

# Smart Cities Monitoring using Internet of Things: Opportunities and Challenges

Praveen Kumar Malik  
SEEE, Lovely Professional  
University, Phagwara, Punjab,  
India  
pkmalikmeerut@gmail.com

Rashmi Roges  
School of Electronics and  
Electrical Engineering, Lovely  
Professional University, Jalandhar,  
Punjab, India  
rashmibinson@gmail.com

Praveen Tiwari  
Assistant Registrar at Swami  
Rama Himalayan University,  
Uttaranchal, India  
pravti@gmail.com

Pooja Malik  
SEEE, Lovely Professional  
University, Jalandhar, Punjab,  
India  
er.pujamalik50@gmail.com

Vinish kumar  
Raj Kumar Goel Institute of  
Technology, Ghaziabad Uttar  
Pradesh  
vinishk18@gmail.com

Anita Gehlot  
Division of Research &  
Innovation, Uttarakhand  
University, Dehradun, India  
dranitagehlot@gmail.com

**Abstract:** Smart cities are an implementation of the Internet of Things (IoT) concept. Growth in population and urbanisation have accelerated the development of novel approaches to dealing with urbanisation while minimising the consequences on the ecological balance, human lives, and government. As a result, equipment and tools empower us to become wiser and create many parts of smart cities better approachable and relevant. The present article's purpose is to give a comprehensive assessment of the smart city concept, as well as its numerous functions, perks, and conveniences. Furthermore, the majority of the conceivable IoT devices are described, and respective capacities to interate into this and adapt towards the various components of smart cities being explored. A further important topic covered in this study is the possible applicability of smart cities in upcoming technological growth. Lastly, several of the difficulties and possibilities discovered during an exhaustive existing literature on smart cities.

**Keywords:** *IoT, sensors, smart cities,*

## I. INTRODUCTION

With the advent of smart gadgets and related subsequent improvements, the notion of linking common things over communication lines has gained popularity. The Internet of Things (IoT) evolved from traditional systems that link billions of mobile networks. Smart cities have risen to prominence in recent centuries as a result of increasing urbanisation throughout the world. Using ICT to conduct operational processes has

made cities more productive in a variety of ways. In general, a smart city is a municipality that uses ICT as well as other technological applications to enhance the productivity economy of routine municipal activities and the Quality of Services (QoS) given to urban people. Experts have characterized smart city using official words by taking into account many factors and views. According to one prominent conception, a smart city links geographical, societal, commercial, and ICT facilities to improve the town's cognition [1].

As a result, it has resulted in a phenomenal increase in the number of digital technologies, such as detectors, sensors, mobile phones, and home automation, which keep driving the massive economic goals of the IoT, since all gadgets can be interconnected and communicate with one another via the Web [2]. Combining various digital gadgets was formerly challenging, if not prohibitive. Similarly, obtaining information all day activity monitoring and long-term growth plans with in city is critical. The power of intelligent and self-configuring gadgets that are properly connected together through worldwide grids networks is the IoT paradigm. IoT is often characterised as a real item that is widely scattered and has limited data memory and computing abilities, with both the goal of improving the dependability, productivity, and safety of smart cities and associated architecture [3, 4].

