Excavating the Role of Digital Twins in Upgrading Cities and Homes Amidst 21st Century: A Techno-Legal Perspective

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Abstract

Considering factors like technological up-gradation, digital awakening, sustainability, and smart living with machines, the concept of smart cities and smart homes have stepped in with the helping hand offered by digital twins in this era of the 21st century. Aiming to connect physical objects with virtual ones, digital twins using bi-directional connectivity helps maximize the potential of a city, pushing it to grow beyond its capabilities. A rise in the use of virtual simulation technologies reflects the importance of digital twin technology in today's complex world. With different countries around the world adopting the concept of smart cities and homes to address various issues, the question is who addresses the detriments of walking in with this new adaptability, and who will be liable in situations of mishappening? The Narendra Modi government has initiated the birth of smart cities in India, thereby mending ways for Amravati to become the first city born out of digital twin technology. Walking in with the great potential to transform urban governance and increase urban metabolism, digital twins powered with Artificial Intelligence, the Internet of Things, 5G, blockchain technology have made a significant place in a man's daily life. A feasible device for urban planning, the subject of digital twins is divergent enough to have an exhaustive coverage. Therefore, there lies room for further development, study, and implementation of this technology. One must not forget that paralyzed laws and regulations welcoming new sets of challenges possessed by the revolutionary digital twins have been in the spotlight of discussion for some time now. Channelizing the same stands utmost in the era of smart living with the help of a

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well-planned legal framework to address issues arising from the claws of this technology.

Keywords: Digital twins, smart cities, smart homes, IoT, Big Data, Artificial Intelligence

I. Introduction

Aiming to connect physical objects with virtual ones, digital twins using bi-directional connectivity helps maximize the potential of a city, pushing it to grow beyond its capabilities. A rise in the use of virtual simulation technologies reflects the importance of digital twin technology in today's complex world. A common misconception about "Digital Twin" is that it is a simulation process that makes use of the potentials exerted by physical models, sensors, and operational history data, among other things, to initiate the integration of information from multiple disciplines, physical quantities, scales, and probabilities. As a result, the digital twin may be thought of as a virtual replica of a physical product in a virtual environment. The mirror body serves as a reflection of the physical entity product's whole life cycle. One cannot ignore the fact that there are currently various theories and understandings concerning the concept of digital twins. Therefore, the term could not be decorated with a consensus definition. However, the elements that constitute digital twins include physical entities, virtual models, data, connections, and services.[3] The 21st century has been ornamented with technological applications involved in the up-gradation of a man's life. The advent of digital twins has been a boon for developing smart cities[4] and homes across the globe. Followed by this, it goes without saying that the developed countries will be a few steps ahead in implementing smart cities and homes when placed in comparison with developed or developing countries. Nevertheless, India has been able to utilize technology in building smart cities to a significant extent. To summarize, the digital twin is the driving machinery to create an inevitable

[3] Li Deren, Yu Wenbo, and Shao Zhenfeng, *Smart city based on digital twins*, Springer Link (March 29, 2022, 9:30 PM), https://link.springer.com/article/10.1007/s43762-021-00005-y.

[4] DR. Jayanta Ghosh And A. Nanda, Legal Implication Of Blockchain Technology In Public Health, Book Chapter 16 in Digital Health Transformation With Blockchain And Artificial Intelligence, (Publisher CRC Press, Taylor and Francis 2022).

trend of tech transformation aiming to help cities realize real-time remote monitoring, thereby allowing more excellent, effective decision-making.[5]

II. Digital Twins and Smart Cities

Any city that uses the updated form of digital technology to improve its infrastructure, services offered, and the lives of its people are considered a smart city under this definition. When a step forward to the broader interpretation of smart cities is made, it can be interpreted as a socio-technical identity that encompasses economic, social, political, and environmental perspectives.[6] The notion of a smart city has slowly developed from static 3D modeling to digital twin technology, mixing dynamic digital technology with a static 3D model to create a new concept for smart city development.[7] It may thus argue that the digital twin city is an alternative implementation of the digital twin idea at the city level.

Using this program, you may create a massive, interconnected system that connects the real world with the virtual world, allowing the two to map and interact in both directions. Physical cities can be matched to their "twin cities," resulting in patterns of cohabitation and integration in the physical and digital dimensions. Building a digital twin city relies heavily on data as well as a solid technical base as well. Instead of big urban data created continually from different sensors and cameras all around the city daily, the latter refers to the digital subsystems that the city's management departments are gradually building to answer daily demands.[8] The British government proposed the Smart London Plan to upgrade the lives of their citizens and the overall development of the capital city. Working on the same track is another smart city plan recognized by Singapore Intelligent Nation, which was brought up in 2015 to consider Singapore as a smart nation eventually. The strategy focusing on four core areas, namely industry, open government system, access of information, and engagement,

[5] Tianhu Deng, et al., *A systematic review of a digital twin city: A new pattern of urban governance toward smart cities*, Science Direct (June. 25, 2022, 8:45 PM), https://www.sciencedirect.com/science/article/pii/S2096232021000238.

