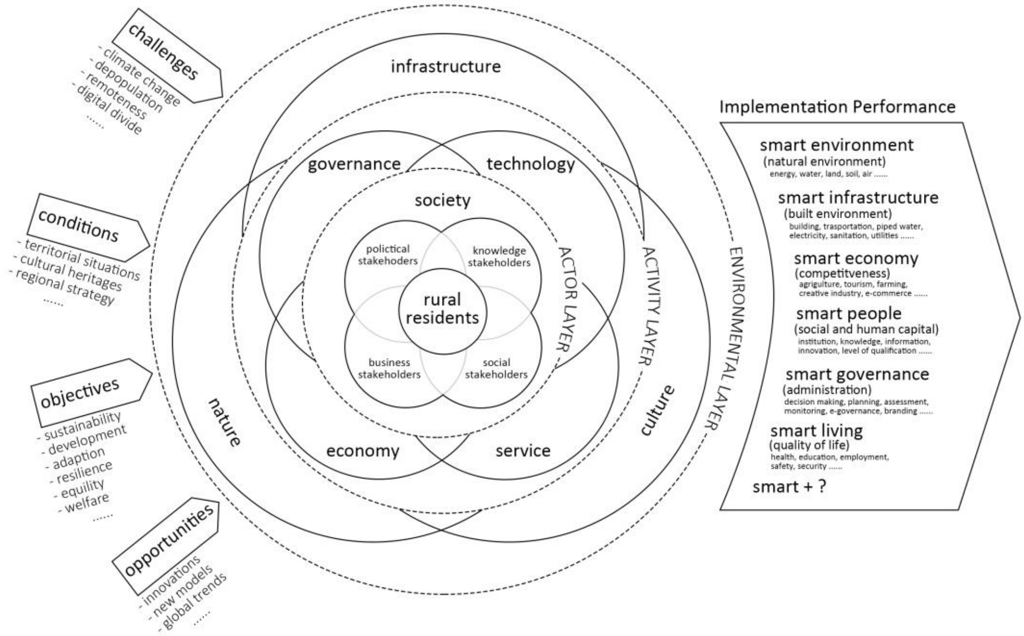


Figure 10. A dynamic conceptual model of a smart village. Proposed by the authors based on Giffinger and Gudrun, 2010 [86]; Fernandez-Anez et al., 2018 [112]; Mishbah et al., 2018 [36]; and Zhang and Zhang, 2020 [85].

4. Discussion

4.1. Rural Smart Development Needs Tailored Solutions

Our review of smart village initiatives indicates that rural smart development strategies and implementations have different priorities depending on specific economic, geographical, and cultural realities. The overarching goal is to discover, promote, and maximize the potential of rural communities and their settlements to create interconnected, yet self-sufficient, ecosystems. As Tödtling and Trippl point out, there is no fixed model for innovation policies [113]. Camagni and Capello also argue that policies addressing the smart growth goal in Europe had to diversify their approach to comply with the specificities and potentials of each particular region [114]. The case study in Poland proves that the implementation of the smart village concept is related to the different conditions of the agricultural and spatial structure of rural areas [115].

Hence, the smart village concept does not propose a one-size-fits-all solution. It is territorially sensitive, based on the objectives and realistic conditions of the respective villages, and influenced by new challenges and opportunities [116]. Smart villages know what to do and what is feasible and are able to find a unique profile that sets them apart from other areas and activates their potential and attractiveness [117]. It is worth noting that the self-sufficiency that we mentioned above emphasizes the stability and resilience of the village in the face of external shocks. The smart village ecosystem is not isolated or closed. It actively interacts with other systems and establishes relations.

Therefore, the model we propose in this study is highly elastic. The positions, sizes, and inter-relations of the components in the proposed model can be modified adaptively in a dynamic form, thus enabling customization for specific cases.

4.2. Technology Serves as a Means Rather than an End

As Lytras et al. [118] mention, the concept and approach captured by the term "smart village" go beyond the techno-hype; they seek to do much more than showcase how sophisticated ICTs can be employed in rural settlements. Indeed, ICT-enhanced technologies benefit communities and their inhabitants in many respects; hence, the technology dimension is often highlighted and favored in some urban or rural community conceptualizations of smartness [119,120]. It is undeniable that technology has a great deal of potential to facilitate decision-making, implementation, and evaluation processes for smart development with an appropriate objective. For example, D'Andria et al. outlined an innovative multi-criterion analysis tool for the selection of the best project initiatives in small towns [121], while Nesticò et al. developed an algorithm-based model capable of identifying the best practices of sustainable regeneration projects [122]. They proved that modern techniques are flexible and can be effectively applied to deal with the complexity of various small realities.

