Sustainable Smart City to Society 5.0: State-of-the-Art and Research Challenges

Priyanka Mishra, Prabhat Thakur and Ghanshyam Singh

Abstract— **With the growth of data traffic, demand of huge number of digital devices and their interconnection to establish a reliable communication, the internet has become a potential demand of the society. To develop a system that securely connects the internet to real-world space would aid in the advancement of a human-centered society that balances economic progress with the resolution of social issues. This paper provides a detailed aspect of Society 5.0 with its requirements, architecture, and components. We have proceeded extensively with the state-of-the-art Society 5.0 and its link with Industry 4.0/5.0. Furthermore, the role of Society 5.0 in the sustainable development goals of the United Nations is well elaborated. Several emerging communication and computing technologies such 5G/5G-Internet of Things (IoT), edge computing/ cloud computing/ fog computing, Internet of everything, blockchain, and beyond networks have been also well explored to fulfill the demands of Society 5.0. The potential application of super smart cities (Society 5.0) with some real-time experience of inhabitants is thoroughly discussed. Finally, we highlighted several open research challenges with opportunities.**

Index Terms— **Smart City; Internet of Things (IoT); Society 5.0; Sustainable Development Goals (SDGs); Information Communication Technology (ICT); Smart City Architecture.**

I. INTRODUCTION

THE developed urban (urbanization) environments where any inhabitant can use any service anywhere and anytime is known as sustainable smart cities and plays an integral role in the economic and societal progress. According to the projections of United Nation World Urbanization Prospects 2018 [1], nearly 70% of the world population will live in urban areas by 2050. However, several megacities are already under pressure to cope with the current inflow of people, therefore the research fraternity are working to create sustainable smart cities (city of tomorrow) in order to make these urban areas more livable and truly sustainable. The concept of sustainable smart city is to create liveable, sustainable, and prosperous societies through the state-of-the-art across the waste management, mobility, water, buildings, heating and cooling, and smart energy systems, however, it also put strains on a city's infrastructure [2]. Further, the infrastructure and services in the sustainable smart city must be more efficient and environment friendly as well accessible to all inhabitants. Hence, the sustainable smart city will enhance the quality of life of inhabitant to reduce the ecological footprint of the cities and ultimately support to achieve the United Nations Sustainability Development Goals (UN-SDGs). The sustainable smart cities address the social, environmental, and economic impacts of urban planning and administration. However, the focus is on the technological solutions for significantly more efficient urban development. The sustainable development usually refers to issues within the administrative boundaries of the city. In the ever-growing urbanization, the demand for efficient application as well as management of natural/manmade resources, efficient with speedy commutation/transportation, growing demand of healthy environment, public safety with efficient energy consumption are the major driving factors for the development of sustainable smart cities market [3]. As per the global forecast, the focus research areas of the smart cities market are the intelligent transport systems, smart buildings, smart utilities, smart inhabitant services such as public safety, smart and connected healthcare, smart education, smart street lighting/smart energy, and e-governance. As per the smart city market forecast [3], the smart city market size will grow up to USD 873.7 billion by 2026 as compared to USD 457.0 billion in 2021 with a compound annual growth rate (CAGR) of 13.8% during the forecast period [3].

A revitalized industry will, in turn, have a transformational effect on society. Industry 4.0 has shifted away from fundamental ideas like social justice and sustainability and focused more on digitalization and Artificial Intelligence (AI) driven technologies for improved production efficiency and flexibility over the last decade. Industry 4.0 refers to a future vision for technological innovation and further technological development of European industries [4]. Due to the changing world and economy, it explains how industry will utilize technology to better manage. Currently, the Industry 5.0 takes a different approach, emphasizing the role of research and innovation in assisting industry in providing long-term service to the humanity. Industry 5.0 is an open and evolving concept that is intended to serve as a platform for the development of a collaborative and cooperative vision for European industry of the future. A key part of Industry 5.0 is the integration of the physical and virtual worlds. It includes innovations and cost cutting that benefit all parties involved, whether they are consumers, workers, investors, environment, or the society. The human centricity, sustainability, and resilience are the three attributes of Industry 5.0. Entrepreneur can be resilient providers of prosperity by adhering to our planet's boundaries and prioritizing the wellbeing of their workers. This approach recognizes the potential of industry to achieve social goals beyond job creation. Industries need to be environmentally aware and design circular processes for reusing, recycling and repurposing natural resources, while reducing waste and pollution. To achieve sustainability, energy consumption and greenhouse gas emissions must be lowered to avoid depleting

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natural resources, and to meet the demands of current generations without putting future generations at risk. Improved resource efficiency and reduced waste can be accomplished using technologies like, AI and additive manufacturing. By "resilience", we mean improving industrial production's robustness, equipping it better against disruptions, and supporting it in times of crisis. Eventually, we can say that companies and workers both benefit from Industry 5.0. It is not surprising that Industry 5.0 and Society 5.0 are related, since both describe fundamental changes to our economy and society. However, the main purpose of Society 5.0 is to build a balance between the economic growth and management of society with an environmental issue. By integrating physical and virtual spaces, the technology does not focus exclusively on the manufacturing sector, but also deals with larger social issues. Therefore, the Society 5.0 is a society based on advanced technologies and augmented reality, which are mostly used to benefit and facilitate citizens/inhabitants [5, 6].

To achieve the balance between commercial progress and social issues through a network that tightly connects the internet and real space is the main motive of Society 5.0. Although, the Society 5.0 appears to be radically new in nature due to its use of futuristic technologies. In fact, it is based on categories of societal members that have existed since Society 1.0 (hunter age of human progress) and even the earliest human civilizations. Further, we have now moved from the agricultural (Society 2.0) to industrial (Society 3.0) eras and are heading beyond the information society (Society 4.0). AI that will reach every nook of society as depicted in Fig. 1, has transformed the Internet of Things (IoT) collected big data. The goal of Society 5.0 is to build a society in which societal constraints are addressed by emerging technologies such as 5th generation/6th generation (5G/6G) communication systems, IoT, AI, big data, with other emerging communication, computing and sensing/actuation technologies into the industrial and social life. The global trend into a more sophisticated model of society, which is now associated with Industry 4.0/5.0, necessitates the creation of a super intellectual Society 5.0. The establishment of a highly intellectual Society 5.0 is necessitated by the worldwide trend toward a more advanced model of society, which is fully related to the industrial revolutions. Further, it is defined as a human-centered civilization that achieves a ratio of economic growth and social issues resolution through a system that tightly connects online and physical space.

Currently, the IoT has become a key technology of the smart cities and targeting to overcoming the challenges inherent in traditional urban developments. This involves a network of physical objects containing embedded technologies to sense, collect, compute/process, communicate, and interact with their internal states or external environment through the wireless or wired connections. This technology uses unique addressing schemes and network infrastructures to create new application or services. The nature of IoT information exchange among the connected objects and remote locations for data storage and data processing provides an ability to collect numerous amounts of data about individuals, and other things in the sustainable smart city. New urban approaches as a Society 5.0 have been developed as an alternative way to make sustainable human settlements have emerged recently [7].