[6] Mervi Hämäläinen, *Smart city dvelopment with digital twin technology*, Research Gate (July 17, 2022, 9:30 PM), https://www.researchgate.net/publication/342715735_Smart_city_dvelopment_with_digital_twin_technology.

[7] *Id.* at 3.

[8] *Id.* at 3.

generated by New York to step forward as the "world's most digital city" demands a special mention here. Followed by this, the particular emphasis of the Chinese President Xi concerning modernization of the government system and the governance must not be ignored in the context of smart cities and smart homes.[9]

Research conducted by Angelidou (2017)[10], that involved the examination of smart city plans designed for implementation in 15 major cities across the world, revealed that there exists coordination between the upper and the lower layers of a smart city which helps in the efficient functioning of these kinds of cities. The concept of smart cities and the role of digital twin technology in implementing the idea has been discussed hereunder from different lenses.

A. The New Applications of a Smart City: All One Needs to Know

Smart cities alone cannot function unless the applications that form an integral part of the entire set of smart cities are not considered. As a city grows, its inhabitants will help it gain notoriety and build its structure by using applications that make life simpler and better for everyone. This will lead to more individuals participating in the city-wide promotion of knowledge and analysis to help the city operate better in real-time. Smart Cities' focus on social and environmental capital rather than just technology fosters a more holistic vision of cities. Managing urban growth by promoting economic competitiveness, improving social cohesion, and assuring their inhabitants' enhanced quality of life is essential to being smart.

Smart city critical infrastructure (SCCI) provides residents with the security of knowing that essential services, including public transit, communications, electricity and water distribution, hospitals, and schools, would continue to be available even in an emergency. Infrastructures such as gas stations and power

[9] *Id.* at 4.

[10] Margarita Angelidou, *The Role of Smart City Characteristics in the Plans of Fifteen Cities*, IDEAS, (July 17, 2022, 9:30 PM), https://ideas.repec.org/a/taf/cjutxx/v24y2017i4p3-28.html.

plants are among the key infrastructures. Other critical infrastructures include hospitals and transportation.[11]

Administration in a Smart City

As big data and integrated platforms emerge the urban business environment is fast changing. These platforms might be viewed as monopolies owing to their network effects. Priorities such as avoiding unfair competition, ensuring consumer protection, and social equity must be revisited to be addressed.[12] One such endeavor to improve smart city governance is the recent growth in research into the idea of smart governance.[13] As technology's role in city functioning has grown, smart governance forces government agencies to reconsider their responsibilities in these data-rich cities. To upgrade traditional administrative systems (such as e-government) to the city level, smart governance can use various smart technologies (such as big data, the Internet of Things (IoT), and Artificial Intelligence (AI)). These technologies can streamline city operations, make better decisions, and improve the quality of life for citizens. Smart city governance, on the other hand, is characterized by a technocratic, supply-oriented approach to city government. The importance of technology in data collection and knowledge production is heavily emphasized to make government operations smarter and automate urban system activities. A technology-driven, digital approach to solving urban problems is frequently seen as a universal answer.[14]

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[11] Shruti, Prabhat Kumar Singh, and Anurag Ohri, *Towards Developing Sustainable Smart Cities in India*, International IJEAT (Nov 22, 2022, 2:40 PM), https://www.ijeat.org/portfolio-item/B3653129219/.

[12] Seunghwan Myeong, et al, Smart City Strategies—Technology Push or Culture Pull? A Case Study Exploration of Gimpo and Namyangju, South Korea, MDPI (Dec 24, 2020, 3:45 PM), https://www.mdpi.com/2624-6511/4/1/3/htm.

[13] S.P. Chakrabarty, Jayanta Ghosh and S. Mukherjee, "Privacy Issues of Smart Cities: Legal Outlook". In: Chakraborty C., Lin J.CW., Alazab M. (eds) Data-Driven Mining, Learning and Analytics for Secured Smart Cities. Advanced Sciences and Technologies for Security Applications. Springer, ISBN: 978-3-030-72139-8 Cham (2021).

[14] Huaxiong Jiang, Stan Geertman, and Patrick Witte*, Smart urban governance: an alternative to technocratic "smartness"*, ResearchGate (Nov. 4, 2022, 2:30 PM), https://www.researchgate.net/publication/345678222_Smart_urban_governance_an_alternative_to_technocratic_"smartness".

Public participation in urban development promotes a more democratic and legitimate decision-making process, but it also acts as an intelligence-gathering tool for the government. Citizen knowledge and expertise are crucial for setting goals and allocating finite resources, and they go hand in hand with the strategic understanding of enterprises. Citizens' participation has proved difficult to come by. Therefore, cities are turning to new information and communication technologies (ICTs) to see if they might help boost public participation.