However, in the smart city research field, scholars have noticed that technology-driven methods should be considered as the means to reach certain ends rather than as ends themselves [123–126]. Now, this issue also arises in the rural context. As intimated by many practical cases in rural areas, the technological component is not the only, or even the most important, factor in achieving smartness [7]. Based on a case study in the Czech Republic, Vaishar and Šť'astná [127] found that the main barrier to the promotion of the smart village concept was not the coverage or accessibility of digital technology but the rural population's lower level of education and conservatism. An investigation carried out in Northern Ireland also revealed that the most successful intervention of the smart rural development project was the improved access to local services [128].

Thus, in the dynamic model of a smart village, the technology dimension was set in the activity layer as one of the essential means by which to facilitate smart initiatives.

4.3. People Are at the Core of the Smart Village Ecosystem

Technology is socially constructed, and societal forces control its impact [21]. A decade of trial and error in smart city practices suggests that smart strategies start with people, not technology [129–132]. Zavratnik et al. [133] emphasized the need to develop a community-centered approach to achieving sustainability for both smart cities and smart villages, which transcend the urban–rural boundary and regard the community as an organic whole rather than a group of individuals. Despite the limitations of the time periods in which they lived, ancient philosophers can shed some light on this issue. The concept of Ren (humanity, love, and humaneness; pronounced "jen") is a central concept in Confucianism that has undergone more than 2000 years' worth of evolution [134]. Confucianism advocates the governance philosophy of ruling the country through benevolence (Ren), valuing people, and respecting talents. The Socratic philosophers in ancient Greece were equally insightful about human-centric perspectives. Socrates claimed that human demands create poleis. In Plato's thought, the function of an ideal polis is to promote its people's wealth, freedom, wisdom, knowledge, and happiness [135]. In other words, what makes communities smart rests on the smart capabilities of their inhabitants. The answer to the question of how we can shape smartness highly depends on the demands of the community itself. In the smart city context, the attention of researchers has switched to a more human-centered direction [136]. Humane smart cities have emerged as a new sub-field of study that addresses what has to be done in cities to make them more livable and more in tune with their citizens' wishes and needs [137,138].

To date, the academic discourse on smart villages has surprisingly overlooked human-centered perspectives, such as society, services, and culture. This finding is in agreement with a study based on policies related to the concept of smart villages. Stojanova et al. [31] noticed that the social aspect of living is falling behind compared with other areas. They called for an expanded discussion of issues regarding education, free-time activities, and cultural activities as well as issues concerning the general well-being of people.

In this case, we put society at the center of the dynamic model, indicating that at the heart of the smart village approach is the well-being of rural inhabitants.

5. Conclusions

This paper offers a comprehensive and in-depth scientometric analysis of the current academic literature on smart development in rural areas, centering on the concept of smart villages. To this end, we drew some enlightening conclusions by targeting the previously mentioned research goals.

First, an overview of the current implementation and understanding of smart village initiatives and models provided practical and theoretical insights crucial for comprehending the concept. Based on existing studies, smart village research topics can be generally classified into eight dimensions: society, resources, infrastructure, the economy, governance, technology, services, and others (e.g., challenges, objectives, and conditions). It is noteworthy that, although rarely mentioned in the existing smart village literature, culture plays an important role and should not be dismissed.

Second, to the best of our knowledge, this is the first comprehensive scientometric study in the smart village field and will establish baseline data for future analysis and comparison. It may help us describe the state of the current scientific landscape in this field and identify patterns, hotspots, trends, and gaps based on quantitative analysis and an intuitive visualization. The volume of smart village publications is still small compared with that of smart city research. Thus, there is still a great deal of potential for smart development in the rural context.

Finally, considering the current tendency to place technology in a significant position, a dynamic conceptual model was proposed in order to call for more discussion on the dimensions of society, services, and culture. More perspectives on human-driven methods are expected in future studies. We believe that a knowledge-based, community-led, and human-centric rural society is the core of a smart village ecosystem.

Despite its contributions, this study has certain limitations. First, the data-driven nature of the scientometric approach can lead to unintended consequences if it is used uncritically. Bibliometric measures, although seemingly objective, still require peer review judgments to ensure that the results are valid and reliable [139,140]. In addition, we only used one data source and set exclusion criteria to refine the set of retrieved documents (e.g., the language and the types of documents) for higher data quality and a compelling analysis. Combining Scopus with other databases and including more non-English publications could provide a more complete dataset and broader insights. Moreover, we widened the range of adopted terms and included several relevant concepts (e.g., smart countrysides and smart rural areas) to take a holistic view of smart rural development. It is worth mentioning that a village is conceptually different from the aggregate construct of a rural area or countryside [28]. Future studies could make more precise distinctions in terms of conceptual boundaries as more studies become available.