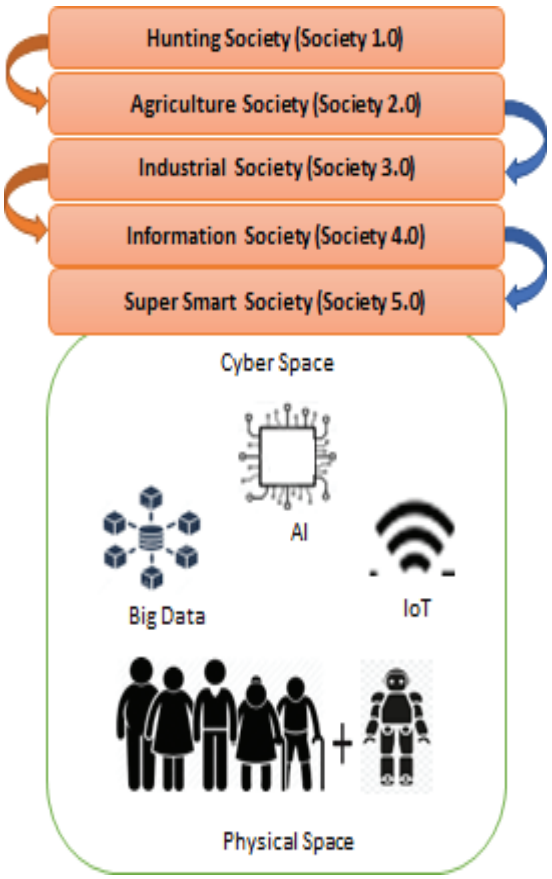


Figure 1: Realization of Society 5.0 with its evolutions and involvement of emerging technologies.

The concept of IoT has been introduced for the realization of a sustainable smart city/Society 5.0. The rapid development of IoT technology encouraging researchers to create its recent potential applications [8] with context to the sustainable smart cities and bring awareness about exchange of data/information collection within IoT services [9]. Further, the AI enhances the city's ability to respond to urban challenges especially, in the densely populated cities. In addition, information and communication technology (ICT) for the better management of resources has been integrated into the city expansion, which enhances the quality of life and provides better quality of services to the inhabitant. In a sustainable smart city infrastructure, the ICT provides potential development in various aspects of society such as health quality, mobility management, resource management etc. Several researchers have explored different theories for a sustainable smart city. Silva et al. [10] have outlined the demand to establish connection among social, physical, business, and ICT infrastructure to enhance urban intelligence. Further, an environment monitoring [11] and living standards (climate, transport, environment, and human flow) [12] in a sustainable smart city are presented. Deshpande et al. [13] have suggested about an intelligent urban environment embedded in ICT technology to improve the city's daily functioning and performance in individuals. This reported literature provides research on smart governance, smart transportation, smart infrastructure, smart healthcare, and smart security.

A. Contributions

In this paper, we have prioritized the concept of Society 5.0 with sustainable smart city by determining available themes in this research. The presented work in this paper examines the sustainable smart city to Society 5.0 concept from a technical, societal, and economic perspective. Further, we have emphasized on the modern technologies and their involvement in the design of smart cities. Various reported literatures in this area explores the sustainable smart city concept from the perspective of technologies such as AI, blockchain, big data, IoT/IoE (Internet of Everything), ICT, 6G etc. The paper contributes to the area by providing a comprehensive overview that constitutes fundamental challenges in the development of a super sustainable smart city. The contribution of author's is summarized as follows.

- We have introduced various facets of Society 5.0 from available literature, which aids in gaining a better knowledge of it from various aspects. Further, we discussed number of additional features of Society 5.0 comparing with Industry 4.0/5.0 evolutions.
- Further, we have presented most promising key enabling technologies extensively and their requirements to be developed for Society 5.0, including IoE, COBOTs, edge computing (EC), digital twins (DT), big data analytics, blockchain, and future 6G communication systems and beyond.
- We have explored and connect the United Nations Sustainability Development Goals with the Society 5.0.
- Despite extensive research and development efforts, Society 5.0 faces numerous issues and challenges. Finally, we describe these challenges in terms of essential social needs, privacy, security, and rights. In addition, we outline possible research avenues for achieving Society 5.0.

B. Organization of paper

The rest of the paper is organized as follows. A background of Society 5.0, its relation with Industrial Revolution and requirements in the current global scenarios are presented in Section II and III, respectively. The sustainable smart city architecture with its connection to the Society 5.0 is presented in Section IV. In Section V, several components of the sustainable smart city are analyzed including smart governance, smart transportation, smart building and infrastructure, smart technology, and smart healthcare. SDGs for Society 5.0 are presented in Section VI. The potential research challenges, issues and opportunities are explored in Section VII. Finally, Section VIII concludes the paper and recommends the future scope.

II. Background of Society 5.0 and its Relationship with Industrial Revolution

With the Industry 4.0, the idea is focusing only on the industrial output however with Society 5.0, it is seeking to expand into every aspect of society [14, 15]. Industry 4.0 entails collaboration among private enterprises and academia to establish systems with the government who provides a budget for research and development [16]. With the use of technologies, the main aim of Society 5.0 is to boost the Japanese society's growth pace and reduce the inverse impacts such as an aging people in the society [17-19]. Recently, several efficient and effective systems have been established, utilizing technology such as cyber physical systems (CPS), AI, and IoT [20,21]. The primary technologies are AI, cloud computing, big data, CPS, and IoT. A massive quantity of information is collected in the area of both industry and day-to-day life because of rapid technological development, and all of these data are referred to as big data, which is obtained, from a variety of sources. The collected big data are unprocessed data, and their precise deceit via AI has a significant impact on the business. A cloud system is required to store large amounts of data and undertake fast analysis. The utilization of a cloud-based system is available by hiring them from different companies with the internet connectivity. Japan has agreed to establish Society 5.0 to resolve various societal issues and prioritizes its precedence according to the innovation, technology, science, and the UN SDGs. However, the AI is considered the solution to many problems pertaining to Society 5.0, such as unemployment, poverty, and air pollution. Two prominent subsets of AI are the machine learning (ML) and deep learning (DL). The machine learning is an AI technique that get smarter, smarter over time without human intervention and self-learned based on the algorithm. It entails enabling a machine to learn more efficiently and intelligently. The purpose of the machine learning process by making AI solutions speedier and smarter to provide intelligently best results. ML approaches are in great demand since AI technology has the potential to have such a large impact on society and modern business practices, such as strategy, logistics, management, and manufacturing. It's already been used for a wide range of tasks, and especially, useful for applications that need collecting, analyzing, and responding to volumes of data. This technique is very effective in a wide range of applications, including healthcare, retail, manufacturing, banking and finance, and transportation. Similarly, the other subset of AI that is DL approaches are gaining attraction in a variety of social settings and applied on large data sets. Nevertheless, there are many challenges, including data security, management, latency, and scalability. In order to address these issues, DL-based IoT-oriented architecture for a secure society is advantageous as reported in detail in [22]. At the application layer, a deep learning-based cloud is used to address communication latency, centralization, and scalability. It enables cost-effective, high-performance computing resources in Society 5.0 applications.

