A Decade Review on Smart Cities: Paradigms, Challenges and Opportunities

TARANA SINGH1, ARUN SOLANKI1, SANJAY KUMAR SHARMA1, ANAND NAYYAR2, (Senior Member, IEEE), AND ANAND PAUL3, (Senior Member, IEEE)

1Department of Computer and Engineering, Gautam Buddha University, Greater Noida, Uttar Pradesh 201308, India
2Faculty of Information Technology, Graduate School, Duy Tan University, Da Nang 550000, Vietnam
3School of Computer Science and Engineering, Kyungpook National University, Daegu 41566, South Korea

Corresponding authors: Tarana Singh (taranasingh14@gmail.com) and Anand Paul (paul.editor@gmail.com)

This work was supported in part by the National Research Foundation of Korea under Grant 2020R1A2C1012196; and in part by the School of Computer Science and Engineering, Ministry of Education, Kyungpook National University, South Korea, through the BK21 Four Project, AI-Driven Convergence Software Education Research Program, under Grant 4199990214394.

ABSTRACT Smart City has been an emerging research domain for Government, Businesses, and researchers in the last few years. The Indian government is also interested and investing lots of funds to develop smart cities. These cities are technology-based and require interdisciplinary research and development for successful implementation. Over the last few decades, various technological interventions have created a tendency to provide smart everyday objects to make human life more comfortable. The emergence of the smart city paradigm is a response to creating a future city that guarantees the well-being and rights of its citizens from the perspective of industrial development: industry, urban planning, environment, and sustainable development. There are several subdomains in the smart city for the research. To work with the different subdomains in a smart city, proper guidance about the background of the smart city is required. This research paper is a guide for the same. This research paper represents a systematic literature review of the smart city domain. This paper carries out a systematic review of research papers published in various well-reputed journals like IEEE, Springer, Elsevier, etc., between 2011 and 2021. This paper will help the government, businesses, and researchers aiming to enhance the smart city concept. Initially, this paper discusses the origin and emergence of this concept, followed by a few definitions and characteristics with the real roadmap and primary supporting pillars of the smart city. This paper discusses a typical architecture having different layers like Sensing, Transportation, Data Management, and Application Layers. There are various supporting technologies and platforms for the smart city; hence implementations are impossible without these technologies and media. This research paper discusses different components of the smart city. A broad literature survey is being done to observe various challenges, opportunities, and future trends in the smart city. This research paper can guide the researchers and provide the research direction in the smart city domain.

INDEX TERMS Smart city, Internet of Things, big data, cloud computing, sustainability, cyber-physical system.

I. INTRODUCTION
Smart City is extremely famous among upcoming researchers and Smart Actionists at the national and international levels. Implementing a smart city requires the utilization of different kinds of technical innovations. Nowadays, almost the whole world population lives either in the metropolises or in the urban zones [1]. In this current time, rapid growth in cities and urban areas directly impacts the number and standard of the services provided to the citizens by the city’s administration. Here smart city comes into the picture to help provide an optimized solution. Different smart city initiatives, either by the government or by the private industry, have utilized Information and Communication Technology (ICT) to discover a new optimized and effective solution to tackle the growing challenges of the cities and urban areas [2], [3]. Implementing a smart city requires healthcare, education, power, transport, waste management, unemployment, and...
cybersecurity challenges [4]. Smart City is based on easy-to-use information and communication technology implementations developed by large industries for urban space. Since then, its meaning has extended to the future of cities and their development. Looking to the end, intelligent cities provide advanced, resource-efficient, and high-quality living. They promote social and technological innovation and connect existing infrastructure.

The smart city is a rapidly emerging research domain nowadays. To better understand the emergence of the domain, a bibliometric analysis is performed using the Scopus database. The smart city domain has a huge opportunity for the researcher to work. To perform the bibliometric analysis [257], the Scopus database of one decade (2011-2021) is being utilized. To limit the search criteria, different parameters like different sources of documents like IEEE Access, Sensor Switzerland, Procedia Computer Science, Applied Science Switzerland, etc. keywords like Smart City, Internet of Things, Sensors, Machine Learning, Energy Efficiency, Green Building, Deep Learning, Intelligent Buildings, Smart grid, etc., subject area like Computer Science and Engineering, Artificial Intelligence, Machine Learning etc., document type like journal articles, conference papers, book chapters etc., are being utilized. To accomplish the task of analysis query is being executed to filter the results and set the particular search criteria. The results are shown in graph 1 that the domain has been emerging rapidly every year in the last decade. It is visible that according to the adopted search criteria, in the year 2011, there were only four publications. However, with the time and after one decade, the number is increased to approximately 400 and still increasing. Graph 1 is the evidence for the emerging trend when the analysis is performed on the Scopus data. The adopted search criteria aim at identifying the literature published between 2011 to 2021.

The interest in applying bibliometric methods and techniques is to explore the developments of smart city research that have grown considerably over the last decade. Graph 1 shows the absolute increasing trend in the research domain of smart city. Thus, this analysis clearly states that this research has a good scope of work.

A. ORIGIN AND GROWTH OF SMART CITY CONCEPT
In the 1990s, the rise of digital and the internet in urban areas began publishing the smart city concept. However, the research was done on smart city previously, but the first work was published in 1994. During the 2000s, and especially 2010, this work grew exponentially with some success. When IBM, Cisco, other multinational ICT companies, and international bodies such as the European Commission and OECD began to express interest, the European Union designated smart cities as an international body. These organizations were paying particular attention to the smart city as one of the important areas of development [5]. Another similar concept is Digital City, but the main difference between digital cities and smart cities is the emphasis on ICT. Digital cities are generally considered “information systems that collect real-world city data and place it in a virtual public space.” People can communicate with the administration and other consumers. Second, the smart city is an extension and development of the digital city, relying on various tools and material procedures and working to improve people’s living conditions and comfort [6]. But in countries with advanced economic and scientific development, the existence of smart cities is more powerful. In addition, the size of the city also plays an important role in realizing a smart city. As cities grow larger, smart city solutions need to address environmental impacts, but they may also share data, knowledge, and electronic services [7]. Finally, the concept of smart cities is now widespread on different continents in theoretical research and empirical implementation. Also, improving citizens’ quality of life is considered one of the major goals of urban areas.

B. THE RISE OF THE CONCEPT - SMART CITY
The concept of a smart city first emerged in the 1990s when the focus was on the impact of ICT on new infrastructure within the city. The “California institute of Smart Community” focused on how to plan cities to implement information technology and how the community will become smart [7]. A few years later, the University of Ottawa Government criticised that smart city were too technically concentrated. Several years ago, researchers began to seek to get up to the real smart city and explain the hidden aspects behind the term smart city. The researchers stated that the smart city label could be used interchangeably with similar terms such as “smart city” and “digital city” [7]. In figure 1; the conceptual relatives are divided into three dimensions: technology, people, and community [8], [9]. Dimensions give rise to the definitions described in Table 1, but they have certain similarities. There seem to be two interpretations of the proposed definition. First, smart cities are living solutions that can effectively improve the service of citizens by effectively integrating various living facilities such as transportation, electricity, and buildings. Second, smart cities show the importance of sustainability for next-generation resources and applications.

C. DEFINITIONS OF SMART CITY
Smart cities have many definitions given by different authors, as there is no universal definition for a smart city. A set
of conceptual variants can usually be attained by substituting “Smart” with other terms such as “intelligence” or “digital.” A smart city is an ambiguous idea and is not always used consistently. There is no single model to build a smart city or a single definition for defining a smart city [10]. Table 1 shows some different definitions and meanings of the “smart city” concept. By emphasizing the spread of ICT in cities, it’s necessary to progress the function of each subsystem, improve the quality of life, and clarify its aspects. [11] explained the idea of smart city and other interrelated terms (digital cities, smart cities, ubiquitous cities, etc.). The differences between the three variants are technology, people, and communities [11] shown in figure 1. From a technical perspective, smart cities are cities where ICT is widely used in critical infrastructure and services [12], [97]. Information and communication technology have saturated smart mobility products and services, artificial intelligence, and the decision making of machines [13]. Smart homes and buildings are systems with numerous mobile terminals, in-vehicle devices, and associated sensors and actuators [14]. [15] provided a summary of advanced sensors for monitoring the physical structure of a smart city and several related applications [1], [16], [17]. For instance, progressive energy detection capabilities enable more precise measurements for developing smart city power networks, and mobile sensors can expand traffic management systems. Global R&D presently includes WSN technology, system miniaturization, intelligent wireless technology, heterogeneous communications and networks, network planning and deployment, comprehensive information recognition and processing, code analysis services, information exploration, and monitoring [2], [18], [23]. All the research is done to improve the smart space to the complete city scale. The concept of a “smart city” appears at the intersection of knowledge society and digital cities [19]. According to [20], the smart city is consciously trying to use IT to change their lives and jobs.

The smart label supports learning, technological development, and innovation in the city. It can be stated that every digital city is not necessarily intelligent, but every intelligent city has digital components, although it doesn’t yet include the “people” component [21]. In “smart cities,” cities are a mixed concept consisting of realities, physical entities, real residents, and virtual cities in parallel cyberspace. There is another term, “Universal City,” which extends the digital city concept from the wide viewpoint of accessibility [19]–[21]. It brings ubiquitous computing to the elements of cities around the world [22], [23], [247]. Its feature is to create an environment where all citizens can access any service anytime, anywhere from any device. Ubiquitous cities are different from virtual cities. Virtual cities reproduce urban elements by visualizing them in a virtual space, and ubiquitous cities are created by including computer chips or sensors in the urban elements [24]–[26].

D. CHARACTERISTICS OF SMART CITY

Smart cities include a few attributes like qualities, themes, and structure that define the smart city’s features. The theme is the pillar of the smart city. Here, the infrastructure for the smart city operation platform is being provided. Smart City is built up of some attributes. smart city applications are depended on four key features, as shown in Figure 2, sustainability, comfort, quality of life, urbanization, and intelligence [27], [28].

Sustainability is related to pollution, energy, climate change, and ecosystems. The quality-of-life attributes of citizens are intended to progress their welfare. Urbanization and smartness attributes include transforming technology, infrastructure, and management from rural to urban environments. “Intelligence” is explained in terms of the wish to raise the community, environmental, and financial standards of cities and their people [29]–[31]. In recent years, sustainability has been regarded as one of the leading examples of town expansion. Sustainability has kept a significant character in the rise of the smart city [32]–[34]. Modern cities are naturally
developing. Therefore, it is significant to identify the lack of non-renewable energy.

Consequently, the protection of natural sources and energy turns out to be a sustainability prerequisite for a smart city [27], [35], [36]. During the first few years of the smart city concept, the goal was to improve the luxury of inhabitants. This is accomplished by joining technological resolutions that reduce the social learning limitations and boundaries to social involvement. Thus, the nature of metropolitan administrations is improved while simultaneously improving the comfort and economic state of the everyday lives of qualified representatives [37]–[40]. Under such conditions, tests have been led in different urban areas around the globe to improve the inhabitant’s satisfaction. Some researchers focused on intelligent lighting. Ten thousand street lights are equipped with sensors that allow citizens to regulate the illumination according to their light requirements. The target is to decrease power feeding by 70% [41]. The Norwegian example impacted other European cities that have accepted electronic street projects. Eleven countries have promised to reduce electricity consumption by connecting street lights. “San Francisco, USA” is one of the cities using technology to be the smartest in the world, considered by a set of interconnected answers [42]. The city is devoted to maintainable expansion and garbage reusing and provides 100% renewable electricity to all civic facilities.

In another example, 85% of the “Singapore” population owns smartphones, and the city has launched a smart national plan to solve transportation issues, energy management, and green innovation. The city that sponsors “Clean Tech Park” is the ecology business park of “Singapore,” which includes various sectors such as industry and green architecture [43]–[45]. When it comes to mobility, the goal is to minimize vehicle use and save electricity. [129] developed a smart city model that assesses Europe’s medium-sized smart cities based on six attractive characteristics of the economy, transportation, citizenship, location, supremacy, and quality of life. Therefore, this is an organisational instrument and can see the city’s current state to identify areas that need special attention for its development [43], [46], [47].

1) SMART ECONOMY
Comprises issues associated with the competitiveness of a city’s economy that as the economic importance of the city in national and international markets, entrepreneurship, flexibility in work and production, innovation, and entrepreneurship [48], [49].

2) SMART PEOPLE
This results from various attributes connected to the expansion of social investments [50]. This includes the qualifications of citizens, and the level of education, social variety. Some authors worked on certain e-education schemes, such as online courses offered by cities, and distance learning has had beneficial results in developing the field of smart people [51], [52].

3) SMART GOVERNANCE
The definition of smart governance considers all features associated with political participation, civil facilities, and administrative openness [53], [41].

4) INTELLIGENT TRANSPORTATION
Transportation includes information and communication technology availability, regional and international accessibility, and modern and sustainable transportation systems. These factors are very important in today’s globalization. The most effective way to provide advanced transportation is city planning, which focuses on the collective use of information and communication technology rather than individual transportation [54], [55].

5) SMART ENVIRONMENT
Aspects related to usual and climatical situations, contamination, store organization, and environment guard are progressively significant. Urban areas are committed to minimizing ecosystem footprints and clean energy (solar, wind, etc.) and resource management. Other innovations can also increase efficiency [55]–[57].

6) SMART LIVING
This feature covers all aspects of improving quality of life, such as health, travel, safety, and culture [58], [59].

E. ROADMAP OF SMART CITY
Smart City roadmap combines four components (the first part is a preliminary inspection). Figure 3 shows the smart city roadmap.

1) DEFINE COMMUNITY
This includes geography, connections between urban and rural areas, and the flow of people between urban and rural areas [60], [61].

2) STUDY OF COMMUNITY
Before deciding to build a smart city, the developed need to analyse the requirement of the particular development. This can be done by determining the benefits of such an initiative. Study communities to understand citizens,
business needs, and the unique attributes of citizens and communities, such as age, education level, hobbies, and city appeal [62]–[65].

3) DEVELOP SMART CITY POLICIES
Define roles, responsibilities, goals, and objectives, and develop policies to guide plans to develop plans and strategies to achieve those goals [66]–[68].

4) CITIZEN INTERACTION
This can be achieved by engaging citizens through e-government initiatives, open data, sporting events, and more [69], [70]. In short, people, process, and technology (PPT) are the three principles that make a smart city plan successful. Cities need to survey citizens and communities, understand processes, business drivers, and develop policies and goals to meet their needs. This technology can be implemented to meet the needs of citizens, improve the quality of life, and create real economic opportunities [70]–[72]. This requires a global, personalized approach that considers urban culture, long-term urban planning, and local regulations [73].

F. PRIMARY SUPPORTS OF SMART CITY
Official, Physical, Social, and Economic Infrastructures (II, PI, SI, EI, respectively) are considered the four primary supports of the smart city. The European Union (EU) has adopted an effective four-pillar approach [74], similar to the four-pillar mentioned in Figure 4. Figure 4 shows the four pillars of a smart city. Smart cities govern under institutional infrastructure. It combines decision-making participation, public and social services, transparent governance, political strategies, and perspectives [75]. Serious and proper consideration of political views has facilitated the city’s governance. Ensuring maximum human capital is essential for improving smart cities [76].

Citizens and their participation and cooperation have a great positive impact on the use of human capital [77]. Governance plays an important character in organizing inhabitants and government. The second pillar works with local and chief governments to increase the benefits of the smart city [78].

The smart city can integrate public, private, state, and national administrations to ensure interoperability among facilities. Thus, this integration of various government agencies provides citizens with more reliable, effective, and efficient services [79], [80]. The technological organization is another important function of the second pillar, assuming that all metropolitan facilities and functions can be provided through technological solutions [81]–[83]. Thus, because of the computing power of smart cities, complex social problems can be solved easily, followed by instrumental rationality and solutionism. Physical infrastructure includes natural resources and man-made infrastructure [84]. The pillars of physical infrastructure ensure the sustainability of resources to keep the city running today and, in the future, [85]. The superiority of the ICT organization optimizes smart city outcomes. Additionally, ICT infrastructure, the superiority and accessibility of smart object networks are just as important in enabling smart cities [86], [87]. PI has been expanded to green buildings, green urban planning, building and equipment makeover, and smart energy. Because of these essential benefits, smart cities are considered a solution to natural resource insufficiency [88], [89]. Therefore, most smart city plans focus on protecting the city’s natural resources: waterways, green spaces, and drains [90], [91]. Smart cities use technology for improved organization while improving the sustainability of natural resources. The smart city’s SI includes intellectual capital, human capital, and quality of life [92], [93]. Public responsiveness, accountability, and promise play a vital part in promoting the smart city concept. Therefore, SI is essential for the development and sustainability of the smart city. Even if a smart city is implemented, uses technology, and is equipped with advanced equipment, sustainability cannot be guaranteed without society’s awareness [94]–[96].

The use of ICT to progress the standard of the lifestyle of inhabitants is the backbone of social infrastructure. It can be said that SI has an excessive influence on the superiority of the lifestyle of urban inhabitants. As the foundation of SI and its connections, it has been viewed as a significant resource for smart urban areas [97]. Compared to traditional cities, smart cities provide people with a developed living and quality life. Therefore, experienced and knowledgeable
inhabitants tend to gather in smart cities, which is beneficial for town expansion [98].

Therefore, information-based urban development is considered an important element of the modern smart city [99], [100]. Industry and academic experts have stated that SI is a central pillar of the smart city due to its infinite reputation. In [101], [102], smart cities boom with sustainable and stable economic and job growth and are considered smart economies. The smart economy is an idea that arrives at the restrictions of mini and full-scale economies. From an overall perspective, utilizing best practices, online business, and web-based business applications to improve the profitability of a city is known as the smart economy. Also, the smart economy will incorporate ICT development, the production and passage of ICT-related administrations, and the combination of cutting-edge innovations that can improve the firm’s quality and execution of financial administration. Lombardi et al. investigated a smart city financial framework utilizing an overhauled triple helix model and execution markers [103]. Public spending on innovative work, per capita GDP of the city, markers of all-out inner energy utilization, the extent of ventures financed by common society, and business rates in various enterprises [104] evaluate the exhibition of financial foundation.

G. ORGANIZATION OF PAPER
This paper is organized into eight sections, which discuss the details of the whole chapter. Section II discusses Methodology, section III outlines the Architecture of the smart cities, section IV discusses various technologies which support the smart city and various supporting platforms, section V discusses the components of the smart city, section VI discusses different types of related work which have been done in this domain of smart city and its sub domains. Section VII elaborates the case study of the smart city. Section VIII discusses various challenges and opportunities in the domain of Smart City, and the paper concludes with future scope in section IX.

II. THE METHODOLOGY OF THE WORK
Figure 5 shows the methodology followed in this article. The entire work is divided into four stages. First, a review of the existing literature is being done in different areas to determine the need for an integrated smart city and fulfill the breach between smart city implementations and conceptual discussions. The second step introduces the idea of the smart city.

This paper will discuss numerous issues such as the emergence and dissemination of the concept of smart cities, the emergence of smart cities, various definitions and features of smart cities, roadmaps, and significant pillars of smart cities. The third step is to deliberate the smart city with the description of its layered architecture and complete the narrative description of the smart city through the supporting technologies and existing platform description. The final step details the components, challenges, opportunities, and future work.

III. THE ARCHITECTURE OF SMART CITIES
Researchers are determined to define an explicit smart city architecture to facilitate the actual deployment of the smart city. However, while theoretically feasible, the viability of essential common smart city architecture for deployment in the real world is far away from reality. General architectural guesses are limited by major changes in required functionality but are impractical. After a detailed analysis of some existing architectures, this paper presents the bottom-up architecture shown in Figure 6. This architecture consists of four layers: the detection layer, i.e., the sensing layer, the transmission layer, the data management layer, and the application layer.

Protecting sensitive data is an important issue in any smart city. Therefore, security modules are built into each tier. Collecting data from physical devices is a key feature of the sensing layer at the lower part of the design. The transmit layer sends data to the upper layers via various communication technologies. The information management layer processes and stores significant data that help provide high levels of service provided by different applications.

A. SENSING LAYER
Real-world, smart cities include large amounts of data, composite designs, data storing, and smart executive capabilities. Experts believe that the employment of a smart city is so important in decision making that it trusts all procedures of information and calculation [105]. Information gathering is also the most vital part of managing the operation of another smart city. Data gathering is the furthermost difficult job because of the large heterogeneity of the information. Information collection mechanisms and technologies are closely related to the type and context of the information. Smart City has various data, including different city operations, control of smart home devices to balance smart grid loads, epidemic management of personal health, and community waste management to Disaster Management. Therefore, the data generated by the operation of the city makes these differences very different. In addition, generating large amounts of data complicates data collection. The lower layer expresses the recognition/information collection layer, as appears in Figure 6. Smart gadgets, WSNs, and other information collection gadgets make up the detection layer. It catches a wide range of information from various sensors and gadgets [106].

The identification layer offers an assortment of advancements to improve the productivity of information collected in various settings. The identification layer of the sensor network gathers different information boundaries, for example, humidity, temperature, weight, and light. Additionally, there is a Global Positioning System (GPS) terminal [97]. Like broad information collection abilities, most extreme organization insertion also encourages ubiquitous access and
insight. As per existing writing reports, metropolitan knowledge increments with sensor network presence. The identification layer gathers information from various gadgets and physical foundations, expanding the number of gadgets associated with a smart city organization. A huge insertion doesn’t ensure wise and solid information transmission. Subsequently, perceptual models are now characterized to connect activities to articles or sensors to decrease the vulnerability of the gathered information [98].

B. TRANSMISSION LAYER
When connecting a data source to a management station, the transport layer is the primary support of the smart city architecture. The transport layer is the assembly of different correspondence organizations. Therefore, many gadgets associated with a private organization fulfill steering with a solitary addressability. The vehicle layer incorporates different kinds of wired, remote, and satellite advancements.

Thinking about this addition, this is partitioned into two sublayers, access transport and organization transport.

Bluetooth, Zigbee, Near Field Communication (NFC), M2M, RFID, and Zwave is known as short-extend access network advancements [99]. Correspondingly, more extensive inclusion advancements, specifically long draw adaptable 3G, 4G (LTE), 5G and wide territory organizations, and low force utilization (LP-WAN), are called transmission network technology. RFID innovation utilizes the radio frequency (RF) part of the electromagnetic range to distinguish an article, individual, vehicle, or creature remarkably. RFID is like a scanner tag framework as it is contrasted with scanner tag frameworks but can recognize things from a distance. NFC is an entrance network innovation that encourages correspondence between two gadgets 10 cm separated. NFC performs acknowledgement while sharing data between NFC-empowered gadgets [100]. Bluetooth is another well-known admittance network innovation that utilises short frequency radio signs to diminish correspondence power utilization.

ZigBee gives low force correspondence inside 10m between ZigBee-empowered gadgets. Above all, ZigBee utilizes a self-sorting out and solid multi-jump work organization with a long battery life [101]. Consistent development in smart gadgets, portability, and all angles is driving the interest for remote broadband as a feature of the plan and usage of smart urban communities. The interest in general access has expanded the utilization of remote innovation. LTE is the main 4G remote service and has been demonstrated to be better than 3G, Wi-Fi and WiMAX in fast, high bitrate and low inertness [102]. Regarding transmission organizations, 3G and 4G assume a significant function in portable organizations. Be that as it may, fifth era (5G) cell networks are a trendy expression for present-day broadcast communications. In 5G organizations, many huge multi-input, multi-output (MIMO) radio wires are incorporated into the base station to send remote traffic at the gigabit level. Mobile services utilize authorized transfer speed to offer versatile assistance, while Wi-Fi utilizes unlicensed transmission capacity. Wi-Fi is the most notable remote neighbourhood (WLAN) innovation in the IEEE 802.11 arrangement determination. Wi-Fi generally offers high transmission capacity. In any case, Wi-Fi correspondence works in the unlicensed 2.4 GHz range and depends on impedance. LP-WAN is another sort of transmission network worldview pointed toward improving the energy proficiency of mechanical organizations [103]. Consequently, LP-WAN is a promising contender for future smart urban communities since it can diminish power utilization and spread a wide scope of inclusion. Devotion (Li-Fi) is another famous transmission network innovation that utilizes surrounding light discharging diodes (LEDs) for information transmission. Li-Fi is the fate of remote correspondences because of its spectral accessibility and broadband potential [104].

C. DATA MANAGEMENT LAYER
This layer is the mind of the smart city between the sensing and the application layer. This layer accomplishes various activities, including association, examination, storing, and dynamic jobs. The administration execution of smart city activities depends on information management, so proficiency in information management is basic to a feasible smart city. The fundamental assignment at the information level is to keep the information dynamic with attention to cleaning,
repairing, combining, and updating the information [105]. Information management can be separated into information combination, information preparation, stockpiling, and occasion and choice administration. Information combination consolidates information from various sources to improve exactness and produce clear choices without depending on a solitary information source [106]. Information sifting can improve the productivity of information preparation in a smart environment. The current writing follows numerous strategies and techniques for performing information combinations. In [46], the authors actualized Kalman filtering innovation and performed information combination at the information management level. Essentially, experts utilized information examination and preparing systems to reveal important information that was ambiguous and covered up on an artificial level [107]. For this reason, specialists suggest the utilization of information mining strategies [36], [54], [56].

