JIKO (Jurnal Informatika dan Komputer)
Vol. 6, No. 3, December 2023, pp. 196-202
DOI: 10.33387/jiko.v6i3.6967

Accredited KEMENDIKBUD RISTEK, No.105/E/KPT/2022
p-ISSN: 2614-8897
e-ISSN: 2656-1948

MAPPING INFORMATION TECHNOLOGY ADOPTION IN SMART CITIES: A LITERATURE REVIEW AND RESEARCH THEMES

Nur Hadian[1]

[1] Pekalongan Institute of Technology and Science Nahdlatul Ulama
*Email: [1]nurhadian97@gmail.com

(Received: 14 November 2023, Revised: 7 December 2023, Accepted: 9 December 2023)

Abstract

In the growing digital era, Information Technology (IT) has created breakthroughs in various fields before finally playing a significant role in the Smart City (SC) concept, as has been proven in many studies. Previous studies have shown that IT implementation in SC varies significantly as it has to be customized to the SC domain. Thus, it is necessary to map the feasible IT adoption for each SC domain. Here, we conducted a literature review and found several research themes of IT adoption in SC. Our findings include: (i) IT adoption in SC and (ii) SC domains. In this study, a literature review was conducted manually on journals that examined IT adoption in SC and SC domains. The extraction and synthesis results identified several research themes, including Geographic Information Systems, the Internet of Things (IoT), Big Data Analytics, and Wireless Sensor Networks. Research questions are posed in each theme, which can be helpful to insights for future research.

Keywords: *Information Technology Adoption, Smart City, Digital Era, Literature Review, Research Themes*

**Corresponding Author: Nur Hadian*

1. INTRODUCTION

Various information technologies that have been applied to Smart Cities show the important role of information technology in the success of the Smart City concept. Previous studies explain that the Internet of Things (IoT) is the basis for realizing the smart city concept. The use of IoT to optimize network traffic in real-time using DBN and clustering models has significantly impacted city network management[1]. The role of blockchain for IoT-based Smart cities provides confidence in the level of security in transaction storage and privacy of citizens from the threat of cybercrime [2]–[4]. However, IoT devices have an impact on energy waste in the city. So, there is a need for further management of IoT devices, namely energy management with analytical data[5]. On the other hand, it is about protecting citizens' privacy and improving citizens' quality of life by adopting big data to build media literacy[6]. Cloud computing and big data effectively integrate information to make more comprehensive decisions on various data to coordinate city operation management and industrial development. In the wireless infrastructure of smart city cities, network deployment directly affects the quality of city network services[7], as done by [8], which designs social physical security systems in the form of complex and heterogeneous network systems to integrate human characteristics and social life. Research on the impact of IT on all smart city sectors has been widely conducted, as described earlier, and almost all smart city programs must-have technology in use. However, it is important to note that researchers have used various definitions of IT adoption and Smart City for each city's problems. Therefore, a literature review is required to delineate the different IT adoptions used and enable a reduction in the risk of implementation failure [9]. Where themes and future research directions can be identified, research's contribution lies. Other research has been conducted by [10]. A review of ICT Governance refers to the investment and effective use of ICT to guide organizations to achieve their strategic goals. Then [11] provides direction for using ICT in each aspect, such as e-services based on G2C, G2B, and G2G. To enrich this research, in addition to identifying IT adoption in smart cities, it also categorizes previous research topics into themes. So, research on IT adoption in the context of smart cities can be mapped regarding technologies that can be applied, and new

studies emerge based on these themes. The following will explain what IT has been implemented in SC and what SC domain mapping has been developed.

2. RESEARCH METHOD

This study's literature review methodology is based on the method developed by [12]. Determining the study objectives, the literature collection process, research inclusions and exclusions, data extraction, and synthesis are all part of the research technique. The next sections will go over each stage in detail.

2.1 Research Objective And Literature Search

This study identifies the IT scope employed in SC-related investigations. Furthermore, the IT adoption and SC domains will be determined. This must be done with the broad scope of SC in mind, both in terms of the concept of SC and the domains of SC. The grouping of prior investigations into topics is the end consequence of this research. This is expected to spark further investigation. This research was conducted manually using the terms "Information Technology" and "Smart Cities" in leading online databases such as IEEE, Science Direct, ACM, Springer, Emerald, Google Scholar, AIS Electronic Library, and Wiley Online Library. These keywords were chosen to produce search results that reflect the extent of IT in South Carolina. A total of 2,717 journals were found in the search results. The selection method yielded 48 journals, including 32 articles and 16 conference journals. The next section will review the inclusion and exclusion criteria used.

