

Review

# Smart City Research Classification: A Systematic Literature Review

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**Abstract:** In the digital era, technological advances are always evolving as well as urban problems in a city. A smart city is an implementation in dealing with urban problems by providing public services. This public service is also related to one of the uses of applications that are integrated with ICT in public services. Smart cities also have various types of applications that can be used to provide services to the community. The progress of the internet of things and big data analysis has become the infrastructure in implementing smart city applications. This study aims to classify 25 cities that implement smart cities based on smart applications used using a systematic literature review method. With this research, researchers are expected to be able to identify the types of smart city applications that are classified in each city.

**Keyword:** Smart City, Systematic Literature Review, Smart Application

## Introduction

The more developing times the human population is also growing too. It is this population that creates many urban problems in each city. The development of a smart city in city can be a strategy for dealing with many urban problems (Madyatmadja *et al.*, 2018a). The urban problem creates such as energy consumption, pollution, waste treatment and traffic. Smart cities using technology that can create opportunities for urban problems. Smart city creates strategized around the environmental, social challenge and economic. Smart city has so many concepts such as ubiquitous city, intelligent city, knowledge city, digital city and information city (Gupta *et al.*, 2019). The urban problem is getting more and more challenging. Use help from Internet of Things (IoT), Information and Communication Technologies (ICT), Data Mining, Big Data Analytics and Data Fusion become a component to support smart city strategy (Madyatmadja *et al.*, 2018b). Several cities worldwide have implemented smart cities such as New York to enhance the quality of water, improve the quality of resident life, reduce the environmental impacts and create more street light efficiency. London using the smart city to create smart streets to collect wide data that provide world-class connectivity and security. Paris wants to improve citizen

services, digital transformation, sustainability and urbanization. There is also a city like Singapore and Tokyo that implement smart cities. Singapore wants to enhance the national digital identity of its citizens by creating e-payment systems, smart nation sensor platforms, smart urban mobility and smart community initiatives. Tokyo wants to improve transportation and other sectors of its economy. several cities in China also implemented smart city to facilitate economic and social development to build a high-income smart city (Lau *et al.*, 2019).

Other than the city in an outside country, several cities in Indonesia have also implemented the smart city concept such as Bandung, Jakarta, Surabaya, Banda Aceh and others but not going smoothly (Firmanyah *et al.*, 2017). This happens because some people do not understand what a smart city is, do not know how to use a smart city and do not know what benefits can be obtained from a smart city (Anindra *et al.*, 2018). Advances in smart city technology have led to many types of applications that can be used in the various city both abroad and domestically. An application that has been raised includes smart living, smart urban area management, smart environment, smart industry, smart human mobility, smart economics and smart infrastructure. Each application has its own respective field (Lau *et al.*, 2019).

## Literature Review

### *Definition of Smart City*

Smart city has many definitions based on many experts according to (Firmanyah *et al.*, 2017) a smart city can be conducted when human, infrastructure traditional, social, infrastructure modern like ICT supporting the economic growth and quality of life. Smart city has a specific characteristic that is efficient information and communication technology, a co-creative platform to engage stakeholders from idea generation to product solution stages, effective use of the data generated through interfaces of key stakeholders using state of art system with big data availability. Smart city are essentially people, technologies and processes in how they connect with various sectors including healthcare, education, transportation, telecom, tourism, public safety and buildings (Khan *et al.*, 2017).

### *Definition of Internet of Things*

The Internet of Things is a system of internet-connected and interconnected computing devices, mechanical and digital machines that provide unique identifiers and have the ability to transfer data across networks. In a smart city, the internet of things acts as an infrastructure that is very important to support the development of smart cities. IoT provides valuable and beneficial information by various user devices through wireless and wired internet network IoT provide user-customized services, the data collected by electronic home appliances, including refrigerators, are shared and stored in a smart home environment. Various services utilizing IoT technologies in a smart city can bring about a sustainable and pleasant living environment for its citizens (Park *et al.*, 2018).