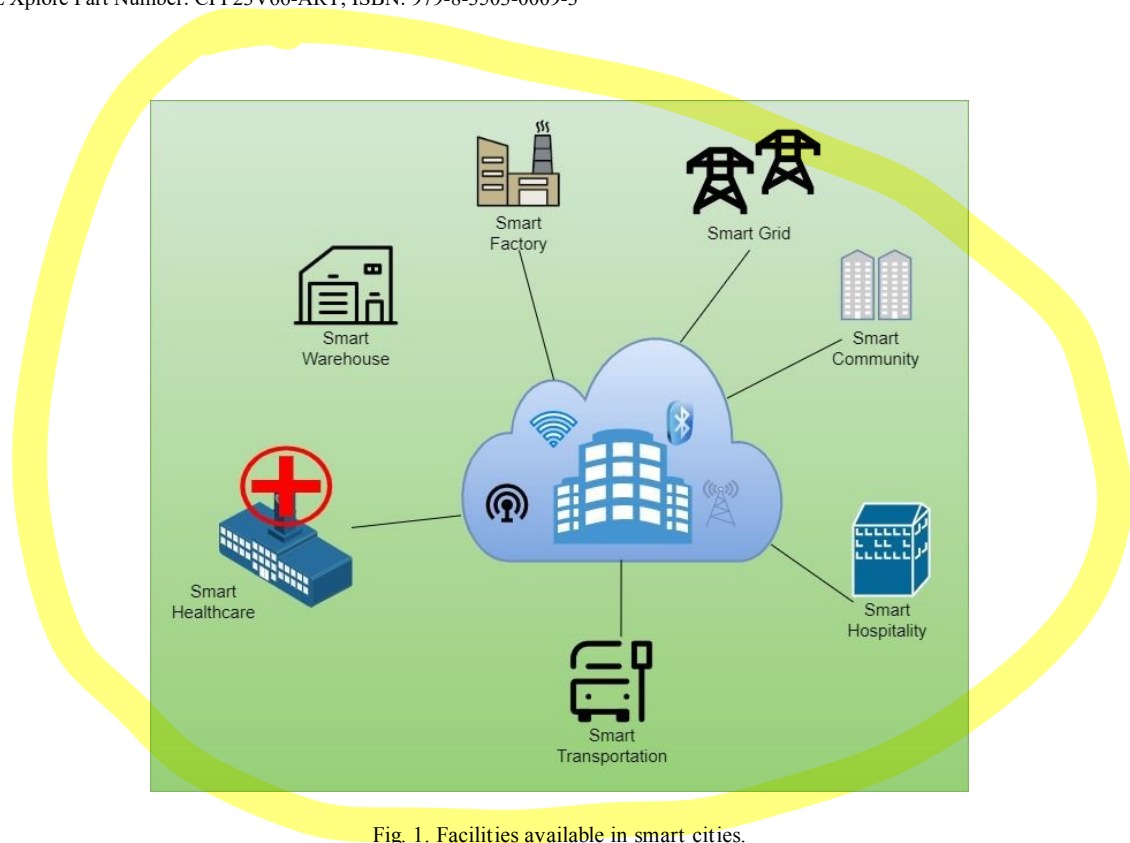


Fig. 1. Facilities available in smart cities.

As a consequence of today's proliferation of digital technology, the smart city is growing wiser in comparison to the previous. Smart cities are made up of numerous forms of electronic technology used by application areas, including such cameras inside a monitoring program and sensors in a transportation network. Additionally, the use of particular cell phones can indeed be distributed. As a result, with the diverse environments in mind, numerous words such as object characteristics, users, incentives, and protection laws will be investigated. Smart cities include smart residents, energy management systems, building automation, smart transportation, cognitive technologies, smart medical, smart facilities, smart government and learning, and lastly smart defense. IoT enhances cities and impacts various aspects of human existence by developing cost-effective local services, promoting public change, lowering transportation gridlock, and maintaining inhabitants healthy and secure. Furthermore, it is critical at the federal level in terms of policy formulation (e.g., conservation of energy and emission control), surveillance methods, and required facilities. Therefore, it contributes to delivering a system with greater effectiveness, cheaper costs, and much more secured operations via saving energy regulations, economic attentiveness, and dependability level.