2.2 Inclusion Criteria

The journals covered in this study are all in English. Journals that discuss Smart City domains or IT adoption applied to Smart City domains (such as Smart Water, Smart Waste, and so on) are the primary criterion for journal selection. Data was taken from the 49 selected journals based on specific criteria, which would subsequently be used to develop research themes. The following information was taken from the journals: study questions, terminology, IT adoption utilized in SC, Smart City domains, and variables supporting the Smart City concept. Section 3 will go over the data extraction outcomes.

3. RESULT AND DISCUSSION

This subsection will discuss two main points resulting from the data extraction and synthesis. First, it will explain the scope of information technology used in each Smart City domain identified in the previous research. Secondly, it will discuss the division of the research into various themes.

3. 1 Information Technology and Smart City Domain

Previous research has indicated diversity in the scope of Information Technology (IT) applications in the Smart City (SC) context. In this sub-section, we will explain the terms used in this context. However, before further discussion, it is necessary first to describe the domain at the core of Smart City. In their article, Vito et al. [13] provide a comprehensive overview of definitions, dimensions, performance, and initiatives in the context of smart cities. They highlight that the smart city concept focuses on Information and Communication Technology (ICT) and pays great attention to the 'quality of people and communities'. Damiri Riciardi argues that ICT technologies can be used to monitor, assess, and improve the sustainability performance of smart cities. She also proposes the Smart City Intellectual Capital (SC-IC) Framework, which comprises six significant ideas: human, social, institutional, process, renewal, and environmental. Furthermore, he proposed five projected smart city outcomes: value, competitiveness, resilience, sustainability, and quality of life. This study demonstrates that information technology is critical to achieving the Smart City aims.

3.1.1. Information Technology Adoption in the Context of Smart City

Based on several studies, Information Technology (IT) infrastructure, such as the Internet of Things (IoT), is believed to have a direct influence on Smart City (SC) implementation [13], [14]. However, most IT research in the context of a Smart City regards IT as a variable or construct that can be used across various areas of a Smart City. A major theme that emerges in Smart City research is the critical role of IT, and this approach is consistent with the recommendations that researchers put forward in a Smart City context. Adopting Information Technology (IT) in a Smart City context has many ways. For example, [11] suggested using smart sensing systems to collect and manage real-time data on cyclists' health and air pollution. Wireless networks and the Internet of Things (IoT) are the core emphasis of communication technology, serving as the main infrastructure of a data-driven Smart City. In addition, the most frequently emerging components in research in the Smart City field are IT adoption, such as wireless networks, big data analytics, and the Internet of Things (IoT).

1) Internet Of Things (IoT)

In many studies on the Internet of Things (IoT), two primary references are often mentioned, namely [16], which discuss the concept of IoT. The IoT paradigm encourages the potential of IoT to support the vision of smart cities globally, so the idea of IoT is considered one of the key elements in realizing smart cities [15]–[17]. This paradigm has been the basis for research that identifies elements that support the idea that the Internet of Things (IoT) is an important component of smart cities. The Internet of Things concept has been used in several studies, such as [18], [19], to monitor energy consumption, forecast energy

demand, and reduce energy expenditure costs. Furthermore, research [20] utilizes IoT to manage municipal waste, while [23] is used to detect city fires. In addition, the Internet of Things is also capable of addressing urban problems and providing rapid responses. IoT also plays a role in addressing urban issues and providing quick responses, improving the city structure [21].

2) Big Data Analytics

Some researchers have utilized Big Data technology to develop smart city concepts, as shown by [22]–[24], using Big Data by utilizing artificial intelligence to detect fires in the city early [25] utilizing Big Data to reduce the use of expensive devices such as sensors and air condition monitoring facilities in the city to address the city's pollution problem. In addition, innovation in public policy is an essential component of smart city development. These innovations include plans and policies made to achieve specific goals in improving the welfare of society. With Big Data, policy definitions can be enhanced to achieve unprecedented levels of effectiveness in various domains, such as economic or social. However, maintaining residents' privacy is also important to attain a better quality of life in smart cities. According to previous studies that researchers reference, many technologies are used by researchers to solve problems uniquely. For example [26] menggunakan Internet of Things untuk mendeteksi kebakaran kota secara dini, dan [27] using big data to tackle urban fires. Various technologies can be used to solve similar problems. Therefore, it is important to identify the most appropriate technologies to implement the smart city concept and minimize the use of useless applications, as discussed in this study.