Silva et al. [56], [57] proposed a consolidated huge information examination to perform effective continuous information investigation and handling from smart city stages. Information sifting plays a significant part in sending brilliant urban communities, as information investigation and handling can’t ensure improved metropolitan execution. Subsequently, information sifting is needed to help solid and versatile admittance to a lot of information. Because of its significance, specialists have seen critical effects on distributed storage designs, massive capacity frameworks, huge cross variety frameworks, and dynamic information, the executive’s structures in accomplishing an association’s high-limit sifting objectives of smart city design. The executives and choice administration parts occasion smart tasks in smart urban areas. It coordinates the information gathered from heterogeneous sources and the information extricated from the information sifting to plan the correct choices. Dynamic is basic to the proceeded with the activity of smart urban communities, so definite examination is being led around there. The choice administration segment utilizes various calculations and innovations to progressively get precise choices. As the final task of the information management layer, the conditional choices are passed to the application layer and executed likewise.

D. APPLICATION LAYER
The application layer is the highest layer of smart city architecture and acts as an intermediary between city dwellers and data management. Application-level performance directly impacts the audience and influences the operator’s perspective and fulfillment with smart city operations. Citizens are worried about the smart behaviour of cities that provide smart services (such as smart weather forecasts). The application layer comprises different components from multiple disciplines [109]. Key application layer administrations incorporate network improvement, network provisioning, smart transportation, climate assessment, etc. The application layer improves city execution through applications that handle and store the information.

The advantages of sending disengaged smart applications are little distinguished from improving the presentation of metropolitan tasks. Therefore, sharing information between different applications seems promising for smart urban development. The smart application is responsible for making the decisions submitted by the data management layer. The information management layer clears up and procedures the gathered information to choose the ideal insightful choice that coordinates the specific circumstance. In this manner, the application layer executes that choice when the information management layer chooses. Citizens do not understand the middle tier of data management, so their perception of performance gains depends only on the outcome of the application tier [110].

Therefore, while maintaining interoperability between other intelligent applications, higher-layer intelligent systems must analyse the uncertain needs of citizens and deliver them with the highest precision. Moreover, practitioners recognize and believe that integrating unconventional and classy technology is not enough to achieve user fulfillment in the real smart city. More research on design challenges, analysis of optimization needs, security aspects, and standards is encouraged to meet these requirements [111].

IV. ENABLING TECHNOLOGIES AND PLATFORMS TO SUPPORT SMART CITY
It is a very important point to discuss while discussing a smart city. This paper presents some mutual enabling technologies observed in the whole literature review.

A. ENABLING TECHNOLOGIES OF SMART CITY
Four key technologies used in the smart city software platform were observed during the literature review. Cyber-Physical System (CPS), Internet of Things (IoT), Big Data, Cloud Computing.

Figure 7 shows the technologies that support smart cities. The technologies used in smart cities have five requirements: detection, processing, networks, interfaces, and security [112]. The IoT and CSPs can supervise expose and organization necessities, large information, and distributed computing to manage smart city administrations’ interfaces. Security is significant for all related advancements. Standards organizations also believe that these four technologies are the main catalysts for a smart city.
1) INTERNET OF THINGS

It describes how objects are uniquely identified, has a recognized location and status, and become part of the Internet in a way accessible from the network [113]. Three components can define the IoT environment: sensors, actuators, hardware including integrated communication circuits, user-accessed hardware that calculates and contains the conventional data received from the device and the presentation layer. Middleware that manipulates and visualizes data. Smart city platforms are expected to offer similar components. Due to the huge number of devices utilized to gather city data. The information accumulated from these gadgets must be sent over the interconnect network for accumulation and handling to give progressed smart city administrations. In [62], some potential uses of the IoT in a smart city are introduced. For example, defining energy consumption when checking the condition of historic structures, sensing load levels in waste containers, noise in the city centre, and monitoring traffic lights. Signage, smart home analysis, etc. CSP and the Internet of Things are related technologies. The CSP is liable for checking, planning, controlling, and incorporating physical elements inside the data framework [114]. On the other hand, one or more objects connected to the IoT are connected to the Internet infrastructure. Although these two terms can be used interchangeably [115], they are distinguished because the platform goals and platform requirements associated with these two platforms are very different.

2) BIG AND OPEN DATA

This can be considered many advancements and devices for storing and handling huge informational indexes. To store and process large information, conventional advances, for example, social data sets and consecutive preparing instruments, may not be acceptable. Big data has five main characteristics, as shown in Figure 8. “Volume” is the measure of information created and gathered is developing quickly, and the devices need to address this difficulty. In the smart city, the measure of information is huge and originates from many distributed information sources. “Variety” of the information is that the information gathered from various sources can be organized, semi-organized, or unstructured (video, social data set, unique content, and so forth). This test is significant for shrewd urban communities since they incorporate information from residents’ cameras, sensors, and individual gadgets.

“Velocity” of the information handling should be quick and constant. City framework, administrators, and directors must have the option to react rapidly to metropolitan issues, for example, clog, mishaps, and floods. “Veracity” guarantees that the information quality is significant as information is gathered and different information sources are utilized. Utilizing untrusted sources can bargain for information examination. Low-quality information sources can incorporate wrong GPS readings, sensor disappointments, and malevolent clients in urban areas. “Value” refers to the possible advantages of large information to the venture, in light of legitimate assortment, the board and examination of enormous information [116]. Smart cities are now using big data tools to provide large amounts of information produced by urban equipment. The sensor network consistently sends information on metropolitan conditions, for example, temperature, air quality and precipitation. Residents use cell phones and interpersonal organizations to produce information, and vehicles, for example, transports and cabs, consistently send occupations. Another crucial part of smart city information is the idea of open information [117]. By uniting the free access of residents, organizations and NGOs, urban communities can utilize inventive biological systems to offer new answers to metropolitan issues. Numerous urban communities around the globe distribute various datasets identified with wellbeing, instruction, travel, and land, and that’s just the beginning [118]. Anybody with the important imagination and specialized aptitudes can create applications that serve residents, organizations, and regions.

3) CYBER-PHYSICAL SYSTEMS

CSPs can be sorted by utilizing register and correspondence techniques to improve the usefulness of physical frameworks. [66] characterizes CSP as the reconciliation of calculation and physical cycles to encourage the checking and control physical cycles utilizing nearby and far off PC models on network PCs. For example, some genuine applications, for example, smart city communities, framework control frameworks, and electronic clinical gadgets, use CSP. The physical organization framework associated with the smart city is Wreck Watch [119], an application for identifying car crashes. Produced for cell phones can peruse the gadget’s accelerometer and GPS to decide the driver’s current speed and increasing speed. Wreck Watch identifies a solid deceleration on the off chance that the mishap expectation model investigates the information and alarms the focal worker when the information shows a mishap.

4) CLOUD COMPUTING

It gives an extremely huge and adaptable high accessibility framework for information storage and computing. It is significant for complex smart city frameworks. Also, it can support the framework reconfiguration required for intensely
A virtual representation or digital reproduction (copy) of assets, people, processes, systems, devices, and locations is known as a digital twin. Vehicles, aircraft engines, and humans are among the items that may be recreated through digital twin technology. The digital twin of a real vehicle is created when an automotive business creates a virtual representation or digital duplicate of a car model. The (digital) duplicated process is a digital twin of the physical process if a manufacturer builds a virtual model of its production process. A digital twin is a digital profile of the present and historical status of a process or physical item. The dynamics and aspects of how an IoT device lives and works are represented in this virtual image. The digital twin can offer physical assets’ location, condition, and/or status in real-time because of continuous learning and upgrades. Organizations can monitor systems, establish strategies, and predict issues before they arise because of this combination of the physical and digital worlds. Digital twin technology is used to produce digital twins. This technology combines the internet of things (IoT), software analytics, artificial intelligence, network infrastructure graphs, etc.

The concept of the smart city through digital twins is evident. From urban planning to land usage optimization, this technology has the power to govern the city effectively. Digital twins allow the simulation of plans before implementing them in real-time, exposing problems before they become a reality. Only with a digital twin in place can government agencies effectively analyse what can be done with the data and improve citizen living, create economic opportunity and revitalize a closer community.” The concept is still new in many countries, but it is predicted to become mainstream within five to ten years. [248], [255], [256].

5) BLOCKCHAIN TECHNOLOGY
Over and beyond the position of the Blockchain technology behind cryptocurrencies, it is an emerging technological platform for constructing decentralised applications and data storage. The platform’s central principle is that it enables the creation of a distributed and replicated record of events, transactions, and data created by different IT processes, with strong cryptographic assurances of tamper resistance, immutability, and verifiability [123]. Even when untrusted people are members of distributed apps with the capacity to transact on the network, public blockchain systems enable us to ensure these qualities with overwhelming probability. Even though blockchain technology has become well-known due to its usage in implementing cryptocurrencies such as Bitcoin and Ethereum, the technology itself has a lot more potential in areas like time management.

6) DIGITAL TWIN
A digital twin is a digital profile of the present and historical status of a process or physical item. The dynamics and aspects of how an IoT device lives and works are represented in this virtual image. The digital twin can offer physical assets’ location, condition, and/or status in real-time because of continuous learning and upgrades. Organizations can monitor systems, establish strategies, and predict issues before they arise because of this combination of the physical and digital worlds. Digital twin technology is used to produce digital twins. This technology combines the internet of things (IoT), software analytics, artificial intelligence, network infrastructure graphs, etc.
A. SMART COMMUNITY

Smart people’s groups are energetic about improving inhabitant’s satisfaction and the prosperity of city occupants. The smart network coordinates various smart structures for this situation, including the board frameworks, waste administration frameworks, etc. Smart structures incorporate smart homes and different business frameworks: workplaces, schools, server farms, manufacturing plants, distribution centres, etc. As mentioned in section 3, in terms of performance, independent components have little effect. Therefore, smart networks are associated with different parts to amplify the advantages of smart urban communities. Smart gadgets, sensors, committed programming, and equipment are coordinated into basic smart structures. Smart structures and green structures share a typical thought process in energy the executives. Green structures are focused on streamlining energy utilization and decreasing carbon dioxide outflows [70]. However, energy the executives in smart structures follows certain systems to improve smart productivity. It implies associating smart structures with brilliant frameworks and sustainable power source plants through existing organizations.

The intelligent building’s data-driven decision-making capabilities maximize energy efficiency and minimize operating costs. But smart buildings don’t just focus on power effectiveness. Smart structures are also linked to other parts to achieve safety, surveillance, lights control, automation, etc. In addition, using the knowledge found through the available networks, smart buildings can improve the QoS presented to families. Because of these favourable circumstances, the incorporation of smart structures in smart networks significantly affects the activity of smart urban areas. Smart homes, workplaces, distribution centres, etc., perform tasks successfully and precisely to give top-notch administrations to residents. For instance, smart homes control, home apparatuses, energy utilization, investigation, and lighting controls to advance the personal satisfaction of occupants [126]. Smart stockrooms increment the efficiency of flexibly chaining the board and advantage network partners. Besides, current society considers smartness to be the board as a significant aspect of any smart network. Waste generation is expanding quickly because of extreme urbanization and industrialization. Smart waste administration can successfully deal with the waste created by the workforce, city public administrations, and private workplaces [127]. Waste management is isolated into four primary stages: squander collection, removal, reusing, and recovery. Waste management is basic for the economic improvement of smart urban areas, as poor and mismanaged waste management creates difficulties in human wellbeing and the earth [128].

B. SMART TRANSPORTATION

Since the beginning of civilization, transportation has been essential to humanity. This requirement has been extended to the road, water, train, and air transportation with technological development. The conventional transportation strategies for the world were not associated or intra-associated. The idea of ordinary interfacing objects has changed the customary
transportation framework into an advanced interconnected transportation framework. Accordingly, current vehicles are incorporated into different correspondence and route frameworks. In this way, every molecule of a specific transmission type is associated with one another. By broadening the network inside a solitary transporter, various transporters can be interconnected to give a worldwide transportation framework. The Ad Hoc Vehicle Network (VANET) has gotten a lot of consideration in the idea of Intelligent Transport Systems (ITS) [129]. VANET has been generally used to oversee rural gridlock through vehicle-to-vehicle (VV) and vehicle-to-infrastructure (VI) correspondence capacities. The transportation system could operate the real-time database effectively regarding the actual communication function.

In addition, intelligent transportation systems provide passengers with information about road congestion, alternative routes, and alternative modes of transportation. In addition, the intelligent transportation system adopts safety measures for passengers and pedestrians to improve its performance. Thus, the most recent framework offers worldwide centre points, astute street organizations, intercity train organizations, tram and metro organizations, coordinated public security transport, ensured bike paths, and ensured passer-by courses [130]. In rundown, the smart city’s joining of smart transportation frameworks improves the operational proficiency of urban areas while advancing the time, cost, unswerving quality, and wellbeing of metropolitan transportation. [131] proposed a crash identification calculation for cutting edge air transportation. This is avoided by predicting air crashes and trading information between them. The rail traffic the board framework from Mazzarello and Ottaviani gives continuous travel speed signs to improve reliability, fuel utilization, and forestall impacts. Correspondingly, numerous scientists deal with supervision clashes and clogs in rail organizations [132]. Much exploration has been done on street traffic, the executives and traffic wellbeing. Likewise, new transportation applications incorporate RFID cost assortment, stopping the executives, air terminal identification control, and versatile application taxi rental and following. Incorporating these new transportation framework measurements misuses the personal satisfaction of metropolitan occupants while guaranteeing metropolitan supportability [133].

C. SMART HEALTHCARE

Rapid population growth is causing many healthcare encounters at the current time. As a result, traditional medical practices are insufficient, obsolete, and ineffective in meeting the medical needs of the world’s population. The situation is intensified as the number of doctors in the health sector has not increased directly to the proportion of the population. Then the risk of prescribing the wrong drug, the risk of getting an incorrect diagnosis, and the risk of misunderstanding an infectious or contagious disease. Lack of resources and excessive demand intensify the gap between expectations and actual healthcare. The solutions presented a smart medical services framework that balances medical care issues gracefully and requests while looking after productivity, exactness, and maintainability. Combining conventional clinical practices with complex clinical mediation techniques (clinical gadgets, sensors, cell phones, crisis administrations, ICT, etc.) is called “Smart Medical Care.” To fulfill the need and improve the nature of administration, current smart wellbeing administrations use sensor organizations, ICT, distributed computing, computer fog, cell phone applications, and incredible information handling systems [134].

Smart Healthcare Services uncovered delicate patient information to approved clients’ specialists, medical attendants, and lab experts through a safe organization of clinic frameworks, encouraging continuous status choice tolerance. Additionally, incorporated Electronic Clinical Records (ECRs) permit settling on constant choices dependent on the most recent data [135]. The proposed smart medical system utilizes RFID, WSN, and smart, versatile innovations interconnected through CoAP. [74] proposed another smart medical care structure that conceptualizes portable and cloud-based brilliant medical services frameworks. [75] took care of vagueness in different circumstances. A wise clinical system dependent on information combination has been proposed. [75] proposed another idea for setting delicate portable wellbeing in brilliant urban communities. Improving clinical administrations implies improving the personal satisfaction of metropolitan inhabitants. Along these lines, the coordination of brilliant medical care in smart urban communities is required to speak to significant achievement in acknowledging the smart city idea worldwide.

D. SMART ENERGY

Energy is an essential component to achieving any task. Different fuel sources are inexhaustible or non-sustainable. In contrast to sustainable assets (for example, petroleum products), inexhaustible assets (i.e., sun oriented, wind, geothermal energy) are not depleted because of the idea of recovery. In late many years, specialists have advanced the ideas of smart energy [76], green energy [71], and sustainable energy [78] to bring issues to light and advance the best energy utilization strategies. Eco-friendly energy intends to consume energy that has minimal effect on the earth. A definitive objective of maintainable energy is to help current and people in non-sustainable power source utilization. The idea of smart energy is generally more appealing because it elevates an all-encompassing way to deal with coordinating environmentally friendly power energy, maintainable energy, and a sustainable power source. To put it simply, smart energy should meet sustainable power source needs to meet the energy requirements of keeping up the manageability of the non-sustainable power source while limiting negative natural effects, for example, decreasing carbon dioxide outflows. As referenced above, a sustainable power source is truly appropriate for the world’s energy requests since it is a sustainable power source [136]. With the expanding interest in energy, the prominence of sustainable power sources
has developed in late many years. Thus, much examination has been done to coordinate sustainable power sources into smart structures. Sustainable power sources might be associated with smart structures, or sustainable power source plants might be coordinated into smart frameworks. [137] proposed microgrid energy the board framework that coordinates a photovoltaic (PV) generator with a serious storing unit. In [95], the author proposed comparable engineering that utilizes solar and wind energy for the home condition. Different investigations have been directed to accomplish proficient energy for executives in brilliant conditions coordinating sustainable power sources. This has a huge effect on total energy consumption, so various energy board frameworks are accommodated the home condition. The estimated energy report indicates that homegrown energy requests will increment by 24% in the coming years [81]. Consequently, the fundamental administration of energy utilization is promising for growing energy for the executives and is reasonable at the city level. Analysts have extended their work to supervise smart frameworks to improve energy use. In [138], the energy utilization arranging technique dependent on the game hypothesis is proposed. This methodology diminished complete energy requests, all-out energy cost, and per-capita day by day power rates. A comparable circumstance was discussed in [82]: accomplishing a successful synchronization among flexibility and request, diminishing energy expenses, and decreasing carbon discharges. Conveying HEM for network energy, the board boosts energy use at the city level [139].

VI. RELATED WORKS IN SMART CITY
Nowadays, the smart city is the newly emerging domain for research. There are several subdomains in the smart city for the research, attracting young researchers. In this section, a comprehensive literature review of the smart city and smart homes is being done.

A. RESEARCH WORK IN SMART CITY
Several researchers worked in the different domains of the smart city. Still, this domain has many research opportunities for new researchers. Here, Table 2 represents the research done by the different authors in the different different domain. This table also clearly elaborates the research domain in which the author is working, the approach proposed by the author with the simulation tool the author has worked with, and the results achieved with the future research direction given by the author. Table 3 represents the year wise review of the author’s criteria discussed in their respective proposed research papers.

Seravalli et al. [83] presented the requirement for a comprehensive, coordinated, multidisciplinary way to deal with the idea of smart urban communities. Smart urban areas are advancing with the assistance of the formation of exceptional devices which are applications dependent. Consequently, the scientific classification of the European smart city application is assessed, and the connections between various European smart scientific classifications are dissected. Also, to see how the hypothetical ideas of the real world and smart urban areas fit together, the authors investigated 61 applications for 33 smart urban areas circulated in North America, South America, Europe, and Asia. Sixteen applications from 8 urban areas were chosen and given a point-by-point diagram of existing instruments for different applications characterized by European principles. After presenting the true smart city, we will conclude with a concept and stage of future smart city construction.

Efthymiopoulos [84] investigated, analysed, and discussed strategic management, innovation, and development elements. The purpose of explaining the strategic security elements is to establish urban cybersecurity in intelligent network and service provider environments. Li et al. [85] separated the smart city framework into four subsystems: smart foundation, economy, administration, investment, and the relating pointer framework. At that point, utilizing data entropy and indistinct relationship examination, the heaviness of each list is resolved, and the knowledge level of the city is assessed independently. Twenty significant urban communities in China are viewed as the author’s survey cases. The authors said they evaluated the grey correlations of these cities and the changes from 2012 to 2016.

Arora [86] examined the financial development levels of India’s top 20 smart cities. The authors reveal that interstate and intrastate inequality is high because cities with high and low FSI are located in developed countries in the western and southern regions. A similar situation occurs in low-income countries such as Madhya Pradesh in low-developed countries. The study’s authors emphasized that smart cities vary greatly from state to state in financial development. Finally, the authors note that a holistic approach to smart city development requires a vibrant and developed financial sector.

Lu et al. [91] proposed a comparative analysis targeting ten smart cities in China. By analysing self-organizing maps of unsupervised computer neural networks (SOM), one can draw maps of different cities depending on their performance. Social network analysis was also used to discuss demo effects and interactions between these ten smart cities. Based on the performance of smart cities and cluster networks, the author highlights the current issues of smart city development in China.

Picon et al. [92] conducted contextual analyses that fall into topographical classes (Middle East urban communities, Northern European urban areas, Mediterranean and Asian urban communities). Noticeably, it refers to three unique kinds of urban areas and networks, particularly those that refer to the degree of development and human capital. This is a key factor in accomplishing a smart turn of events. The recently constructed city in the Middle East is a city that plans everything without any preparation in a white paper to restrict outflows and improve the personal satisfaction of its residents. Cassandras [101] identified some of the key features of smart cities and discussed some of the lessons learned from treating them as CPS, with some fundamental research
issues still largely unsolved. Masera *et al.* [111] described the main impacts of deploying smart grids in different ways and proposed ways to extend cost-benefit analysis that can go beyond other rigorous financial aspects. The methodology indicated competently can be stretched out to assess smart city advancement proposition.

Tcholtchev *et al.* [113] proposed how to assemble an ICT scene in urban areas dependent on the new norm of smart urban areas in Europe and Germany to advance a versatile and adaptable biological system of ICT segments and partners in the smart city. After presenting the principles and strategies, the author proposes contextual investigations of two late exploration tasks to approve the proposed strategy. Fernández-Güell *et al.* [115] published an article that describes cities more comprehensively and introduces urban functional systems that can promote the effective participation of local stakeholders in the planning process of sustainable development planning. Akande *et al.* [118] classified 28 European capitals according to intelligence and endurance. Using hierarchical grouping and principal component analysis (PCA), 32 indictors were combined into four components, and a classification score was calculated. Rankings of European capitals are based on ranking scores. The results show that Berlin and other Nordic capitals have the highest rankings, and Sofia and Bucharest have the lowest scores, so achieving smart and sustainable development is still impossible.

Gupta *et al.* [125] focused on how experts in these biological systems facilitate their arrangement of information plans. The City of London information arranging contextual investigation features the difficulties of complex metropolitan information conditions and the significance of coordinated perspectives. The author examines three components of the smart city information environment: transparency, correspondence, and smart vision, recognized as the principal impetuses for metropolitan information arranging inside government offices of London.

Engelbert *et al.* [127] conceptualized smart cities in Europe to collect peripheral operations of smart city networks and core operations of smart city projects. Both methods primarily search the “intelligence,” an adjective for prestigious cities in Europe. This usually means obtaining a significant reward or grant from Europe. In this article, the author focuses on European-sponsored smart city projects and explains why the specific vision of European cities shapes these projects and how they affect citizens’ participation. The author was generally discussing, especially, smart European cities. Geray *et al.* [138] published an article on Impact-Driven Smart and Sustainable Urban Frameworks to Address Urban Challenges. The author takes the Smart Dubai experience, for instance. Pourzolfaghar *et al.* [142] proposed a structure zeroing in on the meaning of relevant necessities and the foundation of brilliant city frameworks and administrations. Unlike the other methods, the author focuses on two important layers: the context and services layers and the relationship with other normal layers. This framework is of great value in the development of smart services, but it also helps us understand the enterprise architecture of smart cities.

Pereira *et al.* [143] focused on smart administration as another exploration zone with critical, logical and strategic considerations. All the more explicitly, the author’s motivation is to understand the definition and connections of smart administration and ideas, for example, smart e-government with regards to smart urban communities. Breuer *et al.* [144] applied a social constructivist approach to developing personal data protection in smart city planning, arguing that personal data protection in smart cities is at the “explanatory flexibility” stage. The concept suggests different meanings. The authors evaluated the explanations, opportunities, and challenges associated with the most influential actors and factors based on the semi-empirical scenario analysis. Fernández-Güell *et al.* [258] presented a more comprehensive description of cities and a system of urban functions that could facilitate the effective participation of local stakeholders in the planning process of Smart City planning.

Chiaraviglio *et al.* [149] aimed to clarify the location of 5G network plans that support EMF, especially 5G BS devices that comply with downstream EMF limits. The author introduced the latest technologies for EMF-enabled mobile networks and outlined how current exposure limits and EMF constraints affect 5G planning. The author reports two realistic case studies showing the current EMF saturation in 2G/3G/4G networks and the adverse effects of strict regulations on network planning and user quality of service (QoS). Finally, the author discusses the expected impact of 5G technology on EMF and creates rules for EMF-aware 5G arrangement.

Alhuseini *et al.* [152] proposed another utilization case-driven system to plan and transport measured 5G administrations. The structure actualizes the standards of Agile and as-a-support of furnish 5G use case clients with admittance to administrations and plan and operational benefits. The system incorporates the Third Generation Partnership Project (3GPP) detail by planning network slicing techniques for planned life cycle tasks. The system empowers sending by utilizing any innovation and empowering the establishments accessible for explicit space computerization. The author refreshes organized 5G network resources with vertical client parts through programmable client stories through an organized joint effort between 5G administrators and clients twist and improve focus on use cases. Lab testing of 5G network slicing for private telephone and item following administrations was led to approve the proposed strategy in useful applications.

Wang *et al.* [155] conducted a comprehensive survey of sensor placement in wireless sensor networks, covering an overview of motivation, problem formulation, solutions, and performance. Next, the author discusses future research topics. Mozurinaitė *et al.* [156] discussed and planned the idea of the smart city. The author considered the perspective of urban design to discover and highlight the important contacts, relationships, and roles of urban design, planning, and landscape design in building smart cities. The authors
point out that this will lead to establishing healthy smart city principles in Europe, which will lead to sustainable development, effective urban growth, and better cityscapes. Veiga et al. [160] proposed a system for making smart city benefits and exhibited the malignancy of smart city administration particulars utilizing traffic signal administrations. The administrations offered that information can be gathered and smart between gadgets inside metropolitan regions. The benefits of the specification have been proven, and identify specific topics to develop.