## II. CHARACTERISTICS OF SMART CITY

A smart city is built by combining numerous qualities. According to Saruja et al., the preponderance of smart urban ideas has four basic characteristics: sustainability, quality of life,

urbanisation, and general intelligence [5]. Each feature is concerned with a few sub traits. Sub-attributes of viability include infrastructure and administration, contamination and waste, the environment and climate warming, public considerations, finance, and healthcare. Sustainability refers to a city's capacity to preserve the equilibrium of the ecological system across all of the foregoing dimensions while servicing and conducting city activities. The psychological and economic well-being of urban citizens suggests an increase in QoL. The urbanisation attribute is concerned with the technical, economical, architectural, and governmental elements of the transition from rural to urban environments.

Since the 1980s, sustainable has been viewed as a dominating model in urban design. In reality, widespread concern about sustainability had a significant influence in the birth of smart cities. Sustainable development sub-aspects correspond to the threefold bottom lining concept. The threefold bottom liner concept considers the interaction and dependency of the sub characteristics depicted in Fig. 2. Modern cities are continuously expanding by exploitation of natural resources. As a result, it is critical to investigate the consequences of non-renewable energy shortages. As a result, protecting biological resources and fuel supplies has evolved into a pressing requirement for smart city viability.

# I Introduction

With the increase of urbanisation, smart cities became more and more popular because the usage of ICT (including IoT) helps improve the QoS offered to individuals.

# II Characteristics of Smart Cities

- 4 central characteristics: sustainability, quality of life, urbanisation, and general intelligence
- sustainability = balance all dimensions of the ecological systems without decreasing the proposed services (and/or Def. hole)
- urbanisation: shift to urban areas like: technology, environment, economy, infrastructure, and government
- QoL = emotional and financial well-being

The goal of city intellect is to enhance the living standards of the urban population in terms of financial, social, and biological conditions. Caragliu et al. examined partial correlations between human resources, e-government, public transit network width, per capita GDP, and jobs in the amusement sector to evaluate the intellectual prowess of European towns [6]. Despite discussing the smartness notions, academics carried out studies over the past two decades to assess the relationship between ICT architecture and industrial expansion.

### III. IoT TECHNOLOGIES FOR SMART CITIES

- *Radio-Frequency Identification (RFID)*: RFID, comprising scanners and labels, plays an important role in the Internet of Things. It should be feasible to use techniques on each connected object, achieving automated recognition and assigning a single online signature to each of the things, including the network related to digital data and applications [7]. RFID has several uses in smart metering, such as item tracking and localisation, biomedicine, car parks, and wealth management. Every tag may function as a sensor since it contains not only voluntarily entered data but then also recorded data such as environment facts.
- *Near Field Communication (NFC)*: It is mostly used for bilateral short-distance transmission, particularly in devices. This range is often measured in centimetres. The adoption of NFC in smartphones allows us to employ it in smart cities too though. One of their uses is to utilise smartphones with NFC as a pocketbook, allowing us to use cell phones as personalized credentials such as debit cards, identity cards, public transportation cards, and user access cards. Furthermore, because NFC is reversible, it can be utilized to exchange information between devices, as well as video and files [8].

- *6LoWPAN*: It is designed to support IPv6 connectivity. According to the expiration of its addressing ranges and the impossibility to independently handle millions of terminals, that is a feature of IoT networks, IPv4, which had been the primary address development and infrastructure by Web servers, has been supplanted by IPv6 throughout time. IPv6 resolves the shortage of nodes in Networks by giving 128-bit identifiers, but also introduces a new issue: interoperability with restricted devices. This issue is solved by 6LoWPAN, an IPv6 compressing protocol [9].

- *Wireless Sensor Networks (WSNs)*: WSNs make many types of data public and may be used in a variety of applications like healthcare, governmental, and ecological benefits. Furthermore, WSNs and RFIDs may be used to achieve a variety of goals, including obtaining data on the location of persons and items, movements, weather, and so on. A wireless sensor network (WSN) is made up of wireless nodes that have a radio transceiver, an analogue-to-digital converter (ADC), several sensor, storage, and a battery pack [8].

