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Research Models and Methodologies on the Smart City: A Systematic Literature Review

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Abstract: A smart city is a sustainable city that solves urban problems and improves citizens' quality of life through the fourth industrial revolution technology and governance between stakeholders. With the advent of the fourth industrial revolution and the concept of smart cities changing, many smart city studies have been conducted. Still, studies on the overall flow of smart city research and major issues are insufficient. Therefore, this study analyzed the trends and characteristics of smart city research and proposes research directions through smart city literature analyses conducted over the past 10 years, from 2011 to 2020. This study conducted a systematic review of studies related to smart cities over the past 10 years. Smart city research was analyzed by dividing it into research methods and contents. In terms of research method, year, research methodology 1, research methodology 2, research purpose, data collection method, and use of research results were included in the analysis frame. In terms of research content, keywords related to research topics, analysis units, and the general classification criteria and security of smart cities were included. The research results mentioned in this study are expected to serve as useful guidelines for future smart city development projects.

Keywords: smart city; smart city research; case study

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1. Introduction

A smart city is a sustainable city that solves urban problems and improves citizens' quality of life through the fourth industrial revolution technology and governance between stakeholders. Due to rapid urbanization, smart cities are emerging to solve urban problems from various fields such as transportation, environment, welfare, economy, safety, energy, and the efficient distribution of urban resources.

Smart city development is emerging as a global trend. According to a report released by the Korea Agency for Infrastructure Technology Advancement (KAIA) [1], foreign countries have actively been implementing smart city-related policies since early 2010.

Japan's Cabinet Department announced the "New Growth Strategy in Japan" in 2010 and promoted the "Environmental, Energy-wide Strategy by Green Innovation", which includes smart cities. In October 2013, the EU announced the Smart Cities and Communities Innovation Partnership Strategy Implementation Plan to implement smart city development in the three areas of energy, transportation, and ICT. China built 320 cities nationwide as smart cities during the twelfth five-year rule period from 2011 to 2015 and, as of 2010, has invested more than USD 48.3 billion to increase energy efficiency by 16% by 2015. Spain established the RECI (Spain Smart City Network), a smart city network platform for sharing and operational efficiency of smart city information, in June 2011.

This smart city trend is expected to continue in the future. According to a report by Technavio [2], the smart city market share is expected to increase by USD 151.99 billion from 2020 to 2025, and the growth momentum of the smart city market is expected to accelerate to a CAGR of 19.43%.

Various smart city studies have been accumulated amid the global smart city trend, and many researchers have conducted systematic reviews related to smart cities.

Coccchia [3] conducted systematic literature research on smart cities and digital cities from 1993 to 2012. Thomas et al. [4] also conducted a systematic review of 30 papers related to citizens' participation in smart cities. Souza et al. [5] conducted a systematic review of 39 major data mining and machine learning technologies used in smart cities. Yigitcanlar et al. [6] conducted a systematic review of 35 papers related to smart cities' smartness and sustainability. Laufs et al. [7] conducted a systematic review of 121 papers related to the security technology of smart cities, while Abusaada and Elshater [8] conducted a systematic review of 44 papers related to the specificity and location of smart cities.

In previous studies, systematic review studies focused on smart cities' leading technologies and characteristics, such as security and data mining technologies. However, with the advent of the era of the fourth industrial revolution and the concept of smart cities changing, research on the overall research trend and the major issues of smart city papers is insufficient. Therefore, this paper attempts to identify the major issues of smart cities and propose research directions through a literature analysis of smart cities over the past ten years, from 2011 to 2020.

2. Theoretical Background and Previous Studies

2.1. Definition of Smart City

The concept of smart cities is changing from infrastructure supply-oriented to improving citizens' quality of life and sustainability. In addition, the subject of smart city promotion is gradually changing from government-centered to open governance consisting of government-business citizens. Accordingly, the role of citizens has also changed from information consumers (passive) to information producers and suppliers (active). The definition of smart cities is variously defined according to each country's economic level and degree of urban development. The definitions of smart cities suggested by several researchers are discussed below.

According to Nam and Pardo [9], smart cities inject information into practical infrastructure with a series of goals. The main objectives are to improve convenience, increase efficiency, preserve energy, improve water quality and air quality, detect and solve problems quickly, recover from disasters, collect data for better decision making, use effective resources, and share data across regions. Caragliu et al. [10] define these cities as smart cities when investment, human and social capital, and ICT infrastructure efficiently utilize resources to improve sustainable economic growth and quality of life.