Disaster Management in a Smart City

There are four significant competencies in developing resilient cities that are redefining the paradigm of smart cities. These are: plan/prepare; absorb; recover and adapt. Beyond the idea of pure prevention and hardening, resilience may be viewed as a proactive strategy to improving infrastructures' ability to prevent harm before disruptive events, reduce suffering during disruptive events, and increase recovery capabilities after the events. Traditional approaches to risk management, on the other hand, do not take dependencies and related cascade consequences into account. Resilience management takes risk management a step further by bringing together a system's temporal capacity to absorb and recover from destructive events and adapt as a result of those events. Resilience complements traditional risk management by utilizing adaptation and mitigation techniques.[15]

Disasters are complicated. Therefore, creating a smart city environment is crucial for increasing resiliency while also increasing public awareness. A sensor tier is in charge of receiving and updating information about reality from sensors; a database tier gathers information from relevant domain resources, and a system architecture consists of four levels. This tier is responsible for examining the continually updated conditions and making emergency decisions. The alert tier is in charge of notifying and warning residents who live in the high-risk region. This layer is also responsible for providing decision support.[16]

[15] IPCC, Special Report of the Inter-Governmental Panel on Climate Change, Managing The Risk of Extreme Events and Disaster To Advance Climate Change Adaptation (2018), https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_Full_Report-1.pdf.

[16] Aravindi Samarakkody, et al, *Technological Innovations for Enhancing Disaster Resilience in Smart Cities: A Comprehensive Urban Scholar's Analysis*, Research

Controlling Traffic and Accidents in a Smart City

Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) to efficiently monitor and regulate traffic flows will be a critical component of future smart cities. To enhance the overall functioning of the traffic system, the ATMS/ATIS is used, for instance, by lowering emissions, noise, and travel times. Most ATMS/ATIS systems use data taken from loops and radar detectors to arrive at a fixed point (eulerian). Eulerian sensors have the potential to collect data in terms of speed, flow, and occupancy. The drawback that accompanies these sensors is the inadequacy of providing a trajectory-based measurement that enhances traffic flow behavior. Nevertheless, tracking large-scale mobility patterns can be carried out by these sensors.[17]

Implementing varying time delays for red, green, and yellow at different intersections and places might be an excellent answer to this problem. It is recommended that the wait at crossings with large traffic volumes be greater than the delay at intersections with low traffic volumes. Emergency vehicles like ambulances and fire engines might stay trapped for hours when there is a traffic bottleneck. Estimating OD matrices from this data has recently become increasingly popular. The difficulty of obtaining access to this sort of data from cellular providers has previously been a limiting issue. Orange recently published a study data set on cellular networks, which piqued the interest of academics and practitioners throughout the world. This might help researchers learn more about the data source's potential while making it more straightforward for other cellular service providers to contribute their data.[18] Many cities across the world have already installed a considerable number of heterogeneous traffic surveillance devices. Data collected from these sensors isn't enough to enhance road users' knowledge (such as trip time) or give highway authorities the tools they need to manage traffic.[19]

Gate (Nov. 4, 2022, 2:30 PM), https://www.researchgate.net/publication/372949356_Technological_Innovations_for_Enhancing_Disaster_Resilience_in_Smart_Cities_A_Comprehensive_Urban_Scholar's_Analysis.

[17] Andreas Allström, et al, Traffic management for smart cities, (Nov. 4, 2022, 2:30 PM), http://www.diva-portal.org/smash/get/diva2:975199/FULLTEXT01.pdf.

[18] *Id.* at 12.

[19] *Id.* at 13.

Economy in Smart City

When the rural economy was replaced by the urban economy, which now accounts for a significant portion of GDP, what defines economic progress in smart cities arose. What distinguishes it from other forms of urban economic activity? Is conventional urban economic theory and practice still viable in a smart city economy, or do we need to look at novel theories and practices for smart city economic development?

A 21st-century city is equipped with a high-speed communication center along with a robust information and communication technology (ICT) infrastructure that links it in real-time to other cities across the world. Desktop computers have evolved into laptops and slates, with wearable devices like mobile phones and other gizmos following suit. Metropolises serve as economic growth engines, and they have a significant impact on both the local and national economies. Furthermore, cities function as hopeful beacons for a wide range of individuals, both skilled and unskilled. These people are drawn to cities in search of more significant opportunities for work and living standards. Compared to their rural equivalents, cities have more substantial infrastructure and services, supporting their agglomeration economies and the associated creative and technological production process. Cities can fulfill these many tasks.[20]

Unprecedented urban economic growth is occurring, yet many employees in emerging nations are trapped in precarious (commonly referred to as informal) employment. In many ways, the growth of urban economies is hampered by a scarcity of qualified employees, especially those with technical education and training. As part of the broader issue of sustainable development, economics is intertwined with social and environmental considerations in urban development. Cities must thus be designed with an atmosphere conducive to human transformation via lifelong learning if they are to be justified.