### IV. COMPOSITION OF SMART CITY

#### A. Smart Homes

Smart houses may be examined by leveraging data generated by numerous sensors [10]. For instance, innovative demand response (DR) approaches can be used, or consumers can be warned if pollutants exceed an adequate level via monitoring systems. IoT technology, in reality, contributes to home automation and equipment such as smart TVs, home surveillance systems, lighting systems, firefighting, and temperature control. The sensor within those devices analyze the surroundings and surroundings and transmit monitoring information to a central computer at home, allowing the homeowner to continually watch and operate the residence especially from afar and choose the best option in any situation [11].

Similarly, these collected information assist in forecasting future occurrences so that they may be prepared ahead of time by making an effective assessment to avoid losing ease, protection, relaxation, and a high quality of life. Furthermore, smart dwellings in a neighbourhood may be linked to form a smart society via the Neighbor Area Network (NAN) [12]. In just this example, households can exchange intelligence information such as outdoor cameras to help identify an

## III IoT Technologies for Smart Cities

- RFID
- NFC
- 6LoWPAN
- WSN

## IV Composition of Smart Cities

### A. Smart Home

- "automation, equipment (Smart TV), surveillance systems, lighting systems, fire fighting, and temperature control"
- house owners can react to monitoring information that is being sensed by sensors <sup>↑</sup> in the house (e.g. temperature) or cameras
- There exists system where data can be shared in neighborhoods like camera footage for example → "Smart Society"

incident or report incidents to a police precinct. Other uses of smart cities include healthcare, pooled resource management, and supporting social media. As a result, this notion encompasses not simply the connectivity of neighbours, as well as

the expansion and growth of a complete smart city capable of monitoring and controlling all actions in a smart city.