3.1.2. Smart City Dimension

This section describes the domains that will be covered in this research. Innovative city domains generally include smart water management, waste management, pollution control, energy management, transportation systems, and healthcare. The following is a further explanation:

1) Smart Water

Water is a very important resource in human life. Therefore, intelligent water management plays a crucial role in the context of smart cities. [25] proposes using Internet of Things (IoT) architecture for intelligent water system management and monitoring. This architectural solution is designed to support a paradigm shift in water distribution network management by developing IoT-based Water Wise System software powered by machine learning, large-scale clustering algorithms, deep learning, and integration with SCADA and GIS systems. It is hoped that this architectural solution can help overcome problems in urban water management [28]–[31].

Using conventional methods to manage the city's current water resources can result in excessive and uncontrolled water usage. To overcome this problem, [32] introduced smart meters that utilize big data technology to create an intelligent system that can manage the water cycle, from water procurement to water distribution, to improve the efficiency of city water use.

2) Smart Sewage

To better understand the role of information technology in smart waste management, it is essential to identify approaches to address waste management issues in many countries. The merging of information and communication technologies (ICT) and the Internet of Things (IoT) into new approaches to improving the efficiency and effectiveness of waste management systems worldwide is one of the new approaches. Examples of ICT and IoT integration include using local sensors, data fusion, extensive data analysis, and understanding-based actions in waste management. This approach enables real-time monitoring of waste management processes, which in turn allows more efficient and effective waste management and transforms complex waste characteristics into valuable resources, materials, and energy [20], [33]–[38]. In addition, [39] has developed a cyber-physical system application to physically integrate intelligent waste collection systems and digital technologies to calculate, control, and communicate all components of waste management, including technologies, facilities, information, sensors, actuators, and networks that connect physical and digital work in waste management.

3) Smart Pollution

Sensors, mobile devices, social media, and the ubiquitous availability of accessible data have altered how data is utilized to assist policy and science. These changes open up opportunities and pose challenges for science and policymaking. To explore potential benefits and mitigate risks, it is important to address current limitations, especially in Internet of Things (IoT) deployment in smart cities and environmental monitoring. Such limitations include the development of new spatiotemporal analysis techniques, sensor interoperability, data quality, and access security [40]. In this perspective, this article presents an overview of the AirSensEUR initiative. The project aims to create a low-cost multi-sensor hardware and software platform that monitors air pollution at low concentration levels. AirSensEUR is introduced with a focus on data management and offers insight into numerous use-case scenarios where trustworthy and fast air quality data is crucial [17][41], [42].

4) Smart Energy

As social and environmental changes are significant globally, many cities worldwide have changed their infrastructure strategies to promote

sustainable mobility, develop renewable energy sources, increase renewable energy production, improve waste management, and adopt ICT infrastructure. In smart city energy systems, more significant heat and power source integration and a high degree of integration between households, businesses, industries, and utilities are required. The Internet of Things (IoT) application enables intelligent cities to control energy efficiently through comprehensive monitoring and secure communication [18]. Wireless Sensor Networks (WSNs) are a key component in the Internet of Things (IoT) and smart cities. IoT relies on WSNs as an important sensing and data exchange platform today. One of the main strategies to reduce energy consumption in WSNs with highly dense sensors is to maximize the sleep period of the sensors at all times since WSN platforms use a large amount of energy [6], [19].

5) Smart Transportation

The city's scarce resources, notably transportation, are under severe strain as the city's population continues to grow [3], [40], [42], [43]. Under the new era of the Internet of Things (IoT), the dynamic improvement of transportation has become a significant focus on developing smart cities. Urban road traffic is at the core of many challenges in various fields, including traffic congestion problems and processing center system planning. One proposed solution is transportation planning based on real-time data from IoT and Geographic Information Systems (GIS). This data is then processed using Deep Belief Networks (DBN) and the K-means algorithm to create a near-practice solution that can meet the requirements of high performance and cost-efficiency [2].