According to Kourtit, Nijkamp, and Arribas [11], smart cities are the product of knowledge-intensive and creative strategies for socioeconomic, ecological, and urban competitive advantage. These smart cities are based on the appropriate harmony of human capital (skilled labor), infrastructure capital (high-level communication facilities), social capital (open network connections), and corporate capital (creative and risk-taking corporate activities). Desideri and Verducci [12] refer to a city that reuses existing land, protects and strengthens urban green areas, improves energy efficiency, and reduces pollution emissions to improve citizens' quality of life.

Dameri [13] mentioned that a smart city, a digital city, and a sustainable city are the terminology definitions of the concept. There is a well-being city, and the elements that make up a smart city are land, technology, citizens, and government. In addition, it can be classified into smart cities, smart regions, smart city networks, smart countries, and global smarts, according to the range.

Svítek [14] pointed out that the basic concept of smart cities is to support the private sector (employment), public sector (education, security, and healthcare), and daily sectors (housing, culture, and sports). For smart cities to support this, infrastructure and resources (water, gas, and land), including transportation, information, and energy, are needed. According to Zanella et al. [15], smart cities improve citizens' quality of life with databases, advanced transportation systems, and intelligent buildings to connect people and share

information. According to Piro, Cianci, Grieco, Boggia, and Camarda [16], smart cities are urban environments supported by a wide range of information and communication technology (ICT) systems that provide advanced and innovative services to improve the overall quality of civil life.

According to Monzon [17], smart cities are systems where humans and social capital interact through technology-based solutions. Based on partnerships through local autonomy, smart cities aim for efficient, sustainable, and stable development and a high quality of life. According to Marsal-Lacuna et al. [18], smart cities (SCs) seek ways to provide high-quality services to citizens, improve quality of life, provide better public services, encourage innovative businesses, monitor and optimize urban infrastructure, and preserve the environment.

Snow et al. [19] define it as a community in which citizens, businesses, knowledge institutions, and local governments work together to continuously improve system integration and efficiency, civic participation, and quality of life. Lara et al. [20] define it as a flexible community that promotes the overall well-being of all members, and that it can be a proactive and sustainable place for life, work, and entertainment.

Finally, Azevedo Guedes et al. [21] explain that smart cities enhance intelligence and sustainability through governance that integrates interactions between stakeholders and technologies that optimize services and infrastructure. In summary, a smart city can be defined as a sustainable city that solves urban problems and improves citizens' quality of life through the fourth industrial revolution technology and governance between stakeholders.

2.2. Previous Studies

In previous studies that conducted a systematic review on smart cities, paper analyses focused on the major technologies or characteristics related to smart cities.

Cocchia [3] conducted a systematic review on smart cities and digital cities from 1993 to 2012. As a result, it was revealed that the smart city and digital city are rapidly spreading in the same research field and reality.

Antonoulos [22] conducted a systematic review of 41 publications related to the smart city domain. The literature analysis found that ICT trends such as IoT, big data, open data, e-government, and smart grid appeared clearly.

Thomas et al. [4] conducted a systematic review of 30 papers related to citizens' participation in smart cities. They suggested that most smart city studies lack discussion on people living in smart cities.

Daneva and Lazarov [23] conducted a systematic review of 32 papers related to ICT. They pointed that most researchers performed a bottom-up approach to the requirements of smart cities. In addition, security and privacy issues were mentioned as a fine, but new, trend.

Souza et al. [5] conducted systematic reviews of 39 major data mining and machine learning technologies used in smart cities. They presented "machine learning", "model", "data mining", "prediction", and "energy nodes" through network analysis. Yigitcanlar et al. [6] conducted a systematic review of 35 papers on the smartness and sustainability of smart cities, emphasizing the importance of smart people, policies, and technologies and the need for a post-entropy approach for sustainable urban development.

Laufs et al. [7] conducted a systematic review of 121 papers on the security technology of smart cities. They presented three categories of security intervention in smart cities (intervention combining new sensors and existing actuators, the intervention that makes existing systems smart, and intervention that introduced new functions).

Abusaada and Elshater [8] conducted a systematic review of 44 papers related to smart city specificity and location decision and suggested that 22 principles to create singularities among smart cities can be summarized and that the smart city should be ranked in consideration of the principle of location decision to increase the specificity of smart cities.

Esashika, Masiero, and Mauger [24] conducted a systematic review of papers from 1997 to 2010, focusing on keywords related to smart cities. As a result, five main characteristics of smart cities were presented: advanced ICT technology, knowledge-based economy, sustainability, high-tech government and citizen partnership, innovation, and a highly-skilled society.

Systematic reviews related to smart cities are being studied, focusing on smart cities' leading technologies and characteristics such as security technology, data mining technology, sustainability, and specificity. With the advent of the era of the fourth industrial revolution and the concept of smart cities changing, research on the overall research trends and major issues of smart city papers is insufficient. This paper attempts to identify major smart city issues and proposes future research through a literature analysis of smart cities over the past ten years, from 2011 to 2020.