We believe that this paper will become a significant reference that will enable researchers and practitioners to capture a holistic view of the smart village research field. The research framework established in this study provides guidance on the analysis of the knowledge base of other research fields. Additional future work should also consider employing other analysis approaches in order to extend this analysis and verify the results.

Author Contributions: Conceptualization, Q.W.; methodology, Q.W. and K.F.; software, Q.W. and J.Z.; formal analysis, Q.W. and S.L.; investigation, Q.W. and S.L.; data curation, Q.W. and J.Z.; writing—original draft preparation, Q.W.; writing—review and editing, Q.W., S.L., J.Z. and K.F.; visualization, Q.W.; supervision, K.F.; project administration, K.F.; funding acquisition, Q.W. and K.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by JST SPRING, Grant Number JPMJSP2109 (Japan).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We thank all reviewers for their valuable comments on this paper.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Details of the data retrieval criteria and results.

		Query 1	Query 2	Query 3	Query 4	Query 5
Query string		TITLE-ABS-KEY ("*smart* village*")	TITLE-ABS-KEY ("*smart rural*" OR "*smart countryside*")	TITLE-ABS-KEY ("*smart cit*") AND KEY (rural* OR village* OR countryside*)	TITLE-ABS-KEY ("smart growth*" OR "smart develop*") AND TITLE-ABS-KEY (rural* OR village* OR countryside*)	TITLE-ABS-KEY ("smart communit*" OR "smart territor*" OR "smart region*" OR "*smart settlement*") AND TITLE-ABS-KEY (rural* OR village* OR countryside*)
Limit to	Document Type		Article (ar) or Review (re) or Conference Paper (cp)		LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE,"re")	
	Language		English		LIMIT-TO (LANGUAGE, "English")	
Search results		209	75	181	96	58
After screening		207	75	121	61	56
Retrieval period		16 October 2021 to 6 November				
Removed duplicates		95				
Final records		425 (Articles, 201; Conference papers, 208; Reviews, 16)				

Appendix B

Table A2. Top 50 most frequently used keywords.

Author Keywords			Indexed Keywords		
Dimensions (Freq.)		Keywords (Freq.)	Dimensions (Freq.)		Keywords (Freq.)
Others	Challenges (9)	climate change (6) depopulation (3)	Others	Challenges (13)	climate change (13)
	Objectives (83)	rural development (17) sustainable development (13) smart growth (12) sustainability (12) smart development (7) regional development (5) resilience (4) village development (4) adaptation (3) climate change adaptation (3) community development (3)		Objectives (128)	sustainable development (53) rural development (39) sustainability (15) urban growth (12) regional development (9)
	Conditions (38)	rural area (21) rural (8) urbanization (5) India (4)		Conditions (296)	rural area (201) village (29) United States (18) developing countries (14) European union (12) urban and rural area (11) urban area (11)

Table A2. *Cont.*

Author Keywords		Indexed Keywords	
Dimensions (Freq.)	**Keywords (Freq.)**	**Dimensions (Freq.)**	**Keywords (Freq.)**
Governance (27)	digitalization (9) e-governance (6) policy (4) smart specialization (4) spatial planning (4)	Governance (110)	regional planning (30) decision-making (19) planning (17) urban planning (17) surveys (11) e-governance (8) information management (8)
Technology (97)	IoT (35) ICT (16) big data (7) artificial intelligence (6) GIS (6) AHP (5) lpwan (5) sensors (5) cloud (3) cloud computing (3) clustering (3) digital technology (3)	Technology (118)	IoT (50) big data (25) artificial intelligence (15) ICT (15) agricultural robots (13)
Economy (16)	climate-smart agriculture (9) agriculture (4) e-commerce (3)	Economy (81)	agriculture (21) investment (18) commerce (14) economics (10) tourism (10) costs (8)
Infrastructure (13)	smart grid (7) micro grid (6)	Infrastructure (68)	electric power transmission network (23) smart power grid (23) smart grid (12) micro grid (10)
Resource (18)	renewable energy (7) energy efficiency (4) solar energy (4) energy (3)	Resource (66)	energy efficiency (17) renewable energy resources (13) solar energy (10) renewable energies (9) water quality (9) ecosystem (8)
Society (7)	smart community (7)	Society (44)	information system (13) smart community (12) rural community (10) digital storage (9)
Services (7)	mobility (4) connectivity (3)	Service (34)	information use (13) energy utilization (11) water supply (10)

Note: Concept terms (e.g., smart village, smart city, climate-smart village, and smart region) are omitted in the table.

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