Addressing Man's Needs in a Smart City

Urban systems should work better in smart cities since they encourage sustainable development and improve the quality of daily living.[21] Water is a need. Water use varies from house to house since the individual demands of the residents

[20] *Id.* at 13.
[21] *Id.* at 14.

determine it. The amount of water used varies by season. An IoT device[22] is installed in the water tank of every home in the smart city, and it sends notifications to residents' mobile phones when there is a pipeline problem, such as an overflow or leak, or when the water supply is sour or unsafe drink. The company uses IoT devices to detect pipeline leaks. The Internet of Things gadget also regulates water flow to tanks containing drinking water and sour water through valves. The IoT gadget is immediately attached to a charger powered by the house's electrical system.[23] Cities will be zero polluting and self-sustaining if renewable energy sources are correctly utilized to generate power. Only when the standard of living for its residents improves can a city be considered smart. It need more dispersed, linked, and intelligent infrastructure for smart power.[24]

Cities are getting smarter and more manageable thanks to the development of various infrastructures and amenities. Multiple situations (e.g., smart homes, community health centers, and smart hospitals) and scenarios can make use of its ability to assist smart healthcare systems (e.g., abnormal behavior monitoring, disease prevention and diagnosis, clinical decision-making, prescription recommendation, rehabilitation, and post-marketing surveillance).[25] While organizations in the healthcare industry were still thinking about whether digitizing their patient and medical and health personnel records would be the right call or not, a consistently growing number of technologies and innovations were already being introduced in the background. One of such is Big Data Analytics.[26]

There are several drawbacks to current wastewater management methods, such as SCADA (Supervisory Control and Data Acquisition) systems. As a result, water utilities have developed more efficient and intelligent wastewater systems to satisfy the growing demand for freshwater.[27]

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[22] Jayanta Ghosh, *Powerplay of Artificial Intelligence upon Intellectual Property Law*, Vol. 11 No. 1 (Part III), INDIAN JOURNAL OF LAW AND JUSTICE, March 2020, p 84 – 99.
[23] *Id.* at 15.
[24] *Id.* at 16.
[25] *Id.* at 17.
[26] *Id.* at 18.
[27] T.M. Vinod Kumar, and Bharat Dahiya, Smart Economy in Smart Cities, Research Gate (Jan 5. 2022, 4:30 PM),https://www.researchgate.net/figure/Smart-Cities-

a. A Sound Information Security Guarantee Mechanism

The concept and initiative of a Smart City are still in development, and the frameworks in mind of the many stakeholders may change from one Smart City to the next. Policy formulation is critical from the standpoint of security since it helps stakeholders understand "what kind of security policy should be developed for a Smart City as a whole," "what kind of security standards should be required," and "what kind of organizational structure should function.". The Personal Information Protection Law, the Basic Law for Promoting Public-Private Data Utilization, the General Data Protection Regulation, and business laws/guidelines in each area should be considered while establishing Smart Cities policies.

b. The City Information Model (CIM)

Euro step Group developed Share-A-space, the software on which CIM is built. Instead of gathering information from several sources and consolidating it into one collaborative hub, CIM will achieve its goal if all needed information is always readily available and up-to-date. The significant finding is that the municipality may use CIM as a substitute tool in their job.[28] Because of the necessity for evidence-based and collaborative planning and decision-making in urban planning and decision-making, the idea of Smart Cities is driving the digitization of urban development. 3D models, Digital Twins, Urban Analytics and Informatics, Geographic Information Systems (GIS), and Planning Support Systems are enabling this digital transition (PSS). City Information Modelling (CIM) is a new term used to describe the convergence of these disparate technology forces.[29]

Maturity-Model-Source-140-p-7-Note-KPI-key-performance-indicators_fig25_306924920.

[28] *Id.* At 12.

[29] Jorge Gill, *City Information Modelling: A Conceptual Framework for Research and Practice in Digital Urban Planning*, ResearchGate (Dec 5, 2022, 3:25 PM), https://www.researchgate.net/publication/346548523_City_Information_Modelling_A_Conceptual_Framework_for_Research_and_Practice_in_Digital_Urban_Planning

c. Smart Farming

When it comes to building and integrating IoT features like linked devices, gateways, and apps into digital platforms, cloud-based digital platforms have become standard. Platforms in the cloud make it possible to manage IoT services' creation, distribution, and evolution. Rural agricultural countries benefit from innovative ideas that are helping agriculture become more efficient and thriving on a day-to-day basis. In reality, sensors, IoT connections, and self-driving cars were all developed on a farm, and they're all now part of smart cities. They are using real-time data from a network of sensors, smart grids in the city supply power exactly when and where it's required. Smart relays and switches automatically redirect energy around issues while monitoring electricity use and immediately report shortages or outages. This technology is being implemented to make the electric grid more robust and dependable while also consuming less energy. Modern agriculture uses similar technologies and resource optimization techniques. Several new technologies are available to farmers that provide them with precise information on every aspect of their business, from the moisture in the soil to the number of nutrients and salt.[30]

Traditional agricultural practises can't compete with the efficiency of modern farming. Small farmers in rural and urban areas have a tough time integrating the digital and physical infrastructures. Agri start-ups can reach all of these farmers and make it a practical and cost-effective choice. Kisan Suvidha, a government-funded app, gives farmers access to real-time weather data, market prices, dealer information, and more. On the app, you can also see rates in your immediate neighborhood and across India at a glance. Agri-tech start-ups may assist farmers in obtaining crop insurance and institutional finance by evaluating various data, including that provided by Bhuvan, the ISRO Geo-platform. India's Agri industry will continue to thrive even after Covid, thanks to the efforts of these IT agencies and government programmers.