### *Definition of Big Data Analysis*

Big data as the name suggests is a very large piece of data that cannot be processed by traditional methods. Big data generates an incredible amount of diverse and high-speed data. The amount of data can be obtained from many sources. Big data has three component variations, namely volume, velocity and variety. It specifies that when an enormous amount of high-speed data is to be collected to process and analyze through various sources (Rathore *et al.*, 2018)

### *Definition of Smart City Application*

Smart city application has a lot of types and has its own respective fields such as Smart Living with Smart Health, Smart Home, Smart Community. Smart urban area management with Smart Governance, Smart Urban Planning, Smart Building. Smart Environment with Landscape Monitoring, Urban City modeling, Waste

Management. Smart Industry with Smart Manufacturing, Smart Maintenance, Smart Agriculture. Smart Economics with Smart Commerce, Smart Supply Chain, Smart Tourism. Smart Human Mobility with Smart Location-Based Services, Human Mobility Understanding, Smart Transportation System. Smart Infrastructure with Smart Grid, Smart Energy, Smart Facility, Smart Communication.

### *Definition of Smart Living*

Smart living increases the understanding of how people and technology can come together to bring up a decision that becomes a concept of integration:

- Definition of Smart Health: Describes the digitalization of health care. By using the technology, It creates electronic health records, the development of assistive systems for the elderly and people and remote diagnostics through telemedicine
- Definition of Smart Home: Incorporates sophisticated automation systems to provide occupants with detailed monitoring and control over building functions. with this smart home, people can remotely manage their homes, such as turning on lights with remote devices such as cellphones, laptops and others
- Definition of Smart Community: Several cities implement smart communities such as the USA, Canada, Australia, Singapore, China and others. smart communities can be useful as state-owned systems to collect data from both public such as traffic cameras, transit data and others then as private online shopping, fitness tracker and others as data that can be used to detect user behavior that helps community welfare
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### *Definition of Smart Urban Management*

Smart urban management can be used to handle urban areas. This smart has many types namely:

- Definition of Smart Governance: Aims towards a performance improvement of administration topics, to enhance accountability and transparency. It includes e-government, the efficiency agenda and mobile working scenarios several cities such as Singapore, Tokyo, Oslo and many others are using smart governance
- Definition of Smart Urban Planning: This smart urban planning helps pay attention to the welfare of the urban population all the data that combine to understand city development sometimes this has a negative impact, namely data that is not neatly arranged but with this urban planning it can create an ideal city
- Definition of Smart Building: Smart building in a city is used as a regulator in managing existing resources in buildings in a city. settings can be electricity, air conditioning, ventilation and other electronics in a building. besides managing resources in a building. a smart building can also be used as a tool for emergencies

### *Definition of Smart Environment*

This smart environment is used to study the environment in a city. With this smart environment, we can handle urban areas such as global warming. This smart environment can also be used to calculate waste in cities

Definition of Landscape Monitoring:

- Landscape monitoring is used to see changes that have occurred in a city, commonly used to visualize changes that occur in a city, data sources are collected using satellites
- Definition of Urban City Modeling: The use of urban city modeling is used to understand the diversity of species that exist in a city such as mountains, trees and others by using satellite data for distribution
- Definition of Waste Management: This waste management is used to regulate waste pollution in a city. With this waste management, the waste can be processed and categorized from each type of waste. then waste management can monitor a polluted area from time to time

### *Definition of Smart Industry*

With the industry standard 4.0 in the future, the industry will experience a transformation of the approach with this smart industry, so the industry can take advantage of the data collected from sensors and buildings:

- Definition of Smart Manufacturing: Smart manufacturing is used to optimize the manufacturing process in a factory, such as using robots with sensors for product delivery
- Definition of Smart Maintenance: Smart maintenance is useful for detecting the state of a machine whether the machine is as well as a flexible machine maintenance system by detecting errors accurately
- Definition of Smart Agriculture: Smart agriculture is mainly aiming towards sustainably increasing agricultural productivity and income of farmers as well as supporting the agricultural lifecycle by implementing smart farming strategies

### *Definition of Smart Economics*

Smart economics are used to generate commercial value in a trade, supply chain, logistic, finance center and tourism:

- Definition of Smart Commerce: Smart commerce is used to help customers in a city in determining a decision when they want to buy an item. In addition to smart commerce customers, it can also help investors make investment decisions by utilizing financial data
- Definition of Smart Supply Chain: The smart supply chain is used as a tracker in understanding

the flow of process objects such as food with this smart supply chain, customers can check the authenticity of the food brand

- Definition of Smart Tourism: This smart tourism is useful for recommending places for customers who want to travel and customers can also use this smart tourism application to track where they want to go

### *Definition of Smart Human Mobility*

Smart human mobility is useful for improving strategies in the transportation system with smart human mobility so we can see the movement of citizens based on the data collected:

- Definition of Smart Location-Based Services: This smart location-based service is used to get an accurate position and provide navigation services for a comfortable and smooth trip with the use of technology such as smartphones
- Definition of Human Mobility Understanding: Human mobility understanding is defined as solutions and services which offer the possibility for energy-efficient, low-emission, safe, comfortable and cheap mobility that can be used smartly
- Definition of Smart Transportation System: smart transportation system is used to deal with congestion that occurs in a city as well as handling such as accidents

### *Definition of Smart infrastructure*

Smart infrastructure describes the implementation of inter-connected technologies in infrastructure and the equipment they interact with:

- Definition of Smart Grid: Smart grids are used to provide a stable and reliable power supply commonly used to handle and detect demand for electrical loads in certain areas, both buildings and houses in a city.
- Definition of Smart Energy: Smart Energy is mainly related to the solutions and services that are integrated into the living environments and aims to foster more efficient lifestyle energy.
- Definition of Smart Facility: Smart facilities are used to provide services such as parking facilities, clean water and others. These smart facilities can be useful for detecting water leaks and proposing the condition of the water data.
- Definition of Smart Communication: Communication in a city is the most important thing. smart communication is useful for designing efficient and smooth communication so that people can communicate with each other without any obstacles (Lau *et al.*, 2019)

### Comparison Between Smart Cities in Developing and Developed Countries

As we know that developed and developing countries have different levels in terms of technology. Of course, developed countries have a higher level in the use of technology for smart city implementation. However, developing countries are also not inferior to the use of technology, although not as high as developed countries. Developed countries have a wealth of human resources, but as advanced as they are, countries certainly have weaknesses. One of the weaknesses of these developed countries is natural resources. Singapore is one of the developed countries that have adequate human resources but lacks natural resources, in contrast to developing countries such as Indonesia which have abundant natural resources but inadequate human resources. If Indonesia and Singapore can work together in natural resources and human resources, this has advantages in both countries, Singapore can take advantage of the natural resources owned by Indonesia and at the same time can be an example for human resources in Indonesia in processing their natural resources.

### Methodology

The research method used in this study is a systematic literature review. This method is used to analyze several studies of cities from both developed and developing countries that use smart city applications and then classified into several types. Research data is taken from several sources: Link Springer, IEEE Xplore, Research Gate, Science Direct, Taylor, Sage Journal, Google Scholar, ACM, MDPI and others. the method starts from the number of studies obtained, determines the study candidate and determines the selected study from the specified candidate. Make a Venn diagram of the entire paper you are looking for. determine the author of each paper found and where the author is from and create a bar chart. Fig.1 shows Searching strategy for systematic literature review. Fig. 2 shows Diagram venn for systematic literature review.

### Results

#### Study Found

The first keyword is (Smart City Research Classification) obtained 64 papers then the second keyword is (smart city Internet of Things and Big data) obtained 26 papers and the third keyword is (Smart City “Country”) obtained 25 papers. The total of the paper is 115 papers. Each paper is checked manually and which paper is searched for according to the topic to be worked on. Table 1 shows distribution of the selected studies.

### Candidate Studies

Of all the papers that have been found, as many as 115 papers, several papers are needed to be used as candidates by adjusting the abstracts and research questions, 59 papers were found to be candidates for this study.

### Decide the Selected Studies

For the selection of papers that will be used in this study, the criteria must be:

- research on the identification of "Smart City" which is implemented in several cities, both developed and developing countries
- The article must be related to the research question
- the articles you are looking for must be published at least from 2011-2021
- From the results sought, as many as 25 papers were found according to the specified criteria

From the distribution table above, a Venn diagram will be made as a result of the systematic literature review. It was built using the following scheme:

- Set C (Selected Studies) is a subset from set B(Candidate Studies)
- Set B(Candidate Studies) is a superset from set A(Selected Studies)
- $C \subseteq B$
- $(C \cap B) = 25$
- $A = 115 - (59+25) = 31$
- A is contain journal articles that are not include as selected or candidates

**Table 1:** Distribution of the selected studies

Source	Studies Found	Candidates Studies	Selected Studies
ACM	4	2	0
ASCE	1	0	0
CEEOL	1	1	0
CS Canada	1	0	0
Emerald Insight	1	0	0
Google Scholar	5	4	2
IEEE xplore	22	14	8
IOP	3	1	1
Korean Science	1	0	0
Link Springer	10	4	2
MATEC	1	1	0
JOCGPP	1	1	1
MDPI	10	6	2
Research Gate	2	1	1
Sage Journal	3	1	1
Science Direct	43	20	6
Taylor Francis Online	5	3	1
UDS	1	0	0
Total	115	59	25