Mukti et al. [165] clarified that the utilization of IoT innovation is the foundation of the smart city idea. The author examined the current advancement of the smart city environment dependent on the IoT, which brought up some subsequent issues. Partners are fundamentally separated into clients, gadget makers, middleware engineers, and application designers in this biological system. The authors discovered the future challenges of smart cities based on the Internet of Things revolve around coordination among these stakeholders. Anthopoulos et al. [170] measured the correlation between smart cities and urban planning and determined their intersections. The size of urban planning derives from European regional cohesion policies and is related to the building layers of smart cities.

Khan et al. [169] developed key aspects of blockchain technology, including its working mechanism styles, stake proofs and custom variants of other proposed improvements, and tried seven challenges using different technologies. In addition, the author described the latest technology for non-financial blockchain applications such as healthcare. A personalized 4-layer blockchain model is associated with precision medicine and notable in clinical trials in this technology. In addition, the authors described a mobile application model called HDG that can automate medical records without compromising confidentiality.

Brock et al. [173] examined four particular plans of action that empower occupant associations to enter this smart city market. Because of a top to bottom examination at Philips Lighting of four smart city cases over five years. The author creates and analyses four plans of action as far as individual and shared worth creation and worth catching, and shows how every plan of action can support holders, contingent upon the task and biological system. Through Philips Lighting’s progress from public lighting to smart urban communities, the creators portrayed these action plans and gave execution particulars to existing organizations. Morello et al. [196] planned to feature progress in executing and utilising smart frameworks and rising advancements in urban communities. Utilize progressed identification frameworks and smart transducers to improve the presentation of grids and metropolitan administrations. The author inspected a clearer image of the present status of the subject by depicting a specific application and proposing new highlights and thoughts in the field of sensors and discovery frameworks committed to smart electric grids and smart cities.

Xu et al. [202] anticipated that more than 20 billion IoT gadgets would be sent internationally by 2020. These gadgets offer help for various significant applications, for example, smart urban communities, smart matrices, and the industrial web. To ensure the proper operation of these applications, these devices and the data they produce must be authenticated. The author proposed DioTA, a new IoT device authentication framework based on distributed ledgers. DioTA utilizes a two-level appropriated registry design with a lightweight information verification system to encourage IoT gadgets and information on the board. The author likewise investigated the exhibition and security of DioTA. Hakak et al. [204] proposed a theoretical design to secure smart urban areas utilizing blockchain innovation and portrayed it utilizing possible use case investigations. The author additionally gave a diagram of three genuine world blockchain-based smart city case investigations. Finally, the authors identify and discuss some of the required research issues. Zhang et al. [203] discussed the progress of global ITS research, and explained the current challenges in it, and provide all researchers in this field with more insight into ITS development.

Mocrii et al. [207] reviewed the key smart home technologies based on the IoT. The author began with a review of the smart home definition that defines the perspectives adopted and describes the supplementary features of the user and smart home system. The author presents a plan based on the IoT and places smart homes in the wider environment of smart grids. Mroue et al. [172] changed Category A and Category B of LoRaWAN MAC layers. Instead of waiting for the upstream operation to finish, a receive-only time interval for station limits is transferred, so these limits are directed earlier than the send interval. The author performed the simulation in MATLAB. Suppose the number of supporters is usually less than 500, equated to LoRaWAN in minor and average-sized urban areas. In that case, the proposed fix will significantly reduce the packet rejection rate and PER by 20% compared to LoRaWAN. As a result, the quantity of gateways compulsory in the system is also compact, reducing the cost of network infrastructure.

Bibri et al. [216] provided a comprehensive, up-to-date overview and integration of sustainable smart. Smart urban areas and related enormous information examination, with essential and principal uncertainties, research questions and conversations, openings, and advantages, were additionally considered for the survey. The survey offers applications, mechanical turns of events, developing patterns, future practices, difficulties, and open inquiries. The authors also discussed that smart urban areas are related to misinterpretations having holes in their commitments. Different open doors were additionally breaking down. Large information and its application in smart urban areas of things to come will improve its commitment. Streamlining and improving activities, capacities, administrations, plans, systems, metropolitan arrangements, and discovering answers to
troublesome inquiries encourage information structures for accomplishing supportable improvement objectives.

Sanchez-Gomez et al. [209] focused on assessing the performance of the technology under different working conditions. The author introduced two LoRaWAN commercial gateways and compared and discussed the results obtained in the two deployments. As a result, LoRaWAN is an excellent solution for deploying smart cities to support specific IoT applications. Ramos-gonz et al. [211] reviewed the definition received for the term “smart city” and reviewed the features of the most commonly used platforms that provide technical support to cities.

Ismagiloiva et al. [212] gave a significant combination of important writing on smart urban areas by examining and talking about the primary discoveries of existing examination on the issue of smart urban areas in setting up maintainable urban area’s communities and networks. The aftereffects of this examination can give researchers and specialists a data system for smart city research. Authors in 2015 intended to explain the importance of “insight” in urban communities in light of a point-by-point investigation of the significant exploration and authority records. The author also decided on the smart city’s key measurements and components. Various indicators of urban intelligence were examined to show that a common definition of the characteristics and performance of a smart city needs to be defined compared to traditional cities. In addition, the authors have identified several smart city performance indicators and measurements.

Santana et al. [214] conducted the latest survey on smart city software platforms. The author examined 23 projects, including the most broadly utilized empowering innovations and useful and non-utilitarian prerequisites, and sorts them into four classes: digital, physical frameworks, web of things, large information, and distributed computing. In light of these outcomes, the author concocted a reference engineering to control the advancement of cutting-edge programming stages for smart urban areas. At last, the author frequently refers to open exploration challenges and talks about future chances. Chamoso et al. [215] reviewed the writing on smart urban communities and led a total investigation of the ideas and existing stages. The creator had a missing form of the administrations that smart urban communities must offer, the advancements used to build up these administrations, and the extent of this idea. The author recognized holes and requirements for smart urban areas and proposed a model for planning smart city structures.

Bibiri et al. [216] gave the premise to metropolitan scientists to use many applied systems for future examination. The proposed structure, which can be repeated and tried in exact exploration, adds profundity and meticulousness to the investigation. Notwithstanding audits of key investigations, the author additionally features key applications, difficulties, and open issues. Wiig [217] distributed a contextual analysis of a computerized light program motivated by IBM’s strategic counsel in Philadelphia. The arrangement gave a web-based media specialist preparing an application that permits up to 500,000 ignorant people to work in the data and information economy, regardless of whether the city’s Chairperson reported that the venture was effective yet didn’t satisfy hopes.

Wang et al. [220] presented the fundamental structure and primary elements of the blockchain and totalled up the security necessities to improve the Internet of Things and Industry 4.0. Next, the author investigated how to utilize security devices and advancements to apply blockchain to the Internet of Things 4.0. The author portrayed the most significant blockchain-based IoT applications to advance the capacities and advantages of blockchain innovation on IoT and IIoT stages.

Mohanta et al. [221] considered five databases for this research: Science Direct, IEEE Xplore, Web of Science, ACM Digital Library, and Inderscience. After completing the initial phase, more than 250 research articles were considered in the final research database. The study’s primary purpose is to provide the university research community with a comprehensive analysis of the broad applications of blockchain technology. This article discusses some of the challenges in implementing blockchain and the associated security and privacy issues. Woon et al. [222] studied the cybersecurity theme of smart cities. The author introduced how the particular characteristics of the smart city constituted cybersecurity issues and reviewed the various threats. Finally, the author reviews some of the key cybersecurity solutions proposed for the smart city.

Tawfik et al. [224] solved several issues related to development, modelling, tools, design methods, case studies, and innovative ideas for security, performance, usability, and security. Sustainability of smart environments in smart cities. Mohanta et al. [225] described an overview of the Internet of Things technologies and their application areas. The major CIA security issues (confidentiality, integrity, availability) and layer issues were identified. Next, the author systematically researched three major machine learning (ML) technologies, artificial intelligence (AI), and blockchain to solve the security problem of the Internet of Things. Finally, the analysis of this study mentioned research and security challenges solved by ML, AI, and blockchain. Basford et al. [226] clarified that LoRaWAN is a low-power wide-zone organization (LPWAN) innovation explicitly intended for the IoT arrangements. The author portrayed his experience sending a city-wide LoRaWAN network in Southampton, UK. An organization was acquainted with helping the establishment of air quality screens and investigating the abilities of LoRaWAN. This organization blends standard business passages and custom entryways. The area of these entryways is picked dependent on network access, site approval, and openness and isn’t the best area in principle. The 20 gadgets dissected sent more than 135,000 messages. The information worker effectively got 72.4% of the messages during the full sending. Of the messages received, 99% were gotten within 10 seconds of being sent. The author reasoned that LoRaWAN is an appropriate interchanges innovation for city-wide air quality checking and other smart city applications.
Khan et al. [169] used probable proof of participation and other custom variants to elaborate on key aspects of blockchain technology, such as its operating mechanism style, and try seven new challenges through different technologies. The author also described state-of-the-art technologies for non-financial blockchain applications such as healthcare. The contribution of customized 4-tier blockchain models related to precision medicine and testing is notable. Another important contribution is a mobile application model called HDG that automates medical records without compromising confidentiality. Oughton et al. [227] discussed that the industry integrates the new 5G spectrum and densification. It will use various improved Mobile Broadband Infrastructure (eMBB) strategies to analyse existing networks’ capacity, coverage, and cost. A Dutch case study was used to conduct a supply-side and demand-side investment analysis. Before small cells needed to densify their networks, suppliers analysed and estimated the capacity they could offer their users over the new spectrum. A demand-side analysis tested various speed ranges that each user needed, such as 30 Mbps, 100 Mbps, and 300 Mbps, and quantified the investment strategy’s performance to meet this demand. The authors describe the key contributions that can be used to estimate the threshold of user-provided traffic. Based on the integration of the 5G band on the existing Dutch macro cellular network. Based on the data from this analysis, the authors found that the average service capacity of each user in the Dutch 5G band increased by about 40% compared to the existing LTE capacity.

Wilson [229] discussed the four foundations of information and communications technology, smart cities, to explore UK progress, data, governance, public engagement, and goals for the next 20 years. The author described the architecture and building blocks of the PortoLivingLab, focusing on IoT technologies and the challenges they encounter. The author presented proof-of-concept use cases (for example, passenger flow from a Wi-Fi connection). It provides new information on the various components of a constantly changing and moving city. Nelson et al. [232] identified common barriers to IoT adoption and replication from technology and organizational perspective and listed the methods used to overcome these barriers in these projects. Jabłoński [236] described the application of graphic signal processing to search for complex heterogeneous data and systems, especially in monitoring smart residential environments in cities, countries, continents, and elsewhere. The authors explained that sensor networks are considered the base layer of intelligent habitats. It can directly manipulate the collected signal, but it can also identify the network model of the data. This model was identified for recording ozone (O3) at 100 measurement points deployed in Poland. This describes the multi-scale prediction results for the ozone dataset. Furthermore, unlike conventional signal processing, the author has done the spectral analysis of graph signals, such as reconstructing the Laplacian graph and calculating the Fourier transform the signal across the graph vertices.

Du et al. [239] focused on issues of device deployment (this is the design/configuration part of the system) and device inspection management (this is the operational part of the system). The author also described selecting from existing algorithms for different smart city monitoring applications such as structural health monitoring, water networks, and traffic monitoring. The authors also discussed future research opportunities and challenges in smart city surveillance. An et al. [241] portrayed instances of two worldwide IoT norms, FIWARE and oneM2M, effectively utilized in many smart cities. They dissected them to see the achievability of IoT stage interoperability. The author planned and executed another IoT interworking engineering that gives a semantic driven combination structure for smart urban areas in light of the examination. The author introduced a framework dependent on these forces of lawyers and assessed it in Santander Smart City. The outcomes show that it can identify and oversee IoT sensors associated with oneM2M and FIWARE. The author saw that the semantic methodology gives the adaptability and dynamic flexibility required for a quickly developing and quickly changing metropolitan condition.

Several researchers worked in the different domains of the smart city. Still, this domain has many research opportunities for new researchers. Here, Table 2 represents the research done by the different authors in the different-different domain. This table also clearly elaborates the domain of the research in which the author is working, the approach proposed by the author with the simulation tool the author have been worked, the results achieved with the future research direction given by the author. Whereas Table 3 represents the year wise review of the author’s criteria discussed in their respective proposed research papers.

**B. SMART HOMES IN SMART CITY**

Several researchers worked in the different domains of the smart city. Still, this domain has many research opportunities for new researchers. Here, Table 4 represents the research done by the different authors in different-different smart homes domains. This table also clearly elaborates the research domain in which the author is working, the approach proposed by the author with the simulation tool the author has worked with, and the results achieved with the future research direction given by the author. Table 5 represents the year wise review of the author’s criteria discussed in their proposed research papers.

Boulos et al. [167] accepted that smart cities, driven by the IoT, will become more beneficial urban areas. The World Health Organization (WHO) Healthy Cities Network and related public organizations, which have countless parts of urban areas around the globe, can profit from the Internet of Things and improve the healthcare and prosperity of the populace. Seravalli et al. [83] presented the requirement for a comprehensive, incorporated, multidisciplinary way to deal with the idea of smart urban communities. Smart urban communities are developing with the assistance of the formation...
### TABLE 2. Year-wise literature review of smart city: Author with their research objectives, research domain, proposed approaches with the simulator tools, and results with the research gap.

| Author                      | Year | Objective                                                                 | Domain                          | Proposed Approach and Simulation Tools      | Research Gaps and Results                                                                 |
|-----------------------------|------|---------------------------------------------------------------------------|---------------------------------|---------------------------------------------|--------------------------------------------------------------------------------------------|
| Rodríguez-Hernández et al. | 2019 | Propose a model for media transmission traffic management and improve the nature of administration in a smart city | Telecommunication in a smart city | OMNET++                                      | Utilizing this instrument, one can have the right assessment of the correspondence needs and cost before administration sending. |
| Pan et al.                  | 2018 | Nature of Assessment of Encrypted YouTube versatile real-time for energy sparing. | smart city                      | ML-based Bivariate Estimation (MBE)          | MBE is a double and exceptionally powerful assessment approach with 95% precision.          |
| Park et al.                 | 2017 | Packet flooding mitigation in the content-centric network-based wireless multimedia sensor network. | Wireless Sensor Network in smart city | Packet Diffusion Limited Protocol Tool: NS3 Simulator | Convention limits flooding of information bundles and accelerates content download time by utilizing the briefest way. |
| Kalandaivel et al.          | 2019 | To propose an Intelligent Data Delivery Approach for Smart City using Road Side Units | smart city                      | A new technology-based Routing Structure     | The planned directing plot gives a lot of display than existing conventions for constant applications. |
| Ghaisari et al.             | 2019 | An Edge Computing Architecture for protection safeguarding in IoT-based Smart City. | Security and Privacy in smart city | Dynamic protection saving strategy on the head of philosophy | The system provides privacy in real-time. |
| Vo et al.                   | 2018 | 5G improved reserving and downlink asset sharing enhancement structure.    | smart city                      | Joint storing and Downlink asset sharing advancement system | The structure gives the best exhibition regarding hit rate and framework conveyance limit. |
| Oughton et al.              | 2019 | An open-source Techno-Economic Assessment Framework for 5G arrangement.    | smart city                      | Tool: PySim-SG                               | Deployment cost reduction by 30%. |
| Li et al.                   | 2019 | A large scope metropolitan Vehicular organization structure plays out a non-continuous information gathering task in the smart city. | Vehicle Networks in smart city   | Location-Based Urban Vehicle Network (LVN)  | Reliable and predictable wireless connectivity simplifies topology. |
| Jedari et al.               | 2017 | A Social Based Watchdog System to recognize epileptic hubs in the crafty portable organization. | smart city                      | Social-Based Watchdog System (SoWatch)       | The framework outshakes a benchmark contact-based guard dog framework for recognition time by 45% and identification proportion by 10%, with less correspondence overhead. |
| Borkova et al.              | 2018 | Usefulness between the size and indicators of Smart City.                 | smart city                      | Statistical Analysis using Decision Tree Modelling | 96.2% correct Classification. |
| Mohammad et al.             | 2018 | Semi-Supervised Deep Reinforcement Learning in Support of IoT and Smart City Services. | smart city                      | Semi-Supervised deep reinforcement learning Model. | Close estimation of the target location is improved by 23%, and 67% received Rewards. |
| Muhammad et al.             | 2018 | A customized Ubiquitous cloud And edge-empowered Networked medical care System. | smart city                      | Ubiquitous Healthcare Framework (UBHealth)    | Latency Reduction By 50%. |
| Liao et al.                 | 2018 | Fog Computing empowered Vehicle as a Service for figuring Geographical Migration in Smart City. | smart city                      | Vehicle Mobility-based geographical migration model. | The advantage and efficiency of the model are significant. |
| Samani et al.               | 2016 | Robotic and Computerized outer defibrillator rescue vehicle for crisis administrations in a keen city. | Healthcare in smart city         | Ambulance Robot (Ambubot)                    | Help the critical patients during an emergency in a smart city. |
| Tuwalbeh et al.             | 2016 | Greener and Smarter telephones for future urban areas and characterize the effect of GPS signals on power utilization. | Mobile Computing in smart city   | The connection between the energy utilization of a limitation application and the quality of the GPS signal. | Higher SNR estimation of GPS signals devours less energy while low GPS signal causes quicker energy channel, for example, 30% when contrasted with 13%. |
| Lai et al.                  | 2015 | Plan and investigation of confided in network hardware access confirmation convention. | Security and Privacy in smart city | Trusted Network Equipment Access Authentication Protocol. | All the nine objectives that choose the convention's security have been accomplished. |
| Jemehidi et al.             | 2019 | Utilizing Time Location labels and guard dog hubs to shield against hub replication assault in a portable remote sensor organization. | Security and Privacy in smart city | Novel algorithm using watchdog node Tool: J-SIM Simulator | Detects 100% replica node false detection rate is 9.5%. |
| Sharma et al.               | 2018 | Blockchain-based half and half organization engineering for the smart city. | Network communication in a smart city | Novel hybrid network architecture.           | Low inactivity, lessening transmission capacity utilization, improving security, protection, and versality. |
| Mousse et al.               | 2020 | An expansion of LoRaWAN conventions to lessen framework cost by improving the nature of administration. | Network communication in a smart city | Modified LoRaWAN MAC layer Tool: MATLAB | Decreases the dismissed packet rate and PER by up to 30%. |
| De Paz et al.               | 2016 | To develop an intelligent system for lighting control in the smart city.   | smart city                      | Adaptable architecture for public lighting and intelligent management. | Optimised energy consumption and reduced cost. |
| Martins et al.              | 2020 | To develop Smart city platform architecture.                             | smart city                      | CityAction                                   | Better discussions in smart city management behaviours, improved response time, safety, and well living. |
| Pan et al.                  | 2019 | To forecast the organization traffic of a smart city dependent on DE-BP neural organization. | Networks in smart city           | Differential evolution back-propagation (DE-BP) neural network traffic Prediction Model. | Accurately predict the trends of network traffic. |
TABLE 2. (Continued.) Year-wise literature review of smart city: Author with their research objectives, research domain, proposed approaches with the simulator tools, and results with the research gap.

| Year | Author | Research Objectives | Research Domain | Proposed Approaches | Results | Research Gap |
|------|--------|---------------------|-----------------|---------------------|---------|--------------|
| 2017 | Ullah et al. [179] | Energy and blockage mindful Routing Metric for shared lattice AMI networks in the smart city. | Networks in smart city | Energy blockage mindful directing measurement (ECRM) for brilliant meter organization. | More remarkable organization execution regarding normal force utilization and parcel conveyance proportion. |
| 2019 | Rodriguez-Hernandez et al. [184] | Planning Communication in Smart City. | Communication in a smart city | SimulCity Tool | The best execution assessment of SimulCity will be gotten when the Valencia Smart City is conveyed. |
| 2018 | Alotaibi et al. [187] | Enrollment Centre based client confirmation comprises for smart e-administration application in the smart city. | smart city | Advance multi-factor user authentication scheme. | Formal verification performed using the AVISPA tool confirms the security of the proposed scheme. |
| 2017 | Mohamed et al. [188] | Service-oriented middleware for cloud and haze empowered smart city administrations. | smart city | Servo-oriented middleware (SOM) called SmartCityWare | To anticipate the organization traffic of a smart city dependent on DE-3P neural organization. |
| 2017 | Kotevikas et al. [194] | An organization model for Smart City Data resilience strength and city-to-city network for the wrong investigation. | Networks in Smart City | Dynamic Network Model. | The maximum improvement was 7.8%, with an average improvement of 5.6%. |
| 2020 | Fallis et al. [198] | To build up a force proficient sound obtaining framework for smart city applications. | smart city | Plan of a tested for savvy mouthpiece frameworks. The advances, for example, wifi (2.4 GHz), Bluetooth low energy (BLE) 4.0 and Zigbee, were inspected. | Power consumption is lowered by 97%. |
| 2020 | Fernandez-Ares et al. [201] | To identify and examine the oddities in individuals’ thickness and portability through remote Smartphone following. | Transportation in Smart City | System to distinguish the development of individuals from the data sent by brilliant cell phones. | The philosophy causes the city policymakers to oversee versatility and transport assets better. |
| 2019 | Fujiehara et al. [210] | Confirmation of work in the vicinity for a crowded detecting framework for communicant traffic data gathering. | Traffic management in Smart City. | Distributed Crowd Sensing System for Collaborative gathering of traffic information. | The framework makes confined verification of work-based agreements, and the blockchain reacts to semi constant traffic status in the street fragment. |
| 2020 | Ali et al. [223] | To secure Smart City Surveillance. | Security in Smart City. | Utilizing lightweight symmetric key natives and fleeting certifications, an iTCALAS Scheme is proposed. | Gives realized security include and complete validation in 2.295 ms. |
| 2019 | Mohammad et al. [233] | A Formal Analysis of Human Assisted Smart City Emergency Services. | smart city | An all-encompassing way to deal with model the probabilistic just as the non-deterministic part of the criteria, the board administrations of Smart city by utilizing probabilistic model checking. | The model is effective in different complex situations. |
| 2016 | Filippi et al. [240] | To propose a WE-Government instrument for Smart peripheries in the smart city. | smart city | MiraMap WE-Government Tool | This tool facilitates the communication and management between citizens and public administrations. |
| 2016 | Batsimi et al. [242] | To sense and classify roadways obstacles in Smart City using a smartphone application. | Transportation in Smart City | Foundation free methodology for abnormality recognition and recognizable proof dependent on information gathered through a Smart Phone Application named Street Bump. | A genuine dataset given by the city of Boston delineates the possibility and viability of the framework. |

of uncommon instruments which are applications explicit. The scientific classification of the European smart city application is evaluated, and the connections between various European smart scientific classifications are dissected. Also, to see how the hypothetical ideas of the real world and smart urban communities fit together, the author examines 61+ applications for 33 smart urban communities dispersed in North America, South America, Europe, and Asia. Sixteen explicit applications from 8 urban areas were chosen and given a definite outline of existing apparatuses for different applications characterized by European norms. In the wake of introducing the genuine, smart city, the author finished with an idea and phase of future smart city development.

Albino et al. [213] planned to explain the importance of “insight” in urban areas because of a definite investigation of global associations’ applicable examination and authority records. The author likewise decided the key measurements and components of the smart city. Various indicators of urban intelligence were examined to show that a common definition of the characteristics and performance of smart cities needs to be defined compared to traditional cities. In addition, the authors have identified several smart city performance indicators and measurements. Wiig [217] distributed a computerised light program case investigation brightened by IBM’s arrangement interview in Philadelphia. The arrangement gave a web-based media labourer preparing an application that permits up to 500,000 ignorant people to work in the data and information economy, regardless of whether the city’s chairman reported that the undertaking was effective yet didn’t satisfy hopes.
### TABLE 3. Year-wise review of smart city: with authors with the author’s criteria discussed in the research paper.

| Author                        | Year | Domain    | 1* | 2* | 3* | 4* | 5* | 6* | 7* | 8* | 9* |
|-------------------------------|------|-----------|----|----|----|----|----|----|----|----|----|
| Borsekova et al. [87]         | 2018 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Mora et al. [89]              | 2019 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Monzon et al. [90]            | 2015 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Eckhoff et al. [102]          | 2018 | Security   | Yes|    | Yes|    |    |    |    |    |    |
| Falco et al. [103]            | 2018 | Security   | Yes|    | Yes|    |    |    |    |    |    |
| Samih et al. [108]            | 2019 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Saba et al. [110]             | 2020 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Dameri et al. [112]           | 2015 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Komeily et al. [116]          | 2017 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Picon et al. [117]            | 2017 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Kolozali et al. [121]         | 2014 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Lau et al. [122]              | 2019 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Handy et al. [123]            | 2018 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Fernandez-Anez et al. [129]   | 2017 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Silva et al. [130]            | 2018 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Kandpal et al. [131]          | 2017 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Garcia-Roger et al. [132]     | 2018 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Ahmed et al. [133]            | 2019 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Oja et al. [135]              | 2015 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Pereira et al. [143]          | 2018 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Khatoun et al. [145]          | 2017 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Hoogen et al. [146]           | 2019 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Ghalmi et al. [147]           | 2017 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Roblek et al. [148]           | 2019 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Al-Ammal et al. [259]         | 2019 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Fernández-Güell et al. [258]  | 2016 | smart city | Yes|    | Yes|    |    |    |    |    |    |
| Morocho-Cayamceleta et al. [150] | 2019 | Networks   | Yes|    | Yes|    |    |    |    |    |    |
| Raghavan et al. [151]         | 2019 | Communication | Yes|    | Yes|    |    |    |    |    |    |
| Ghosh et al. [153]            | 2019 | Networks   | Yes|    | Yes|    |    |    |    |    |    |
Efthymiopoulos [84] investigated, analysed, and discussed strategic management, innovation, and development elements. The purpose of explaining the strategic security elements is to establish urban cybersecurity in intelligent network and service provider environments. Cassandras [242] identified approximately the important geographies of smart cities and discussed some of the lessons learned from treating them as CPS, with some fundamental research issues still largely unsolved. Fernández-Güell et al. [115] published an article that describes cities more comprehensively and introduces urban functional systems that can promote the effective participation of limited investors in the development progression of sustainable development planning. Breuer et al. applied a social constructivist way to improve individual information insurance in smart city arrangements, contending that the security of individual information in smart urban communities is at the “illustrative adaptability” stage. The idea recommends various implications. Because of the semi-experimental situation examination, the author assessed the clarifications, openings, and difficulties related to the most compelling entertainers and variables.