3. Research Method

3.1. Research Subject

This study analyzed studies registered in international journals over the past ten years, from 2011 to 2020. This study looked at the major academic journals of SCI and SSCI to comprehensively examine issues in the scientific/technical and social science aspects related to smart cities. Academic journals have selected the top two journals in the number of papers published among SCI- and SSCI-level journals that have researched smart cities since 2011.

In the case of academic journal searches, papers were collected for research from journals using the keywords 'smart city', and by using 'smart city' in Web of Science (Table 1). The selected papers include 85 in the SSCI-class sustainability, 56 in the Sustainable Cities and Social Studies journals, 136 in the SCI-class IEEE, and 106 in the Sensors journal (Table 2). A total of 387 papers were searched from 2011 to 2020 during the research period, and three papers without the original text and one withdrawn paper were excluded (Table 3). Table 3 shows the number of documents by year.

Table 1. Criteria for the analysis of trends in the literature on smart cities.

Items	Contents
Keyword	'smart city', 'smart cities'
Language	English
Document type	Journal articles
Source	Web of Science
Time interval	2011–2020

Table 2. Journals of smart city research.

	Journal	Count	Rate (%)	IF
SCI	IEEE Access	136	35.5	3.745
	Sensors	106	27.7	3.275
SSCI	Sustainability	85	22.2	3.251
	Sustainable Cities and Society	56	14.6	7.587
Total		383	100	

Table 3. The number of documents by year.

Year	Total
2011	0
2012	1
2013	1
2014	4
2015	14
2016	28
2017	35
2018	63
2019	92
2020	145
Total	383

3.2. Systematic Review

This study conducted a systematic review of smart city studies from the last ten years. The research question was set as 'What are smart cities' main issues and research trends over the past ten years?' According to the research question, the analysis framework was set as follows.

In terms of research method, year, research methodology 1, research methodology 2, research purpose, data collection method, and use of research results were included in the analysis frame. First of all, in terms of the nature of the analysis data, the quantitative, qualitative, and mixed research methods used in Kim's research [25] were used. In research methodology 2, the case studies, literature studies, surveys, and interviews used in Jeong and Yoo's research [26] were used. The research purpose of Kim's study [27], to conduct an exploratory study, descriptive research, and explanatory research, was also used. The data collection method used the data types, such as primary and secondary, used in Mok et al.'s [28] study. Finally, the research results, basic research, applied research, and evaluation research used in Kim's study [29] were used. In addition, the analysis criteria included analysis units and classification of research topics suitable for the characteristics of smart city research.

In terms of research content, keywords related to research topics and topics, analysis units, general classification criteria for smart cities, and the presence or absence of security were included in the analysis frame. First of all, regarding the subject and keyword, the topic modeling used by Park and Lee [30] was used. As a result, this study classified topics into infrastructure/monitoring, citizens/sustainability, big data/algorithms, smart grids, the internet of things/cloud, governance, and transportation. Next, keywords in the study were extracted and classified for each subject. The analysis unit was subdivided from micro-level technology to macro-level countries and local governments. Nam and Pardo's [9] smart city classification criteria (technology and infrastructure, institute, and human resources) were used for the general classification of smart cities. In line with the recent trend of smart cities in which informatization is progressing due to the active introduction of ICT technology, this study analyzed smart cities' research in terms of security (cybersecurity and privacy).

4. Results and Discussion

4.1. Results of Research Method Analysis

As a result of the analysis of research method 1, 249 (65.0%) of the total 383 quantitative studies constituted the highest number of those published, followed by 114 (29.8%) qualitative studies and 20 (5.2%) mixed studies (Table 4). The high number of quantitative studies includes statistical methods for data analysis (Alablani and Alenazi; Munjal et al.) [31,32] and computer simulations for algorithm analysis (Reddy et al.; Alwajee et al.) [33,34]. Mixed studies include research that conducted both surveys and case studies (Deveci et al.) [35], computer simulation and case studies (Elseidi et al.) [36], literature research

and survey research (Kirimtat et al.) [37], and literature and case studies (Malik et al.) [38]. Overall, quantitative, qualitative, and mixed research show an increasing trend.

Table 4. Research methodology 1.