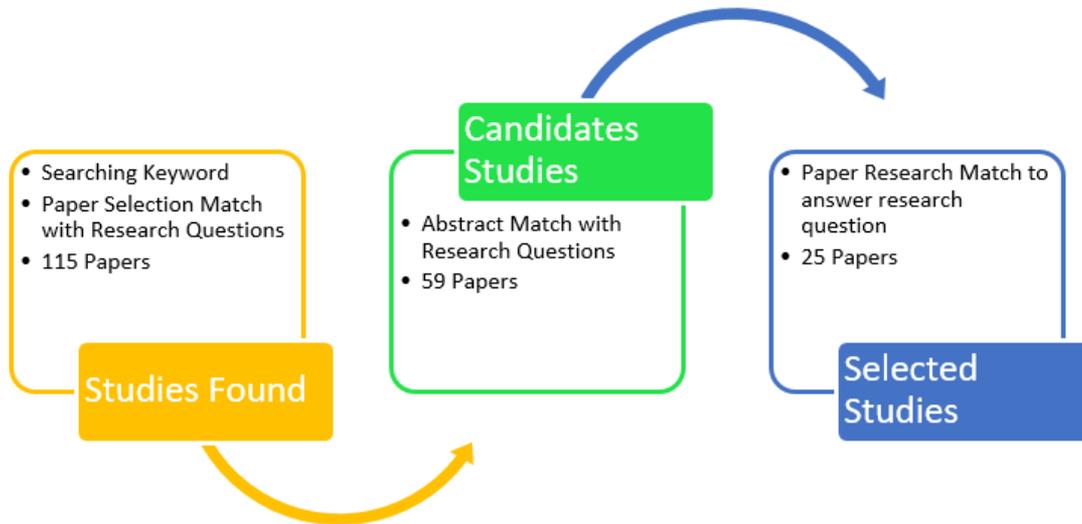
*Selected Studies Overview*

Of the 25 papers selected, there were 90 authors with 14 institutes, 56 universities and 3 companies. here is the distribution of affiliates.

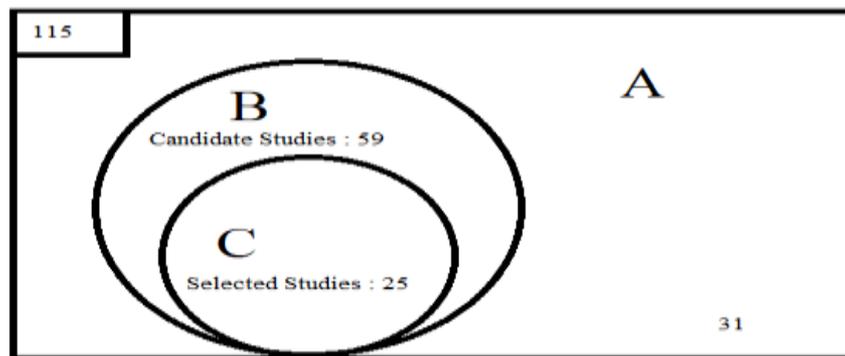
Geographically, the affiliations of each author are scattered throughout the world including Indonesia,

Taiwan, Finland, France, Spanish, India, America, Korea, Canada, Singapore, Pakistan, China, Qatar, Italy, Australia, Brazil and Swedish.

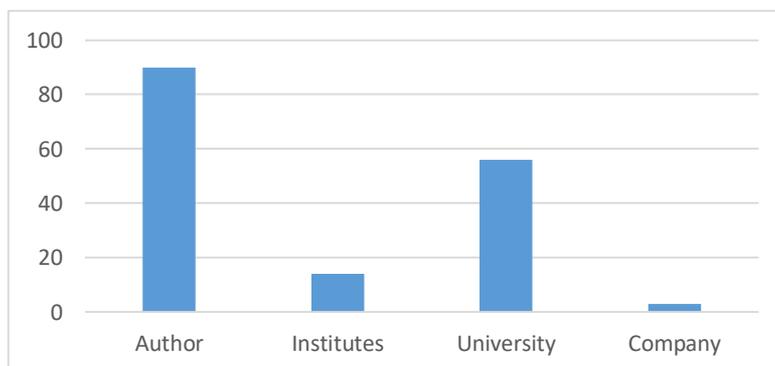
Figure 3 shows Distribution of affiliations. Figure 4 shows Author affiliations across the country.