Fernández-Güell et al. [258] presented a more comprehensive description of cities and a system of urban functions that could facilitate the effective participation of limited investors.
investors in the development progression of the smart city. Kulkarni et al. [234] proposed remote network contemplations and an all-out expense of proprietorship (TCO) structure for assessing applicant arrangements and featured the experience of a smart water case analysis including two European public administrations. Hui et al. [245] defined the main requirements of the SH structure. Seven recommendations for unique requirements are distinct and categorized, rendering the exact excellence of SH structure chunks. Soe et al. [88] examined the two arrangements of cases in East Asia, including Singapore and Hong Kong and Northern Europe, including Tallinn and Helsinki. The connection between smart urban communities and electronic instalments is normally separated. To break down the degree of electronic instalment frameworks in these urban communities, select two urban communities with higher digitization territories.

Picon et al. [92] conducted contextual investigations into topographical classes (Middle East urban areas, Northern European urban communities, Mediterranean and Asian urban areas). Perceptibly, it refers to three unique urban areas and networks, particularly those that refer to the degree of development and human capital. This is a key factor in accomplishing a careful turn of events. The recently manufactured city in the Middle East is a city that plans everything without any preparation in a white paper to restrict outflows and improve the personal satisfaction of its residents.

Alhuseini et al. [152] proposed a new use case driven framework for the project and distribution of modular 5G facilities. The structure actualizes the standards of flexible and as-a-support of furnish 5G use case clients with admittance to administrations and plan and operational benefits. The system coordinates with the Third Generation Partnership Project (3GPP) by planning network sharing methods to plan environment lifespan activities. The structure empowers sending by utilizing any innovation and empowering the establishments accessible for explicit space robotization. The author refreshes organized 5G network resources with vertical client segments through programmable client stories through an organized, coordinated effort between 5G administrators and clients to modify and improve focus on use cases. Research centre testing 5G network cutting for private telephone and item following administrations was directed to approve the proposed strategy in reasonable applications. Morello et al. [196] highlighted progress in implementing and applying smart grids and emerging technologies in cities. Utilize progressed discovery frameworks and smart transducers to improve the exhibition of grids and metropolitan administrations. The writer purposed to furnish the peruse with a clearer image of the present status of the theme by portraying a specific application and proposing new highlights and thoughts in the arena of devices and location frameworks devoted to 5G, energy networks, and smart city.

Santana et al. [214] directed the most recent smart city programming stages overview. The author broke down 23 activities, including the most generally utilized empowering innovations and useful and non-utilitarian prerequisites and arranged them into four classifications: digital, physical frameworks, the web of things, huge information, and distributed computing. The authors recorded the open examination challenges and discussed about future probabilities. Venkatesh et al. [228] applied a particular way to deal with IoT applications. For smart healthcare, this decreases reaction times to crises, adequately distinguishes health-related conditions, and permits ensuing initiations in smart city conditions. The authors exhibited the capability of three arrangements of setting smart interconnected applications and extracted healthcare-related workforce, for example, client presence, client movement, air quality, and IoT sensor area. Jablonski [236] described the application of graphic signal processing to search for complex heterogeneous data and systems, especially in monitoring smart residential environments in cities, countries, continents, and elsewhere. The authors explained that sensor networks are considered the base layer of intelligent habitats. It can directly manipulate the collected signal, but it can also identify the network model of the data. This model was identified for recording ozone (O3) at 100 measurement points deployed in Poland. This describes the multi-scale prediction results for the ozone dataset. Furthermore, unlike conventional signal processing, the author has done the spectral analysis of graph signals, such as reconstructing the Laplacian graph and calculating the Fourier transform across the graph vertices.

Hu et al. [237] proposed another coordinated strategy for programmed object recognition in metropolitan observation frameworks. The author utilized this new technique to decide and choose the most elevated energy recurrence locale of the picture from the picture sensor of an advanced camera. Select the car license plate—vehicle or vehicle in the photo. Not only the proposed method helps to find the target vehicle quickly and accurately. Li et al. divided the smart city system into four subsystems: intelligent organization, intelligent budget, intelligent administration, intelligent contribution, and established the communication pointer system. Then, using info-entropy and grey-correlation examination, the weight of each index is determined, and the intelligence level of the city is evaluated individually. Twenty main urban areas in China are considered author review cases. The authors said they evaluated the grey correlations of these cities and the changes from 2012 to 2016. Arora [86] examined the financial development levels of India’s top 20 smart cities. The authors reveal that interstate and intrastate inequality is high because cities with high and low FSI are in developed countries in the western and southern regions. A similar situation occurs in low-income countries such as Madhya Pradesh in India (an under-developed country). The study’s authors emphasized that smart cities vary greatly from state to state in financial development.

Engelbert et al. [127] conceptualized smart cities in Europe to collect peripheral operations of smart city networks and core operations of smart city projects. Both methods primarily search the “intelligence,” an adjective for prestigious cities in Europe. This usually means obtaining a significant
reward or grant from Europe. In this article, the author focuses on European-sponsored smart city projects and explains why the specific vision of European cities shapes these projects and how they affect citizens’ participation. The author was generally discussing, especially, smart European cities. Pereira et al. [206] focused on smart administration as another examination zone with huge logical and strategy considerations. All the more explicitly, the author’s motivation is to understand the definition and connections of smart administration and ideas, for example, smart e-government with regards to smart urban communities.

Mozuruniene et al. [156] intended to summarize the idea of smart cities. The author considered the perspective of city plan in command to discover and highlight the important contacts, relationships, and roles of city enterprise, expansion, and landscape design in the building of the smart city. The authors point out that this will lead to establishing healthy smart city principles in Europe, which will lead to sustainable development, effective urban growth, and better cityscapes. Veiga et al. [160] planned a framework for creating smart city facilities and demonstrated these facilities’ applicability using traffic light services. The services offered are information gathered and commonly used among gadgets within metropolitan areas. The benefits of the specification have been proven, and identify specific topics to develop.

Mukti et al. [165] clarified that the utilization of IoT innovation is the foundation of the smart city idea. The author examined the current advancement of the smart city biological system dependent on the Internet of Things, which brought up some subsequent issues. Partners are isolated into this biological system’s clients, gadget makers, middleware engineers, and application designers. The creators found the future difficulties of smart urban communities dependent on the Internet of Things spin around co-appointment among these partners. Brock et al. [173] discussed four different commercial representations that allow mandatory establishments to arrive smart city marketplace. Depend on a detailed knowledge at Philips Lighting of four smart cities. Mocrii et al. [207] reviewed the key smart home technologies that depend on the IoT. The author began a review of the smart home definition that defines the perspectives adopted and describes the supplementary features of the user and the smart home system. The author presents a construction grounded on the IoT and places smart homes in the wider environment of smart grids.

Sanchez-Gomez et al. [209] focused on assessing the performance of the technology under different working conditions. The author introduced two LoRaWAN commercial gateways and compared and discussed the results obtained in the two deployments. As a result, LoRaWAN is an excellent solution for deploying smart cities to support specific IoT applications. Chamoso et al. [215] overviewed the writing on the subject of smart cities and led a total examination of the ideas and existing stages. The author had an away from smart city administrations, the advancements used to build up these administrations, and the extent of this idea. The author distinguished holes and requirements for brilliant urban areas and proposed a model for planning smart city structures.

Santos et al. [231] presented PortoLivingLab, a multi-source recognition foundation that utilizes IoT innovation to distinguish four marvels in the city (climate, climate, public transportation, traffic stream). The author conveyed a vehicle network containing more than 600 vehicles and 19 static natural sensors to recognise these citywide cycles. The author also built up a simple reconfiguring cloud-detecting stage and directed exercises with more than 600 members. Information is gathered on a public backend and stored utilizing a comparable Spatio-transient information model, rearranging sharing, and cooperative investigation to describe metropolitan elements. The author described the architecture and building blocks of the PortoLivingLab, focusing on IoT technologies and the challenges they encounter. The author presented proof-of-concept use cases (for example, passenger flow from a Wi-Fi connection). It provides new information on the various components of a constantly changing and smart city. Nelson et al. [232] identified common barriers to IoT adoption and replication from technology and organizational perspective and listed the methods used to overcome these barriers in these projects.

Gyrd et al. [238] exhibited that the Ontology Catalog could be more Effective in designing and developing smart city Applications? The writer assessed four ontology lists associated with the IoT and smart city that are Ready4SmartCities, LOV, Open Sensing City (OSC), LOV4IoT. The author proposed approaches to advance the ontology index with these ontologies to help the reuse and semantic interoperability of metaphysics-based smart city applications. The procedure embraced by the OSC and LOV4 IoT Ontology Catalog demonstrates that the proposed approach is sufficiently general to be applied to some other order. Analysts and engineers have finished an example assessment of the LOV4 IoT Catalog. The helpfulness of the metaphysics index called attention to assessing advanced ceaseless development and upkeep. The nature of the IoT and the Smart City Ontology was assessed to improve the nature of the Ontology Catalog.

Du et al. [239] focused on issues of device deployment (this is the design/configuration part of the system) and device inspection management (this is the operational part of the system). The author also described how to select existing algorithms for smart city monitoring claims, such as structural wellbeing monitoring, water networks, and traffic monitoring. The authors also discussed future research opportunities and challenges in smart city surveillance. Maser et al. [111] described the main impacts of deploying smart grids in different ways and proposed ways to extend cost-benefit analysis that can go beyond other rigorous financial aspects. The practice shown theoretically can be protracted for evaluating smart city development proposals.

Akande et al. [118] Classified 28 European capitals according to intelligence and endurance. Using hierarchical
grouping and principal component analysis (PCA), 32 indicators were combined into four components, and a classification score was calculated. Rankings of European capitals are based on ranking scores. The results show that Berlin and other Nordic capitals have the highest rankings, and Sofia and Bucharest have the lowest scores, so achieving smart and sustainable development is still impossible. Pourzolfaghar et al. [142] projected a background focusing on the definition of contextual requirements and the establishment of smart city systems and services. Unlike the other methods, the author focuses on two significant layers: the context and services layer and the relationship with other normal layers. This framework is of great value in the development of smart services, but it also helps us understand the enterprise architecture of smart cities.

Bibri et al. [216] provided a comprehensive, up-to-date overview and integrated sustainable smart cities. The review offers its applications, scientific growths, developing tendencies, upcoming applications, challenges, and open questions. The authors also discussed that smart cities are associated with misconceptions, integrations, and gaps in their contribution to sustainable development. Various opportunities were also analysed. Bigdata and its claim in the smart city of the upcoming will advance its influence. Ramos-gonz et al. [211] reviewed the definition received for the term “smart city” and reviewed the features of the most commonly used platforms that provide technical support to cities.

Ismagiloiva et al. [212] provided significant incorporation of applicable writing on smart urban communities made by discussions and brainstorming about the primary discoveries of existing exploration on the issue of smart urban communities in setting up maintainable urban areas and networks. The consequences of this investigation can furnish researchers and professionals with a data system for smart city research. Basford et al. [226] explained that LoRaWAN technology is specifically designed for IoT distributions. The author described his experience deploying a citywide LoRaWAN system in real-time. A system was introduced to sustain the setup of monitoring air quality and to discover the abilities of LoRaWAN. The 20 devices analysed sent over 135,000 messages. The data server successfully received 72.4% of the messages during the full deployment. Out of all, 99% of messages were received within 10 seconds.

Khan et al. [169] used probable proof of participation and other custom variants to elaborate on key aspects of blockchain technology, such as its operating mechanism style, and try seven new challenges through different technologies. The author also described state-of-the-art technologies for non-financial blockchain applications such as healthcare. The contribution of customized 4-tier blockchain models related to precision medicine and testing is notable. Another important contribution is a mobile application model called HDG that automates medical records without compromising confidentiality.

Oughton et al. [227] discussed that the industry integrates the new 5G spectrum and densification. It will use various improved Mobile Broadband Infrastructure (eMBB) strategies to analyse existing networks’ capacity, coverage, and cost. A Dutch case study was used to conduct a supply-side and demand-side investment analysis. Before small cells needed to densify their networks, suppliers analysed and estimated their users’ capacity over the new spectrum. A demand-side analysis tested various speed ranges that each user needed, such as 30 Mbps, 100 Mbps, and 300 Mbps, and quantified the investment strategy’s performance to meet this demand. Based on the data from this analysis, the authors found that the average service capacity of each user in the Dutch 5G band increased by about 40% compared to the existing LTE capacity. Wilson [229] discussed the four foundations of information and communications technology, smart cities, to explore UK progress, data, governance, public engagement, and goals for the next 20 years.

Sivrikaya et al. [230] proposed transforming the complex concepts of smart cities and their digital layers into structured models to generate an active and adaptable service ecosystem for the future Smart City. The authors described three major drivers identified in this direction. These are (i) descriptions of the semantic functions of physical objects or city objects representing abstract services and (ii) a distributed service catalogue that reflects the services. A planning tool for discovering services and (iii) selecting and linking basic services to form new complex services. Javidroozi et al. [235] aimed to understand common and uncommon attributes between BPC contests in SCD and ESI environments. This training gathers statistics from literature reviews, interviews, and literature reviews, suggesting that many of the challenges facing BPC in SCD are comparable to those in ESI. The author has developed a comparison framework. This framework demonstrates that CDSs can use lessons learned from CSE to solve PCB challenges. This will help municipalities design SCD roadmaps, prioritize BPC issues based on their ESI efforts, and consider addressing unresolved issues, helping smart city solution providers to improve their urban processes.

An et al. [241] portrayed instances of two worldwide IoT norms, FIWARE and oneM2M, effectively utilized in many smart cities. They divided them to see the achievability of IoT stage interoperability. The author planned and executed another IoT interworking design that gives a semantic driven combination system for smart urban communities in light of the investigation. The author introduced a framework dependent on these forces of brief and assessed it in the standard smart city. The outcomes show that it can recognize and oversee IoT sensors associated with oneM2M and FIWARE. The author saw that the semantic methodology gives the adaptability and dynamic flexibility required for a quickly developing and quickly changing metropolitan condition. Ansari et al. [243] published an important study of recently proposed coordinated drone and IoT technologies and potential applications to improve the intelligence of smart cities. The author provided a comprehensive study focusing on the recent continuing investigation on cooperative drones and IoT in refining smart city present applications. The authors stated
that the study differs from previous studies in possibility and concentration. Specifically, the authors are attentive to novel concepts of coordinated drones and the IoT to improve smart city applications. The study efforts to represent the intelligence of smart cities using coordinated drones and IoT based on different parameters. Parra et al. [244] proposed the utilization of complete information on every receiving wire to lessen the measure of traffic produced in the fifth era organization (5G) and, in this manner, moderate energy utilization. The IP and its information of the commenced gadget are joined with the information and IP of different gadgets in a bundle containing all the information in the framework. Consequently, fewer headers are utilized to send similar data, diminishing traffic created. The framework has endeavoured with electronic healthcare information from 250 individuals and three health sensors. The outcomes show that information variety sets to save 70% of traffic.

Gupta et al. [125] concentrated on how experts in these ecosystems coordinate their arrangement information plans. The City of London information arrangement case investigation features the difficulties of complex metropolitan information conditions and the significance of coordinated perspectives. The author examines three components of arrangement in the smart city information environment: transparency, correspondence, and shared vision, distinguished as the principal impetuses for metropolitan information arranging inside government organizations of London. Khan et al. [171] developed various key aspects of blockchain technology, including its working mechanism styles, stake proofs and custom variants of other proposed improvements, and tried seven challenges using different technologies. In addition, the author described the latest technology for non-financial blockchain applications such as healthcare. A personalized 4-layer blockchain model is associated with precision medicine and notable in clinical trials in this technology. In addition, the authors described a mobile application model called HDG that can automate medical records without compromising confidentiality.

HakaK et al. [204] proposed calculated engineering to secure smart urban communities utilizing blockchain innovation and depicted it conceivable use contextual investigations. The author also outlined three genuine world blockchain-based smart city case analyses. Finally, the authors identify and discuss some of the required research issues. Ibrahim et al. [218] proposed an enhanced ON/OFF traffic demonstrating innovation that can display IoT information qualities of different applications (particularly smart city IoT). New displaying strategies arrange and investigate the qualities of IoT smart city use cases into five significant examples. In this examination, the author fabricated a practical smart home organization with a trial model as a smart city feature. As indicated by the proposed IoT smart city design model, pilots produce many traffic profiles. Simple Fit devices are utilized in hypothetical models to display diverse pilot traffic circumstances. Traffic demonstrating the idea of a novel method and its five traffic designs are demonstrated in the pilot results.

C. SMART ENERGY MANAGEMENT SYSTEM IN SMART HOMES

Several researchers worked in the different sub-domains of the smart city. Still, this domain has many research opportunities for new researchers. SHEMS is one such domain attracting researchers to work in this domain. This section of the paper provides a comprehensive literature review of this domain.

Privat et al. [13] proposed a common framework that should make it possible to address these environments as comprehensive cyber-physical systems and to support their applications through a shared distributed software infrastructure. The author presented the overall system in this infrastructure as a graph, the nodes of the generic physical entities/sub-systems that make up these environments. A minimal discrete state model can represent these subsystems. It is suitable for real-time and reactive CPS requirements but is derived from the general group ontology. The author stated that the genericity of the infrastructure might result from the flexibility afforded by this multilayer mapping and its self-configuration and self-adaptation capabilities. Moreover, the dispersed idea of the proposed model gives unwavering quality to SG. The author clarified the upsides of the proposed model in detail and introduced a model. As the situation represents, fog computing can expand the productivity of distributed computing-based SG. Along these lines, the author described that in the future, security and protection investigation of the proposed fog based intelligent network model, also the information collection proficiency of servers to show the productivity of the proposed model on information storing would be concentrated in this way. Security threats with their countermeasures were analysed in the context of a specific building Automation System (BAS) implementation called Building Energy Management Open-Source Software.

Masera et al. [111] discussed the challenges faced by the electric grids in peak hours. The authors find that ozone layer harming gases are discharged during the technological advancement of grids. In this survey, a scope of advances is examined, including the condition of their execution and their flow and expected future effect on building power commitments. The author examined that the present literature has concentrated on utilising these gadgets separately to demonstrate building execution, impact inhabitant social energy proficiency, and model perceptive control for progressively more worked structures. The authors expressed that the outcomes proposed that while intelligent meters are the most widely recognized gadget, other lattice associated innovations can additionally improve observation and the executives of the network. There are still remarkable gaps in the writing that require further examination to exploit the recent variety of associated innovations to accomplish a more energy-efficient fabricated condition that can effectively expend power.
| Author            | Year | Objective                                                                 | Domain                        | Proposed Approach                                         | Research Gaps and Results                                                                 |
|-------------------|------|---------------------------------------------------------------------------|-------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------|
| Lai et al. [157]  | 2015 | To design and assessment of the trusted network equipment access           | Security and Privacy          | Trusted Network Equipment Access Authentication Protocol. | All the nine objectives that choose the convention's security have been accomplished.       |
| Samani et al. [139]| 2016 | To develop a Robotic external defibrillator ambulance for backup services  | Healthcare in smart city      | Ambulance Robot (Ambubot).                               | Help the critical patients during an emergency in a smart city.                          |
| Tsawaleh et al.   | 2016 | To propose an environmentally friendly and intelligent phone for          | Mobile Computing in smart city | Identified the relation of the power consumption of a  | Higher SNR estimation of GPS signals extend less energy while low GPS signals cause     |
| [141]             |      | upcoming smart cities and identify the impact of GPS signals on            |                               | location-based application with the power of the GPS     | quicker energy channels, i.e., 30% when contrasted with 13%.                              |
| DePaz et al. [175]| 2016 | To develop a smart system for light control in the smart city.            | smart city                    | Adaptive architecture for public lighting and intelligent | Optimised energy consumption and reduced cost.                                           |
| Rama et al. [186] | 2016 | To propose a direction approximator for pedestrian monitoring             | smart city                    | Direction Estimator for moving pedestrians.              | CASIA-DataSet A: 94.58%, CASIA-DataSet B: 90.87%, Self-Created Dataset: 95.83%          |
| Filippi et al. [240]| 2016 | To propose a WE-Government device for Smart villagers in keen City.      | smart city                    | MiraMap WE-Government Tool.                              | This tool facilitates the communication and management between citizens and public        |
| Brittani et al.   | 2016 | To sense and classify roadways obstacles in Smart City using the         | Transportation in a smart city | Foundation free methodology for peculiarity discovery    | A genuine dataset given by the city of Boston represents the achievability and            |
| [242]             |      | smartphone application.                                                   |                               | and recognisable proof dependent on information          | adequacy of the framework.                                                              |
| Park et al. [109] | 2017 | Package overflowing qualifications in content-centric                   | Wireless Sensor Network       | Packet Diffusion Limited Protocol Tool: NS-3 Simulator   | Protocol limits flooding of data packets and increases content download using the       |
|                   |      | networked radio multimedia.                                               | in smart city                 |                                                          | shortest path method.                                                                   |
| Jedari et al. [120]| 2017 | A Social Based Watchdog System to distinguish egotistical hubs in          | smart city                    | Social-Based Watchdog System (SoWatch)                   | The framework plays out a context-based guard dog framework regarding recognition       |
|                   |      | an ubiquitous versatile organization.                                      |                               |                                                          | time and proportion 45% and 10% separately and that with less                           |
| Mohammadi et al. | 2016 | To build up a semi-managed profound learning administration on the side   | smart city                    | Semi-Supervised deep reinforcement learning Model.       | Close estimation of the target location is improved by 23% and 67% received              |
| [124]             |      | of IoT and Smart City.                                                    |                               |                                                          | Rewards.                                                                               |
| Ullah et al. [179]| 2017 | Energy and clog mindful Routing Metric for smart framework                | Networks in smart city        | Energy clog mindful steering metric (ECRM) for           | Better organization introduction regarding                                        |
|                   |      | AMF networks in Smart City.                                               |                               | shrewed matter organization.                             | normal energy taking care of and parcel move proportion.                               |
| Mohamed et al.   | 2017 | To propose a facility-based middleware for cloud and fog                  | smart city                    | Service-oriented middleware (SOM) called SmartCityWare   | Increases combination and consent for the adoptable presence and use of numerous        |
| [188]             |      | empowered smart city services.                                            |                               |                                                          | facilities.                                                                           |
| Kotevskaya et al.| 2017 | To propose a network architecture for smart city information              | Networks in smart city        | Dynamic Network Model.                                   | The maximum improvement was 7.8%, with an average improvement of 5.6%.                 |
| [194]             |      | loss and the network architecture of different cities to analyse the     |                               |                                                          |                                                                                       |
| Pan et al. [178]  | 2018 | Assessment of quality of encoded YouTube adaptable streaming for saving   | smart city                    | ML-based Bitrate Estimation (MBE).                       | MBE is a feasible and highly effective evaluation approach with 99% accuracy.           |
| Liao et al. [136] | 2018 | To build up a Fog engaged Vehicle as a Service for figuring               | Transportation in a smart city | Vehicle Mobility-Based geographical migration model.     | The advantage and efficiency of the model are significant.                               |
| Alothibi et al.   | 2018 | To propose a Registration Centre grounded operator verification system   | smart city                    | Advance multi-factor user authentication scheme.         | Official confirmation achieved utilizing "AVIOTA-tool" confirm security.             |
| [187]             |      | for "smart e-governance" application.                                     |                               |                                                          |                                                                                       |
| Rodriguez-       | 2019 | Propose a model for telecommunication traffic management and               | Telecommunication in a smart  | Tool: OMNET++                                           | Utilizing this instrument, one can have the right assessment of the correspondence needs |
| Hernandez et al. |      | advance service value in a Smart City.                                    | city                          |                                                          | and cost before administration sending.                                                |
| [93]              |      |                                                                             |                               |                                                          |                                                                                       |
| Gheisari et al.   | 2019 | To propose an architecture for preserving privacy in IoT based              | Cyber Security                | Real-time privacy-preserving method                      | The system provides privacy in real-time.                                               |
| [106]             |      | smart cities.                                                             |                               |                                                          |                                                                                       |
| Oughton et al.    | 2019 | To develop an open-source framework for technical and economic            | smart city                    | Tool: PySim 5G                                           | Deployment cost reduction by 30%.                                                       |
| [109]             |      | assessment for SG deployment.                                             |                               |                                                          |                                                                                       |
| Li et al. [114]   | 2019 | To build up a vehicular organization structure to perform non-constant    | Vehicle Networks in smart     | Location-based Urban Vehicle Network (LUV).              | Reliable and predictable wireless connectivity simplifies topology.                    |
|                   |      | information assortment errands in Smart City.                            | city                          |                                                          |                                                                                       |
| Jannidi et al.    | 2019 | To propose a framework by utilizing time-location tags and                | Security and Privacy          | Novel algorithm using watchdog node Tool: J-SIM Simulator| Detects 100% replica node false detection rate is 0.5%.                                 |
| [159]             |      | watchdog nodes to protect the nodes against the node duplication attack   |                               |                                                          |                                                                                       |
TABLE 4. (Continued.) Year-wise review of literature in the domain of smart home, with the author, objective of the paper, approach used in the article and results obtained.