	Quantitative	Qualitative	Mixed	Total
2011	0	0	0	0
2012	1	0	0	1
2013	1	0	0	1
2014	4	0	0	4
2015	9	5	0	14
2016	16	10	2	28
2017	25	10	0	35
2018	46	17	0	63
2019	51	31	10	92
2020	96	41	8	145
Total	249	114	20	383

Next, the results of the paper distribution analysis according to research methodology 2 consisted of 241 (62.9%) experiments, followed by 76 literature studies (19.8%), 52 case studies (13.5%), 11 surveys (2.8%), and 3 interviews (0.7%) (Table 5). The reason why experimental methods accounted for the largest portion with 241 papers is that among the papers to be studied, papers in the field of science and technology account for a large portion. The main papers of the experimental method are multidimensional modeling (Jia and Wu) [39] for sustainable smart cities (Alwajeeh, Combeau and Avenau) [33] and crowd management systems (Santana et al.) [40] capable of detecting personal information. Literature research methods mainly consisted of an efficient smart city service framework (Li) [41] or a study comparing smart city services in various cities (Balasubramaniam) [42]. The case study method was used to analyze cases by unit (country, local government, and enterprise) implementing smart city policies. As the smart city trend is gradually expanding, the proportion of surveys and interviews that analyze the opinions of service users is still relatively low.

Table 5. Research methodology 2.

	Interview	Case Study	Survey	Experiment	Literature Study	Total
2011	0	0	0	0	0	0
2012	0	0	0	1	0	1
2013	0	0	0	1	0	1
2014	0	0	0	4	0	4
2015	0	1	0	8	5	14
2016	0	5	0	17	6	28
2017	0	5	0	24	6	35
2018	1	5	3	44	10	63
2019	1	13	1	55	22	92
2020	1	23	7	87	27	145
Total	3	52	11	241	76	383

The research analysis over the past ten years shows that exploratory studies account for the largest amount, with 308 (80.4%), followed by descriptive studies, with 50 (13.1%), and explanatory studies, with 25 (6.5%) (Table 6). In exploratory research, which explores ideas related to smart cities and suggests future directions, a study that proposed an environmentally friendly smart city system (Muvuna et al.) [43] and a study that seeks to promote interaction among members of smart cities (Aldelaimi et al.; Devi et al.) [35,44] were included. In descriptive research, which describes smart city-related phenomena and

presenting indicators and standards, ten real estate development projects worldwide (Moch and Wreda) [45] and in Lithuania were evaluated according to the smart city real estate development evaluation framework. Explanatory studies to identify the causal relationship by grasping the real relationship of the phenomenon included a survey of 624 citizens living in smart cities (Oh) [46] and a study to verify whether smart city public services are recognized through 428 urban residents in China (Yu et al.) [47].

Table 6. Research purpose.

	Exploratory	Descriptive	Explanatory	Total
2011	0	0	0	0
2012	1	0	0	1
2013	1	0	0	1
2014	4	0	0	4
2015	11	2	1	14
2016	21	4	3	28
2017	31	2	2	35
2018	56	4	3	63
2019	80	9	3	92
2020	103	29	13	145
Total	308	50	25	383

Next, as a result of the analysis of the distribution of papers according to the data collection method, the primary data was 63.9% with 245 pieces. The secondary data was 36.1% with 138 pieces (Table 7). There is much primary data because many studies applied and analyzed mechanisms or systems created by researchers. Research using surveys and interviews centered on consumers is also steadily increasing year by year. As the implementation of smart cities has expanded and many areas have been settled, the number of studies using secondary data, such as past policies and literature, has been smaller than that of primary data utilization studies.

Table 7. Data collection method.

	Primary Data	Secondary Data	Total
2011	0	0	0
2012	1	0	1
2013	1	0	1
2014	4	0	4
2015	8	6	14
2016	14	14	28
2017	25	10	35
2018	46	17	63
2019	59	33	92
2020	87	58	145
Total	245	138	383

According to the use of research results, most were basic studies, at 200 (52.2%), followed by 137 (35.7%) applied studies and 46 (12.1%) evaluated studies (Table 8). There are many basic studies to explore new knowledge of social phenomena and establish general principles because there are many scientific and technological studies. Basic research is mainly related to IoT networks (Singh) [48], target tracking (Zhang) [49] using IoT and edge computing, water leakage detection (Rojek) [50], and privacy protection (Anistetti) [51] using big data. In the case of applied research, it can be seen that the number has been rapidly increasing since 2018 because smart cities have undergone digital transformation. With the introduction of various technologies, many attempts have been made to solve existing social problems. Evaluation studies also showed an overall increasing trend

according to the increase or decrease in the number of research papers on the entire subject of smart cities.

Table 8. Use of research results.