6) Smart Health

The population's average age increase has driven the demand for better health services. Advances in information and communication technology (ICT) have impeded the development of smart cities in various aspects of life, including smart health (s-Health). In this context, s-Health is used to improve healthcare by providing multiple services, such as patient monitoring and early diagnosis of diseases. One example is the s-Health application developed by [44], which is used to detect various diseases, including glaucoma, Alzheimer's disease, bacterial sepsis, and others, using machine learning approaches. In addition, [45] has proposed a patient care system framework that enables more advanced care and precise tracking of treatment locations. A combination of big data and the Internet of Things (IoT) is used for data management of patients under treatment.

3. 2 Research Themes

This section outlines the identified research themes, primarily based on the types of information technology (IT) that can be applied in the context of smart cities. Figure 1 provides an overview of the research themes in Information Technology in Smart Cities.

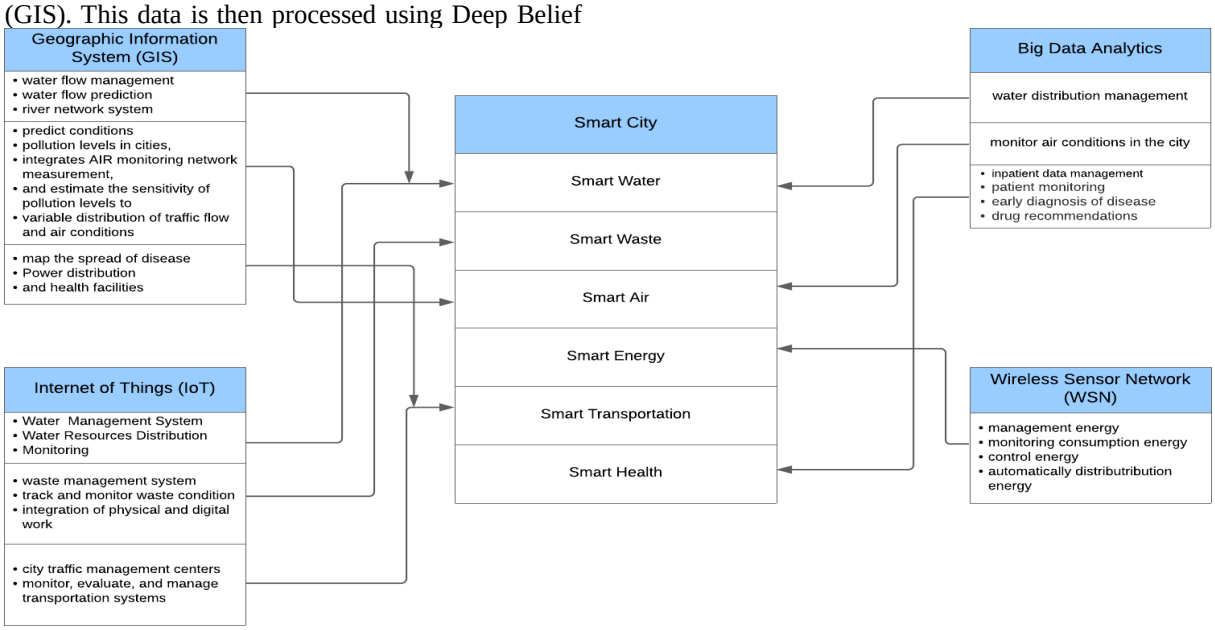

Figure 1. Research themes of IT adoption in Smart City

3.2.1. Geographical Information System (GIS)

This category or theme includes studies involving Geographic Information Systems (GIS) and how GIS plays a role in the Smart City context, such as using imagery such as ALOS ANVIR-2, Landsat ETM, and others. This research highlights the contribution of GIS in smart city development as an essential tool for monitoring city conditions and the impact of related policies[46]. This gives urban practitioners and researchers the means to utilize GIS to improve cities. For example, [28] developed a Water Wise System application that uses GIS to manage the city's water resources, including water

flow management, water flow prediction, and river network management that automatically pumps water if the river flow drops. In addition, GIS is also used to predict city air conditions in real-time, as done by [17], with water system management applications to indicate a city's pollution levels and its sensitivity to traffic-induced air distribution. In addition, GIS is also used to predict the spread of disease in cities, as done by [41], which utilizes machine learning on GIS to predict the spread of diseases, distribution of health workers, and location of health facilities. Based on past research, the first research question (RQ1) is to identify the sorts of urban problems that can be solved using a Geographic Information System (GIS). The first study topic is "*How can we assess the success of GIS implementation in smart cities?*"