While comparing Industry 4.0/5.0 to Society 5.0, it becomes clear that both use similar technologies such AI, cyber physical systems, IoT, big data, robotics, and the cloud [23]. Although, Industry 4.0/5.0 is efficient in a confined region since its specific area is the industry Society 5.0 takes the entire society as its practice region, which includes the industry. Furthermore, numerous social issues are addressed in Society 5.0, such as healthcare, hunger, wealth, food and clean water, modern agricultural methods, and women rights [24]. Nevertheless, the Society 5.0 includes all the SDGs. There is a significant paradox in Japan's development plan for a modernized community with high income and leading techniques. A plan for infrastructure systems is being developed through Society 5.0 in an effective manner. A system tries to figure out how to solve problems by implementing known enabling technologies [25]. This will play a significant role in moving towards Society

5.0. In order to build a sustainable structure, Society 5.0 aims to better integrate women into the workplace and develop agricultural and food applications using smart technology [26]. The Society 5.0 tries to find solutions to society's problems. As a disruptive technology across many industries, cyber-physical systems have a strong impact on economies and society. They have many potential applications, from agriculture to manufacturing, and from critical infrastructure to assistive living, by challenging business, law and technology [27]. There are many economic and social problems including the aging population, labour shortages, and slow economic growth, which will influence the society. The model is primarily concerned with developing a human-centred society and uses technology and creativity to do so. Japan has a goal of becoming the first country to demonstrate that you can grow through innovation even with a declining population [28]. Analysis of 51 OGD (Open government data) portals is discussed in [29]. A review of 60 countries and their OGD portals (51 OGD portals in May 2021) was conducted to determine if they met the Society 5.0 and Industry 4.0 trends through the examination of relevant OGD portals. New eras with cutting-edge technologies are not necessarily built on the extension of current eras. It's also an era marked by "uncertainties". Because of the uncertainty, the industry needs to transform on its own to take the lead [30]. As discussed by Piorunkiewicz and Zdonek [31], there are similarities between open data and the concepts of Society 5.0 and Industry 4.0. These similarities relate to human-centered action, sustainable development, and the physical-to-digital-to-physical loop in conjunction with the OGD portal, combined with geospatial data and real-time data to ensure the sustainable development of a human-centered society.

The role of humans in developing policy and making decisions process is essential to achieving an inclusive and sustainable society. Shiroishi et al. in [32] outline the challenges of achieving the SDGs in Society 5.0 using AI to develop evidence-based policy. Further, Nikiforova [33] have analyzed 60 government portals content in order to determine their matches with the expectations of Society 5.0 and presented in order to assess their content, which reflects the expectation of Society 5.0.

III. Requirements of Society 5.0

The potential requirements for future applications of IoT based "Smart City", the current generation of wireless communication systems need to be enhanced and radical new technologies are required to address the constraints, challenges, and applications of next generation wireless communication systems. The real value of 5G will be realized in automation, smart cities, IoT applications, etc. It must have extremely high capacity (exceeding 100 Gbps), low latency, massive device, high coverage, high reliability, low energy, long battery life, and low cost. Fifth generation mobile communication is going to replace multiple-input multiple-output (MIMO) with massive MIMO to enhance the channel capacity and centralized systems with distributed systems i.e., device to device (D2D) communication. The advantages of having more antennas are capacity gain, diversity gain, and improved bandwidth achieved by transmitting a different stream of data from each antenna. The same data stream is transmitted over each of the transmit antennas in an orthogonal or near orthogonal manner. This exploits multipath fading to its advantage, thereby improving the reliability of the received signal. With a large number of transmitting and receive antennas, diversity gain improves with the number of antennas. Having a large number of antennas allows directing the transmitted signal to very narrow regions in space, referred to as beamforming, mitigating the effects of interference. A sustainable smart city is classified into two parts: one is requirement for the sustainable smart city and second is specification required for these requirements.

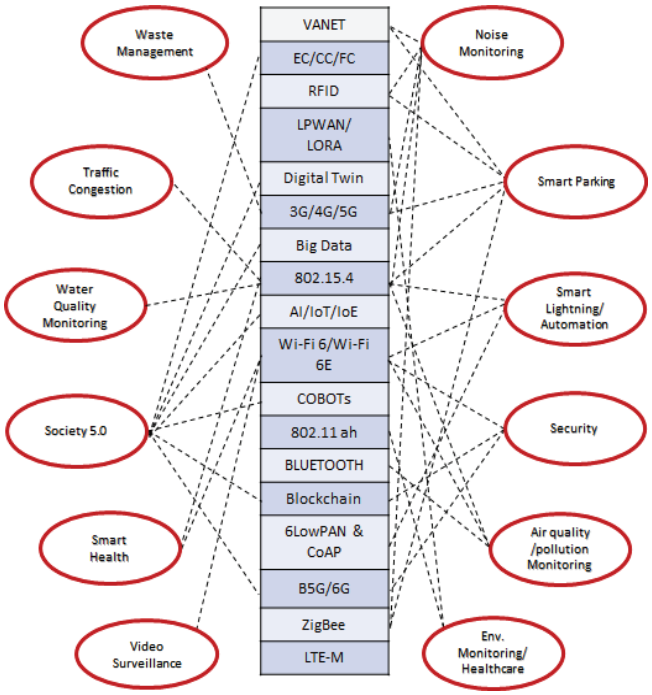


Figure 2: Enabling technologies employed in different domains of Sustainable Smart City.

The main requirement of the sustainable smart city is data rate, or the information rate specified by International Telecommunication Union (ITU) for fifth generation i.e., almost 100 Gbps, because the average rate must be ranging between 10-20 Gbps. This is determined by the closeness towards the Shannon Capacity i.e., maximum achievable capacity in an error-free environment. Therefore, how close we can get with Shannon to achieve a data rate that is compatible to 5G specified by ITU depends on the signal to noise ratio and bandwidth. The second is distributed systems, from a base station to D2D or machine-to-machine (M2M) communication, which means two devices, can operate without any requirement of base stations. The only concept is to replace the heavy base stations because of transferring power from the base station to devices i.e., transferring the power from the centralized system to the distributed systems. Now, in specifications, we have power optimization and reliability. In reliability, the link must be reliable to provide a degree of freedom. If there is an error in one link, we should be able to use another link. Power optimization is the power efficiency that means how power is distributed power fairly among the users; this brings fairness among the users at very low and finite power for long battery life.