	Basic Research	Applied Research	Evaluated Research	Total
2011	0	0	0	0
2012	1	0	0	1
2013	0	1	0	1
2014	2	0	2	4
2015	8	4	2	14
2016	18	5	5	28
2017	25	7	3	35
2018	35	25	3	63
2019	51	34	7	92
2020	60	61	24	145
Total	200	137	46	383

4.2. Results of Research Content Analysis

4.2.1. Infrastructure/Monitoring

With smart cities worldwide, research on smart city infrastructure development and smart city monitoring has been actively conducted. Apanaviene et al. [52] emphasized the importance of smart building development for smart city sustainability. They evaluated real estate development projects in 10 countries by developing a smart city real estate development evaluation framework. Nicolas et al. [53] utilized 50 smart city data sets to provide four clusters (i.e., technological infrastructure, open governance, intelligent community, and innovative economy), and four performance entities (e.g., efficiency). Ramos et al. [54] suggested a technology-agnostic method that can evaluate air quality pollution in smart cities and create pollution-free routes throughout the city amid the rise of air quality pollution as a major social problem. Hurst et al. [55] proposed a well-being monitoring solution through gas smart meter data analysis to solve the problem of energy poverty that lowers the welfare level of citizens in smart cities.

4.2.2. Citizen/Sustainability

In order to efficiently manage resources in smart cities and improve the quality of life of citizens, research on citizens and sustainability is being actively conducted. Suartika and Cuthbert [56] conducted case studies on smart cities in Europe, North America, and Asia on how multiculturalism affects smart cities. The analysis found that effective diversity management promotes the sustainable development of smart cities. Vidiasova and Cronemberger [57] reviewed plans and documents related to the smart city of St. Petersburg to examine the differences between local governments' smart city initiatives and citizens' perceptions. The analysis found that St. Petersburg pointed out that although a high level of linkage is made with existing e-government technology, citizen participation in smart cities is low due to differences in perception between citizens and the government. Oliveira et al. [58] emphasized that citizens' participation in social decision making is a major factor in improving the overall quality of life, and they examined the impact of smart city technologies such as information and communication technology, e-governance, and blockchain on public decision making. Alotaibi [59] suggested an advanced multi-factor user authentication scheme that blocks attempts to infringe on communication between the government and citizens amid the rise of e-governance using ICT in smart cities.

4.2.3. Big Data/Algorithm

Big data and algorithm technologies are being used to quickly and flexibly respond to unpredictable crises, such as disasters and public health crises (Yao and Wang) [60].

Lavale et al. [61] proposed big data visualization techniques that prevent potential risks such as fires and leaks from occurring in smart cities and that support users' decision-making capabilities in smart cities. Elsaeidy et al. [36] proposed a deep learning-based playback attack detection system to prevent playback attacks from occurring in smart cities. Avanzato and Beritelli [62] proposed a multi-layer perceptron (MLP)-based algorithm that estimates rainfall to cope with global climate change and resulting disasters.

4.2.4. Smart Grid

Curiale [63] presented a smart grid as a smart infrastructure within a sustainable city. Smart grids can make smart cities sustainable, increase the degree of innovation, and provide user-friendly urban services. The main keywords of the smart grid include energy efficiency, renewable energy, and environmental efficiency. Malik et al. [38] proposed an efficient computing framework that can effectively manage and transmit data created by IoT resources in smart cities. Pei et al. [64] emphasized the growing scarcity of energy due to the growing global population and, accordingly, the need for renewable energy. To this end, a sustainable probability distribution hybrid genetic approach (SSPD-HG) was proposed. Yao, Huang, and Zhao [65] emphasized that the development of smart city technology created a load on the environment and measured the degree of ecological efficiency according to the development of 152 smart cities in China.

4.2.5. The Internet of Things/Cloud

Jiang [66] suggested IoT, cloud computing, big data, and mobile internet (ICBM) as the core of smart city technology. Therefore, this study selected the internet of things/cloud as the main keywords of smart cities. The internet of things/cloud-related research accounts for the largest portion of all studies, with 97 (25.3%), and there is always a large distribution of research by year. The main keywords of the IoT/cloud include IoT-sensing devices and industrial IoT. Alvarez et al. [67] set up the internet of things device by providing data sources for smart cities. They adopted a pluralistic approach to increase the efficiency of data integration and analysis of IoT-sensing devices. Falco et al. [68] provided a clue to creating a detailed, scalable, and consistent attack tree as a fundamental step in protecting important infrastructure for the security vulnerabilities of the internet of things (IoT).

4.2.6. Governance

According to Purnomo et al. [69], transparent governance is important in smart cities. In order to get to good governance, the democratic system must be legally overhauled and public data must be open to the public. Therefore, this study selected governance as the main keyword for smart cities. The distribution of keyword by year yielded nine pieces in 2018, which had been on the rise since 2011, and the number of recent studies has been decreasing. The keywords related to governance include decision-making frameworks and urban management platforms. Deveci et al. [35] presents a comprehensive decision-making framework to solve many urban problems, such as traffic problems and air pollution, and explains governance that effectively captures the interests of decision makers through the case of Buddha. Westradt and Calitz [70] proposed an integrated urban management platform (ICMP) that strengthens synergy across the smart city sector for effective governance.