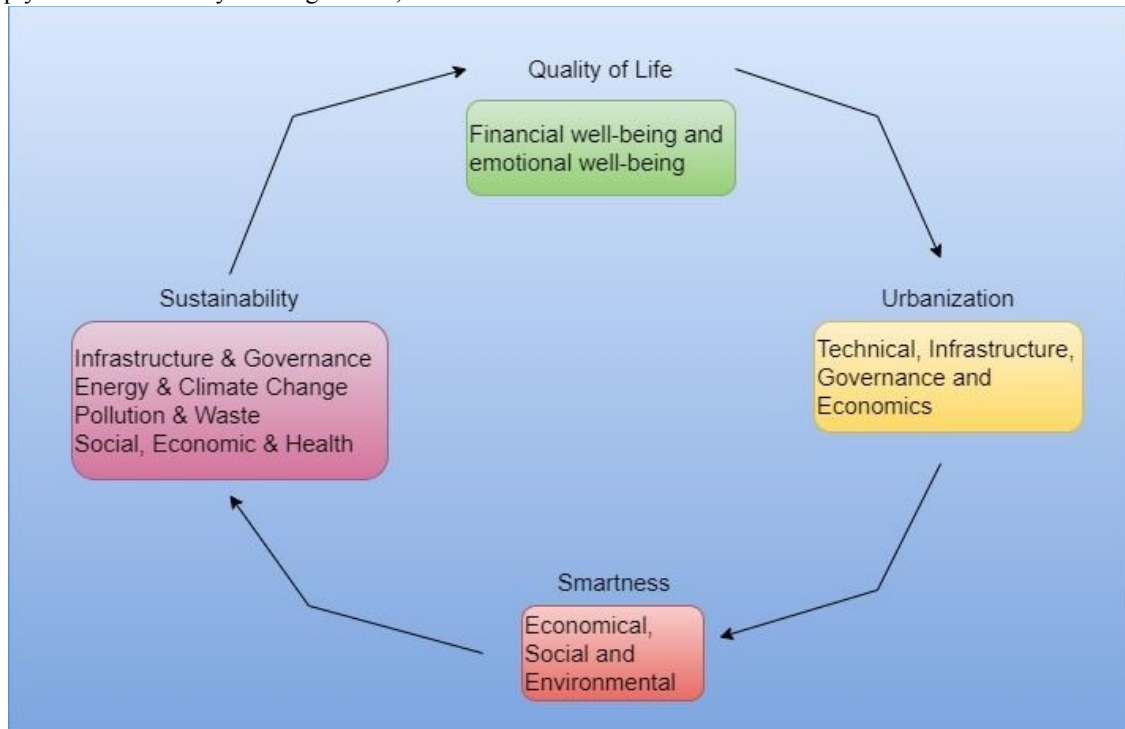


Fig. 2. Benefits of monitoring of Smart Cities using IoT for better quality of life.

### B. Smart transportation

Mobility have been a requirement for humans since the dawn of time. This need has been expanded by technical advancement to include road transportation, sea transport, commuter rails, and air travel. The nation's traditional transportation channels were not linked. The notion of linking ordinary things, on the other hand, has transformed traditional transportation networks into integrated modern transport networks. As just a result, contemporary transit means are outfitted with a variety of transmission and navigational technologies. As a result, each component of an important transport kind is linked to the others. Diverse transportation channels are interlinked with one another to provide a transnational transport network, expanding the linkages within a given channel. Only with concept of intelligent transportation systems (ITS), vehicular ad hoc networks (VANET) have gotten a lot of consideration [14]. VANETs have been extensively employed to control traffic jams in metropolitan outskirts by utilising vehicle-to-vehicle (VV) and vehicle-to-infrastructure (VI) connection capacity.

Because of proper communication abilities, transportation systems can now function effectively based on real-time data. Moreover, smart public

transportation notifies passengers about street traffic, alternate routes, other transit mediums, and so on. Furthermore, smart public transportation imposes measures of safety and security for customers and walkers while also enhancing quality. Modern systems, as a result, provide global airline hubs, smart road infrastructure, intercity rail networks, metro and subway station networks, safety integrated public transit, protected cycle routes, and guarded pedestrian walkways [14]. In conclusion, incorporating smart transport networks into smart cities improves municipal efficiency and productivity while improving time, cost, dependability, and security of municipal transport.

In contrast, RFID-enabled fare gathering, smart parking, airport security at airports, and hiring and monitoring taxis via smartphone platforms are examples of unique mobility uses. Combining these new elements of transportation networks improves urban people' quality of life while maintaining the city's viability.

### B. Smart Healthcare

Smart healthcare refers to the confluence of traditional medical practises with modern medical intervention techniques, such as medical devices, sensors, wearable technology, rescue services, and

ICT. Modern intelligent healthcare services use sensor networks, ICT, cloud computing, fog computing, applications for smart phones and strong data processing technologies to meet requirements and enhance quality of the service. Smart healthcare services disclose delicate patient information to authorised users, such as physicians, caregivers, and lab technicians, through a protected major hospital network to increase real difference processing on individuals' conditions [15]. Furthermore, centrally maintained electronic health records (EHR) enable ultimate decision taking using the most up-to-date facts.

An IoT-enabled health insurance system that analyzes and monitors individuals, healthcare professionals, and medical implants autonomously. RFID, WSN, and smart mobile capabilities are used in the intelligent system hospital environment, and they are linked via CoAP. Another healthcare monitoring paradigm that envisions a data-driven, mobile, and cloud-based smart healthcare system. A perspective data aggregation smart healthcare system is used to resolve ambiguity in diverse circumstances. Effective health predictive maintenance a higher quality of life for city dwellers. Thus, integrated smart health within smart cities is expected to be a significant advance in the worldwide implementation of the smart city concept [16].