[30] Bayer Contributor, *What Smart Cities Are Learning from Smart Farms,* Forbes (Nov 27, 2022, 3:45 PM), https://www.forbes.com/sites/bayer/2019/11/27/what-smart-cities-are-learning-from-smart-farms/? sh=955c6bda

B. Addressing Data Fairness and Equity in Smart Cities

Engineers are building a cyber-physical world where ubiquitously networked devices, things, and processes can uncover previously unimaginable prospects through the continuous amalgamation of diverse technologies. Digital technologies and artificial intelligence (AI) offer new chances to transform information into actionable insights, establishing a balance between social, environmental, and economic prospects because of the rising ubiquity of these devices across society. As a result, smart city design, building, and planning may offer these benefits. With machine learning (ML) approaches, we're capturing and processing more data at a faster rate than ever before. This has implications for everything from water and energy management to traffic and autonomous cars. Smart objects that aren't relevant to and useable by everyone would, at best, inconvenience a significant section of the population if they're produced or distributed. However, using ML approaches to create services that ignore socio-cultural, economic, or political diversity increases the risk of developing a more segregated and discriminatory society.

As cities increasingly rely on automation and machine learning, municipal administration must maintain a high degree of transparency. Similarly, they will have to disclose any intentions behind the provided services publicly, the nature and scope of any collected data, the context in which the information is repurposed and used to decide how services are delivered (and to whom) and, finally, the reasoning behind such decision-making will be similar to GDPR's various requirements. The curtain must be lifted from big data analytics and intelligence.

III. Digital Twins and Smart Homes

Using internet-connected gadgets, a smart home is where appliances and systems, including lighting and heating, can be remotely monitored and managed. [31] Shortly, digital twins will revolutionize production by reducing costs, monitoring assets, streamlining upkeep, and enabling the development of linked goods. Although it's not a new concept, the digital twin model quickly makes its way into

[31] Tech Target, https://www.techtarget.com/iotagenda/definition/smart-home-or-building (last visited Oct. 6, 2022).

fields like manufacturing and construction. One of the driving forces is the Internet of Things (IoT). Digital twins in a non-academic, industrial setting.[32]

A. Role of IoT

The Internet of Things (IoT) is critical in the development of smart houses. Almost any household item may be connected to the Internet via the Internet of Things (IoT). Using IoT, you can keep tabs on and operate any connected device, wherever you are or what time it is. Using different sensors and video feeds, a smart house can keep tabs on the environment around it. Monitoring is critical because it keeps tabs on every activity in a smart home, which is essential for taking any other action or making any other decisions. Monitoring the temperature of a room and providing an alarm to the user to turn on the air conditioning.

B. Smart Home Applications

Home automation includes smart home applications. Smart Homes are about much more than just turning gadgets on and off and on and off again. With these apps, we get a sense of being physically there with and manipulating things. Smart door lock, smart switching off of lights and fans, and smart refrigerator are some of the uses we're considering.[33] These smart home applications can be enhanced in the future to meet our changing requirements and make our surroundings more comfortable and welcoming. While knowing your family is secure is essential, an automatic door lock system ensures that you are alerted when the door is locked or unlocked so that you can close it and grant permission to someone attempting to gain in from your office. Many people find it tedious to keep an eye on their groceries and get hungry for the food that has been consumed. Thus smart refrigerators alert you when food is running low.

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[32] I-scoop, https://www.i-scoop.eu/internet-of-things-iot/industrial-internet-things-iiot-saving-costs-innovation/digital-twins/ (last visited Oct. 6, 2022).

[33] Gopinath V, Yallamanda Ch, et. al, *The Journey of Big Data: 3 V's to 3 2 V's,* ResearchGate (Mar. 27, 2022, 9:29 PM), https://www.researchgate.net/publication/357649275_The_Journey_of_Big_Data_3_V's_to_3_2_.

IV. Role of law in governing the digital twins for smart cities and smart homes

Legal machinery is the one tool to address challenges possessed by the digital twin technology in the presently developing smart cities and homes. Due to their dynamic nature, digital twins offer different dangers that must be addressed through the contract (or contracts) that support them. Any digital twin project might run into legal issues, such as the following:

Intellectual property rights: There are specific essential concerns about intellectual property rights in the digital twin realm, such as: Does your digital twin use the intellectual property rights of third parties? What rights do you have to utilize them in the digital twin in the way you want to? Who owns the intellectual property in creative new works generated when creating a digital twin?

Data use rights: What data do you plan on utilizing in your digital twin, and do you have ownership of it? If not, do you have permission from the data's owner to use it as intended in the digital twin? You should keep it in mind even while using open-source data, which may have usage restrictions. Projects involving the creation of digital twins may face difficult decisions about who is responsible for what aspects of the endeavor.

Privacy and data protection: Is it legal for you to utilize personal information gathered from a digital twin, even if you possess the data to do so?

Cyber security: In terms of privacy and data protection, data collected by mechanical sensors may pose less of a threat, but growing connection also carries with it the danger of new security flaws. Who is in charge of safeguarding the data, and who is exposed to the threat of a cyber-event?