4.2.7. Transportation

According to Azgomi and Jamshidi [71], transportation in smart cities is divided into smart traffic control management and automatic vehicles. In the former case, it is ideal that all vehicles, signals, and controls share data and make appropriate decisions in an optimized environment. In addition, research on self-driving cars is actively underway as a means of transportation in the future. Accordingly, this study selected transportation as the main keyword for smart cities. The distribution of this keyword by year has recently shown the highest number of studies and active smart city research in 2020. Major keywords

related to transportation include vehicle monitoring, intelligent transportation systems, and the internet of things (IoT). Zhou et al. [72] introduced the Hadoop distributed file system (HDFS) path division data block (PDDB) based on the Apache Impala (PDDB-Impala) method, which is a way to increase the efficiency of monitoring data sharing with the rapid expansion of vehicle motoring networks. Gohar et al. [73] proposed an architecture that enables ITS, which is in charge of traffic management and monitoring throughout the city, to analyze and utilize big data efficiently. Ang et al. [74] studied the internet of vehicles, a fusion of the mobile internet and the internet of things, and explained it as IoT that provides applications for intelligent transportation, such as driver safety, transportation efficiency, and infotainment.

The research trends for each keyword are shown in Table 9.

Table 9. Research topics and keywords.

Year	Infrastructure/ Monitoring	Citizens/ Sustainability	Big Data/ Algorithm	Smart Grid	Internet of Things/ Cloud	Governance	Transportation	Total
2011	0	0	0	0	0	0	0	0
2012	0	0	1	0	0	0	0	1
2013	0	1	0	0	0	0	0	1
2014	1	0	1	1	0	0	1	4
2015	1	2	2	1	2	3	3	14
2016	4	3	3	0	10	5	3	28
2017	4	3	7	8	9	3	1	35
2018	5	13	13	5	14	9	4	63
2019	13	15	13	8	28	7	8	92
2020	18	30	20	18	34	3	22	145
Total	46	67	60	41	97	30	42	383

As a result of examining the smart city analysis unit, 39 out of 383 studies (10.2%) are those in which the analysis unit of smart cities is a country and 97 (25.3%) are those in which local government is studied. There were 16 studies (4.2%) in which the private sector was the analysis unit, and 196 studies (51.2%) in which technology was the largest (Table 10). Excluding this, studies in which individuals, theories, concepts, and papers are analysis units were set as others, and as a result of analysis, 35 articles (9.1%) were found. The reason why technology appeared at the highest rate as the analysis unit is that articles listed in the SCI-level academic journal in the analysis target study were studied as analysis units (Jarweh et al.; Chithaluru et al.; Qursehi et al.; Aldelaimi; and Sun) [44,75–78]. In-state, there are studies based on analysis units in Europe, the United States, Singapore, China, and Korea (Šulyová and Vodák; Perboli and Rosano; Guo et al.; Dong et al.; Lytras and Şerban; and Kim et al.) [79–84]. In the case of local government as an analysis unit, studies have been conducted in regions such as Birmingham, Sheffield, Barcelona, Manchester, Glasgow, and Dubai (Khan et al.; Encalada et al.; Amer et al.; Garcia-Font et al.; and Li et al.) [85–89]. In the case of the private sector, such as companies, factories, and universities, studies have been conducted on an analysis basis (Luke-Vega et al.; Saadi et al.; Horjejsi al et al.; Villegas-Chetal; and Mahapatra et al.) [90–94].

Looking at the results of the paper distribution analysis according to the general classification of smart cities presented by Nam and Pardo [9] (Table 11), the most studies (298, 77.8%) were related to technology, followed by 54 related to legal systems (14.1%) and 31 related to human beings (8.1%) (Table 12). The smart city components proposed by Nam and Pardo [9] are set out below. In the papers related to the technology of smart cities (Calavia) [95], the development of protocols to increase the efficiency of the energy transmission of buildings in smart cities (Quareshi; Won, Seo, and Bertino) [77,96] and personal privacy platforms are discussed. This subject mainly deals with the combination of smart city services and technologies. Issues related to legislation include seeking cooper-

ation between stakeholders (Weber) [97], public–private cooperation through a living lab (Braco) [98], smart tourism (Khan) [88], and smart mobility-related financial investment policies (Pina, Masala, and Garau) [99]. Regarding the legal system, research centered on governance, a cooperative structure composed of the citizens of public institutions and private organizations, is the main focus. In addition, human-related studies mainly include civic welfare (Luke-Vega) [91], platform monitoring (Choque) [100], and citizen-centered smart city development (Kuru and Angel) [101]. Since the main characteristic of smart cities is based on public policy, it can be seen that citizens are centered in all components.