| Year | Author | Objective of the paper | Approach used in the article | Results obtained |
|------|--------|------------------------|----------------------------|-----------------|
| 2019 | Rodriguez-Hernandez et al. [184] | Planning Communication in Smart City. | Communication in a smart city | SimuCity Tool: OMNET++ | The most prominent introduction appraisal of SimuCity will be accomplished when the Valencia Smart City is sorted out. |
| 2019 | Fujibara et al. [210] | To propose PoW at closeness for a crowded sensing infrastructure for co-operative congestion data collection. | Traffic management | Distributed Crowd Sensing System for Collaborative gathering of traffic information. | The framework makes limited verification of work-based agreement, and the blockchain answers to semi-ongoing blockage position in the road segment. |
| 2020 | Meuse et al. [172] | To propose the extension of LoRaWAN protocols and decrease infrastructure expenses by enlightening service superiority. | Network communication in a smart city | It modified the LoRaWAN MAC layer. | The model is effective in different complex situations. |
| 2020 | Martins et al. [177] | To develop Smart city platform architecture. | smart city | CityAction | Diminishes excluded package rate and PER by up to 30%. |
| 2020 | Fallis et al. [198] | To propose an energy effective audio achievement system for smart city applications. | smart city | Plan of a tested for smart amplifier frameworks. The advances, for example, with (2.4 GHz), Bluetooth low energy (BLE) 4.0 and Zigbee, were watched. | Better discussions in smart city management/behaviours, improved response time, safety, and well-being. |
| 2020 | Fernandez-Ares et al. [201] | To detect and analyse the irregularities in in-person gathering and movement via radio Smartphone tracing. | Transportation in a smart city | Method to spot the movement of persons from the data communicated by smart-mobile gadgets. | Power consumption is lowered by 97%. |
| 2020 | Ali et al. [223] | To secure Smart City Surveillance. | Security. | Utilizing lightweight symmetric fundamental natives and transient distinguishing pieces of proof, an iTCAALAS System is anticipated. | Provides correct and cost-effective air quality assessment. |

Stepaniuk et al. [48] discussed various notions regarding the environmental change, distinctively advancing and simulating economic energy utilisation. In certain nations, empowering strategies depend on net metering, while others on an assortment of “green taxes”. Since the development of small distributed and interrupted energy ages after some time prompts challenges in managing and adjusting the system (over-immersion, voltage, recurrence control, etc.), to hold the parity, these impetus duties become progressively tough and increasingly unpredictable. The outcome, because of the information acquired from the re-enactment of the three unique situations, shows that the use of a BESS in the mix with RES and lattice may prompt techno-monetary advantages for both structure frameworks, as far as decreasing the expense of energy, just as the general energy systems regarding encouraging the network balance, vitality effectiveness and practical utilization of energy. However, for the last appraisal of the benefit of utilizing various BESS, increasingly exact specialized and financial investigations incorporate the elements of the Lithium-particle component’s cost, the market elements of levies, misfortunes, and enhancement strategies likely methods of improvement ought to be considered in estimations.

Lu et al. [91] proposed a self-map-based home management system (SHMS). The author proposes to create a Home Energy Management System (HEMS), Demand Management Structure (DSM), and Supply Management System (SSM) to participate in the action and durable smart homes. This combined structure has several features that redraw the functionality of the framework, such as price forecasting (PF), price classification (PC), and power warning system (PAS). These upgrading capacities were created and actualized utilizing computational and AI innovations. The author gathered the information on continuous force utilization from a Singapore smart home and a practical trial of the contextual investigation to approve the proposed framework. The author expressed that the contextual analysis indicated that the created framework has performed well and paid vitality to the occupants. This proposed framework additionally shows its capacity to twist the model for various conditions contrasted with conventional intelligent home models. Kabalci et al. [45] introduced a complete review of IoT applications viewed as promising key applications for intelligent grids and intelligent environments. For example, smart urban areas, smart homes, smart metering, and smart energy are the executive’s frameworks. The creator likewise investigated the difficulties and starting opportunities from these applications, trailed by the issues and future examination headings of IoT applications for the EI framework.

Sivrikaya et al. [230] proposed a customer aware energy administrative model with a region-based assistance decision system for smart grids. The model offers smart meters helpful in refreshing the customer data to the cloud and appearing on a smart meter display. In light of the proposals from the smart meter show, the customers can change their utilization patterns. As indicated by the plan, the proposed model arrangements with the intelligence to all its interfacing units and a zone-based help decision for secure and trustworthy access for the cloud organizations in a smart network. It keeps up a record of dependent customers with different confirmation frameworks. An enrolled inside customer gives job-based entry, and customer access limitations rely upon their redundancy of access. A malicious gate crasher or an unapproved customer is limited from getting into the system.
### TABLE 5. Year wise review of literature of smart cities with different parameters used in the research paper by the author.

| Author               | Year | Domain         | 1* | 2* | 3* | 4* | 5* | 6* | 7* | 8* | 9* |
|----------------------|------|----------------|----|----|----|----|----|----|----|----|----|
| Anthopoulos et al.   | 2012 | Urban Planning | Yes| Yes| Yes|    |    |    |    |    | Yes|
| Kolozali et al.      | 2014 | smart city     | Yes| Yes|    |    |    |    |    |    | Yes|
| Monzon et al.        | 2015 | smart city     | Yes|    | Yes| Yes| Yes| Yes|    |    |    |
| Damari et al.        | 2015 | smart city     | Yes| Yes| Yes| Yes| Yes|    |    |    |    |
| Iauale et al.        | 2015 | smart city     | Yes| Yes| Yes| Yes| Yes| Yes| Yes| Yes|    |
| Yun et al.           | 2015 | smart city     | Yes| Yes| Yes| Yes| Yes|    |    |    |    |
| Fernandez et al.     | 2016 | smart city     | Yes| Yes| Yes|    |    |    |    |    |    |
| Lloret et al.        | 2016 | smart city     | Yes| Yes|    |    |    |    |    |    |    |
| Kornsity et al.      | 2017 | smart city     | Yes| Yes| Yes| Yes| Yes| Yes|    |    |    |
| Kandpal et al.       | 2017 | smart city     | Yes|    |    | Yes| Yes| Yes|    |    |    |
| Khatoun et al.       | 2017 | smart city     | Yes| Yes| Yes| Yes|    |    |    |    |    |
| Planeras et al.      | 2017 | smart city     | Yes| Yes| Yes| Yes|    |    |    |    |    |
| Mehmood et al.       | 2017 | smart city     | Yes| Yes| Yes| Yes| Yes| Yes| Yes| Yes|    |
| Brock et al.         | 2017 | Network        | Yes| Yes| Yes| Yes| Yes| Yes| Yes|    |    |
| Bhati et al.         | 2017 | smart city     | Yes| Yes| Yes| Yes| Yes| Yes| Yes| Yes|    |
| Sharma et al.        | 2017 | Network        | Yes|    | Yes| Yes| Yes| Yes| Yes|    |    |
| Aldairi et al.       | 2017 | Security       | Yes| Yes| Yes| Yes| Yes|    |    |    |    |
| Cui et al.           | 2017 | Security       | Yes| Yes| Yes| Yes| Yes| Yes| Yes|    |    |
| Morello et al.       | 2017 | Sensors        | Yes| Yes| Yes| Yes| Yes| Yes|    |    |    |
| Borsekova et al.     | 2018 | smart city     | Yes|    | Yes| Yes| Yes| Yes|    |    |    |
| Eckhoff et al.       | 2018 | Security       | Yes| Yes| Yes| Yes| Yes| Yes| Yes|    |    |
| Falco et al.         | 2018 | Security       | Yes| Yes| Yes| Yes| Yes| Yes| Yes|    |    |
| Hendy et al.         | 2018 | smart city     | Yes| Yes| Yes| Yes| Yes|    |    |    |    |
| Silva et al.         | 2018 | smart city     | Yes|    | Yes| Yes| Yes|    |    |    |    |
| Garcia-Roger et al.  | 2018 | smart city     | Yes| Yes| Yes| Yes| Yes|    |    |    |    |
| Pereira et al.       | 2018 | smart city     | Yes| Yes| Yes| Yes| Yes|    |    |    |    |
| Tzafesta             | 2018 | smart city     | Yes| Yes| Yes| Yes|    |    |    |    |    |
| Serrano              | 2018 | smart city     | Yes| Yes| Yes| Yes|    |    |    |    |    |
| Diaconita et al.     | 2018 | smart city     | Yes| Yes| Yes| Yes|    |    |    |    |    |
through various hash-based imprint check frameworks that ensure the cloud is secure. Further, the passage meetings are confined to shield the system from being affected by flooding assaults. The preliminary outcomes show that the proposed model improves similar to high throughput and nature of affirmation than other existing methods.

Stepaniuk et al. [75] proposed a residential energy flow model. This includes a PV group, a single wind turbine on the premises, a battery compartment, and a heat pump combined with HWST. The author said that this article examines the adaptability to each situation and summarizes the results in detail. This result shows that the heat pump can adapt to movement without compromising customer comfort, even without a battery with the smallest heat storage size (0.25m³). In this case, the load is very satisfactory, with an accuracy of 14.8%. The battery appears not to be exceptionally proficient in northern atmosphere conditions by demonstrating the exhibition that doesn’t surpass 16% as far as RES energy protection. The creator expressed that still, the outcomes got in his investigation, the battery may, in any case, be progressively alluring in different areas with various RES age and power demand patterns, just as dependent on benefits given from the system side. The author proposed three infrastructure layers: data gathering, transportation, and application management.

### TABLE 5. (Continued.) Year wise review of literature of smart cities with different parameters used in the research paper by the author.

| Year   | Parameters       | Authors          | Year | Parameters       | Authors          | Year | Parameters       | Authors          |
|--------|------------------|------------------|------|------------------|------------------|------|------------------|------------------|
| 2019   | Communication    | Raghavan et al.  | 2019 | Networks         | Ghosh et al.     | 2019 | Security         | Alam Khan et al. |
|        |                  | [151]            |      |                  | [153]            |      |                  | [171]            |
|        |                  |                  |      | Wireless Sensor  | Shafabadi et al. | 2019 | smart city       | Roblek et al.    |
|        |                  |                  |      | Network          | [154]            |      |                  | [148]            |
|        |                  |                  |      |                  |                  |      | smart city       | Al-Ammar et al.  |
|        |                  |                  |      |                  |                  |      |                  | [259]            |
|        |                  |                  |      |                  |                  |      | smart city       | Hoogen et al.    |
|        |                  |                  |      |                  |                  |      |                  | [146]            |
|        |                  |                  |      |                  |                  |      |                  | Alam Khan et al. |
|        |                  |                  |      |                  |                  |      |                  | [171]            |
|        |                  |                  |      | Urban Planning   | Pires et al.     | 2019 | smart city       | Rahman et al.    |
|        |                  |                  |      |                  | [182]            |      |                  | [192]            |
|        |                  |                  |      |                  |                  |      |                  | Muqluin et al.   |
|        |                  |                  |      |                  |                  |      |                  | [193]            |
|        |                  |                  |      |                  | Hosahalli et al. | 2019 | Networks         | Zhang et al.     |
|        |                  |                  |      |                  | [200]            |      |                  | [203]            |
|        |                  |                  |      |                  |                  |      | smart city       | Saba et al.      |
|        |                  |                  |      |                  |                  |      |                  | [110]            |
|        |                  |                  |      |                  |                  |      | smart city       | Fallis et al.    |
|        |                  |                  |      |                  |                  |      |                  | [198]            |
An electronic module named PZEM004T was utilized to detect voltage, flow, and other electrical boundaries. Through a microcontroller ESP8266, the information was handled and sent to an application layer through a current remote system. The real and chronicled information of power was envisioned on high-goal charts. The trial was directed at the place of business. The exploratory outcomes demonstrated that information on electrical energy use could be caught near-continuous, and power abnormality and example can be figured. Execution and usefulness testing indicated worthy utilization of this framework with over 99% exactness. The author expressed that the framework is planned to enable structure supervisors to assess the electrical system balance just as envisioning harm because of over-load, overvoltage, and voltage drop. In that event, this model is broadly executed. It will deliver large information that is helpful for advanced investigation. The authors reviewed ML and DL models in a singular group per the techniques utilized. The ANN, SVM, DT, Ensembles, Bayesians and neuro-fuzzy strategies have been the most utilized AI techniques. This paper likewise uncovers an unanticipated outcome: the huge importance and admiration of DL strategies. The DL strategies have been understood significantly well known in smart city applications for the most part distributed in 2018 and 2019. The author additionally recognized future patterns in the progression of learning calculations for intelligent urban areas. The model of the smart city community seems to follow the general form of the model. This is a trend towards more sophisticated intersections, clustering, and deep learning models [91], [140], [141]. Some authors observed the energy utilizations and the indoor comfort with exceptionally powered information utilizing IoT innovation. Three kinds of separate strategies for this information were acquainted, making powerful activity plans. The author gathered almost constant information from 13 families and broke them down. Recently, the energy effectiveness and indoor comfort, however, more established older and wooden houses did not. Information investigation could be valuable to make successful activity plans for various family units with distinctive productivity. The author expressed that the paper shows them proof from IoT information [145]–[147].

Moroch-Cayameccla et al. [150], Raghavan et al. [151], Ghosh et al. [153], Shafiabadi et al. [154] classified household appliances and displayed them thinking about their physical highlights and satisfactory constraints from the clients. A thorough MILP-based structure is then proposed to smartly plan the activity of residential appliances, RES, ESS, PEV for a base expense of power with ensured fulfillment of the client’s requirements. To additionally utilize the ESS and PEV and drag out their battery carries on, an explicitly planned system for charging and releasing force and time-frame as indicated by the RTP and energy leftover had been incorporated into the booking issue, which empowers an ideal exchanging plan among home and utility. The re-production results show that the proposed strategy acquires better exhibitions as far as economy and computational productivity more effectively ensures the client’s comfort and the consummation of the assignments of residential machines, augments the RES usage and levels the peak load. The author expressed that the recent examination shows that with the EES and PEV control technique, the complete expense can additionally be diminished by 28%.

Stumatescu et al. [21] discussed that the advancement of heavy network introduced sensor systems in checking and control applications, which has enabled the variety of data, information dealing with, decision, and incitation at in advance disguised transient, spatial objective and scale. The author expressed that the manufactured condition offers critical chances and difficulties for utilising such insightful sensor frameworks with substantial financial, ecological, and social advantages. As a sign of worldwide urbanization inclinations, structures can use present-day innovations to work effectively and improve lifestyles and employed circumstances. This location, between others, angles identified with power management, inheritance identification and forecast, comfort, and security. At a bigger scope, smart city foundations can execute these advances towards more extensive advantages in ecological observing, traffic the executives, improved utility systems, and social administrations. Plan of human-insider intelligent approaches offers residents important direct input instruments towards the insightful frameworks and directors for constant adjustment and responsiveness with medium-term power on reasonable arrangement and advancement.

Lai et al. [157], Akyildiz et al. [158], Jamshidi et al. [159], tzafestas et al. [161] discussed a smart home appliance scheduling problem formulated and optimized using novel restricted and multi-restricted time range scheduling techniques while satisfying all time and energy constraints. The first objective deals with the minimization of monthly electricity costs. The second and third objectives minimise the PAR and maximum peak load demand, respectively. Since the problem is non-convex type, two powerful binary type metaheuristic optimization algorithms, i.e., GWO and PSO, effectively resolve the issues. The system is integrated with a 5-kW rooftop PV panel with eight shift able load appliances. Eight case studies are considered with and without PV integration, and a detailed comparative analysis is presented to solve the problem. The author stated that the results showed the effectiveness of the GWO technique over PSO in minimizing the cost of electricity, PAR and maximum peak load demand. PV integrated system enables users to export surplus energy to a utility grid and benefit from the feed-in tariff. The futuristic enhancement of the current work may solve the problem with modified GWO algorithms such as GGWO or other recent meta-heuristic techniques such as ITLO under a multi-objective optimization framework for further optimizing the solution.

Serrano et al. [162], Plageras et al. [163], Sharma et al. [164], Mehmood et al. [166] introduced a best in the class of ML models and assessed the exhibition of these models. Through a precise survey and a far-reaching scientific
categorization, the advances of ML are purposely researched, and promising models are presented. Lloret et al. [168], Bhati et al. [174], De-Paz et al. [175], Sharma [176] presented a detailed clarification of the current situation of intelligent structures and their ideas. The author portrayed different origination regarding basic IoT engineering structures, which are a perspective for existing smart structure approaches and formats. The author also defined the normal basics of an intelligent structure and examined its different themes, for example, segments, advantages, impediments, and requirements, which spin around its investigation. Likewise, underlined related ideas like distributed computing, edge IT, sustainable power source resolution, intelligent meters, smart grids, and intelligent lighting. Additionally, procedures for planning, displaying, sparing, and assessment are likewise indicated. In the long run, the difficulties and future work are commented on in the resolution. The author communicated that they hold on to the thoughts of smart structures to change the future and advantage the issues proceeding with conservation assets of energy.

Yuen et al. [224] explored an energy cost minimization issue for a smart home without a structure warm elements model with the thought of an agreeable temperature extension. Because of model vulnerability, boundary vulnerability (e.g., inexhaustible age outcomes, non-movable power demand, outdoor temperature, and power cost) and transiently coupled operational limitations. The author expressed that it is very difficult to plan ideal energy the broad calculation for booking Heating, Ventilation, and Air Conditioning (HVAC) frameworks and energy-storing frameworks in the intelligent home. The author initially figures the above issue as a Markov choice procedure and proposes energy the broad calculation dependent on Deep Deterministic Policy Gradients (DDPG) to address the difficulty. The author expressed that it merits referencing that the proposed analysis doesn’t require the earlier information on questionable boundaries and building a dynamic thermal model. The author expressed that the real-time results dependent on true follow exhibit the viability and power of the proposed calculation.

Erol-Kantarci et al. [82] focused on energy optimization aspects of IoT applications, especially towards enhancing the sustainability of battery life. In his study, the author adopted a novel approach based on a converging rough set with a DNN to forecast the battery life of the IoT network with optimum accuracy. The normal pre-processing steps used in this approach were further refined, incorporating the rough set approach for extracting significant features, contributing immensely to more accurate predictions. The model results were equated with advanced methods to establish its superiority. Zafar et al. [59] introduced an extensive review of the HEMS writing with references to primary ideas, designs, and empowering advances. The author expressed this likewise gives a synopsis of HEMS registering patterns and well-known correspondence developments for demand-response applications. The author expressed that the study also outlines current and future patterns in HEMS arrangements and developments.

Washburn et al. [12] proposed a HEMS, the association of RES and ESS. The goal was to limit our framework’s energy cost and PAR during the day. The author’s calculations in the framework were the blend of PSO and BPSO. This HEMS can use the power of the primary framework at the low-value time to accommodate home machines at significant expense time with the help of ESS and RES. Also, these HEMS bolster offering power to the outside. The author fabricated general scientific recipes for energy cost and PAR and assessed the HEMS by performing broad reproductions to accomplish the goal. With new capacities, the vitality cost of the HEMS was altogether decreased to 19.7% when contrasted with past aftereffects of BPSO calculations. When the framework just spotlights the minimization of energy cost, the PAR of the framework stays exceptionally high. The author utilized the weighted technique for MOO to limit both energy cost and PAR to decrease PAR. The simulation results indicated that with suitable estimations of weight constants $w_1$, $w_2$, energy cost and PAR of the framework can be diminished to values smaller than both energy cost and PAR of BPSO calculation. Specifically, with $w_1 D_1$; $w_2 D_2$, the framework’s energy cost and PAR were decreased by around 10%. As far as ESS boundaries, simulation results likewise represent an impressive decrease in the error rate. The energy cost of the framework was diminished by 4.3% and 8.5% with 0.6 kW and 0.9 kW separately, and ESS must have adequate ability to store energy.

Martins et al. [177], Pan et al. [178], Ullah et al. [179] explored the energy effectiveness of the open division. The author proposed an ML model for forecasting energy utilization and the design of smart ML-based energy, the executive’s framework for the open area that could be utilized as a piece of intelligent city idea. The information is gathered from two sources: first, the focal database of open division working from the EMIS framework, and second, the IoT system of open structures. The author utilized three ML strategies for displaying energy utilization: DNN, Rpart and Random Forest. The techniques for anomaly removal, missing information substitution, and variable decrease are proposed dependent on past exploration. The outcomes show that the most precise model for approval information was the random forest model, which has delivered the SMAPE (System Metric Mean Average Percentage Error) of 13.5875%, indicating a capability of ML strategies in energy the executives in the open area. All three techniques have separated a comparable arrangement of significant highlights for anticipating energy utilization. The majority of them have a place to gather energy power utilized for warming, interior temperature, and word-related information. Likewise, the author also recommended engineering the smart framework, which comprises six levels beginning from the Big Data gathering level, which gathers, stores and searches the information, trailed by the level where the information is pre-prepared to be utilized prescient displaying.
Moroch-Cayamceia et al. [150] introduced HEMS-IoT, major information and AI-based intelligent home energy, the executive’s framework for home comfort, security, and energy-saving. The author utilized the J48 ML algorithm. And Weka API to learn client practices and energy utilization. The creator expressed that the outcomes acquired from the restorations were agreeable, confirming HEMS-IoT is solid and steady to invoke IoT benefits when the provider receives the proposed new worldview. At last, the author reasoned that apparent fulfillment strongly affects the client’s goal to utilize HEMS-IoT.

Aldairi et al. [180] introduced the hybridized smart home renewable power source management model to limit the expense of smart home power by expanding sustainable power source use. In the model, it is accepted that the energy utilization of all machines is consistent at each span, and it isn’t steady dependably. This demonstrated the proposed energy planning technique limits the energy utilization by 48% and expands the sustainable power source expended at the pace of 65% of the absolute energy produced. The proposed effective control calculation reduces the multi-layered nature and controls home energy utilization. Requesting the executive’s frameworks is a remarkably feasible approach to appropriately control customers’ power assets. It limits bills or spares energy and expands power grids’ effectiveness by moving the heat to off-top hours, changing interest to gracefully proportion of sustainable power source or by its method of response to crisis conditions. To control the electric energy of private clients, double-cross scales can be utilized, which are the day ahead and constant. In the everyday case, the client working arrangement (or nonexclusive future time skyline) is built up based on information estimated throughout the following 24-hr cycle. In all the above, the proposed model is superior when contrasted with other existing techniques.

Ianuale et al. [181], Pires et al. [182] examined ongoing developments in ICT inside IoT and introduced a practical acknowledgement of a smart city idea in a smart building use case. The acknowledged IoT framework utilizes advanced technologies, particularly cloud computing, virtualization and automation for infrastructure management. The model is centred around the observing and the executive parts of an IoT organization, which are significant while conveying an answer with many entryways and sensors for adaptability reasons.

Elseaedy et al. [254] focused on demonstrating by the trial tests that the uses of the CNN, with a moderately basic structure contrasted with those utilized in literature, offers fascinating discovery and classify the IM opening stator winding faults outcomes. The best possible recognition of the beginning between turn short-circuits of the IM stator winding was accomplished in the wake of estimating the most extreme 2000 examples of the demonstrative sign—stator current transient. Likewise, it should be stressed that the utilization of such few examples, contrasted with those utilized in writing, permitted one to restrain the most extreme time of stator winding flaw discovery to a limit of 0.2 s, which is straightforwardly associated with the size of the information grid.

The online tests represent that the high exactness of deficiency location is acquired because of under 200 examples proportional to 0.02 s of estimation. Besides, the location framework reactions are not subject to the engine working conditions. The effect of changes in the structure of the dissected CNNs, just as boundaries of the learning procedure, has been broken down in the introduced research. The point-by-point conversation was introduced in the fourth segment of this article. The two created structures of CNNs, one for the appraisal of the level of harm to a solitary stator stage and the other one for evaluating the level of harm to each of the three stages, keep up an exceptionally serious extent of adequacy, in light of the immediate handling of the crude estimated stator current information, without the utilization of advanced signal preparing techniques (FFT, DWT, HHT) in the symptomatic methodology. As indicated by the best of the authors’ information, this is a curiosity in the issue analytic and grouping of the stator winding deficiencies utilizing Neural Networks and narrow and profound learning structures [183]–[185].