Sensor network that are worn monitor physiologic parameters. Sensors that detect vital signs - pulse, respiration rate, and skin temperature - are suggested since they are the fundamental signals for pressing needs health. Blood pressure and blood oxygen detectors might also be used, as these values are frequently measured along all three crucial signs. For devices that concentrate on a particular state, special-purpose detectors including such blood-glucose, monitoring devices, and angular position sensors might be used [17]. The information out from sensor network is received by the central hub. It analyses this data, may make certain decisions, and then passes it onto an external site. A specialized base station would be preferable than a smartphone since having just capabilities essential to a medical IoT system will enhance battery capacity.

## V. CHALLENGES

- One of the primary problems for actual smart city deployment is the expense of construction and upkeep. The cost is divided into two categories: design cost and operating cost. The cost of design is the economic centre needed to install the smart city. As a result, the lower the development cost, the greater the likelihood of real-world adoption.

Daily municipal maintenance and operating chores generate operational expenditures. Low operating costs are strongly desired to ensure the long-term viability of service supply without putting further cost burden on municipalities. Therefore, cost control over the lifespan of a smart city remains a difficult challenge.

- Smart cities are made up of cross and multi-purpose monitors, devices, and gadgets, among other things. The capability to bring together each of these disparate items at the application layer is critical to realising the smart city concept. Yet, system mismatches caused by diversity impede the ability to communicate and interconnect at the application layer. While providing accessibility is a time-consuming and difficult endeavour, smart cities concentrate on selecting, and acquiring equipment and programming that permits the combination of these diverse components.

- Smart connected cities are committed to safeguarding the city ecosystem and supplies for coming generations by reducing carbon footprints and utilising commodities more wisely. As a result, contemporary cities are focused on sources of renewable energy to decrease their environmental footprint whilst also maintaining the long-term viability of municipal activities and non-renewable resources.

- As a result of pollution and open dumping, waste disposal is yet another major concern in today's smart cities. The ultimate goal of intelligent waste management is to accelerate the collecting and sorting procedures.

## VI. RECOMMENDATIONS

- The concept of smart cities is still growing, and exploration and deployment are restricted to industrialised countries. Singapore have made efforts to monitor daily life by leveraging citywide sensor information. The advantages of smart cities, on the other hand, are diverse and relevant to every urban context. As a result, more research on cost-effective design and execution is greatly sought in order to popularise the smart city strategy across the globe.

- Smart gadgets create massive amounts of data, necessitating massive data storage. Traditional data handling approaches and methods are becoming outdated for usage in new smart city designs as a consequence of Big Data creation. As a result, it is critical to investigate and incorporate Big Data insights into smarter city ecosystems. In reality, just a few research aimed to tackle this problem. Yet, the majority of them are concepts that have not

been tested in real-world circumstances. As a result, presenting and testing Big Data analytics in real-world smart cities is a viable research avenue for prospective smart cities.

- Another important field of research is maximising the benefits of embedded systems. To provide prompt and dependable offerings, smart cities combine numerous components at the application level. Decomposition at the application layer is something worth investigating deeper. Because of its ubiquitous availability, the web-inspired IoT concept is considered as an attractive alternative for integrating potential uses. As a consequence, despite inconsistencies in operating platforms and wireless communications, smart city elements will indeed be capable of interacting with one another.

### C. CONCLUSION

The smart city nation evolved as an IoT particular application. Smart city distinguishes out between identified several keys that use ICT in urban environments, such as smart cities, greener city, town centre, measures to effectively, and so forth due to its comprehensive perspective. In other words, smart cities are a synthesis of many urban

ecosystem managing projects. In perspective of concepts, norms, and ramifications, this study addressed the principles of a smart city. The qualities and attributes are given in a straightforward way to assist readers get the core of the smart city concept. Following a detailed examination of suggested smart city designs, the architecture consists of a smart city is outlined. A smart city is a platform that promotes interconnection across many subsystems in a bid to enhance urban people' quality of life. To recognise the significance of the architecture, the major parts that comprise a smart city are all now discussed in detail. Despite the fact that smart cities have evolved into a term in the contemporary environment, it faces significant hurdles and challenges owing to massive data processing applications and the diversity of linked smart objects. Few discovered obstacles and potential areas for improvement are presented to increase the knowledge, understanding and give recommendations for future study.