Table 10. Analysis unit.

	Country	Local Government	Private Sector	Technology	Etc.	Total
2011	0	0	0	0	0	0
2012	0	0	0	1	0	1
2013	0	1	0	0	0	1
2014	0	1	0	3	0	4
2015	1	1	0	11	1	14
2016	1	9	0	16	2	28
2017	3	8	2	21	1	35
2018	2	8	2	44	7	63
2019	7	17	4	51	12	92
2020	25	52	8	49	12	145
Total	39	97	16	196	35	383

Table 11. General classification criteria for smart cities.

	Technology	Legal Systems	Human Beings	Total
2011	0	0	0	0
2012	1	0	0	1
2013	1	0	0	1
2014	4	0	0	4
2015	12	2	0	14
2016	22	3	3	28
2017	27	4	4	35
2018	52	7	4	63
2019	73	12	7	92
2020	106	26	13	145
Total	298	54	31	383

Table 12. General classification criteria for smart cities (Nam and Pardo, 2011).

Sort	Technology	Legal Systems	Human Beings
Main Source	Technology integration	Governance	Creativity
Details	Infrastructure, network facility, information and communication technology, and platform system	Department teamwork, policy, transparency, civic participation, and public partnership	Creative education, innovative job, open mind, public participation, and collective intelligence

According to Braun [102], efficiency and quality of life in a smart city must be preceded by the participation of citizens. For continuous participation and interest, it is necessary to have confidence and sufficient protection such that citizens participate. Therefore, the

basic security and privacy of smart cities are very important factors in the success of smart cities. Hasbini [103] defined security importance in smart cities as a factor that cannot be achieved because it lags behind sustainability and cost-effectiveness. If security is not considered important, future smart cities can suffer irreversible damage. Therefore, this study viewed security as an important item in the smart city trend study, and an analysis was conducted of the research on this topic. Security-related topics were analyzed by dividing them into cybersecurity and privacy, and related keywords are shown in Table 12. Looking at the distribution by year, the recent emergence of security-related keywords has increased by 733% compared to 2011–2017, and privacy keywords have appeared since 2018 (Table 13). Entering the digital era, information and communication technologies (ICT) such as big data, AI, blockchain, and IoT have played an important role in realizing smart cities (Singh et al., 2020). In this situation, many studies have been conducted on how to increase smart city security by analyzing the impact of ICT application on smart city security and utilizing ICT.

Table 13. Security keywords.

	Cybersecurity	Privacy	Total
2011	0	0	0
2012	1	0	1
2013	0	0	0
2014	0	0	0
2015	0	0	0
2016	2	0	2
2017	3	0	3
2018	9	5	14
2019	15	8	23
2020	26	8	34
Total	56	21	77

Jarawesh et al. [76] conducted a study on smart city security and privacy using edge computing amid the spread of IoT applications. Qureshi et al. [77] proposed a new and secure framework to detect the presence of smart city security threats in IoT and IIoT networks. Rahman et al. [104] designed an intrusion detection system (IDS) for sustainable resource management and the network infrastructure protection of smart cities amid the expansion of IoT. Andrade et al. [105] proposed and verified a model for evaluating the IoT cybersecurity maturity of smart cities in an IoT environment. Yu et al. [106] pointed out the security vulnerabilities of IoV, which combines ad hoc vehicle networks (VANET) and the internet of things (IoT) in smart cities. They designed a safe and efficient message authentication protocol for IoT in a smart city environment. Elsaeidy et al. [36] developed a deep learning-based model that protects smart cities by accurately detecting response attacks that damage smart city infrastructure.

As the number of smart cities applying ICT increases, many studies have been conducted to diagnose and present solutions to smart city cybersecurity problems in this environment.

Sifah et al. [107] proposed a distributed employee evaluation system using blockchain to achieve smart governance, a major element of smart cities, and solve the security and privacy problems existing in the existing employee evaluation system.

Geisari et al. [108] viewed the detection of sensitive privacy data in a smart city environment as an important issue in privacy protection and suggested a new protection architecture within IoT devices for privacy protection.

Anisetti [51] studied big data public policies that harmonize the two values in the compatible value of improving the quality of life and protecting information due to privacy exposure.

Researchers recognize privacy issues as a major threat to smart city governance and citizens' lives, and they actively conduct privacy protection research to ensure citizens' participation. The research trends for each keyword are shown in Table 13.