Apanaviene et al. [134] proposed the Smart Building in Smart City (SBISC) plot was applied to nine smart buildings in eight distinct urban communities. The examination of chosen projects uncovered that the smart energy and smart environment are the most developed areas in intelligent buildings combined with the smart city stage, speaking to 35% and 26% of the joining limit. As per the outcomes, smart buildings have the most notable interoperability potential by expanding joining abilities by 37% and 30% in smart environment and smart life, separately. The proposed SBISC structure fills the gap and launches the interoperable abilities between the intelligent buildings and the outer world that is smart city advanced stage, underlining the future patterns of man-made consciousness in Smart buildings and smart cities.

The author presented the assessment technique, which can fill in as a structure for the proprietors, land engineers, and contractual workers when building future smart/intelligent buildings in smart urban communities. The assumed choices concerning future structure innovations could be viewed as worth the expense at the idea stage by the managers, or extra support should be assigned for building innovation renovating sooner rather than later if the city ICT stage upgrade is under the usage of a dynamic smart city advancement plan. The significant difficulties for land designers are readjusting the idea of things to come with intelligent structures with key advancement plans of the smart city.

D. BLOCKCHAIN TECHNOLOGY IN SMART CITY

Blockchain is another domain of research in the smart city. Several authors are working in this domain. The work of some of the authors is being discussed and represented here in this section.

Raman et al. [186], Alotaibi et al. [187], Mohamed et al. [188] focused on sustainable and comprehensive development.
This is achieved by using technology to consolidate and manage the infrastructure, provide better services, and make effective and optimal available resources. The author also explained that incorporating new technologies into smart city development provides new ways to rethink different services. In their article, the author studied the application of blockchain technology in the development of smart cities. They conclude that blockchain technology can more effectively form improved smart communities in the future and improve quality of life.

Sun et al. [178] discussed the background of blockchain-based shared services and stated that blockchain could contribute to smart cities. The authors say that smart cities have become popular in recent years. The advantages of advanced utilization of new ICT to cover multiple aspects and support community sharing are conditional on the sense of intelligence. Based on a previous literature review, the author proposed a three-dimensional conceptual framework of people, knowledge, and society and investigated an established set of basic factors that make cities smarter in terms of the sharing economy. As a result, the authors said that using a triangular framework, new blockchain technology could contribute to these factors, which will help develop shared services in smart cities. Finally, the author summarized the entire article and stated that blockchain-based sharing services could contribute to smart cities based on a conceptual framework.

Alam et al. [171] discussed smart city solutions based on blockchain expertise and their potential impact on smart city development. In particular, the author uses blockchain technology to make various applications of the smart city online business processes reliable and secure and how this technology can help the overall development of smart cities. I’m trying to address my concerns. The author proposes a blockchain-based security framework for smart cities and identifies various application and process areas that can benefit significantly from blockchain technology. This makes these applications smarter, more reliable, and applicable to any smart city.

Hakak et al. [204] explored the characteristics of blockchain technology have listed the essential requirements for integrating blockchain technology into smart cities. The author proposes a conceptual architecture that uses blockchain technology to protect smart cities and describes it using possible use case studies. The author also raised some urgent issues in the field of study.

Shah [189], Tian et al. [190], Cui et al. [191] analysed blockchain-based services for security with the integration of ML and big data that could contribute to the development of smart cities, proposing a smart city ecosystem model based on independent identity authentication models and smart conventions between entities, citizens, and people’s management departments. He also reviewed areas where technology could be used. The authors conclude that the rapid development of urbanization has caused new infrastructure problems in public management. The authors state that governance and management become more complex as cities develop and expand their services. Studies show that accelerated urbanization is putting pressure on existing infrastructure. To support the growing population of big cities, the authors said they needed a new smart infrastructure to support the efficiency of services and quality of life. Blockchain provides promising solutions to the various challenges facing smart cities. Next, the author explained that the implementation depends on the needs of city management and the community. The authors said that blockchain-based smart city infrastructure can improve efficiency because it can automatically interact with citizens, optimize resource allocation, and reduce fraud.

Rahman et al. [192], Mulquin et al. [193], Kotevska et al. [194] discussed that blockchain as a new driving force for technological change in the development of smart cities includes many underlying technologies and protocols and potential impacts on smart cities. The author specifically discussed how blockchain technology could help urban development. Based on a detailed literature study, the author proposed a research framework. The authors have identified several application areas of blockchain technology in urban intelligence, including health, logistics, supply chain, mobility, energy, management and services, electronic voting, factories, homes, and education. Hakak et al. [204] described current developments in these areas, explained their impact on blockchain technology, and recommended further research opportunities. Smart urban areas utilize computerized innovation to work on personal satisfaction, productivity and security, and cooperation between residents, the public area, and different partners [195]. Blockchain raises the chance of cooperation models that can’t be planned by brought together models through its nonstop dispersed record. The idea of brilliant urban communities is promoted as one of the key regions where blockchain-based applications are relied upon to achieve central and troublesome advancement. Blockchain is emerging as city management and services are digitized, and smart city plans are developed. Government departments worldwide face increasing demand for combating corruption, improving system efficiency, transparency and security, developing collaborative and interactive platforms, and providing democratic services. Blockchain can work on large numbers of these viewpoints through a straightforward, impartial, non-various levelled, open, non-functional, and secure data and worth stage. Blockchain is especially reasonable for conditions with numerous partners, and the trust between members is low [197]. It is one of the primary attributes of metropolitan intricacy and administration in the present urban areas. The following are potential blockchain applications for smart administration, smart individuals, smart networks, etc.

1) REPUBLIC AND CONCLUSION CREATION

This includes improving public participation and participation in political processes at all levels. Blockchain is for decision making, including the ability of citizens to participate directly in the voting process, novel traditions for legislators,
professionals to strengthen their integrity, specialist, and delegation of voting rights to specific areas. Can provide a destructive new model of. (In some cases) the possibility of the authorities [198].

2) BLOCKCHAIN VOTING
This involves designing a secure, transparent, and reliable electronic voting system, but it can still be kept confidential. Regarding the current use case, the city of Zug utilized the blockchain ID to lead the primary electronic democratic upheld by the blockchain. West Virginia (USA) and Moscow (Russia) have proposed casting an election dependent on the blockchain stage [198].

3) BLOCKCHAIN FOR PUBLIC ACCOUNTANCY, CONTRACTS, TAXES
When it comes to accounting, one can scan all the incomes and payments and record them on your blockchain, with full access to see who, when, and how all the pennies consumed. Smart agreements can fund real-time tax collection and display the paid and non-paid taxes. One can also view and track complete public procurement information, including terms, deliverables, and payments. A significant portion of Estonia’s administration is based on this technology. Several cities in different countries are also working to implement this technology [199]. For example, by 2021, Dubai’s administration will be digitized and paperless.

4) BLOCKCHAIN IDENTITY
Blockchain can give a circulated character arrangement without outsider approval or uncovering more data than the particular discourse needed for recognizable proof. Advanced ID is a blockchain use case in taxpayer-driven organizations and is also incorporated into the incorporation and usefulness of numerous other blockchain administrations. There are several projects that utilize the Austrian advanced personality framework to tackle issues identified with misrepresentation, counterfeit news, and wellbeing information during the COVID-19 pandemic. These projects can depend on the blockchain to approve personalities, put together tests, reserve a spot, and trade results [199]. For house-to-house tests, the blockchain recognizes the analyzer. Clients will want to deal with their information and offer it when they consider it suitable to determine information security and protection issues.

5) BLOCKCHAIN FOR LEGAL SYSTEMS AND LAW ENFORCEMENT
Transparency and immutability increase confidence in the legal system by recording police records and legal data on the blockchain. Today, the legal systems of many countries lack transparency, are slow to access, and are easy to operate. Many blockchain projects of law enforcement and forensic systems worldwide, such as tracking police gun use and recording police surveillance cameras to record data and prevent it from being tampered with or tampered with [199]. It has been proposed.

6) BLOCKCHAIN FOR CERTIFICATIONS
Blockchain frameworks can give continuous admittance to individual and authoritative verification. Simultaneously, blockchain permits people or associations to possess their information yet guarantees that the data is valid and exceptional. The prospects here are tremendous, and the significance of these arrangements is generally perceived [198]. One model is Malta, which will start giving blockchain authentications for professional and casual schooling.

7) BLOCKCHAIN FOR THE TITLE AND ASSET REGISTRATION
Blockchain has been proposed to enroll land and different resources to forestall the misfortune or altering of freely available reports. Moreover, intelligent systems permit to change of proprietorship continuously [199]. The Swedish cadastral has a task that utilizes blockchain for land enlistment, and numerous different nations are doing likewise.

8) BLOCKCHAIN IN MOBILITY AND TRANSPORTATION
Versatility and transportation are fundamental administrations for the proficiency and usefulness of urban communities and the personal satisfaction of their residents. Blockchain offers a fascinating answer for further developing transportation and versatility. For instance, blockchain furnishes vehicles and clients with an installation stage for administrations, such as charging, leaving, releasing, and transportation. Likewise, it tends to be utilized as a component of gathering, sharing, and dissecting applicable information to develop liquidity further. Blockchain can likewise be utilized to work with the arrangement of shared administrations. For this situation, transient distributed vehicle-sharing applications dependent on blockchain innovation, and intelligent systems can uphold the vehicle sharing business sector since they are far from unified data set workers that can be assaulted [198].

9) EDUCATION
Blockchain helps build better education systems in various ways while increasing flexibility, transparency and adaptability to individual needs. The whole instruction can be customized to singular requirements and capacities, and study plans, results, and endorsements are recorded on the blockchain. The information is additionally possessed and overseen by the actual understudies. The Token Economy can additionally appropriate tokens to residents for deep-rooted schooling [199]. It energizes explicit learning yet can likewise fulfil everybody’s adapting needs.

10) HEALTHCARE SERVICES
Blockchain offers a new way to accomplish public health services based on the token economy (“tokens” reward good behaviors). This allows for more efficient and transparent systems, tools to provoke desirable behaviors, simple application
data analysis and artificial intelligence to improve healthcare services and strategies [198].

11) SOCIAL CARE
Blockchain can be used in profit sharing valuation systems and smart contracts to deliver reasonable, profligate, effective and clear processing. The Token Economy can also be utilized to distribute tokens to pay for various facilities and goods. Recipients can be conditioned on the incitement or control of certain behaviors. On the other hand, they can use tokens to pay for facilities and goods without the seller or provider’s knowledge. Social protection systems are funding them [198]. Several countries, including Australia, consider using blockchain for social welfare.

12) ENVIRONMENT
According to the World’s Sustainable Development Goals, sustainability and habitability are two major goals cities are trying to achieve. Actions need to be performed worldwide, and limited scale and blockchain can provide high added value. For example, blockchain is the faultless stage to support the rotary budget. It can track materials’ life cycle within a particular supply chain and is often applied [199]. It can also be used for air pollution control, waste recycling and water quality recording applications.

13) FINANCE
The monetary business is the business generally influenced by blockchain innovation. The idea of blockchain hangs out in Bitcoin’s digital forms of money. It is likewise reasonable that monetary challenges keep driving the advancement of many of the most significant blockchain items and administrations in today’s society. Cryptocurrencies enable real-time transfers without intervention. The Initial Coin Offering (ICO) model makes it easy for businesses to stay updated without bank intervention. In addition, the iconic economy allows the construction of a completely new economic ecosystem outside of traditional financial markets [199]. Smart city plans that use blockchain can impact financial inclusion, management regulations, and management fees. These blockchain technologies for finance are already in use in Dubai.

14) TELECOMMUNICATION
The broadcast communications industry is advancing toward hyper-network. The number of items associated with the Internet utilizing the Internet of Things and 5G rapid associations is expanding. Many directed perspectives, like computerization between administrators, versatile wandering guidelines, characters, and portable instalments, can profit from the speed and straightforwardness of the blockchain [199]. Certain blockchain answers for the Internet of Things likewise offer open doors concerning urban areas.

15) ENERGY
Blockchain is used in the traditional business model and new disruptive model of the energy sector. Blockchain can be used to optimize network organization and circulated power systems. These new reproductions improve energy efficiency, support renewable energy integration, increase flexibility, enable true regional energy trading markets, and balance supply and demand while reducing costs. It has the potential [199]. Blockchain empowers distributed p2p exchanges among residents and energy units, particularly those created by sustainable power sources.

VII. CASE STUDY OF SMART CITY
Several smart towns throughout the globe use current technology in many sectors. This section depicts several smart city examples grouped into geographical divisions and macroscopically correspond to three main sorts of cities and communities, particularly in connection to varying degrees of technology innovation and forms of human capital. Smart cities, smart energy, buildings, smart people, smart transportation, and other aspects are all important in achieving smart development goals [200], [206]. The Masdar smart city and its many components are explained next.

A. MASDAR CITY
Masdar is a completely maintained secondary of the Mubadala Development Corporation, founded by the Government of Abu Dhabi [84] in 2006 as a tool to achieve the economic goals of the United Arab Emirates [25]. Abu Dhabi has launched a 10-year plan to transform its economy from a natural resource-based economy to knowledge, innovation, and state-of-the-art export-based economy.

This transition is driven by the paper “Abu Dhabi Economic Vision 2030”. It identifies the steps that will be taken over the next 20 years to transform the economy of the Emirate. Abu Dhabi has long played an important role in the global energy market as a hydrocarbon producer. Via Masdar, Abu Dhabi seeks to leverage its properties and knowledge in this range to preserve direction in the rapidly changing worldwide energy markets. To complement his strong position in hydrocarbons, his goal is to develop a global preserver for renewable energy and workable technology [2].

This leadership can be demonstrated in a variety of ways. Abu Dhabi has long remained recognized as a worldwide energy player. Masdar can do what “responsible” oil producers can to balance hydrocarbons and renewables to combat climate change and energy security. Shows. As you know, cities now make up more than half of the world’s population, and this number is expected to grow to 70% by 2030, with cities accounting for more than 70% of the world’s carbon dioxide emissions. However, if “sustainability” is economically viable, the community can only deploy technologies and processes on a scale sufficient to make substantial development in this range [201]. This is why Masdar City is the most maintainable city in the world and is committed to creating an attractive and economically viable place to live.
B. SMART CITY
Masdar Metropolis has a heavy task for oil exporters. It is the world’s first fully sustainable city. Many people believe that clearing Abu Dhabi’s public image using an uncertain promise of the United Arab Emirates government publicized plans to figure the first “zero-emission” city within 20 km of Abu Dhabi in 2007. Instead, the first “sustainable satellite city” was officially launched in 2009. Conforming to the plan, the metropolitan will have numerous alternative energy researches institutes, training facilities, manufacturing centres, and financial and marketing professionals. It can accommodate up to 50,000 people and is expected to be self-sufficient with zero emissions or waste. The cost of the project was $22 billion. 4 billion is devoted to building infrastructure for local governments [3]. Direct investment and other financial formulas, especially applicable to the construction, cover the remaining $18 billion. Abu Dhabi Future Energy, managed by the Mubadala Expansion Corporation, is funding the Masdar development. The project is revolutionary, and it is no chance to take place in the United Arab Emirates, home of oil money, where the World Upcoming Energy Conference, the world’s major collection of renewable energies, is also held [205], [208]. Abu Dhabi Future Energy’s research strategy is to establish a major future energy research centre to produce new, additionally effective schemes, based on the recognition that oil will soon be a scarce energy source and ineffective.

The following are some of the project’s main concepts, which interpret many characteristics which characterize the notion of a smart metropolitan:

1) SMART ENERGY
Energy acquired from solar and wind power plants, waste handling, and additional recycling and reuse routes.

2) SMART BUILDING
Constructions that are meant to provide a “near-zero energy” supply by installing renewable energy classifications on the rooftops of constructions [201].

3) SMART MOBILITY
A new concept in the transportation industry. There is no clear distinction between municipal and remote transportation. Still, a compressed and extensive system of micro metropolises to semi-personal (1500 stations), called high-speed transportation systems, provides quick access to all local cities. In addition, these modes of transportation provide easy access to the Abu Dhabi city centre and the airport. For those who want to roam the shaded streets [210].

4) SMART PEOPLE
Through establishing the Institute of Science and Technology, the city aims to become a world-leading centre for research on efficiency, alternative energy, and environmental sustainability [201].

C. SMART ENERGY
Masdar City will have 640 hectares when the project finishes, with 600 ha being constructed. Different activities are Residential use (30%), Special Economic activities (24%), Business (13%), Service and Transport (9%), Cultural activity (8%), University (6%). Because of the project’s vastness and strong technical content, it will be built in seven phases. The city’s development began in 2006, and the initial stage is expected to be finished in 2016. The initial stage is building a “solar-power plant” capable of generating 40000 megawatts of sustainable energy. All of the other structures will be created due to the energy generated. Masdar Metropolis is the world’s first zero-emission, waste-free city with a solar heat and wind energy harvesting system to meet its energy needs without polluting the environment or emitting harmful CO₂ [248]. The statistic of the venture began after the ground up has several benefits that should not be overlooked: for example, managing the orientation and form of buildings reduces the amount of energy needed for cooling. A mix of light and shade is achieved in the streets and open spaces, facilitating natural circulation and using well-known bioclimatic design concepts. Instead of using a traditional compressor, the cooling air is provided by condensation devices that directly use solar energy [209].

Water usage is also maintained to a minimum, minimizing the amount of energy necessary for desalination; moreover, 80 per cent of water is recycled using subsurface collecting systems. Masdar Metropolis is anticipated to use 75 per cent less energy than a typical city of comparable size. The 7-square-kilometre city of Masdar is a narrow street surrounded by green spaces and small waterways, designed to take advantage of the wind for ventilation [249]. In addition, the city uses its constant exposure to sunlight to achieve energy self-sufficiency. Masdar requires 200-240 MW of energy to operate at full capacity. It is entirely generated from renewable energy, 80% of which comes from solar, the megaprojects, including the construction of large factory cities and solar panels arranged on all roofs in the city.

Masdar avoids the generation of about 1 million tons of CO₂ annually. It could be sold over the next 21 years to recover some of the construction costs, the Green Credit System [219]. Everything from waste (only 2% is landfilled and the rest is recycled or used as biofuel) to water (60% is recycled and reused after consumption and cleaning) is recycled and reused. Shopping will be futuristic: one of the presently being explored options is the development of stores equipped with a touch screen system that allows anybody to choose and purchase things. Using a home delivery service will alleviate mobility issues [250]. Private automobiles will be prohibited in the city. The public transportation network is structured so that you will not have to travel an additional 200 meters to reach a mode of municipal transportation.

In particular, Masdar City aims to be completely independent with renewable energy, so there are many winds and solar power generation, research institutes, and farmland for
A municipal mobility strategy that prohibits private automobiles for both inhabitants and tourists was selected to obtain the designation of “zero emissions city” [2]. The city is divided into two levels: a street-level with stores, schools, and residences for pedestrians and bicycles, and an underground level with automated and autonomous vehicles. The city will be able to accommodate 1500 of these taxis once they are completely operational. They may be pre-programmed by inputting the location before departure. It will not be a door-to-door service but rather operates with predetermined stops within 150 meters of the destination. A centralized control system will continually contact the cab, which will take the quickest route to the destination [254]. The complete route that taxis may travel is made up of 87 stops. They can run through the city core as well as the neuralgic areas. However, one may see a much more widely available service in the upcoming time. If the projections of roughly 1500 firms, in addition to inhabitants, are right, Masdar people will relocate a lot.

VIII. DISCUSSION: CHALLENGES, OPPORTUNITIES IN SMART CITY

Though the idea of “Smart Cities” has been extensively recognized and applied in the real world, solving existing problems in certain areas is still important for additional development. This portion briefly defines the challenges and opportunities facing practical implementations of smart cities. Challenges have been recognized over a detailed literary analysis of the latest research on Smart Cities. Similarly, opportunities have been found with the help of the existing work and practical experience in smart city research [246].

A. CHALLENGES FOR SMART CITY

The “Smart City” application is tested through the prototype, application, and operations phases. The main issues are design and operational costs, equipment heterogeneity, huge information assemblage Analysis, data safety, and comfortability. Figure 12 illustrates some of the key issues in prototyping a genuine Smart City [87].

1) COST

Strategy and preservation costs are key challenges in practically applying “Smart Cities”. Costs are divided into design costs and operating costs. Design cost is the economic capital of the implementation of Smart City. Therefore, the lower the design cost, the more likely it is to be realized in the real world. The operating costs are due to the city’s daily operations and maintenance work. Minimum operating costs may be argued to ensure the comfortability of facility delivery without any extra-economic load on the municipality. Optimizing costs throughout the life cycle of a smart city remains a discouraging task [90].

2) HETEROGENEITY

Another important issue with smart city architectures is heterogeneity. Many sensors, devices, and equipment result in a
smart city. The recognition of the smart city concept depends on the facility to associate all the different heterogeneous environments at the “Application Layer”. Heterogeneous infrastructures deficiencies can impact application-layer integration and interoperability. While enabling widespread ability is a complex and detailed mission, “Smart Cities” emphasise scheming, classifying, and buying computer hardware and software system which enable the combination of these subsystems [102].

3) SECURITY
While high security has additional design and maintenance costs, smart cities provide strong infrastructure and information security. Technological advances are transforming the revolutionary changes in the world’s major cities. Technologies applicable to cities can improve the life of inhabitants, tourists, and trades. However, the similar development of expertise and harmful malware has created a significant debate around protecting smart cities and processing them from different attacks. Attacks on city-management systems coordinate different functionalities, which offer multiple options for harmful impact [110].

4) PRIVACY
An attack on the water-supply-service-control-system in 2011 devastated a “pump” and cut off water to 2,200 inhabitants. As a result, infrastructure and information security must be tightly implemented in “Smart Cities”. However, high security can lead to extra design and maintenance costs. City networks collect different types of data, including very sensitive information about citizens. It is subject to many safety threats such as sidewalks, cross-site scripting, and data breaches. Therefore, data privacy is a fundamental characteristic of the “Smart City” structure. Data confidentiality, faith, and privacy come at a cost. Residents connect to major “Smart City” services using different devices like computers, smartphones, and other smart devices. So, it is crucial to accomplish confidentiality problems, i.e., interception. Preserving the safety actions to confirm the security of citizen information has become a very difficult and important task [130].

5) DATA COLLECTION AND ANALYSIS
As countless devices continuously generate data. Smart City data sizes incline to produce rapidly and grow exponentially. Therefore, sending, storing, transferring, and analysing large amounts of information is essential for the various operation of smart cities. Therefore, Smart Cities are keen to determine novel areas and attractive approaches for managing big data production and analytics. Protecting the city’s environment and resources for future generations by minimizing carbon dioxide emissions and using resources effectively is the main dedication of modern smart cities. Therefore, nowadays, cities focus on renewable energy and reduce carbon dioxide emissions [130].

6) WASTE MANAGEMENT
Ensure city management and non-renewable energy sustainability. Due to the essentiality of power use, comfortability, and reduction of carbon dioxide emissions, the Greater London Agency (GLA) discusses London’s Smart Opportunity Report on improving network efficiency for utilities. Waste management is another important matter in recent “Smart Cities” with pollution and landfill. The ultimate focus of smart waste management is to accelerate the assemblage and segregation process. The GLA noted that inadequate properties and residents’ evolution are major problems to be resolved in effectively implementing waste-management actions [131].

7) FAILURES MANAGEMENT
It is the main focus of smart city development projects. Failures can result from natural disasters such as floods, earthquakes, tornados, and system failures such as infrastructure failure or network unavailability. Comfortability or sustainability describes an instant retrieval strategy to face obstacles and return the city’s processes to usual. However, identifying, implementing a recovery, error acceptance strategy can intensify proposal and operating costs. The challenge is to implement a disaster recovery mechanism with minimal impact on cost and operational efficiency [131], [133].

8) OPPORTUNITIES IN SMART CITY
The “smart cities” concept is still evolving, and testing and implementation are limited to developed countries. Singapore is taking steps to use sensor data throughout the city to Monitor everyday life. Singapore’s Smart Nation (SNP) program integrates the present technological structure to attach all online societies. The profits of smart cities are many and can be applied to any city environment. As a result, we are enthusiastic about the additional investigation into profitable proposals and applications to drive smart city practices worldwide. “Renewable-Energy” integration is a different essential way to confirm the comfortability of city processes and accomplish the shortage of non-renewable energy [120].

Smart gadgets produce and require large volumes of information. Traditional data analysis methods and technologies are obsolete in modern smart city buildings through big data production. Therefore, investigate and integrate big data analytics in a smart city environment. Some investigations have tried to identify this essential task. Most of them are
recommendations and have no real-time experience. So, recommending and testing big data analytics in today’s smart cities is a proficient investigation chance for upcoming smart cities. The connected environment must maintain the safety of critical information. If citizens do not believe in the security of sensitive data, they will simply avoid using the smart city’s ICT platform, hindering the sustainability and credibility of the city’s operations. So, introducing smart city security measures is essential and needs further investigation.