3.2.2. Internet of Things (IoT) on Smart Cities

Some of the research that has been discussed in this category includes [2], [3], [29], [42], [45], as well as additional research conducted by [21], [47]. This research has successfully developed the intelligent city concept by adopting Information Technology (IT), especially the Internet of Things (IoT), as a key technology. The outcomes of this research include city water use efficiency, city waste management, and city traffic management. However, this research mainly focuses on the technological aspect and has not considered the significant energy consumption required by IoT devices. Therefore, [18] tries to provide solutions to reduce the energy consumption of IoT devices. Based on the previous literature review, the second research question (RQ2) is: *Does the implementation of IoT in smart cities ensure the physical safety of citizens, and how does it impact the efficiency and effectiveness of smart cities?*

3.2.3. Big Data Analytics

In addition to IoT as a key adoption technology for smart cities [22], [23] adopted big data analytics as the technology used to develop the smart city concept. The variable of water distribution management and automatic process is used by [25], [28], [32] to manage water sources and automate the process of water distribution in the city to cut unnecessary city energy. Then, the city's water control and monitoring variable is carried out by [17] to monitor air pollution conditions in the town. This needs to be done to keep the air quality in the city healthy and free from bacteria and viruses. To maintain the city's health, [43] developed s-health applications to monitor patients and diagnose disease early. Then [48] combines big data analytics with IoT to track the location of the referral hospital and monitor the patient's condition in real-time while on the way to the referral hospital. Based on previous research (RQ3), what *smart city variables can use big data?*

3.2.4. Wireless Sensor Network (WSN)

In the context of IoT adoption, IoT devices are known to have considerable energy consumption, making it important to manage energy sources in smart cities. As a solution, [19] utilizes wireless sensor networks (WSN) embedded in IoT devices to reduce the use of energy sources. In addition to minimizing energy consumption, implementing WSN enables city energy consumption surveillance, energy usage monitoring, and more efficient automation in city energy management. In addition, regarding security [26], using WSN technology in IoT devices to detect fires caused by over-energization or electrical faults might cause fires. Based on previous research, the fourth research question (RQ4) is: *Can WSN minimize energy usage in the smart city context? And how do WSN and IoT compare in smart cities?*

4. CONCLUSION

In summary, this research uses a systematic literature review method to explore IT adoption in the context of SC and its implementation in each domain of SC. This research aims to identify technologies that can be adopted in the smart city concept so that the technology used genuinely benefits the city. However, several areas still need to be investigated in this research. Firstly, whether the technologies described in this research, such as those described by [22], [47]; secondly, enabling factors, including the role of people, have not been fully identified in the context of technology adoption, as described by the researchers. Second, enabling factors, including the role of humans, have not been fully recognized in the context of technology adoption, as explained by [2], [19], [22], [28]. Third, the indicators for each technology domain have not been identified. All these questions will be the focus of this research as they indicate that research on information technology adoption in smart cities still has an important need. Based on the findings of the literature evaluation, this study effectively developed four relevant research questions based on the resultant research theme. This research theme will address future challenges with various IT adoptions in SC and other fields. It is important to map the appropriate technology to make IT procurement investment efficient and effective.

5. REFERENCE

[1] J. Yang, Y. Han, Y. Wang, B. Jiang, Z. Lv, and H. Song, “Optimization of real-time traffic network assignment based on IoT data using DBN and clustering model in smart city,” *Futur. Gener. Comput. Syst.*, vol. 108, pp. 976–986, 2020, doi: 10.1016/j.future.2017.12.012.

[2] U. Majeed, L. U. Khan, I. Yaqoob, S. M. A. Kazmi, K. Salah, and C. S. Hong, “Blockchain for IoT-based smart cities: Recent advances, requirements, and future challenges,” *J. Netw.*

Comput. Appl., vol. 181, no. August 2020, p. 103007, 2021, doi: 10.1016/j.jnca.2021.103007.