The 5G wireless communication networks has become a key driver for 5G-IoT due to the demand of large data exchange rate with huge numbers of connected devices which supports low-latency, use cases at the network edge, thereby empowering communication service providers (CSPs) and enterprises to connect mobile IoT devices, data centres, and public/private cloud platforms. Further, the advancement of Long-Term Evolution-Advanced (LTE-A) to 5G is expected to gain pace to support the requirements of emerging IoT applications which are categorized as massive machine-type communication and mission-critical applications [34].

As shown in Fig. 2, various communication, computing, sensing and other wireless technologies domains are all involved in Society 5.0 and plays an important role in a range of applications by adopting enabling technologies such as EC, DT, IoE, big data analytics, COBOTs, 6G, blockchain, etc. Further, an innovative thinking and cognitive skills can increase the competitiveness of industries with all these enabling technologies. Through the growth of EC, the Society 5.0 has minimized latency, reduced network bandwidth, improved privacy and security of data, and facilitated transactions that were previously affected by problems in connectivity. It enables societies to exchange information using standard hardware and software resources. The DT aids super smart cities in overcoming technological issues by detecting them more quickly, developing better decisions, forecasting future failures, and avoiding big financial loss. COBOTs are utilized to boost productivity while also reinforcing a new human-machine relationship. By removing the bottlenecks on channels of communication and lowering latency, the IoE gives a chance to minimize operational expenses [35]. Manufacturers for real-time analysis to help them produce and manage massive amounts of data in big data can use the data from smart systems and data centers. The blockchain provides authentication and automated service-oriented operations with enhancing security. In the next generation networks, the 6G networks will address the demands of intelligent information society, as well as high-energy efficiency, high reliability with low latency.

IV. Sustainable Smart City Architecture

The experts are being convened to define sustainable smart city architecture to facilitate real-world future city placement. However, to determine the possibility of sustainable smart city architecture for the real world is an extension of the far-off case, but it is theoretically possible. The radical variation of property is required to limit the overall architecture is not real. The vision of 5G-IoT solutions will create a city of tomorrow that is a sustainable smart city where humans and technology will interact in connected and intelligent ecosystems. The municipalities will be able to turn infrastructure such as roads, streetlights, water, energy, waste and traffic signals management into smart city resources that can deliver real-time data and information, which will assist for instance to reduce the congestion and improve the quality and services of the inhabitants. For this vision of a sustainable smart city to become a reality, several aspects at technological, business, legal and regulatory levels, need to be properly addressed in order to ensure the scalability, reliability, security and liability aspects are properly tackled in increasingly diverse application scenarios, especially considering that by 2050, 68% of the entire world's population will live in urban areas [36]. To face such massive urban population growth and empower the next generation smart cities, businesses and public authorities are increasingly investing in 5G-IoT technologies, with spending that is predicted to reach USD 158 billion in 2022 [37]. The sustainable smart cities services will rely on big data analytics fed by data captured through IoT sensors and networks, with edge computing bringing data storage and processing closer to the data source and 5G networks ensuring ultra-fast and reliable data transfer, while connecting sensors and smart assets [38]. Global 5G-IoT market size is expected to grow up to billion 40.2 USD by 2026 which is 73% CAGR as compared to 2.6 billion USD in 2021 [34]. Thus, the 5G is foreseen as a strongest enabler in the development of IoT market due to its high processing speed, massive capacity, and super low latency. The 5G-IoT network has the potentiality to support a massive number of communication devices, which have a distinct range of speed, bandwidth, and quality-of-service (QoS) requirements. Due to broad bandwidth, massive scalability, high reliability, low latency, and unprecedented speed of the 5G network planned applications, such as autonomous vehicles, consumer virtual reality/ augmented reality (VR/AR) with high data rate and rapid response requirements enables faster implementation of these technologies [34].

Making a city truly 'smart' means turning a city into a platform of growth for innovation, economic development and well-being. By adopting common standards and information models, cities can achieve this transformation with minimum impact, joining forces to build an ecosystem where they can connect and collaborate. 5G will play a major role in connectivity within Smart Cities of the future especially when it comes to close to real-time data management like autonomously driving cars or flying drones. We have presented the upended architecture illustrated in Fig. 3 for an in-depth analysis of several existing architectural models discussed in most of the reported literature. There are four main components of the presented architecture: 1) the sensing layer, 2) transmission management layer, 3) data layer, and 4) application layer. Further, the privacy and security of the information are also very important concerns for the sustainable smart city. Therefore, the securities devices have to be integrated into each of the layers. The information collection of the physical devices is the main task of sensing devices, which is located near the bottom of the structure. The communication devices assist to communicate information to the next layer.

Sensing layer: The lowest layer of the IoT is the sensing layer comprises the wireless sensor network, smart devices, and data grabbing devices use to capture data from devices and sensors. It offers various methods [13] to improve the performance of data collection and storage in various frameworks depending upon various parameters like pressure, temperature, light, humidity, etc. radio frequency identification (RFID) sensors, cameras, GPS, actuators, Bluetooth, Zigbee are different sensing equipment used by experts [39]. Mostly based on literature, the intelligence of cities is growing along with the occupancy of sensor networks [40]. Further, the sensing layer collects information from different mediums and infrastructure, resulting in an increasing number of connected devices in the sustainable smart city network.

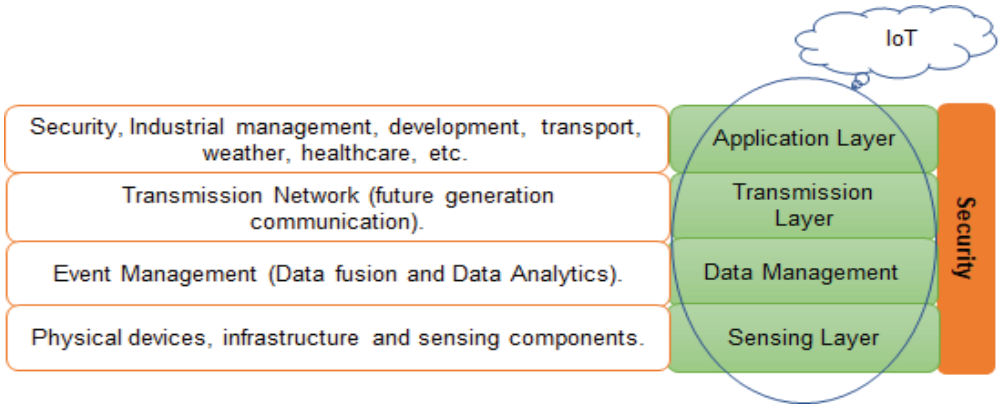


Figure 3: ICT architecture with IoT for sustainable smart city.