Malicious use: While digital twins have several advantages, they may also be used for malevolent ends, mainly if they are made publicly available. Ransomware or even terrorist attacks might take advantage of digital twins to cause the most harm or disruption. What safeguards are in place to guard against malicious usage, and who is responsible if any damage is done as a result? Digital twins are expected to grow in importance for infrastructure and governance in the future, which means hostile actors may decide to attack digital twins directly. GDPR Art. 6 demands consent of the information provider or data subject as a

pre-requisite to collect information and processing under GDPR. At the same time, IT Rules Rule 5 guarantees the lawfulness of data processing as a natural method of limiting ill-intentioned usage.

Responsibility for data quality: How will you ensure the data is correct, and who is in charge of doing so? How suitable is the data used in your digital twin to simulate a mission-critical system for mission-critical systems? This is especially important if the digital twin is going to pull data from various places and systems.

Liability: Is there anything you can do if your digital twin doesn't work? To what extent can you recover a mistaken investment choice based on a digital twin's model if you can prove the digital twin was wrong? When a digital twin has numerous interconnected components or subsystems, these dangers become much more significant. It is a requirement under Section 43A IT Act, 2000 and Rule 8(1) IT Rules, 2011 that damages caused by data infringement be compensated and that responsibility is exempted under specific situations. Section 72A of the IT Act of 2000 and Article 83 of the GDPR improve these provisions. Both provide provisions for financial penalties for infractions.

Integration risk: Is legacy infrastructure going to be a problem when incorporating digital twin technology? Who is in charge of any risks associated with the integration?

Connectivity and availability: When things go wrong, such as power failures, software bugs, or delays in deployment, it will be challenging to achieve the overarching aim of interconnectivity. When will outages have legal repercussions, if any?

Assurance, governance, and trust: Getting people to believe in new technologies is essential for adoption. Who is responsible for ensuring that a digital twin or IoT platform is operating as intended?

Standardization: Digital twin interoperability is hampered by the absence of a standardized technique for modeling them. What interoperability standards will be used in a digital twin?

Ongoing maintenance: Digital twin planning, pricing, and contracting must account for unavoidable continuous administration and maintenance due to software upgrades, physical asset changes, and enhancements to the digital twin.

The digital twin's entire life cycle cost will be dominated by the cost of maintenance and administration, much like with their physical counterparts.[34]

A. Addressing challenges

Numerous difficulties must be overcome to create a smart house that uses a digital twin method. The following are some of the most typical roadblocks to making a smart twin house:

Data privacy: The sharing of residential data poses a serious threat to individual privacy. The data will be sold to industry vendors via data administrators and cloud service providers. Up to 80% of the market might be restricted due to privacy and security concerns.[35] There are three privacy rights provided to the data owner by IT Rules, 2011, Articles (14-18), Art. (20-22), and Art. 7(3) of GDPR: the right to correction, the right of information, and the right to withdraw permission (Rule 5(6), Rule 5(3), Rule 5(7)).

Security: Smart twin solutions' security is gravely jeopardized. Because the solution's price must be raised, the market's value and demand will be reduced. It is required that the Common Data Protection Security Practices include the implementation of internal policies and security audits and adherence to a voluntary code of conduct and certification mechanisms under Rule 4 of the IT Rules, 2011.

Hardware: The upkeep of smart homes necessitates many more sensors, actuators, and controllers. This gear will be expensive, both to buy and to use in delivering smart solutions [34].

Connectivity: The architecture and protocols that link devices to the cloud or network are connectivity. Both virtual and physical products are becoming interconnected [35]. We could use sensors and a virtual representation of the house to keep tabs on where it is at all times.[36]

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[34] Lexology, https://www.lexology.com/library/detail.aspx?g=dda9e40b-f8ed-4ee0-96ea-4848711dd4c2 (last visited Oct. 6, 2022).

[35] Gopinath V, Yallamanda Ch, et. al, *The Journey of Big Data: 3 V's to 3 2 V's,* ResearchGate (Mar. 27, 2022, 9:29 PM), https://www.researchgate.net/publication/357649275_The_Journey_of_Big_Data_3_V's_to_3_2_V's.

[36] *Id.* at 35.

B. Data Protection Laws

If used as intended, a digital twin may simply be used to store data on the design and construction of a given asset. When it's developed to its full potential, a digital twin can include virtual projections of nearly everything, posing new problems. Data ownership, causality, and responsibility are just a few of the topics that might be controversial and difficult to sort out. Companies are under more pressure to comply with data privacy rules, such as the EU's recently implemented GDPR. Art.5 of GDPR, read with Art 4 and 8 of the statute vis a vis Rule 5 of IT Rules, 2011, functions with the similar objective of Collecting data for a lawful purpose as specified in the legislations with prior consent from the original owner.[37]

In terms of privacy and security, the GDPR is the strictest law in the world. For all its European origins, the GDPR imposes duties on companies worldwide that collect or target data about EU citizens.[38] Those who commit less severe infractions may be subject to a punishment of up to €10 million, or 2% of the previous financial year's worldwide annual revenue, whichever is greater. Among the things they look for are infractions of the rules controlling:

1. Companies that collect, control, or personal process data (controllers) and those hired to do so (processors) are both subject to the same set of standards regarding data protection, the lawful basis for processing, and other considerations. These are the articles you, as a company, should read and follow.
2. Bodies tasked with certifying organizations (Articles 42 and 43): Accredited bodies are required to carry out their evaluations and assessments in an objective and transparent manner.
3. As outlined in Article 41, entities recognized as having the necessary knowledge must demonstrate their independence and adhere to established procedures when processing complaints or alleged infractions in an unbiased and open way.