[3] O. B. Mora, R. Rivera, V. M. Larios, J. R. Beltran-Ramirez, R. Maciel, and A. Ochoa, "A Use Case in Cybersecurity based in Blockchain to deal with the security and privacy of citizens and Smart Cities Cyberinfrastructures," *2018 IEEE Int. Smart Cities Conf. ISC2 2018*, pp. 0–3, 2019, doi: 10.1109/ISC2.2018.8656694.

[4] P. Kumar, G. P. Gupta, and R. Tripathi, "TP2SF : A Trustworthy Privacy-Preserving Secured Framework for sustainable smart cities by leveraging blockchain and machine learning," vol. 115, no. September 2020, 2021.

[5] M. Babar, A. Saeed, M. Ahmad, and M. Usman, "Energy aware smart city management system using data analytics and Internet of Things," *Sustain. Energy Technol. Assessments*, vol. 44, no. August 2020, p. 100992, 2021, doi: 10.1016/j.seta.2021.100992.

[6] X. Xiao and C. Xie, "Rational planning and urban governance based on smart cities and big data," *Environ. Technol. Innov.*, vol. 21, p. 101381, 2021, doi: 10.1016/j.eti.2021.101381.

[7] W. Wang, "Deployment and optimization of wireless network node deployment and optimization in smart cities," *Comput. Commun.*, vol. 155, no. February, pp. 117–124, 2020, doi: 10.1016/j.comcom.2020.03.022.

[8] X. Zhou, S. Li, Z. Li, and W. Li, "Neurocomputing Information diffusion across cyber-physical-social systems in smart city : A survey," *Neurocomputing*, vol. 444, pp. 203–213, 2021, doi: 10.1016/j.neucom.2020.08.089.

[9] A. E. S. Setyadji *et al.*, "Causes of Ineffective Implementation of It Governance in Risk Management: a Systematic Literature Review," *JIKO (Jurnal Inform. dan Komputer)*, vol. 6, no. 2, pp. 88–96, 2023, doi: 10.33387/jiko.v6i2.6182.

[10] L. C. D. Reis, S. B. L. Ferreira, F. C. Bernardini, and C. Cappelli, "Towards a good practices catalog for ICT governance in the Brazilian smart cities context," *ACM Int. Conf. Proceeding Ser.*, pp. 670–673, 2020, doi: 10.1145/3428502.3428600.

[11] M. E. Cortés-Cediel, I. Cantador, and O. Gil, "Recommender systems for e-governance in smart cities: State of the art and research opportunities," *ACM Int. Conf. Proceeding Ser.*, no. April, 2017, doi: 10.1145/3127325.3128331.

[12] D. Ridwandono and A. P. Subriadi, "IT and organizational agility: A critical literature review," *Procedia Comput. Sci.*, vol. 161, pp. 151–159, 2019, doi: 10.1016/j.procs.2019.11.110.

[13] R. P. Dameri and F. Ricciardi, "Smart city intellectual capital : an emerging view of territorial systems innovation management," 2015, doi: 10.1108/JIC-02-2015-0018.

[14] A. Zanella *et al.*, "Internet of Things for Smart Cities," *IEEE Internet Things J.*, vol. 1, no. 1, pp. 22–32, 2014, doi: 10.1109/JIOT.2014.2306328.

[15] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, and W. Zhao, "A Survey on Internet of Things : Architecture , Enabling Technologies , Security and Privacy , and Applications," vol. 4, no. 5, pp. 1125–1142, 2017.

[16] J. P. D. Comput, P. G. Vinueza, Z. Pooranian, M. Shojafar, and M. Conti, "FOCAN : A Fog-supported smart city network architecture for management of applications in the Internet of Everything environments," *J. Parallel Distrib. Comput.*, vol. 132, pp. 274–283, 2019, doi: 10.1016/j.jpdc.2018.07.003.

[17] A. A. Diro and N. Chilamkurti, "Distributed attack detection scheme using deep learning approach for Internet of Things," *Futur. Gener. Comput. Syst.*, vol. 82, pp. 761–768, 2018, doi: 10.1016/j.future.2017.08.043.

[18] A. Kotsev, S. Schade, M. Craglia, M. Gerboles, L. Spinelle, and M. Signorini, "Next Generation Air Quality Platform : Openness and Interoperability for the Internet of Things," pp. 1–16, doi: 10.3390/s16030403.

[19] X. Zhang, G. Manogaran, and B. A. Muthu, "IoT enabled integrated system for green energy into smart cities," *Sustain. Energy Technol. Assessments*, vol. 46, no. February, p. 101208, 2021, doi: 10.1016/j.seta.2021.101208.