Transmission Layer: The transmission layer acts as the support of the sustainable smart city building. It is basically, meeting of different communication networks [41], consists of many wired, wireless, or satellite technology. In terms of coverage, it is classified into access and network transmission. Small range coverage technology i.e., Zigbee, near field communication (NFC), Bluetooth, M2M, and Z wave are access network technologies. The same technique to provide wider coverage in transmission networks technologies are 3G/4G LTE/5G, LoRA, and low power wide area network (LPWAN). For the identification of any object or person, RFID technology makes use of a part of the electromagnetic spectrum. However, it does a good job of identifying all of the things seen from afar, similar to system of bar codes. NFC is a network technology that allows two devices to communicate and identify each other over a ten centimetres distance. Bluetooth wireless technology is a well-known technology for access to the network, which greatly reduces the power consumption of the communication on the part of short-wave radio signals. Zigbee is self-organized, reliable, and offers communication at a very low power within a range of 10m with an expendable battery [42]. LTE has been the leading-edge wireless technology, a 4G network, which has proven its advantage over 3G, Wi-Fi and WiMAX, in terms of increased bandwidth, faster data transfer speeds, and low latency. However, the fifth generation is a prominent technology that supports massive MIMO to transfer bulk data in gigabit [43]. Cellular service providers use licenses, bandwidth to offer mobile services, and Wi-Fi works on unlicensed frequency bands offering high bandwidth. LPWAN is a promising and novel transmission networking model for smart cities intent to improve the energy efficiency of industrial networking [44] for wide area coverage at low power. Light fidelity (Li-Fi) is another trend in data transmission techniques that uses ambient light-emitting diodes (LEDs) to transmit data. Based on the availability of spectrum, as well as the potential of high-speed communication, Li-Fi is considered as the future of the wireless communication network.

Data Management Layer: The data management layer act as the brain of the sustainable smart city that exists in the middle of the application and the acquisition layer works on analysing, organizing, storing, manipulating, and decision-making operation of data. The most fundamental job of the data layer is to sustain the viability of information, mainly, aims at maintenance and data cleaning.

Application Layer: The application layer is the topmost level of the sustainable smart city architecture that works between city residents and information storage management. The performance has a very strong impact from the user's point of view, which directly deals with the citizen himself. Most importantly, the services provided include is the smart transport, the development of the community, etc. Thus, facilitating sharing of data via. different applications are seemed to be favourable for the development of a society.

V. Components of Sustainable Smart City

The components of Smart cities are smart government, smart transportation, smart healthcare, smart technology, smart building & infrastructure, smart environment, smart economy, and smart people [45]. These dimensions deal with the participation in decision making, public and social services [46], transparent governance, political strategies, and perspectives, level of qualification, social and ethnic plurality, flexibility, creativity, cultural facilities, health conditions, quality education facilities, touristic attractively, local accessibility, national/international accessibility, ICT-infrastructure, sustainable, innovative, and safe transport systems, innovative spirit, entrepreneurship, ability to transform, attractivity of natural conditions, pollution environmental protection and sustainable resource management [47]. Some of the components are discussed in this section as depicted in Fig. 4.

A. Smart Governance

Governments can effectively make use of social media to encourage people to contribute and work with smart cities. In addition, smart governments should not only advance in the pursuit of technological advancement but also, must have sound governance and wise policies [48]. In [49], it has been demonstrated that using social media is a viable technique; however, the government must have a role in this. Successful governments in smart cities rely upon giving good services to the inhabitants. The requirements for the sustainable management of resource efficient services must be promoted by cloud-based Information Systems services [50]. To enhance citizen assistance, Information systems and related services

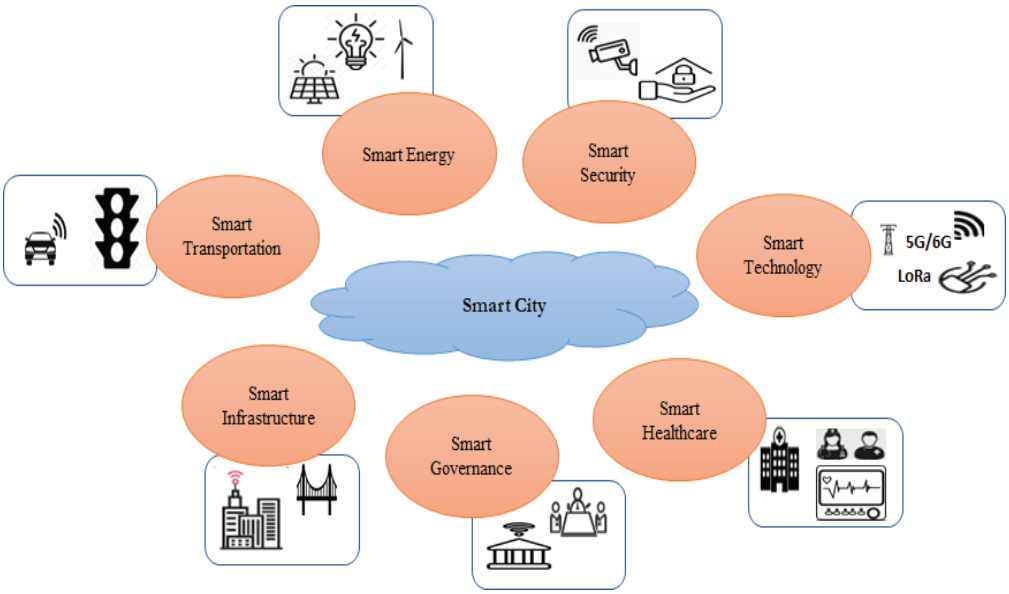


Figure 4: Potential components of the sustainable smart city.

should be encouraged through collaboration between stakeholders and government organizations; therefore, building association in any area can enhance the effectiveness of the intelligent governance approach.

B. Smart Transportation

Transportation is a need for humankind since the dawn of culture. The advent of technology has increased this need for road transport, rail transport, water transport, and air transport. Modernized transportation systems are integrated into a variety of navigation and communication systems. In addition, smart travel systems transmit information related to traffic congestion levels, alternative routes, etc. for passengers. Furthermore, passenger and pedestrian safety and security measures are enforced in smart travel systems and to improve performance. Similarly, modern systems provide global air transport facilities, smart road networks, intersection trains, underground rail and municipal networks, community connected safety, secure lanes, and protected pedestrian routes. An algorithm for detecting air transport conflicts in the next generation was proposed by Hwang and Seah [51] to figure out and prevent air traffic accidents by exchanging flight information. Management in railway system suggested by Mazzarello and Ottaviani [52] raises time and fuel efficiency and avoids clash by providing real time directions on travel speeds. Similarly, experts also worked on governing overcrowding and conflicts in railway networks. Various studies were conducted on road management [53] and road safety. In addition, the new transport applications involve the collection of RFID equipped tolls, passport control at airports, parking management, and the hiring and follow up of taxis via mobile applications. Since the cars with GPS devices and cell phones are familiar with all drivers, many routes use global positioning systems (GPS) information to monitor driver's location and traffic model [54]. This real-time information has been used for public transportation planning. Drivers can also be directed to a nearby free parking location using feature parking systems.