Making the most of the profits of diverse equipment is an additional important extent of the investigation. “Smart cities” assimilate several subsystems at the “application layer” to provide fast and consistent service. Combination at the “application layer” level is worth additional discussion. The “Web-inspired WoT” concept is considered a perfect choice for integrating diverse implementation because of its widespread approachability. As an outcome, different parts of the smart city can interconnect with one another anyhow mismatches between operating platforms and interconnecting technologies.

IX. CONCLUSION AND FUTURE SCOPE

This research paper concludes that the emergence of the concept of a Smart City is improving the living standards of the city’s inhabitants. According to the expert studies, many people will move to the cities in coming years. This will increase the challenges for the city administrations. Some megacities are already facing the problem, for example, Mumbai in India. This paper has discussed that the natural sources available on the earth are very limited and continuously tend to decrease every day. So, the conservation of these resources is becoming a tedious task. In that case, one possible way is to use technologies to conserve natural resources. The one primary objective of the smart city is to increase productivity, reduce the time to achieve any tasks, decrease the cost, and increase sustainability. There are different smart city components like Smart healthcare, warehouses, factories, Grids, community, transportation, hospitality, etc. All these components have the involvement of technologies to achieve the objectives. This research paper is a systematic review of the Smart City domain, which starts with the information about the origin and growth of the smart city’s concept with some definitions given by different authors. A smart city like Quality of Life, Sustainability, Smartness, Urbanization, etc., is essential to achieving a smart city. Later the roadmap followed by the supporting pillars of the smart city is being discussed. A broad survey of the literature is being represented in this paper in Smart City, Buildings, Grids, Energy etc. During the whole literature survey, some of the tools (like OMNET++, JSIM Simulator, Cooja Simulator, MATLAB, PySim 5G etc.), supporting technologies (like Cloud Computing, IoT, Big Data, Machine Learning etc.), supporting platforms (like Kaa, Sentilo, IBM Intelligent Operating Center, CitySDK, Sofia2, etc.) are being used by different researchers. These tools, technologies, and platforms come together to successfully implement the smart city’s applications. This review paper aims to benefit government officials, businesses, and researchers who want to extend the smart city development. Finally, after the literature review, this paper discusses the challenges the developers generally face while implementing smart city applications. Lots of challenges come in the way, but these challenges raise the opportunities in this domain. Some possible research opportunities are being discussed, followed by the possible future research trends in Smart City.

FUTURE SCOPE

Based on the information acquired from the literature survey, this section of the paper presents the future research opportunities that are promising and relevant in the smart city domain. Few authors have expressed the need to improve their ICT strategies and applications to create a smart city that contains a lot of information. More application reference models with more information, difficulties and comments need to be qualitative based on various research and activities. The documentation needs to be coordinated with the ongoing review. The associated element shows that the lines of examination that need more investigation and advancement.

It has been seen in the overview that moves must be made towards the better administration of reasonable data. More exploration must be done in methods, for example, Artificial Intelligence that can deal with scrambled data with no misfortune regarding execution as for the original information. For example, using a scrambled image from a display camera reduces the perception that it is displayed. Aerial and fog computing (discussed in the “smart city Structure” section) can also help solve this problem by performing all calculations locally and preventing the transmission of information to third parties. In addition, another innovation has been developed to build trust between different partners (blockchain). In this way, blockchain is a further innovation to solve smart city information protection and management issues.

On the other hand, a large portion of the Blockchain executions is not imagined for smart cities and their residents’ information management. Supposedly, no improvement furnishing a system to incorporate Blockchain with other smart city administrations has been proposed. It is an entire territory where analysts can contribute, chipping away at structures, guidelines and hypothetical methodologies.

Research is also needed in the field of education. The smart city continues to add new services and applications that citizens can use. However, some citizens may not be trained to use ICT services and applications. Therefore, the opportunity to research is to find effective ways to train urban inhabitants and teach them to use and understand new concepts. Perhaps the largest testing task is in medical services, as information areas such as bioinformatics and biomedical imaging research are becoming increasingly well-known. It is hoped that ICT will be systematically memorized to improve the operation of facilities and clinics, but further research will be carried out with the expression of this innovation.
so that patients can fully understand it. It should improve accuracy. And standardize the display of ICT in the area. Indeed, research in human-machine communication may help promote awareness of innovation.

Computer vision research is very important in medical services. Still, it can be applied in various fields such as intelligent transportation (to improve MSD), urban surveillance (for security purposes, considering protection issues), logistics, advertising, etc. Advancement in this area and the adoption of new procedures within the smart city can be a significant improvement.

Other important areas of research include food and water management around the world. As mentioned earlier, water is a typical asset in water management and control. But currently, the investigation has been done in the management centre and its management areas. The food sector is a growing vertical sector that has undergone some scrutiny, explained concerning the Business Department section. Nowadays, research in this area is inadequate, so it is possible to move in this direction in specific areas (structural development, crop management, genetic modification research, etc.).

REFERENCES

[1] T. Bakici, E. Almirall, and J. Wareham, “A smart city initiative: The case of Barcelona,” J. Knowl. Economy, vol. 4, no. 2, pp. 135–148, Jun. 2013, doi: 10.1007/s13132-012-0084-9.

[2] A. Caraglia, C. D. Bo, and P. Nijkamp, “Smart cities in Europe,” J. Urban Technol., vol. 18, no. 2, pp. 65–82, 2011, doi: 10.1080/10630732.2011.601117.

[3] K. Su, L. Jie, and F. Hongbo, “Smart city and the applications,” in Proc. Int. Conf. Electron., Commun. Control (ICECC), Ningbo, China, Sep. 2011, vol. 25, no. 8, pp. 265–282.

[4] H. Chourabi, T. Nam, S. Walker, J. R. Gil-Garcia, S. Mellouli, K. Nahon, T. A. Pardo, and H. J. Scholl, “Understanding smart cities: An integrative framework,” in Proc. 45th Hawaii Int. Conf. Syst. Sci., Maui, HI, USA, Jan. 2012, pp. 2289–2297, doi: 10.1109/hicss.2012.615.

[5] S. Alawadhi, A. Aldama-Nalda, H. Chourabi, J. R. Gil-Garcia, S. Leung, S. Mellouli, and S. Walker, “Building understanding of smart city initiatives,” Electron. Government, vol. 22, no. 9, pp. 40–53, 2012.

[6] M. Himanen, “The significance of user involvement in smart buildings within smart cities,” in Designing, Developing, and Facilitating Smart Cities, vol. 32, no. 11. Cham, Switzerland: Springer, 2017, pp. 265–314.

[7] V. Albino, U. Berardi, and R. M. Dangelico, “Smart cities: Definitions, dimensions, performance, and initiatives,” J. Urban Technol., vol. 22, no. 1, pp. 3–23, 2015, doi: 10.1080/10630732.2014.942092.

[8] C. Harrison, B. Eckman, R. Hamilton, P. Hartzwick, J. Kalagananam, J. Paraszczak, and P. Williams, “Foundations for smarter cities,” IBM J. Res. Develop., vol. 54, no. 4, pp. 1–17, Jul./Aug. 2010, doi: 10.1147/JRD.2010.2048252.

[9] T. Nam and T. A. Pardo, “Conceptualizing smart city with dimensions of technology, people, and institutions,” in Proc. 12th Annu. Int. Digit. Government Res. Conf. Digit. Government Innov. Challenging Times, College Park, MD, USA, 2011, pp. 282–291.

[10] M. O’Grady and G. O’Hare, “How smart is your city?” Science, vol. 335, no. 6076, pp. 1581–1582, 2012.

[11] M. Batty, K. W. Axhausen, F. Giannoni, A. Pozdnoukhov, A. Buzzani, M. Wachowicz, G. Ouzounis, and Y. Portugali, “Smart cities of the future,” Eur. Phys. J. Special Topics, vol. 214, pp. 481–518, Dec. 2012.

[12] N. Komninos, “Intelligent cities: Variable geometries of spatial intelligence,” Intell. Buildings Int., vol. 3, no. 3, pp. 172–188, Jul. 2011.

[13] G. Stamatescu, I. Fagarasan, and A. Sachenko, “Sensing and data-driven control for smart building and smart city systems,” J. Sensors, vol. 2019, Apr. 2019, Art. no. 4528034.

[14] F. Cugurullo, “How to build a sandcastle: An analysis of the genesis and development of Masdar city,” J. Urban Technol., vol. 20, no. 1, pp. 23–37, Jan. 2013.

[15] A. Tiwari and U. Batra, “Blockchain secured ‘smart buildings’ as cyber physical systems,” in Proc. Int. Conf. Recent Develop. Sci., Eng. Technol. Singapore: Springer, 2019, pp. 35–53, doi: 10.1007/978-3-030-26489-7.

[16] T. Singh et al.: Decade Review on Smart Cities: Paradigms, Challenges and Opportunities

[17] I. Karamitsos and C. Apostolopoulos, “Optical trends in data centres,” IEEE Access, vol. 9, pp. 7193–7210, 2021, doi: 10.1109/ACCESS.2020.3047139.

[18] G. L. Cretu, “Smart cities design using event-driven paradigm and semantic web,” Informatica Economica, vol. 16, no. 4, pp. 57–67, 2012.

[19] T. Bakici, E. Almirall, and J. Wareham, “A smart city initiative: The case of Barcelona,” J. Knowl. Economy, vol. 4, no. 2, pp. 135–148, Jun. 2013, doi: 10.1007/s13132-012-0084-9.
B. N. Silva, M. Khan, and K. Han, "Internet of Things: A comprehensive data mining: concepts and techniques.

J. H. Lee, R. Phaal, and S.-H. Lee, "An integrated service-device-service provision and energy management," in Proc. 53rd Int. Universities

M. Dryjanski, M. Buczkowski, Y. Ould-Cheikh-Mouhamedou, and A. Kliks, "Adoption of smart cities with a practical smart building implementation," IEEE Internet Things Mag., vol. 3, no. 1, pp. 58–63, Mar. 2020.

C. Jung, K. Kim, J. Seo, B. N. Silva, and K. Han, "Topology configuration and multipath routing protocol for Bluetooth low energy networks," IEEE Access, vol. 5, pp. 9587–9598, 2017.

R. Want, "Near field communication," IEEE Pervasive Comput., vol. 10, no. 3, pp. 4–7, Jul./Sep. 2011.

Y. Kabalci, E. Kabalci, S. Padmanaban, J. B. Holm-Nielsen, and E. Takase, S. Ogino, Y. Okano, and S. Arai, "Material property of on-metal magnetic sheet attached on NFC/RFID antenna and research of its proper pattern and size on," in Proc. Int. Symp. Antennas Propag., Oct. 2013, pp. 1158–1161.

C. Padmanaban and E. Holm-Nielsen, "Location-based optimized service selection for data management with cloud computing in smart grids," Energies, vol. 12, no. 23, p. 4517, Nov. 2019.

V. Stepaniuk, J. Pillai, and B. Bak-Jensen, "Battery energy storage management for smart residential buildings," in Proc. 53rd Int. Universities Power Eng. Conf. (UPEC), Sep. 2018, pp. 1–6.

J. Huang, F. Qian, A. Gerber, Z. M. Mao, S. Sen, and O. Spatscheck, "A close examination of performance and power characteristics of 4G LTE networks," in Proc. 10th Int. Conf. Mobile Syst., Appl., Services (MobiSys), 2012, pp. 225–238.

X. Ge, S. Tu, G. Mao, and C. X. Wang, "5G ultra-dense cellular networks," IEEE Trans. Wireless Commun., vol. 23, no. 1, pp. 72–79, Feb. 2016.

M. S. Nazir, F. Alturiise, S. Alshmrani, H. M. J. Nazir, M. Bilal, A. N. Abdalla, P. Sanjeevikumar, and Z. M. Ali, "Wind generation forecasting methods and proliferation of artificial neural network: A review of five years research trend," Sustainability, vol. 12, no. 9, p. 3778, May 2020.

R. Sanchez-Iborra and M.-D. Cano, "State of the art in LP-WAN solutions for industrial IoT services," Sensors, vol. 16, no. 5, p. 708, May 2016.

Y. Khare, V. P. Tiwari, A. B. Patil, and K. Bala, "Li-Fi technology, applications and research of its proper pattern and size on," in Proc. Int. Symp. Antennas Propag., Oct. 2013, pp. 1158–1161.

J. Han, J. Pei, and M. Kamber, Data Mining: Concepts and Techniques, Amsterdam, The Netherlands: Elsevier, 2011.

J. Han, C.-S. Choi, W.-K. Park, I. Lee, and S.-H. Kim, "Smart home energy management system including renewable energy based on ZigBee and PLC," IEEE Trans. Consum. Electron., vol. 60, no. 2, pp. 198–202, May 2014.

B. N. Silva, M. Khan, and K. Han, "Internet of Things: A comprehensive review of enabling technologies, architecture, and challenges," IEEE Tech. Rev., vol. 35, no. 2, pp. 205–220, 2018.

B. Nathali Silva, M. Khan, and K. Han, "Big data analytics embedded smart city architecture for performance enhancement through real-time data processing and decision-making," Wireless Commun. Mobile Comput., vol. 2017, pp. 1–12, Mar. 2017.

B. N. Silva, M. Khan, and K. Han, "Integration of big data analytics embedded smart city architecture with RESTful web of things for efficient service provision and energy management," Future Gener. Comput. Syst., vol. 107, pp. 975–978, Jun. 2020.

U. Zafar, S. Bayhan, and A. Sanfilippo, "Home energy management system concepts, configurations, and technologies for the smart grid," IEEE Access, vol. 8, pp. 119271–119286, 2020.

J. H. Lee, R. Phaal, and S.-H. Lee, "An integrated service-device-technology roadmap for smart city development," Technol. Forecasting Social Change, vol. 80, no. 2, pp. 286–306, Feb. 2013.

L. Coetzee and J. Eksteen, "The Internet of Things-promise for the future? An introduction," in Proc. IST-Africa Conf., Mar. 2011, pp. 1–9.

A. Zanella, N. Bui, A. Castellani, L. Vangelista, and M. Zorzi, "Internet of Things for smart cities," IEEE Internet Things J., vol. 1, no. 1, pp. 22–32, Feb. 2014.

K. Carruthers, "Internet of Things and beyond: Cyber-physical systems," IEEE IoT Newslett., vol. 2014 p. 62–64, May 2014.

M. Chen, S. Mao, and Y. Liu, "Big data: A survey," Mobile Netw. Appl., vol. 19, no. 2, pp. 171–209, 2014.

F. Salim and U. Haque, "Urban computing in the wild: A survey on large scale participation and citizen engagement with ubiquitous computing, cyber physical systems, and Internet of Things," Int. J. Hum.-Comput. Stud., vol. 81, pp. 31–48, Sep. 2015.

M. Janssen, Y. Charalabidis, and A. Zhudervich, "Benefits, adoption barriers and myths of open data and open government," Inf. Syst. Manage., vol. 29, no. 4, pp. 258–268, Sep. 2012.

J. White, S. Clarke, C. Groba, B. Dougherty, C. Thompson, and D. Schmidt, "R&D challenges and solutions for mobile cyber-physical applications and supporting internet services," J. Internet Services Appl., vol. 1, no. 1, pp. 45–56, 2010.

S. Distefano, G. Merlino, and A. Puliafito, "Enabling the cloud of things," in Proc. 6th Int. Conf. Innov. Mobile Internet Services Ubiquitous Comput., Jul. 2012, pp. 858–863.

M. Aazam, I. Khan, A. A. Alsaffar, and E.-N. Huh, "Cloud of things: Integrating Internet of Things and cloud computing and the issues involved," in Proc. 11th Int. Bhurban Conf. Appl. Sci. Technol. (IBCAST) Islamabad, Pakistan, Jan. 2014, pp. 404–410.

B. Eichholtz, N. Kok, and J. M. Quigley, "Doing well by doing good? Green office buildings," Amer. Econ. Rev., vol. 100, no. 5, pp. 2492–2509, Dec. 2010.

O. B. Mora-Sanchez, E. Lopez-Neri, E. J. Cedillo-Elias, E. Aceves-Martinez, and V. M. Larios, "Validation of IoT infrastructure for the construction of smart cities solutions on living lab platform," IEEE Trans. Eng. Manag., vol. 68, no. 3, pp. 899–908, Jun. 2021, doi: 10.1109/TEM.2020.3002250.

T. Huang, S. Fu, H. Feng, and J. Kuang, "Bearing fault diagnosis based on shallow multi-scale convolutional neural network with attention," Energies, vol. 12, no. 20, p. 3937, 2019.

L. Catarinucci, D. De Donno, and L. Mainetti, "An IoT-aware architecture for smart healthcare systems," IEEE Internet Things J., vol. 2, no. 6, pp. 515–526, Dec. 2015.

H. Demirkiran, "A smart healthcare systems framework," IT Prof., vol. 15, no. 5, pp. 38–45, Sep. 2013.

V. Stepaniuk, J.R. Pillai, B. Bak-Jensen, and S. Padmanaban, "Estimation of energy activity and flexibility range in smart active residential building," Smart Cities, vol. 2, no. 4, pp. 471–495, 2019.

H. Lund, "Definitions," in Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modelling of 100% Renewable Solutions. H. Lund, Ed. New York, NY, USA: Academic, 2014.

B. S. Balaji, P. V. Raja, A. Nayar, P. Sanjeevikumar, and S. Pandian, "Enhancement of security and handling the incoincuousness in IoT using a simple size extensible blockchain," Energies, vol. 13, no. 7, p. 1795, Apr. 2020.

S. Chu and A. Majumdar, "Opportunities and challenges for a sustainable energy future," Nature, vol. 488, no. 7411, pp. 294–303, Aug. 2012.

H. Kanchev, D. Lu, F. Colas, V. Lazarov, and B. Francois, "Energy management and operational planning of a microgrid with a PV-based active generator for smart grid applications," IEEE Trans. Ind. Electron., vol. 58, no. 10, pp. 4583–4592, Oct. 2011.

A.R. Boyneugri, B. Yagcicekin, M. Baysal, A. Karakas, and M. Uzunoglu, "Energy management algorithm for smart home with renewable energy sources," in Proc. 4th Int. Conf. Power Eng., Energy Elec. Drives, May 2013, pp. 1753–1758.

Y.-S. Son, T. Pulkkinen, K.-D. Moon, and C. Kim, "Energy management system based on power line communication," IEEE Trans. Consum. Electron., vol. 56, no. 3, pp. 1380–1386, Aug. 2010.

M. Erol-Kantarci and H. T. Mouftah, "Wireless sensor networks for cost-efficient residential energy management in the smart grid," IEEE Trans. Smart Grid, vol. 2, no. 2, pp. 314–325, Jun. 2011.
[83] I. Zubizarreta, A. Saravalli, and S. Arrizabalaga, “Smart city concept: What it is and what it should be,” J. Urban Planning Develop., vol. 142, no. 1, pp. 1–9, Mar. 2016.

[84] M. P. Ethihymiopoulos, “Cyber-security in smart cities: The case of Dubai,” J. Innov. Entrepreneurship, vol. 5, no. 1, pp. 1–16, Dec. 2016.

[85] G. Li, Y. Wustaj, J. Luo, and Y. Li, “Evaluation on construction level of smart city: An empirical study from twenty Chinese cities,” Sustainability, vol. 10, no. 9, p. 3348, Sep. 2018.

[86] R. U. Arora, “Financial sector development and smart cities: The Indian case,” Sustain. Cities Soc., vol. 42, pp. 52–58, Oct. 2018.

[87] K. Borsekova, S. Koróny, A. Vahov, and K. Vitalíšová, “Functionality between the size and indicators of smart cities: A research challenge with policy implications,” Cities, vol. 78, pp. 17–26, Aug. 2018.

[88] R.-M. Soe and O. Mikheeva, “Combined model of smart cities and electronic payments,” in Proc. Conf. E-Democracy Open Government (CeDEM), May 2017, pp. 194–205, doi: 10.1109/CeDEM.2017.11.

[89] L. Mora and M. Deakin, Untangling Smart Cities: From Utopian Dreams to Innovation Systems for a Technology-Enabled Urban Sustainability, Elsevier, 2019.

[90] A. Monzon, “Smart city concept and challenges: Bases for the assessment of smart city projects,” in Proc. IEEE Int. Conf. Smart Cities Green ICT Syst. (SMARTGREENS), May 2015, pp. 1–11.

[91] D. Lu, Y. Tian, V. Y. Liu, and Y. Zhang, “The performance of the smart cities in China—A comparative study by means of self-organizing maps and social networks analysis,” Sustainability, vol. 7, no. 6, pp. 7604–7621, 2015.

[92] A. Kiriintat, O. Krejcar, and A. Kertesz, and M. F. Tasgetiren, “Future trends in the field of smart cities,” in Proc. IEEE/ACM Int. Conf. Utility Computing (UCC Companion), Dec. 2018, pp. 121–127, doi: 10.1109/UCC.Companion.2018.00045.

[93] H. Li, Y. Liu, Z. Qin, H. Rong, and Q. Liu, “A large-scale urban vehicular network framework for IoT in smart cities,” IEEE Access, vol. 7, pp. 74437–74449, 2019.

[94] J. M. Fernández-Güell, S. Guzmán-Arañá, M. Collado-Lara, and V. Fernández-Añez, “How to incorporate urban complexity, diversity and intelligence into smart cities initiatives,” in Proc. Int. Conf. Smart Cities. Cham, Switzerland: Springer, 2016, pp. 85–94.

[95] A. Komeili and R. S. Sririvasan, “Sustainability in smart cities: Balancing social, economic, environmental, and institutional aspects of urban life,” in Smart Cities: Foundations, Principles, and Applications. 2017, pp. 503–534, doi: 10.1002/9781119226444.ch18.

[96] A. Picon, Smart cities: A Spatialised Intelligence. Wiley, 2015.

[97] B. Pankhate, P. Cabral, P. Gomes, and S. Castelleyn, “The Lisbon ranking for smart, sustainable cities in Europe,” Sustain. Cities Soc., vol. 44, pp. 475–487, 2019.

[98] M. A. Hamalainen, “A framework for a smart city design: Digital transformation in the Helsinki smart city,” in Entrepreneurship and the Community. Cham, Switzerland: Springer, 2020, pp. 63–86.

[99] B. Jedari, F. Xia, H. Chen, S. K. Das, A. Tolba, and AL-M. Zafer, “A social-based watchdog system to detect selfish nodes in opportunistic mobile networks,” Future Gener. Comput. Syst., vol. 92, no. 3, pp. 777–788, Mar. 2019.

[100] S. Kolozali, D. Kuepmer, R. Tonjes, M. Bermudez-Esco, N. Farajardav, P. Barnaghi, F. Gao, M. Intizar Ali, M. Fischer, and T. Iggena, “Observing the pulse of a city: A smart city framework for real-time discovery, federation, and aggregation of data streams,” IEEE Internet Things J., vol. 6, no. 2, pp. 2651–2668, Apr. 2019.

[101] B. P. L. Lau, S. H. Marakkalage, Y. Zhou, N. U. Hassan, C. Yuen, M. Zhang, and U.-X. Tan, “A survey of data fusion in smart city applications,” Inf. Fusion, vol. 52, pp. 357–374, Dec. 2019.

[102] M. Hendy, S. Miniaoui, and H. Fakhy, “Towards strategic information & communication technology (ICT) framework for smart cities decision-makers,” in Proc. 2nd Asia-Pacific World Congr. Comput. Sci. Eng. (APWC CSE), Dec. 2015, pp. 1–7, doi: 10.1109/APWC/CSE.2015.4762187.

[103] M. Mohammadi, A. Al-Fuqaha, M. Guizani, and J.-S. Oh, “Semisupervised deep reinforcement learning in support of IoT and smart city services,” IEEE Internet Things J., vol. 5, no. 2, pp. 624–635, Apr. 2018.

[104] B. Gupta, P. Panajiotopoulos, and F. Bowen, “An orchestration approach to smart city data ecosystems,” Technol. Forecasting Social Change, vol. 151, Apr. 2020, Art. no. 119929.

[105] T. Muhammad, R. Meneemoh, A. Albshei, and I. Katib, “UbeHealth: A personalized ubiquitous cloud and edge-enabled networked healthcare system for smart cities,” IEEE Access, vol. 6, pp. 32258–32285, 2018.

[106] J. Engelbert, L. van Zoonen, and F. Hirzalla, “Excluding citizens from the European smart city: The discourse practices of pursuing and granting smartness,” Technol. Forecasting Social Change, vol. 142, pp. 347–353, May 2019.
[128] D. Wang, B. Bai, K. Lei, W. Zhao, Y. Yang, and Z. Han, “Enhancing information security via physical layer approaches in heterogeneous IoT with multiple access mobile edge computing in smart city,” IEEE Access, vol. 7, pp. 54508–54521, 2019.

[129] V. Fernandez-Anez, J. M. Fernandez-Giulli, and R. Giffinger, “Smart city implementation and discourses: An integrated conceptual model. The case of Vienna,” Cities, vol. 78, pp. 4–16, Aug. 2018.

[130] B. N. Silva, M. Khan, and K. Han, “Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities,” Sustain. Cities Soc., vol. 38, pp. 697–713, Apr. 2018.

[131] V. Kandpal, H. Kaur, and V. Tyagi, “Smart City Projects in India: Issues and Challenges,” Title, vol. 3, pp. 54–67, Mar. 2015.

[132] D. Garcia-Roger, “5G functional architecture and signaling enhancements to support path management for eV2X,” IEEE Access, vol. 7, pp. 20484–20498, 2019.