[20] M. B. Dowlatshahi, M. Kuchaki Rafsanjani, and B. B. Gupta, "An energy aware grouping memetic algorithm to schedule the sensing activity in WSNs-based IoT for smart cities," *Appl. Soft Comput.*, vol. 108, p. 107473, 2021, doi: 10.1016/j.asoc.2021.107473.

[21] A. Sharma, P. K. Singh, and Y. Kumar, "An integrated fire detection system using IoT and image processing technique for smart cities," *Sustain. Cities Soc.*, vol. 61, no. December 2019, p. 102332, 2020, doi: 10.1016/j.scs.2020.102332.

[22] P. Brous, M. Janssen, and P. Herder, "The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations," *Int. J. Inf. Manage.*, vol. 51, no. May 2019, p. 101952, 2020, doi: 10.1016/j.ijinfomgt.2019.05.008.

[23] I. Abaker *et al.*, "International Journal of Information Management The role of big data in smart city," *Int. J. Inf. Manage.*, vol. 36, no. 5, pp. 748–758, 2016, doi: 10.1016/j.ijinfomgt.2016.05.002.

[24] A. M. S. Osman, "A novel big data analytics framework for smart cities," *Futur. Gener. Comput. Syst.*, vol. 91, pp. 620–633, 2019, doi: 10.1016/j.future.2018.06.046.

[25] Y. Zhang, P. Geng, C. B. Sivaparthipan, B. Anand, and B. A. Muthu, "Big data and artificial intelligence based early risk warning system of fire hazard for smart cities," *Sustain. Energy Technol. Assessments*, vol. 45, no. March, p. 100986, 2021, doi: 10.1016/j.seta.2020.100986.

[26] M. Sharma, S. Joshi, D. Kannan, and K. Govindan, "Internet of Things (IoT) adoption barriers of smart cities ' waste management : An Indian context," *J. Clean. Prod.*, vol. 270, p. 122047, 2020, doi: 10.1016/j.jclepro.2020.122047.

[27] A. R. Honarvar and A. Sami, "Towards Sustainable Smart City by Particulate Matter Prediction Using Urban Big Data, Excluding Expensive Air Pollution Infrastructures," *Big Data Res.*, vol. 17, pp. 56–65, 2019, doi: 10.1016/j.bdr.2018.05.006.

[28] K. M. Shahanas and P. B. Sivakumar, "Framework for a Smart Water Management System in the Context of Smart City Initiatives in India," *Procedia - Procedia Comput. Sci.*, vol. 92, pp. 142–147, 2016, doi: 10.1016/j.procs.2016.07.337.

[29] I. Figueiredo, P. Esteves, P. Cabrita, I. Figueiredo, P. Esteves, and P. Cabrita, "ScienceDirect ScienceDirect Water wise – a digital water solution for smart cities and water Water wise – a digital water solution for smart cities and water management entities management entities," *Procedia Comput. Sci.*, vol. 181, no. 2019, pp. 897–904, 2021, doi: 10.1016/j.procs.2021.01.245.

[30] M. Singh and S. Ahmed, "Materials Today : Proceedings IoT based smart water management systems : A systematic review," *Mater. Today Proc.*, no. xxxx, 2020, doi: 10.1016/j.matpr.2020.08.588.

[31] M. Brunner, C. Sauerwein, M. Felderer, and R. Breu, "Risk management practices in information security: Exploring the status quo in the DACH region," *Comput. Secur.*, vol. 92, p. 101776, 2020, doi: 10.1016/j.cose.2020.101776.

[32] C. Giudicianni, M. Herrera, A. Carravetta, H. M. Ramos, and K. Adeyeye, "Zero-net energy management for the monitoring and control of dynamically-partitioned smart water systems +," *J. Clean. Prod.*, vol. 252, p. 119745, 2020, doi: 10.1016/j.jclepro.2019.119745.

[33] K. A. Nguyen, R. A. Stewart, H. Zhang, and O. Sahin, "Environmental Modelling & Software Re-engineering traditional urban water management practices with smart metering and informatics," *Environ. Model. Softw.*, vol. 101, pp. 256–267, 2018, doi: 10.1016/j.envsoft.2017.12.015.