C. Smart Buildings and Infrastructure

A smart power grid, often known as a smart grid, is a type of smart infrastructure. It consists of a variety of energy sources, performance control systems, load balancing methods, intelligent meters, fault-tolerant mechanisms, operational control mechanisms, and operation control mechanisms. Green structures target increasing energy use and lowering carbon footprint. A smart home that keeps track of household objects, energy use, surveillance, lighting controls, and much more in order to improve inhabitants' quality of life. Furthermore, in today's world, smart waste management is seen as a necessary component of any smart society. Garbage production is growing more exponential due to the expansion of cities and industries. Waste management efficiently controls man made waste, urban services, and private offices [55]. It works through four key categories namely waste collection, disposal and recycling. Waste management is critical to the long-term viability of smart cities, as improper waste disposal endangers human health and the environment [56].

D. Smart Technology

Smart technology is the key to building, utilizing, and operating smart cities. Various selected technologies used in smart cities are 5G, ZigBee, Bluetooth, LTE A, VANET, RFID, LPWAN, LoRA, Wi-Fi, etc. The technical aspect is often considered even though it may be part of the solution for other things. It consists of hiring technology to develop new solutions to achieve a smart, digital and virtual city [57]. This means using existing technology to improve the city's performance satisfaction of its resident.

E. Smart Healthcare

Traditional health care is surviving due to high population expansion. With growing need and limited resources, conventional health systems require ingenuity, efficiency, and sustainability. Traditional health care, smart biosensors, wearable gadgets, and ICTs are all part of intelligent health care.

Table 1: Description of 17 United Nations Sustainable Development Goals [65].

SDGs	Purpose	Goals (by 2030)
SDG 1	No Poverty	End poverty in all its forms everywhere.
SDG 2	Zero hunger	Ensure end hunger.
SDG 3	Good health and wellbeing	Ensure healthy lives and promote well-being for all at all ages
SDG 4	Quality Education	Ensure that all girls, boys complete free, equitable, and quality primary, and secondary education, substantially increasing the supply of qualified teachers.
SDG 5	Gender equality	Achieve gender equality and empower all women and girls.
SDG 6	Clean water and sanitation	Ensure access to water and sanitation to all.
SDG 7	Affordable and clean energy	Ensure access to affordable, reliable, sustainable and modern energy.
SDG 8	Decent work and economic growth	Promote inclusive and sustainable economic growth, employment and decent work for all.
SDG 9	Industries, innovation and infrastructure	Build resilient infrastructure, promote sustainable industrialization and faster innovation.
SDG 10	Reduce inequalities	Reduce inequalities within and among countries.
SDG 11	Sustainable cities and communities	Make cities inclusive, safe, resilient and sustainable.
SDG 12	Responsible consumption and production	Ensure sustainable consumption and production patterns.
SDG 13	Climate action	Take urgent action to combat climate change and its impact.
SDG 14	Life below water	Conserve and sustainability use in ocean, seas and marine.
SDG 15	Life on land	Sustainability manages forests, combats desertification, halts and reserves land degradation, halts biodiversity loss.
SDG 16	Peace, Justice and strong institution	Promote just, peaceful and inclusive societies.
SDG 17	Partnerships for the goals	Revitalize the global partnership for sustainable development.

Many components of smart health care involve the emergence of body sensors, intelligent hospitals, and quick response in emergency. To meet the needs and raise the standard of service, modernized health care services use of cloud computing, sensor networks, smartphone applications, ICT, and data processing methods [58]. An IoT enabled health system that accordingly diagnoses, and monitors patients, medical personnel, and biomedical equipment was developed. Better health care services signified a higher standard of living for an urban occupant. Therefore, accommodating smart health care into smart cities is considered a major improvement in the worldwide awareness of a smart urban concept [59].

VI. Sustainable Development Goals for Society 5.0

UN member countries adopted 17 SDGs in 2015 aimed at addressing social issues, promoting healthier lives for people, and achieving a sustainable world [60, 61]. Japan launched its Society 5.0 program in 2016, a vision aimed at creating societies that are human-centric and sustainable that enhances productivity and better life through cyber physical systems [62]. Through business innovation and collaboration with customers and partners, social innovation businesses aim to address societal challenges in order to accomplish the SDGs [63, 64]. Keidanren [65], introduces a diverse collection of innovations to achieve SDGs. As the fifth of four societies in the history of human social development, Society 5.0 follows the hunter-gatherer society, agrarian society, industrial society, and information society. IoT, AI, robotics, and other innovative technologies will be used to optimize individual lives and society as a whole in this future society. In addition to this, people of all nations, ethnicities, ages, and genders can live comfortably if economic growth is congruent with solutions to global and local challenges. Creating Society 5.0 adheres to the principles of the UN-SDGs. The aim of 17 SDGs for Society 5.0 is well explained in Table 1. The goal of SDG1 is to eliminate severe poverty, provide humans with simple access to essential resources and services, and safeguard people from economic and environmental disasters. In SDG2, it is hoped that all people would have access to safe, nutritious, and sufficient food, and that global poverty will be eradicated. It is intended to meet people's basic health requirements by providing treatment, diagnostics, medical attention, and cost-effective medicine in SDG3. It is expected that accessibility, equality, and lifelong education will be promoted for all ages in SDG4. The United Nation's goal in SDG5 is to achieve equality, status and rights for women and girls in societies. Water is the utmost requirement for the survival of all living creatures on the planet. As a result, new efforts are being taken to ensure that people have access to clean, fresh drinking water while also maximizing the use of technology in SDG-6. To encourage energy generation from non-CO_2 emitting sources comes under SDG-7.

Figure 5: The connection of Society 5.0 with UN SDGs with its components, enabling technologies and different applications [65].