**Fig. 1:** Searching strategy for systematic literature review



**Fig. 2:** Diagram venn for systematic literature review



**Fig. 3:** Distribution of affiliations

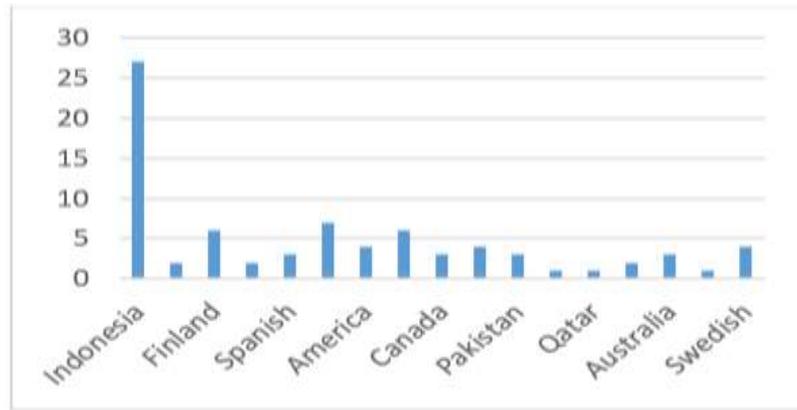


Fig. 4: Author affiliations across the country

Table 2: Research classifications of 25 cities in both developed and developing countries

No	Cities	Nations	Smart application	The form of the application that is implemented
1	Tangerang Selatan	Indonesia	Smart Human Mobility	<b>Smart Transportation System:</b> Improve the quality of the shuttle bus transportation system to attract the urban population and provide satisfaction to users in using public Transportation (Fassa <i>et al.</i> , 2017).
2	Makassar	Indonesia	Smart Infrastructure, Smart Urban Area Management, Smart Human Mobility	<b>Smart Facility:</b> Create a smart operation room to provide services to consumers such as water, electricity, telephone services and others <b>Smart Transportation System:</b> Install CCTV throughout the city of Makassar to collect data and make observations as well as monitor the situation in the city in the Makassar area (Kurniawan <i>et al.</i> , 2016). <b>Smart Governance:</b> Making e-governance, namely smart cards in the city of Makassar to provide quality service to consumers in payments, monitoring traffic jams and online parking payment systems (Hardi and Gohwong, 2020).
3	Vienna	Austria	Smart Infrastructure, Smart Urban Area Management, Smart Human Mobility	<b>Smart Energy:</b> Create Wien Energie as pioneer using blockchain technology, clean heat and stable power grid, energy from metro break and smart traffic light. <b>Smart Governance:</b> Create E-government for regulation in the use of energy efficiency <b>Human mobility understanding:</b> Create mobile application public transport, E-drive Mobility (Roblek, 2019).
4	New York	America	Smart Infrastructure, Smart Environment, Smart Urban Area Management	<b>Smart Facility:</b> Create a smart solution such as water management, air quality control, lightning in the city, improvement in parks and others. <b>Waste Management:</b> Create waste to energy plant (Shah <i>et al.</i> , 2019). <b>Smart Governance:</b> Create energy efficient lightning to urban area (Lau <i>et al.</i> , 2019). <b>Smart Urban Planning:</b> Create cross-department in the city (Zvolska <i>et al.</i> , 2019).
5	Berlin	Germany	Smart Urban Area Management	<b>Smart Governance:</b> Create a smart London plan to overcome congestion, air pollution, increase the strain on healthcare and the management of utilities (Zvolska <i>et al.</i> , 2019).
6	London	United Kingdom	Smart Urban Area Management	<b>Smart Governance:</b> Create energy efficient consumption lightning to urban area (Lau <i>et al.</i> , 2019).
7	Oslo	Norway	Smart Urban Area Management	<b>Smart Communication:</b> Create TPE-Free and ubiquitous Wi-Fi in Taipei city.
8	Taipei	Taiwan	Smart Infrastructure, Smart Human Mobility	<b>Smart transportation system:</b> Create a Realtime CCTV as public services through smartphone to get information and developing intelligent transportation system to deliver a good service for the citizen in Taipei such as You Motor and You Car for rental services (Alamsyah <i>et al.</i> , 2016). <b>Smart Governance:</b> Create E-Governance for citizen to provide services such as E-health, e-perizinan, e-delivery and other for a better administration process (Alamsyah <i>et al.</i> , 2016).
9	Surabaya	Indonesia	Smart Urban Area Management	<b>Smart Commerce:</b> Increase revenue, corporate taxes, stimulation of consumption
10	Hangzhou	China	Smart Economic, Smart Living	<b>Smart Community:</b> Improve indoor living environment dan personal Entertainment (Argyriou, 2019).
11	Amsterdam	Netherlands	Smart Living, Smart Urban Area Management	<b>Smart Community:</b> Engage local community to find a solution for the benefit of the city. <b>Smart Building:</b> Create a smart working to support sustainable real estate development, company energy consumption improvement and employee awareness (Yigitcanlar <i>et al.</i> , 2019). <b>Waste Management:</b> Create water recycling system with technology (Yigitcanlar <i>et al.</i> , 2019)
12	Songdo	Korea	Smart Environment	<b>Smart Transportation System:</b> Create electrified public transport system, walking, and cycling network (Yigitcanlar <i>et al.</i> , 2019).
13	Masdar	United Arab Emirates	Smart Human Mobility	<b>Smart Communication:</b> Create large number of free Wi-fi Hotspot in various public location.
14	San Francisco	America	Smart Infrastructure, Smart Human Mobility	<b>Smart Transportation System:</b> make a twisty Lombard Street to reduce the slope to allow driving (Yigitcanlar <i>et al.</i> , 2019). <b>Smart Transportation System:</b> Create smart traffic system such as digital message signs, CCTV camera, Bluetooth sensor devices to deliver notification.
15	Brisbane	Australia	Smart Human Mobility, Smart Infrastructure	<b>Smart Communication:</b> Create free Wi-Fi in major city park, libraries, shopping mall, etc., (Yigitcanlar <i>et al.</i> , 2019). <b>Smart governance:</b> Create Dubai E-Governance and changes the name into Dubai Smart Governance.
16	Dubai	United Arab Emirates	Smart Urban Area Management, Smart Infrastructure, Smart Economics	<b>Smart Facility:</b> Create Smart parking facility and traffic digitalization governance (Mohasses, 2019). <b>Smart Tourism:</b> Create smart destination technology for citizens (Khan <i>et al.</i> , 2017).
17	Singapore	Singapore	Smart Human Mobility	<b>Smart Transportation System:</b> Create MyTransport.SG features for the citizen (Sukawan <i>et al.</i> , 2021).
18	Barcelona	Spanish	Smart Human Mobility,	<b>Smart Transportation System:</b> Create sensor LED lamppost to monitor traffic, air