[37] *Id.* at 43.

[38] Ze Shi Li, *Complying with the GDPR in the Context of Continuous Integration* (Mar. 29, 2022, 9:25 PM), https://dspace.library.uvic.ca/bitstream/handle/1828/11676/Ze_Shi_Li_MSc_2020.pdf?sequence=3&isAllowed=y.

A punishment of up to €20 million may be levied for more significant infractions, or 4% of the company's worldwide annual revenue for the previous financial year, whichever is greater.

1. Articles 5, 6, and 9 provide the fundamental processing concepts. Legal, fair, and transparent data handling is required. To guarantee its security, personal information must be acquired with a purpose in mind, be kept accurate and up to date, and be treated accordingly. Organizations can only handle data if they fulfill one of Article 6's six legal justifications for doing so. Specific categories of personal data, such as ethnic origin, political convictions and religious beliefs; union membership; sexual orientation; and health or biometric data, are also banned unless under specified circumstances. In addition,
2. An organization must have evidence to establish that data processing is justified based on a person's permission (Article 7).
3. Articles 12-22: Rights of those who have provided personal data It is in everyone's interest to know what information a company collects and how they use it. The right to receive a copy of the data gathered, the right to amend the data, and the right to erase the data are also available. A person's data can be transferred to another organization if they so want to do this.
4. Articles 44-49: Data Transfers to International Organizations and Third-Country Recipients the European Commission must approve a country or foreign organization as providing a sufficient degree of protection before an organization may transmit any personal data there. The actual transactions must be protected.

The Information Technology Act of 2000 (IT Act) and the Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2011 are the Indian rules that govern online data protection. The IT Act was enacted to give “legal recognition for the transactions carried out through electronic data interchange and other means of

an electronic communication."[39] Chapter IX establishes civil culpability, whereas Chapter XI establishes criminal liability. Unauthorized access to or damage to a computer, computer system, or network is punishable by fine and compensatory damages under Section 43 of Chapter IX of the Act. The evidence presented in this chapter is critical to proving criminal culpability under Chapter XI Section 66.

C. Addressing the Threat to Privacy in Smart Cities and Smart Homes

Privacy is the soft target for any digital threat because everything confidential holds importance, value, and worth which is the juicy prey for cyber hackers. As has been mentioned previously, intellectual property has a vital role to play in this digital world. Using digital twins to build smart cities allows hackers to construct and reverse-engineer a specific piece of intellectual property, avoiding the requirement for their in-house research and development. If your digital twin were to put this at risk, the financial and public relations fallout would be immense.[40] GDPR signals Europe's commitment to the privacy and security of personal data at a time when more people are relying on cloud services and data breaches are regularly occurring.[41] Rule 7 of IT Act, 2000 and Art. (44 - 50) of GDPR obligates that data transfers will be allowed only if the receiving party offers the same level of data protection, which behaves as a shield to ensure privacy amidst rising cyber offenses. The redressal mechanism provided by both the Indian IT legislation and GDPR expressed in Rule 5(9) of IT Act, 2000 read with Section 72A of IT Act, 2000 and Art.77, 78, 79, 82 of GDPR respectively, ensure justice to the aggrieved party through different redressal mechanisms. By permitting data processing on legality grounds and categorizing sensitive personal data as to what it must be inclusive of, both the legislations have tried to secure privacy by encrypted means.

Under Section 43A of the Information Technology Act, the Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2011 stipulate a privacy policy alongside reasonable security practices and procedures for security practices under the

[39] A.M. Toli and Niamh Murtagh, *The Concept of Sustainability in Smart City Definitions*, frontiers (June 2, 2022, 11:15 AM), https://www.frontiersin.org/articles/10.3389/fbuil.2020.00077/full.
[40] *Id.* at 43.
[41] *Id.* at 23.

legislation. The rules state that the privacy policy must be posted on the company's website and made available to the public. It must specify the types of data gathered, the purposes for which they were collected, and the recipients of the information. Personal information can only be gathered legally via a contract, according to this policy. Rule 8 explains what constitutes a reasonable security practice or process for the Act. Two requirements must be met before an entity is judged to have adhered to reasonable security policies and procedures:

1. Standard and best practices for information security have been applied if and

2. Information security policies and a thorough program have been put in place. For data protection, this document should include management and technical controls and operational and physical security measures.

Security standards must be IS/ISO/IEC code of best practice or codes officially authorized and notified by the Central government, according to Rule 8. Every year, organizations are required to conduct an audit of their processes and procedures to ensure compliance. Organizations that can successfully show they've put in place specific security procedures will be exempt from paying damages under Sec.43A if they suffer unjust loss or gain due to a failure in data protection.[42] Article 21 under Part III of the Indian Constitution, 1950 guarantees the right to privacy as a fundamental right for the residents of India. Therefore, it is the sole responsibility of the respective states and the government to protect their citizens' privacy.