5. Conclusions and Discussion

This study was conducted in terms of research methods and research contents. To summarize the results in terms of research methods: (1) overall, quantitative research, qualitative research, and mixed research are all showing to be increasing trends; (2) the proportion of questionnaires and interviews that analyze the opinions of service users was relatively low; (3) the smart city trend is still taking shape, so exploratory research accounts for the largest amount conducted; (4) the number of studies using secondary data, such as past policies and literature, was smaller than primary data utilization studies; and (5) in smart city-related studies, the proportion of science and technology research was large, and the number of basic studies was large. Next, in terms of research content: (1) many studies have been conducted using the IoT, the cloud, and algorithms related to smart cities as analysis units, and (2) even in terms of Nam and Pardo's general characteristics of smart cities [9], research related to technology accounted for the absolute majority conducted.

Next, this study conducted keyword analysis and security issue analysis based on the research contents to examine the main issues related to smart cities. This study selected infrastructure/monitoring, citizens/sustainability, big data/algorithms, smart grids, IoT/cloud, governance, and transportation as major keywords related to smart cities. Summarizing the results, the core technologies were based on: (1) IoT, cloud computing, big data, and mobile internet (ICBM) regarding smart city development; (2) research on self-driving cars presented as a means of transportation in the future; and (3) smart grid services to increase sustainability and innovation. All of these were raised as major issues. Regarding the convenience of stakeholders related to smart cities, the major issues were: (1) legal maintenance of democratic systems and opening of public data; (2) efficient resource management and improved citizens' quality of life; and (3) big data and algorithms technology.

In addition, as the number of smart cities applying ICT increases, several studies have been conducted to diagnose and present solutions to smart city cybersecurity problems that may occur in this environment. Furthermore, privacy issues are recognized as a major threat to smart city governance and citizens' lives, and privacy protection research is actively conducted to ensure citizens' participation.

Based on the systematic review conducted in this study, future smart city research directions are as follows:

First, conducting research using surveys and interviews is necessary concerning smart city research methods. Of the 383 smart city studies, there are insufficient surveys (11, or 2.8%) and interview methods (3, or 0.7%). With the concept of smart cities changing from infrastructure supply-oriented to improving citizens' quality of life, surveys and interviews that reflect citizens' opinions need to be used to implement smart city policies that citizens can feel.

Second, it is necessary to conduct explanatory research on the purpose of smart city research. Of the 383 studies, 25 (6.5%) were descriptive studies. Research needs to be conducted on whether various factors such as infrastructure, sustainability, ICT, and governance of smart cities are causative in practically increasing smart cities' efficiency and quality of life.

Third, it is necessary to conduct private-level research on the smart city analysis unit. Private-level studies such as companies, factories, and universities were the lowest at 16 out of 383 studies (4.2%). Research needs to be conducted to analyze cases in which smart city services are applied to private sectors such as smart factories, smart homes, and smart buildings, and in which they measure utility.

Fourth, it is necessary to conduct human-level research on the general classification of smart cities. As a result of the analysis according to the smart city components (technology,

legal system, and humans) proposed by Nam and Pardo [9], humans were the lowest at 31 (8.1%). In smart city research, research was conducted focusing on smart city technologies such as the internet of things, the cloud, big data, and algorithms. In order to develop a smart city that improves citizens' quality of life away from the existing technology center, human-centered research such as public participation, creativity, and collective intelligence needs to be conducted.

Fifth, it is necessary to actively research terms of governance about smart city keywords. Smart city keywords have been actively studied in various fields, such as infrastructure/monitoring, citizens/sustainability, big data/algorithms, smart grids, the internet of things/cloud, governance, and transportation. However, out of 383 studies, only 30 studies (7.8%) were related to governance. As smart city promotion is changing from government-centered to open governance consisting of government–business–citizens, research on smart cities in terms of governance needs to be actively conducted.

Sixth, research is necessary to strengthen smart city security privacy. Research on smart city security is on the rise, and research on privacy began in 2018. Smart city information and communication technology prevents crime and enables efficient the use of urban resources, but citizens' concerns about personal information leakage coexists. In order to prevent smart cities from becoming a major factor in privacy infringement and to prevent a surveillance society, research needs to be conducted to strengthen citizens' privacy.

The significance of this study is that a systematic review was conducted on academic papers related to smart cities to identify research trends and analyze the characteristics of research in terms of research methods and research contents over the past ten years. In addition, keywords in terms of smart city security were analyzed by dividing them into cybersecurity and privacy, and the importance of security was evoked in smart city development. The major smart city keyword domains mentioned in this study will be further analyzed, and new studies with accumulated practical experience for each specific domain will be published as the actual SC project progresses. The research results mentioned in this study are expected to serve as useful guidelines for future smart city development projects.

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