**Table 2:** Continue

		Smart Environment	quality, pedestrian activity and noise.
19	Helsinki	Finlandia	Smart Infrastructure
20	Bandung	Indonesia	Smart Urban Area Management, Smart Economics, Smart Living, Smart Human Mobility, Smart Infrastructure, Smart Environment
21	Bekasi	Indonesia	Smart Infrastructure
22	Iqaluit	Canada	Smart Human Mobility, Smart infrastructure, Smart Living, Smart Economics, Smart Urban Area Management
23	Paris	France	Smart Human Mobility
24	Jakarta	Indonesia	Smart Environment, Smart Human Mobility
25	Toronto	Canada	Smart Living

## Conclusion

This study aims to classify the types of applications that exist in the implementation of "Smart City" in cities, both developed and developing countries. From the research that has been researched, smart city has many types of applications that can be implemented in a city for the benefit of that city. Of course, the smart city application cannot run without the help of the internet of things and big data analysis. This study classifies 25 cities that implement smart city applications. From this research, each city has many types of smart city applications according to the needs of each city. There are many types and types of smart city applications. Table 2 shows Research classifications of 25 cities in both developed and developing countries.

This study shows how smart cities in every city, both developed and developing countries, are considered implemented by looking at the definition of components and measures of city performance. We hope that this study will be useful for researchers who want to classify cities based on the smart city application implemented.

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## Author's Contributions

**Evaristus Didik Madyatmadja:** Lead research project, coordinate developer, doing experiment, be an instructor, data analysis and writing the manuscript.

**Andreas Setiawan:** Advise research project, design the research methodology, data analysis, writing manuscript, proof reading.

**Hendro Nindito:** Advise research project, design the experiment, data analysis and writing manuscript.

**Debri Pristinella:** Advise data analysis and writing manuscript, corresponding author

**David Jumpa Malem Sembiring:** Advise research project, design the application, data analysis, writing manuscript, proof reading.

## Ethics

Authors confirm that this manuscript has not been published elsewhere and that no ethical issues are involved.

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