In addition to promoting economic growth and good employment for people, SDG8 aims to ensure gender equality and include appropriate compensation in exchange for human efforts. It strives to improve people prosperity by generating innovations, producing goods for human needs, utilizing technologies in the industry, and building much better, higher-quality, and stronger bridges, highways, airports, water, and sewer infrastructures in SDG9. The SDG10 seeks to reduce inequity in and between countries, as well as protect people from being discriminated against based on their age group, race, ethnicity, culture, political views, or physical or mental disabilities. In SDG11, there are several key goals, such as minimizing slums, improving transport, organizing sewage systems, and building more sustainable cities are among them. Food, water, housewares, technological equipment, energy, and all fossil fuels must be utilized efficiently and cyclically in SDG12, as the environmental effects of today's products will become more problematic in the future. SDG13 aims to limit fossil fuel use and fossil fuel-based energy use, creating carbon-free cities as a means of reducing climate change, and preparing for and responding to natural disasters. The main goal of SDG14 is to ensure that seas, oceans, and those resources are used effectively, to mitigate for the damage, to build a healthy structure, and to use sustainable resources. SDG15 is concerned with the preservation of ecosystem and species, as well as their long-term use. Many individuals die every year because of gun battles between nations or rebel groups. These disputes inhibit humans from serving others and thus, creating a more just and peaceful community in SDG16. To aid global growth by facilitating successful international cooperation and communication aims in SDG17. Society 5.0 with its components, enabling technologies in various technical aspects along with sustainable developments goals are well depicted in Fig. 5.

VII. Society 5.0: Potential Challenges and Research Opportunities

A huge number of open issues and technical challenges must be addressed in order for Society 5.0 to become a reality. The demand to build Society 5.0 is very divergent and intricate including energy efficiency, sustainability, expenditure, advanced communication link, defence, and surveillance. These factors are driven by a variety of aspects such as the economy, environment, communities, and policy. Financial expenditure such as design and service costs are the utmost very significant factor in the development of a Society 5.0 [66-68]. The construction costs are only once, however, the operational costs are a necessary component to keep a city running. To make Society 5.0 a reality, development costs must be kept to a bare minimum. The low-cost operation will make it easier for Society to function in the long run while putting less strain on their budgets. The key driving aspects for the adaption of sustainable smart city solutions are the reduction in energy consumption and concern over the increase of environmental wastes. Further, the major concern over global warming and ozone depletion has accelerated the efforts of governments of the countries to control their carbon footprint and are imposing stricter regulations to limit the emissions. Therefore, the enforcement of intelligent infrastructure for automation, smart grids, and controlling systems contribute significantly to reduce power consumption and carbon emissions, which minimizes losses and optimizes the sustainable smart city operations. To enhance the sustainability, energy efficiency and reduce the operating costs significant reduction in carbon emission and urban garbage is needed to increase sustainability, efficiency

and reduce operating costs. To deal with the growth of pollution in cities/society and assure everlasting sustainability at the expense of improved operations are the main requirement of the sustainable smart city. The smart cities exist because of the effective use of a variety of smart gadgets that must analyze and store massive amounts of data. The security and privacy have become inevitable requirements to assure the sustainability of the ubiquitous city as motivated by the concept of the IoT, which is the major, planner in the coming smart cities. The security and privacy challenges emerging from the deployment of the IoT in the smart cities with a special emphasis on the IoT device, infrastructures, networking, and protocols, are still an open research challenge in IoT data. Therefore, it is most important and necessary to consider information security and infrastructure in order to create a sustainable smart city. The safety of inhabitants is a predominant research challenge, which need to consider at the planning and design stage of the sustainable smart city. Hence, the smart cities are allocating more funds and resources to security, while tech companies are developing solutions with new built-in safeguards against hacking and cybercrime [69-71]. Many developers are exploring for methods to merge these encryption techniques into new apps using blockchain. The open research challenges with its possible solution are presented in Fig. 6(a).

The Society 5.0 will change the world by giving solutions from various areas. However, there are various potential research challenges but, in this manuscript, we have mainly emphasized following areas like, 1) healthcare, 2) mobility, 3) infrastructure, 4) Fintech, and 5) Anxious feelings of inhabitants regarding the realization of Society 5.0.

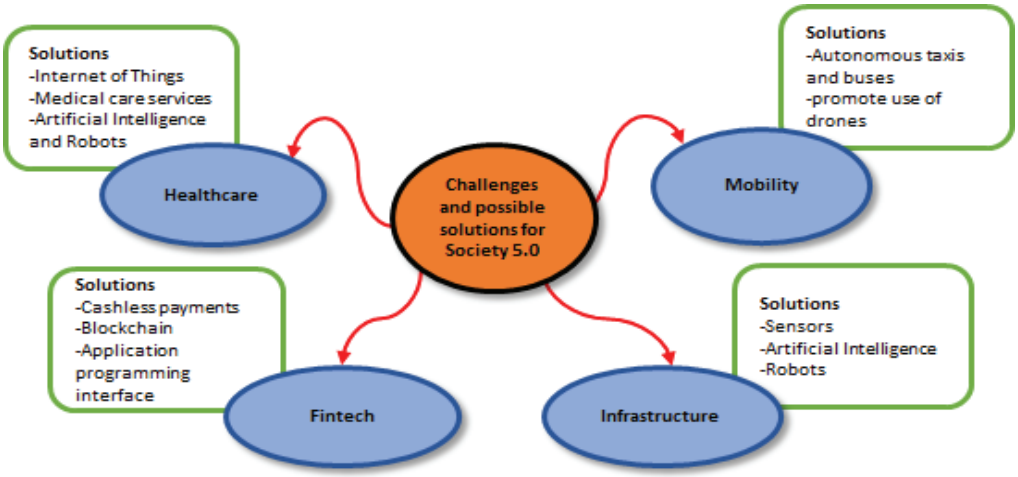
Healthcare: Increasing medical and social security costs, as well as needs for aged care, are putting a strain on society. An effective medical care based on data will be offered by linking and sharing medical data that is currently spread across different hospitals.

Mobility: Leading to a shortage of public transport services, inhabitants in unpopulated places find it tough to purchase and access healthcare. Nevertheless, automated vehicles will make it much easier for them to travel, and delivery drones will allow them to get everything they require.

Infrastructure: Early detection of sites that need maintenance can be made using new technologies such as ICT, robotics, sensors for inspections, and repair systems that require specialist skills. Unexpected accidents will be reduced, and time spent on construction work will be reduced, while safety and productivity will be improved.

Fintech: The use of information technology in businesses is restricted, and the implementation of cashless payment and convenient financial services is limited. Remittances to other countries are inconvenient since they require time and money. In worldwide commercial transactions, blockchain technology will save time and money while ensuring security for money transfer and to promote cashless payment.

Anxious feelings of inhabitants regarding the realization of Society 5.0: The society with super-intelligent capabilities called Society 5.0 has been proposed by Japan in 2016. It represents the 4th industrial revolution, during which the state-of-the-art technology and connectivity, such as IoT, AI, big data, and robotics, will permeate every form of industry and social life. The survey, performed by National Institute of Science and Technology Policy (NISTEP) in Japan with 3000 respondents between age group of 15-69 years as depicted in Fig. 6(b). The question was originally posed as: What do you feel anxious about regarding the realization of Society 5.0? The research teams have used statistics, surveys, and forecasting to collect data based on primary data gathered by their team and secondary data gathered from their collaborators. In this study, NISTEP investigated the concern of Japanese inhabitants about the implementation of Society 5.0. The majority of respondents worry about their personal information being leaked or hacked by a computer virus, and they are typically concerned about cyberattacks. About 45% of female and 36% of male respondents expressed their concern that the personal information might be disclosed by a computer virus if the Society 5.0 is materialized. The majority of them polled fear cyberbullying and a decline in quality-of-life due to AI and robots taking over jobs. A lack of ICT skills causes 38% of respondents to be concerned about their income level and treatment gaps and approximately 24% of respondents do not have any anxiety about Society 5.0 [72].