[34] S. Idwan, I. Mahmood, J. A. Zubairi, and I. Matar, "Optimal Management of Solid Waste in Smart Cities using Internet of Things," *Wirel. Pers. Commun.*, vol. 110, no. 1, pp. 485–501, 2020, doi: 10.1007/s11277-019-06738-8.

[35] B. Fataniya, A. Sood, D. Poddar, and D. Shah, "Implementation of IoT-based waste segregation and collection system," *Int. J. Electron. Telecommun.*, vol. 65, no. 4, pp. 579–584, 2019, doi: 10.24425/ijet.2019.129816.

[36] K. D. Kang, H. Kang, I. M. S. K. Ilankoon, and C. Y. Chong, "Electronic waste collection systems using Internet of Things (IoT): Household electronic waste management in Malaysia," *J. Clean. Prod.*, vol. 252, p. 119801, 2020, doi: 10.1016/j.jclepro.2019.119801.

[37] S. Murugesan, S. Ramalingam, and P. Kanimozhi, "Materials Today : Proceedings Theoretical modelling and fabrication of smart waste management system for clean environment using WSN and IOT," *Mater. Today Proc.*, vol. 45, pp. 1908–1913, 2021, doi: 10.1016/j.matpr.2020.09.190.

[38] S. Dubey, P. Singh, P. Yadav, and K. K. Singh, "ScienceDirect ScienceDirect Household Waste Management System Using IoT and Machine Learning Household Waste Management System Using IoT and Machine," *Procedia Comput. Sci.*, vol. 167, no. 2019, pp. 1950–1959, 2020, doi: 10.1016/j.procs.2020.03.222.

[39] X. Lu, X. Pu, and X. Han, "Sustainable smart waste classi fi cation and collection system : A bi-objective modeling and optimization approach," *J. Clean. Prod.*, vol. 276, p. 124183, 2020, doi: 10.1016/j.jclepro.2020.124183.

[40] S. A. Bagloee, M. Heshmati, H. Dia, H. Ghaderi, C. Pettit, and M. Asadi, "Blockchain: The operating system of smart cities," *Cities*, vol. 112, no. August 2020, p. 103104, 2021, doi: 10.1016/j.cities.2021.103104.

[41] C. Vagnoli *et al.*, "The SensorWebBike for air quality monitoring in a smart city," *IET Semin. Dig.*, vol. 2014, no. 15564, 2014, doi: 10.1049/ic.2014.0043.

[42] Z. Ma and Y. Ren, "Integrated Application of BIM and GIS: An Overview," *Procedia Eng.*, vol. 196, no. June, pp. 1072–1079, 2017, doi: 10.1016/j.proeng.2017.08.064.

[43] B. Esmaeilian, B. Wang, K. Lewis, F. Duarte, C. Ratti, and S. Behdad, "The future of waste management in smart and sustainable cities: A review and concept paper," *Waste Manag.*, vol. 81, pp. 177–195, 2018, doi: 10.1016/j.wasman.2018.09.047.

[44] M. I. Pramanik, R. Y. K. Lau, H. Demirkan, and M. A. K. Azad, "Smart health: Big data enabled health paradigm within smart cities," *Expert Syst. Appl.*, vol. 87, no. 2017, pp. 370–383, 2017, doi: 10.1016/j.eswa.2017.06.027.

[45] Z. Rayan, M. Alfonse, and A. B. M. Salem, "Machine Learning Approaches in Smart Health," *Procedia Comput. Sci.*, vol. 154, no. 1985, pp. 361–368, 2018, doi: 10.1016/j.procs.2019.06.052.

[46] Y. A. Aina, "Achieving smart sustainable cities with GeoICT support: The Saudi evolving smart cities," *Cities*, vol. 71, no. May, pp. 49–58, 2017, doi: 10.1016/j.cities.2017.07.007.

[47] S. E. Bibri and J. Krogstie, "Generating a vision for smart sustainable cities of the future : a scholarly backcasting approach," vol. 0, no. 7491, pp. 1–20, 2019.

[48] N. Nasser, N. Khan, L. Karim, M. ElAttar, and K. Saleh, “An efficient Time-sensitive data scheduling approach for Wireless Sensor Networks in smart cities,” *Comput. Commun.*, vol. 175, no. November 2020, pp. 112–122, 2021, doi: 10.1016/j.comcom.2021.05.006.