V. India and the Influence of Digital Twins in Building Smart Cities and Smart Homes

According to what has been said before, digital twinning is a driving force in manufacturing processes, helping to replicate systems and making it easier to discover and forecast the probable causes of application failure. As a result, digital twinning has been proven to be a more cost-effective method of managing ups and downs. Digital manufacturing has undergone radical change due to the

[42] Maysoun Ibrahim, et. al, *Paving the way to smart sustainable cities: Transformation models and challenges*, ResearchGate (Dec, 2022, 10:04AM), https://www.researchgate.net/publication/307851827_Paving_the_way_to_smart_sustainable_cities_Transformation_models_and_challenges.

Internet of Things (IoT), which includes both industrial and consumer IoT. *"IoT unlocks solutions for gaining visibility into manufacturing at the shop floor level through dashboards as well as providing a control mechanism for processes in the shop floor. Factories become smart and paperless, and operations can be monitored remotely. Precise predictability in running a factory and visibility to the operations are other highlights,"* said Karthikeyan Neelakandan, associate Vice President, Infosys Ltd. Using programmable logic controllers, the procedure may be made possible. India may expect to benefit from digital manufacturing in cost savings, agility, operational efficiency, improved safety, and increased utilization.[43] Being a developing country, India has adopted digital twin technology slowly but steadily, whose reflection will be discussed hereunder. It is notable to mention that the current government ruling in India has shown promising efforts towards adaptation of digitalization in the everyday lives of their citizens. Various applications are also going into the market, which is booming with customers consuming such applications. As technology sneaks into the democratic nation, all have been relatively well till now.

A. Cityzenith's Smart World Pro

Amravati, the capital of Andhra Pradesh, is the first Indian city to use digital twin technology. On January 22-25, a 3D model of the city will be revealed more than 3,000 miles away at the World Economic Forum annual conference in Davos utilizing Cityzenith's Smart World Pro software. As the CEO of Cityzenith, Michael Jansen, has spoken, "everything happening in this capital city will be scenarios in advance to optimize output." Put simply, the digital twin technology will help Amravati get updated concerning what it has to offer when put in the same line with other Indian cities. An IoT/Industrial IoT digital twin uses sensors, drones, and other IoT/Industrial IoT equipment to gather data and uses sophisticated analytics, machine learning, and artificial intelligence to acquire real-time insights into the physical asset's performance, operation, and profitability. This type of technology is expected to become more essential in the development of smart cities across the world and the resolution of critical public health, safety, and environmental concerns.[44]

[43] *Id.* at 51.

[44] Smart Cities World, https://www.smartcitiesworld.net/special-reports/special-reports/the-rise-of-digital-twins-in-smart-cities (last visited June. 6, 2022).

B. Greenfield cities vis a vis Brownfield cities

There are difficulties in increasing urbanization of cities, including poverty expansion, social stress, urban pollution, and a lack of natural resources. Demands for environmental and technical development are also increasing as a result of this. To remain viable, cities must find ways to deal with the tremendous urbanization that is occurring. As a result, many local governments and other organizations are launching Smart Sustainable City (SSC) programmers to deal with the problems that come with increasing urbanization.

The Narendra Modi-led NDA government in India recently announced the beginning of the Smart City Mission, as part of which 100 smart cities would be built across the nation. A greenfield city is a city that is entirely new from the ground up. Brownfield cities are those that were created by repurposing existing urban areas. This notion, however, is not original. On the Delhi-Mumbai industrial corridor, the government, for example, focuses on constructing five brand-new cities. Because big greenfield towns are challenging to build in modern-day India due to the scarcity of vacant land, greenfield cities tend to be tiny. GIFFT, Gujarat's international finance and technology city (greenfield smart city), will be India's first. Chandigarh is regarded as the country's first "greenfield" metropolis, having been built from scratch. Chandigarh was built to serve as the provincial capital's administrative center. Durgapur Airport, India's first privately funded greenfield project.[45]

VI. Conclusion

the digital twin technology has spread its claws over the development of smart cities and homes, going towards the global transformation of infrastructure, utilization of resources, addressing significant concerns of the countries such as climate change, lives of the people, administrative structure, and governance. More to say, the role of digital twin technology from the city governance perspective reveals that the former helps facilitate the virtual image of the latter, thereby improving governance alongside city development initiatives.[46] Although its functions and usage overbuilding in smart cities and homes speak a lot about it. But it is noteworthy to mention that the lack of specificity surrounding digital

[45] Prop Tiger, https://www.proptiger.com/kolkata/behala/greenfield-city-project-llp-greenfield-city-phase-ii-1948465 (last visited Oct. 6, 2022).
[46] *Id.* at 3.

twin technology welcomes new challenges frequently, which subsequently becomes difficult for the existing legal framework to handle and govern. With the rising importance of privacy and security of confidential informations smart cities, along with upgraded applications, require stringent legislation that can curb mala fide activities and function to safeguard the privacy and security of the individuals residing in such cities. As the scope for research, development, and awareness associated with digital twin technology continues to live on amidst the 21st century, complete reliance on digital twin technology cannot be made. And therefore, precautions and challenges preventive mechanisms must be adopted.