### REFERENCES

- [1] Kumar, T. V., & Dahiva, B. (2017). Smart economy in smart cities. *Smart economy in smart cities*, 3-76.
- [2] Rathore, M.M.; Ahmad, A.; Paul, A.; Rho, S. Urban planning and building smart cities based on the Internet of Things using Big Data analytics. *Comput. Netw.* **2016**, *101*, 63–80.
- [3] Haras, M., & Skotnicki, T. (2018). Thermoelectricity for IoT—A review. *Nano Energy*, *54*, 461-476.
- [4] Hancke, G.; Silva, B.; Hancke, G., Jr. The Role of Advanced Sensing in Smart Cities. *Sensors* **2012**, *13*, 393–425.
- [5] Angelidou, M. (2017). The role of smart city characteristics in the plans of fifteen cities. *Journal of Urban Technology*, *24*(4), 3-28.
- [7] Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of urban technology*, *18*(2), 65-82.
- [8] Kosmatos, E.A.; Tselikas, N.D.; Boucouvalas, A.C. Integrating RFIDs and Smart Objects into a Unified Internet of Things Architecture. *Adv. Internet Things* **2011**, *1*, 5.
- [9] Hancke, G.; Silva, B.; Hancke, G., Jr. The Role of Advanced Sensing in Smart Cities. *Sensors* **2012**, *13*, 393–425.
- [10] Zanella, A.; Bui, N.; Castellani, A.; Vangelista, L.; Zorzi, M. Internet of Things for Smart Cities. *IEEE Internet Things J.* **2014**, *1*, 22–32.
- [11] Mocrii, D., Chen, Y., & Musilek, P. (2018). IoT-based smart homes: A review of system architecture, software, communications, privacy and security. *Internet of Things*, *1*, 81-98.
- [12] Sharma, Vinod Kumar, Rajesh Singh, Anita Gehlot, Dharam Buddhi, Simone Braccio, Neeraj Priyadarshi, and Baseem Khan. "Imperative role of photovoltaic and concentrating solar power technologies towards renewable energy generation." *International Journal of Photoenergy* 2022 (2022).
- [13] Govindrai, V., Sathivanarayanan, M., & Abubakar, B. (2017, August). Customary homes to smart homes using Internet of Things (IoT) and mobile application. In 2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon) (pp. 1059-1063). IEEE.
- [14] Hasrouny, H., Samhat, A. E., Bassil, C., & Laouti, A. (2017). VANet security challenges and solutions: A survey. *Vehicular Communications*, *7*, 7-20.
- [15] Agarwal, Y., Jain, K., & Karabasoglu, O. (2018). Smart vehicle monitoring and assistance using cloud computing in vehicular Ad Hoc networks. *International Journal of Transportation Science and Technology*, *7*(1), 60-73.
- [16] Ahad, A., Tahir, M., Aman Sheikh, M., Ahmed, K. I., Mughees, A., & Numani, A. (2020). Technologies trend towards 5G network for smart health-care using IoT: A review. *Sensors*, *20*(14), 4047.
- [17] Tiwari, A., Dhiman, V., Iesa, M. A., Alsarhan, H., Mehbodniya, A., & Shabaz, M. (2021). Patient behavioral analysis with smart healthcare and IoT. *Behavioural Neurology*, 2021.
- [18] Thakur, Amit Kumar, Rajesh Singh, Anita Gehlot, Ajay Kumar Kaviti, Ronald Aseer, Subbarama Kousik Suraparaju, Sendhil Kumar Natarajan, and Vineet Singh Sikarwar. "Advancements in solar technologies for sustainable development of agricultural sector in India: a comprehensive review on challenges and opportunities." *Environmental Science and Pollution Research* 29, no. 29 (2022): 43607-43634.