(a)

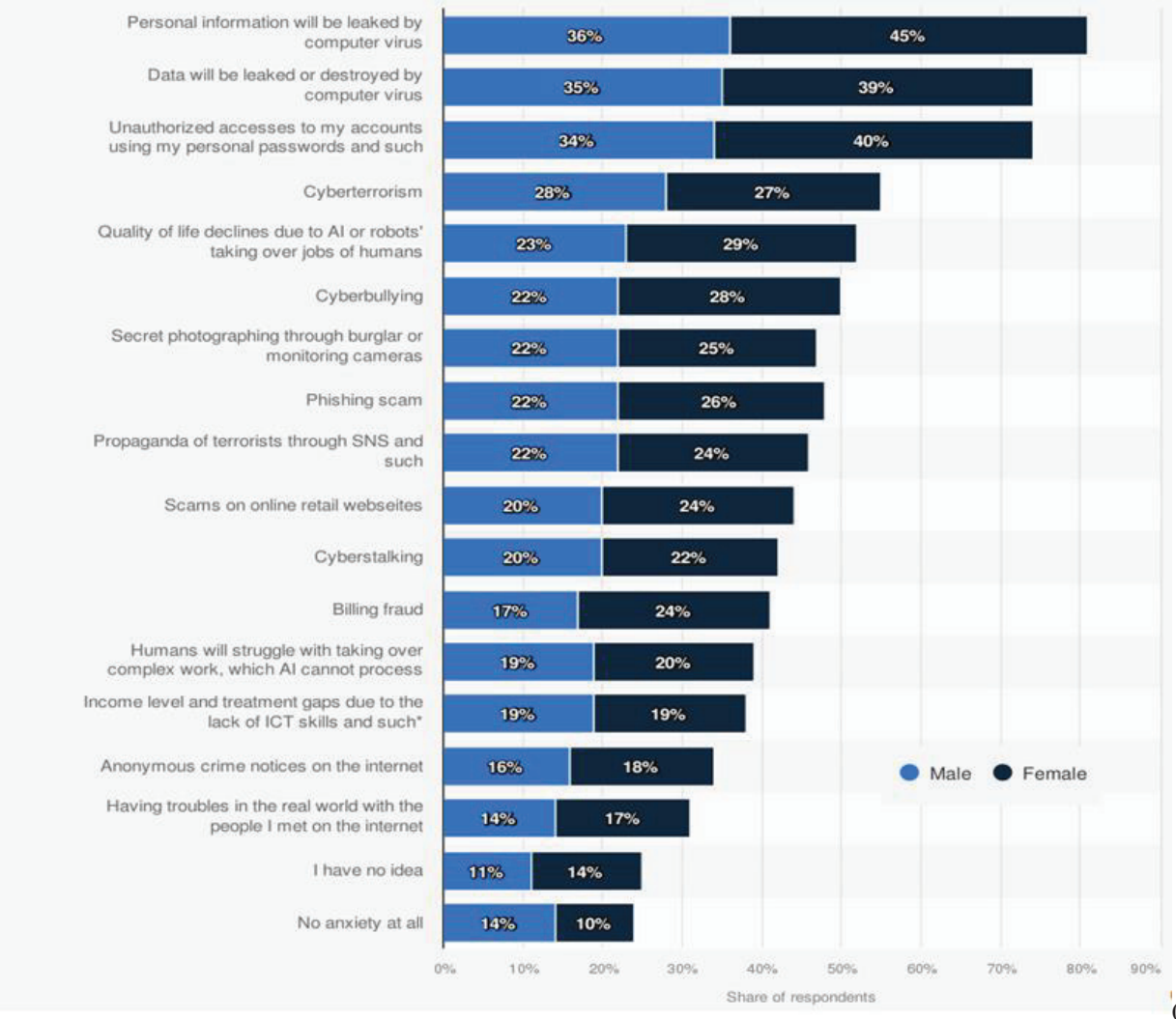


Figure 6: Society 5.0 (a) potential research challenges with possible solutions and (b) anxious feeling of inhabitants regarding the realization: a reported survey [72].

Presently, the 5G communication technology has exploited several major changes in the communication and computing environment of world. For example, the low latency connectivity enables smoother communications and faster data transfers. Further, this technology enables quick access to video analytics and AI, which makes the Society safer, and the facility-managers of city/society could inform decisions and provide intelligent public services. Thus, the evolution of 5G is yet to realize its full transformational potential and provides a great growth opportunity for the smart cities market. The lack of awareness among people is a major factor behind the slow development of smart cities, as this causes ignorance about smart city projects and lowers the level of impetus by the government to implement smart solutions for cities. The infrastructure monitoring and management services allow utility companies to deliver critical services securely and reliably to thousands of customers, irrespective of their location. As per the needs of users, the service provider, provides high-precision information of the entire infrastructure in real-time, regardless of the environmental conditions. Further, the deployment with integrated services involved in the smart transportation industry perform designing, engineering, and customized product development for the users. The deployment and integration service providers help end users to integrate smart infrastructure solutions with their existing infrastructure and save costs by reducing the deployment time of solutions.

VIII. Conclusion

Society 5.0 is a super-intelligent society in which emerging advanced technologies are integrated with industry and social life to solve numerous societal concerns and inhabitants' lives will be more pleasant and sustainable. It envisions a society where everyone enjoys life to the fullest. The purpose of economic growth and technological development is not for the welfare of a select few, but to create prosperity for everyone. In this paper, we have discussed the potential concepts and technologies behind Society 5.0. The primary purpose is to explore new modalities for efficient usage of the resources and infrastructures of Society 5.0 and fulfil the attributes of SDGs. Finally, we have concluded with several open research challenges the Society 5.0 are facing with a suitable design. Current technological developments with their functional execution across the world could be considered as forthcoming emerging projects for the improvement of society. In the emerging technologies, the 5G-IoT is a potential contender,

which plays a crucial role for Society 5.0 such as for facultative distribution of required resources across the inhabitant and identifying resources that are in excess supply, pooling information on wastage with its supply on demand. The societal concerns are global challenges therefore; the Society 5.0 does not serve the needs of one country alone. Further, the 5G-IoT fully assists in connected health, expanding remote education, and empowering relevant segments of society. It also adds the right tools for safety, security and creating capabilities to enable the law to address the problems with a more conclusive method.

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CONTENTS PAGE