[133] I. Ahmed, H. Karvonen, T. Kumpuniemi, and M. Katz, “Wireless communications for the hospital of the future: Requirements, challenges and solutions,” Int. J. Wireless Inf. Netw., vol. 27, no. 1, pp. 4–17, Mar. 2020.

[134] A. Stratigea, C.-A. Papadopoulou, and M. Panagiotopoulou, “Tools and technologies for planning the development of smart cities,” J. Urban Technol., vol. 22, no. 2, pp. 43–62, Apr. 2015.

[135] A. Ojo, E. Curry, T. Janowski, and Z. Dhzusapovua, “Designing next-generation smart city initiatives: The SCID framework,” in Transforming City Government for Successful Smart Cities, Cham, Switzerland: Springer, 2015, pp. 43–67.

[136] S. Liao, J. L. Ji, W. Wu, Y. Wang, and Z. Guan, “Fog-enabled vehicle as a service for computing geographical migration in smart cities,” IEEE Access, vol. 7, pp. 8726–8736, 2019.

[137] D. Puiu, P. Barnaghi, R. Tonjes, D. Kumper, M. I. Ali, A. Mileo, J. Xavier Parreira, M. Fischer, S. Kolozoli, N. Farajadavar, F. Gao, T. Iggena, T.-L. Pham, C.-S. Nechiou, D. Puschmann, and J. Fernandes, “CityPulse: Large scale data analytics framework for smart cities,” IEEE Access, vol. 4, pp. 1086–1108, 2016.

[138] O. Geray, “An impact-driven smart sustainable city framework to address urban challenges: Smart Dubai experience,” in Smart Cities in the Gulf, Singapore: Palgrave Macmillan, 2019, pp. 13–39.

[139] N. Ahmad, “Robotic autonomous external defibrillator ambulance for emergency medical service in smart cities,” Int. J. Trend Scientific Res. Develop., vol. 3, no. 2, pp. 308–310, Feb. 2019.

[140] A. Al-Rahamneh, J. J. Astrain, J. Villadangos, H. Klaina, I. P. Guembe, A. A. Ghaemi, “A cyber-physical system approach to smart city development and implementation in Dubai,” in 5G Evolution: A service for computing geographical migration in smart cities,” IEEE Access, vol. 7, pp. 8726–8736, 2019.

[141] A. Van der Hoogen, B. Scholtz, and A. Calitz, “A smart city stakeholder interrelations and reciprocities,” in Sustain. City Govern. Archit. Art, vol. 9, pp. 49–55, Dec. 2018.

[142] Y. Lai, Y. Chen, Q. Zou, Z. Liu, and Z. Yang, “Design and analysis on trusted network equipment access authentication protocol,” Simul. Model. Pract. Theory, vol. 51, pp. 157–169, Feb. 2015.

[143] I. F. Akyildiz and E. P. Stuntebeck, “Wireless underground sensor networks: Research challenges,” Ad Hoc Netw., vol. 4, no. 6, pp. 669–686, Nov. 2006.

[144] M. Iamshidi, M. Esmәni, A. M. Darwesh, and M. R. Meybodi, “Using time-location tags and watchdog nodes to defend against node replication attack in mobile wireless sensor networks,” Int. J. Wireless Inf. Netw., vol. 27, no. 1, pp. 102–115, Mar. 2020.

[145] A. A. Veiga and C. J. Abbas, “Proposal and application of Bluetooth mesh profile for smart cities services,” Smart Cities, vol. 2, no. 1, pp. 1–19, 2018.

[146] S. Trafasitas, “Ethics and law in the Internet of Things world,” Smart Cities, vol. 1, no. 1, pp. 98–120, Oct. 2018.

[147] W. Serrano, “Digital systems in smart city and infrastructure: Digital as a service,” Smart Cities, vol. 1, no. 1, pp. 134–153, Nov. 2018.

[148] A. P. Plageras, K. E. Psannis, C. Stergiou, H. Wang, and B. B. Gupta, “Efficient IoT-based sensor BIG Data collection-processing and analysis in smart buildings,” Future Gener. Comput. Syst., vol. 82, pp. 349–357, May 2018.

[149] P. K. Sharma and J. H. Park, “Blockchain-based hybrid network architecture for the smart city,” Future Gener. Comput. Syst., vol. 86, pp. 650–655, Sep. 2018.

[150] I. Y. Mukti and Y. Prambudja, “Research direction in realizing sustainable IoT based smart city ecosystem,” in Proc. IOP Conf. Ser. Earth Environ. Sci., vol. 542, 2018, Art. no. 012036.

[151] Y. Mehmoond, F. Ahmad, I. Yaqoob, A. Adnane, M. Imran, and S. Guizani, “Internet-of-Things-based smart cities: Recent advances and challenges,” IEEE Commun. Mag., vol. 55, no. 9, pp. 164–174, Sep. 2017.

[152] M. N. Kamel Boulos and N. M. Al-Shorabji, “On the Internet of Things, smart cities and the WHO healthy cities,” Int. J. Health Geographics, vol. 13, no. 1, pp. 1–6, Dec. 2014.

[153] I. Lloret, J. Tomas, A. Canovas, and L. Parra, “An integrated IoT architecture for smart metering,” IEEE Commun. Mag., vol. 54, no. 12, pp. 50–57, Dec. 2016.

[154] R. Khan, S. U. Khan, R. Zaheer, and S. Khan, “Future internet: The Internet of Things architecture, possible applications and key challenges,” in Proc. 10th Int. Conf. Frontiers Inf. Technol., Dec. 2012, doi: 10.1109/FIT.2012.53.

[155] L. G. Anthopoulos and A. Vakali, “Urban planning and smart cities: Interrelations and reciprocities,” in The Future Internet Assembly, Berlin, Germany: Springer, May 2012, pp. 178–189.

[156] F. A. Khan, M. Asif, A. Ahmad, M. Alharbi, and H. Aljuaid, “Blockchain technology, improvement suggestions, security challenges on smart grid and its application in healthcare for sustainable development,” Sustain. Cities Soc., vol. 55, Apr. 2020, Art. no. 102018.

[157] H. Mroue, B. Parrein, S. Hamroui, P. Bakowski, A. Nasser, E. M. Cruz, and W. Vinc, “LoRa+: An extension of LoRaWAN protocol to reduce infrastructure costs by improving the quality of service,” Internet Things, vol. 9, Mar. 2020, Art. no. 100176.

[158] K. Brock, E. den Ouden, K. van der Klauw, K. Podyoinitsyna, and F. Langerak, “Light the way for smart cities: Lessons from Philips lighting,” Technol. Forecasting Social Change, vol. 142, pp. 194–209, May 2019.
A. Bhati, M. Hansen, and C. M. Chan, “Energy conservation through smart homes in a smart city: A lesson for Singapore households,” Energy Policy, vol. 104, pp. 230–239, May 2017.

J. F. De Paz, J. Bajo, S. Rodríguez, G. Villarrobua, and J. M. Corchado, “Intelligent system for lightning control in smart cities,” Inf. Sci., vol. 372, pp. 241–255, Dec. 2016.

P. Sharma, S. Moon, and J. Park, “Block-VN: A distributed blockchain based vehicular network architecture in smart city,” J. Inf. Process. Syst., vol. 13, no. 1, pp. 184–195, 2017.

P. Martins, D. Albuquerque, C. Wanzeller, F. Caldeira, P. Tome, and F. Sa, “Cityaaction a smart city platform architecture,” in Proc. Future Inf. Commun. Conf., pp. 208–240, 2016.

R. Ullah, Y. Faheem, and B. S. Kim, “Energy and congestion-aware routing metric for smart grid AMI networks in the smart city,” IEEE Access, vol. 5, pp. 13799–13810, 2017.

M. A. Rahman, M. M. Rashid, M. S. Hossain, E. Hassanain, S. S. Alotaibi, “Registration center based user authentication scheme for smart E-governance applications in smart cities,” IEEE Access, vol. 6, pp. 41–47, 2017.

F. M. Pires, L. D. S. Mendes, and L. L. Quilhône, “Integrated system architecture for decision-making and urban planning in smart cities,” Int. J. Distrib. Sensor Netw., vol. 15, no. 8, Aug. 2019, Art. no. 1505147782.

F. M. Pires, L. D. S. Mendes, and L. L. Quilhône, “Integrated system architecture for decision-making and urban planning in smart cities,” Int. J. Distrib. Sensor Netw., vol. 15, no. 8, Aug. 2019, Art. no. 1505147782.

M. A. Rodriguez-Hernandez, A. Gomez-Sacristan, and D. Gomez-Cuadrado, “SimuCity: Planning communications in smart cities,” IEEE Access, vol. 7, pp. 46870–46884, 2019.

V. Diacoina, A.-R. Bologa, and R. Bologa, “Hadoop oriented smart cities architecture,” Syst. Sci., vol. 18, no. 4, pp. 1181–1186, Apr. 2018.

R. Raman, P. K. S. B. Majhi, and S. Bakshi, “Direction estimation for pedestrian monitoring system in smart cities: An HMM based approach,” IEEE Access, vol. 4, pp. 5788–5808, 2016.

S. S. Alothabi, “Registration center based user authentication scheme for smart E-governance applications in smart cities,” IEEE Access, vol. 7, pp. 5819–5833, 2019.

N. Mohamed, M. Al-Jaroodi, J. Jawhar, S. Lazarova-Molnar, and S. Mahmoud, “SmartCity: A service-oriented middleware for cloud and fog enabled smart city services,” IEEE Access, vol. 5, pp. 17576–17588, 2017.

S. A. Shah, D. Z. Seker, M. M. Rathore, S. Hameed, S. B. Yahia, and D. Draheim, “Towards disaster resilient smart cities: Can Internet of Things and big data analytics be the game changers?” Internet Things, vol. 7, p. 91885–91903, 2019.

L. Tian, H. Wang, Y. Zhou, and C. Peng, “Video big data in the smart city: Background construction and optimization for surveillance video processing,” Future Gener. Comput. Syst., vol. 86, pp. 1371–1382, Sep. 2018.

S. Ahmed, “Security and privacy in smart cities: Challenges and opportunities,” Int. J. Eng. Trends Technol., vol. 68, no. 2, pp. 1–8, Feb. 2020.

M. A. Rahman, M. M. Rashid, M. S. Hossain, E. Hassanain, M. A. Alhamid, and M. Guizani, “Blockchain and IoT-based cognitive edge framework for sharing economy services in a smart city,” IEEE Access, vol. 7, pp. 18611–18621, 2019.

M. J. Mulquin, “Roles of IEC in supporting effective smart city standards,” IET Smart Cities, vol. 1, no. 1, pp. 10–18, Jun. 2019.

O. Kotelova, A. G. Kusne, D. V. Samarov, A. Lbath, and A. Battou, “Dynamic network model for smart city data-loss resilience case study: City-to-city network for crime analytics,” IEEE Access, vol. 5, pp. 20524–20535, 2017.

Office of the Government Chief Information Officer, Smart City Development in Hong Kong, IET Smart Cities, Edison, NJ, USA, vol. 19, pp. 23–27.

R. Morello, S. C. Mukhopadhay, Z. Liu, D. Slomovitz, and S. R. Samantaray, “Advances on sensing technologies for smart cities and power grids: A review,” IEEE Sensors J., vol. 17, no. 23, pp. 7596–7610, Dec. 2017.
E. J. Oughton, Z. Frias, S. van der Gaast, and R. van der Berg, “Assess-
J. Venkatesh, B. Aksanli, C. S. Chan, A. S. Akyurek, and T. S. Rosing,
A. S. Ibrahim, K. Y. Youssef, H. Kamel, and M. Abouelatta, “Traffic
T. Singh
F. De Filippi, C. Coscia, G. Boella, and A. Antonini, “Miramap: A we-
government tool for smart peripheries in smart cities,” IEEE Access,

A. A. Elsaeidy, A. Jamalipour, and K. S. Munasinghe, “A hybrid
A. A. Omar, A. K. Jamil, A. Khandakar, A. R. Uzzal, R. Bosri,
W. Hurst, C. A. Curbelo Montanez, N. Shone, and D. Al-Jumneely,
S. Rani, R. K. Mishra, M. Usman, A. Kataria, P. Kumar, P. Bhambi,
A. Nelson, G. Toth, D. Linders, C. Nguyen, and S. Rhee, “Replication
M. Santos, J. G. P. Rodrigues, S. B. Cruz, T. Lourenço, and P. M. d'Orey,
A. Gyrard, A. Zimmermann, and A. Sheth, “Building IoT-based applica-
J. Ireneusz, “Graph signal processing in applications to sensor net-
N. Mohammad, S. Muhammad, A. Bashar, and M. A. Khan, “Formal
P. Kulkarni and T. Farnham, “Smart city wireless connectivity consider-
A. Elsaeidy, A. Jamalipour, and K. S. Munasinghe, “A hybrid
development for smart city: A survey,” IEEE Access, vol. 9, pp. 90738–907429,
2021, doi: 10.1109/ACCESS.2021.3089601.

V. Javidroozi, H. Shah, and G. Feldman, “Urban computing and smart
cities: Towards changing city processes by applying enterprise sys-
tems integration practices,” IEEE Access, vol. 7, pp. 108023–108034,
2019.

J. Ireneusz, “Graph signal processing in applications to sensor net-
works, smart grids, and smart cities,” IEEE Sensors J., vol. 17, no. 23,
p. 7659–7666, Dec. 2017.
L. Hu and Q. Ni, “IoT-driven automated object detection algorithm for
urban surveillance systems in smart cities,” IEEE Internet Things J.,
vol. 5, no. 2, pp. 747–754, Apr. 2018.
A. Gyrard, A. Zimmermann, and A. Sheth, “Building IoT-based applica-
tions for smart cities: How can ontology catalogs help?” IEEE Internet
Things J., vol. 5, no. 5, pp. 3978–3990, Oct. 2018.
R. Du, P. Santi, M. Xiao, A. V. Vasilakos, and C. Fischione, “The sensible
city: A survey on the deployment and management for smart city mon-
toring,” IEEE Commun. Surveys Tuts., vol. 21, no. 2, pp. 1533–1560,
2nd Quart., 2019.
F. De Filippi, C. Coscia, G. Boella, and A. Antonini, “Miramap: A we-
government tool for smart peripheries in smart cities,” IEEE Access,
vol. 4, pp. 3824–3843, 2016.

J. An, “Toward global IoT-enabled smart cities interworking using
adaptive semantic adapter,” IEEE Internet Things J., vol. 6, no. 3,
p. 5753–5765, Jun. 2019.
T. S. Brisimi, C. G. Cassandra, C. Osgood, J. C. Paschalidis, and
Y. Zhang, “Sensing and classifying roadway obstacles in smart cities:
The street bump system,” IEEE Access, vol. 4, pp. 1301–1312, 2016.
M. Ansari and F. Almaliki, “Survey on collaborative smart drones and
Internet of Things for improving smartness of smart cities,” IEEE Access,
vol. 7, pp. 128125–128152, 2019.
S. H. Alsamhi, O. Ma, M. M. Ansari, and F. A. Almaliki, “Survey on
collaborative smart drones and internet of things for improving smartness
of smart cities,” IEEE Access, vol. 7, pp. 128125–128152, 2019.
T. K. Hui, R. S. Sherratt, and D. D. Sánchez, “Major require-
ments for building smart homes in smart cities based on Internet of
Things technologies,” Future Gener. Comput. Syst., vol. 76, pp. 358–369,
Dec. 2017.
T. K. Hui, R. S. Sherratt, and D. D. Sánchez, “Major requirements for
building Smart Homes in smart cities based on Internet of Things
technologies,” Future Gener. Comput. Syst., vol. 76, pp. 358–369,
2017.
A. M. Townsend, Smart Cities: Big Data, Civic Hackers, and the Quest
for a New Utopia, New York, NY, USA: W.W. Norton & Company,
2013.
G. Mylonas, A. Kalogeras, G. Kalogeras, C. Anagnostopoulos, C. Alex-
akos, and L. Munsell, “Digital twins from smart manufacturing to smart
cities: A survey,” IEEE Access, vol. 9, pp. 143222–143249, 2021, doi:
10.1109/ACCESS.2021.3120843.
W. Hurst, C. A. Curbelo Montanez, N. Shone, and D. Al-Jumneely,
“An ensemble detection model using multinomial classification of
stochastic gas smart meter data to improve wellbeing monitoring in
smart cities,” IEEE Access, vol. 8, pp. 7877–7898, 2020, doi:
10.1109/ACCESS.2020.3066885.
S. Rani, R. K. Mishra, M. Usman, A. Kataria, P. Kumar, P. Bhambi,
and A. K. Mishra, “Amalgamation of advanced technologies for sus-
tainable development of smart city environment: A review,” IEEE
Access, vol. 9, pp. 150060–150087, 2021, doi: 10.1109/ACCESS.2021.
3125527.
A. A. Omar, A. K. Jamil, A. Khadakar, A. R. Uzzal, R. Bosri,
N. Mansoor, and M. S. Rahman, “A transparent and privacy-preserving
healthcare platform with novel smart contract for smart cities,” IEEE
Access, vol. 9, pp. 90738–907429, 2021, doi: 10.1109/ACCESS.2021.
3089601.

D. Yang, B. Qu, and P. Cudre-Mauroux, “Location-centric social
media analytics: Challenges and opportunities for smart cities,” IEEE
Intell. Syst., vol. 36, no. 5, pp. 3–10, Sep. 2021, doi:
10.1109/MIS.2020.3009438.
U. M. Butt, S. Letchmunan, F. H. Hassan, M. Ali, A. Baqir, T. W. Koh,
and H. H. R. Sherazi, “Spatio-temporal crime predictions by leverag-
ing artificial intelligence for citizens security in smart cities,” IEEE
Access, vol. 9, pp. 47516–47529, 2021, doi: 10.1109/ACCESS.2020.3068306.
A. Elaieidy, A. Jamalipour, and K. S. Munasinghe, “A hybrid
deep learning approach for replay and DDoS attack detection in
a smart city,” IEEE Access, vol. 9, pp. 154864–154875, 2021, doi:
10.1109/ACCESS.2021.3128701.
S. M. E. Sepasgarz, “Differentiating digital twin from digital shadow:
Elucidating a paradigm shift to expedite a smart, sustainable built envi-
ronment,” Buildings, vol. 11, no. 4, p. 151, Apr. 2021, doi: 10.3390/build-
ings11040151.
F. Dembski, U. Wössner, M. Letzgus, M. Ruddat, and C. Yamu, “Urban
digital twins for smart cities and citizens: The case study of Herren-
berg, Germany,” Sustainability, vol. 12, no. 6, p. 2307, Mar. 2020, doi:
10.3390/su12062307.
F. Dembski, U. Wössner, M. Letzgus, M. Ruddat, and C. Yamu, “Urban
digital twins for smart cities and citizens: The case study of Herren-
berg, Germany,” Sustainability, vol. 12, no. 6, p. 2307, 2020.
J.-M. Fernández-Güell, M. Collado-Lara, S. Guzmán-Araña, and
V. Fernández-Añez, “Incorporating a systemic and foresight approach
into smart city initiatives: The case of Spanish cities,” J. Urban Technol.,
vol. 76, no. 3, pp. 43–67, Jul. 2016.
H. M. Al-Anmal and M. M. Alajawder, “Development of a national
smart city initiatives framework for the Kingdom of Bahrain: A blueprint
for successful smart cities,” in Smart Cities in the Gulf, 2019, doi:
10.1007/978-981-13-2011-8_4.
TARANA SINGH received the B.Tech. degree in computer science and engineering from Banasthali Vidyapith, in 2017, the M.Tech. degree in computer science and engineering from Gautam Buddha University, in 2019, where she is currently pursuing the Ph.D. degree in computer science and engineering. Her research interests include machine learning, big data, the Internet of Things, and energy management system in smart city.

ARUN SOLANKI received the M.Tech. degree in computer engineering from YMCA University, Faridabad, Haryana, India, and the Ph.D. degree in computer science and engineering from Gautam Buddha University, Greater Noida, India, in 2014. He is currently working as an Assistant Professor with the Department of Computer Science and Engineering, Gautam Buddha University, where he has been working, since 2009. He has worked as a Time Table Coordinator, a Member of Examination, Admission, Sports Council, Digital Information Cell, and other university teams from time to time. He has supervised more than 60 M.Tech. dissertations under his guidance. His research interests include expert systems, machine learning, and search engines. He has published many research articles in SCI/Scopus-indexed international journals/conferences like IEEE, Elsevier, and Springer. He has participated in many international conferences. He has been a technical and advisory committee member of many conferences. He has organized several FDP, conferences, workshops, and seminars. He has chaired many sessions at international conferences. He is working as an Associate Editor of International Journal of Web-Based Learning and Teaching Technologies (IJWLTT) (IGI publisher). He has been working as a Guest Editor for special issues in Recent Patents on Computer Science (Bentham Science Publishers). He is an Editor of many books with a reputed publisher like IGI Global, CRC, and AAP. He is working as a Reviewer of Springer, IGI Global, Elsevier, and other reputed publisher journals.

SANJAY KUMAR SHARMA is currently working with Gautam Buddha University (GBU) as a Professor, where he is also the Dean of the University School of ICT. He holds an academic honor of being Chairman of the Institution of Electronics and Telecommunication Engineers (IETE), Ambala a Sub-Centre (Haryana). He has successfully completed a large number of in-house research and development projects. He has actively contributed to many research projects like Search of Super Heavy Elements in Nature Using Meteoritic Crystal funded by CSIR, New Delhi, India, at Kurukshetra University, Kurukshetra, and AMU, Aligarh; Single Pore Sensor for Water Pollution funded by the Ministry of Environment and Forest, Government of India, at G. N. D. University, Amritsar; Calibration and Validation of Data Products Obtained From Remote Sensing Satellites (with the Image Processing Division of Space Application Centre, Ahmedabad) funded by the Indian Space Research Organization (ISRO), Bengaluru, India; and Web-Based Engineering Education System: A Consortium for Technical Institutes funded by MHRD, New Delhi, at the National Institute of Technology, Kurukshetra. His research interests include basic and applied aspects of SSSNTs, heavy ions, the IoT, smart material and sensors, and artificial intelligence, besides nanotechnology. He is a Member of Executive Council of Nuclear Track Society of India; and a Life Member of the Society for Scientific Values (SSV), the Indian Association of Physics Teachers (IAPT) Secretary, Vigyan Bharti, Haryana, and the Swadeshi Science Movement, Delhi (SSMD).

ANAND NAYYAR (Senior Member, IEEE) received the Ph.D. degree in computer science from Desh Bhaghat University, in 2017, in the area of wireless sensor networks and swarm intelligence. He is currently working with the School of Computer Science, Duy Tan University, Da Nang, Vietnam, as an Assistant Professor, a Scientist, the Vice-Chairman (Research), and the Director of the IoT and Intelligent Systems Laboratory. He was a certified professional with more than 100 professional certificates from CISCO, Microsoft, Oracle, Google, Beingcert, EXIN, GAQM, Cyberoam, and many more. He has published more than 130 research articles in various high-quality ISI-SCI/SCIE/SSCI impact factor journals cum Scopus/ESCI indexed journals; more than 50 papers in international conferences indexed with Springer, IEEE Xplore, and ACM Digital Library; and more than 40 book chapters in various SCOPUS, Web of Science indexed books with Springer, CRC Press, Elsevier, and many more with citations 6000, H-index 40, and I-index 150. He has authored/coauthored cum edited more than 30 books of computer science. He has 18 Australian patents, 25 Indian design cum utility patents, three Indian copyright, two Canadian copyrights, and three German patents to his credit in the area of wireless communications, artificial intelligence, cloud computing, the IoT, and image processing. He has reviewed more than 1600 articles for various Web of Science indexed journals. His research interests include wireless sensor networks, the IoT, swarm intelligence, cloud computing, artificial intelligence, drones, blockchain, cyber security, network simulation, and wireless communications. He was a member of more than 50 associations as a Life Member including ACM. He was associated with more than 500 international conferences as a program committee/chair/advisory board/review board member. He was awarded more than 38 awards for the Teaching and Research—Young Scientist, the Best Scientist, the Young Researcher Award, the Outstanding Researcher Award, the Excellence in Teaching, and many more. He is acting as an Associate Editor of Wireless Networks (Springer), Computer Communications (Elsevier), International Journal of Sensor Networks (IJSNET) (Inderscience), Frontiers in Computer Science, PeerJ Computer Science, Human Centric Computing and Information Sciences (HCIS), IET-Quantum Communications, IET Wireless Sensor Systems, IET Networks, IJDSST, IJISP, JCINI, and IJGC. He is acting as the Editor-in-Chief of IGI-Global, USA, journal titled International Journal of Smart Vehicles and Smart Transportation (IJSVST).

ANAND PAUL (Senior Member, IEEE) received the Ph.D. degree in electrical engineering from the National Cheng Kung University, Tainan, Taiwan, in 2010. He is currently a full-time Professor with the School of Computer Science and Engineering, Kyungpook National University, Daegu, South Korea. He is a delegate Representative of Korea for the M2M focus group and MPEG. His research interests include artificial intelligence, data science, and blockchain technology. He is an Associate Editor of the IET Wireless Systems, IEEE ACCESS, Cyber-Physical Systems (Taylor & Francis), International Journal of Interactive Multimedia and Artificial Intelligence, and Human Behavior and Emerging Technologies (Wiley).