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REVIEW ARTICLE

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BLOCKCHAIN INTEGRATION IN SMART CITIES: A SYSTEMATIC REVIEW AND FUTURE DIRECTIONS

Vishal Singh
Assistant Professor, Centre for Distance and Online Education
Punjabi University, Patiala, India

***Abstract*:** We discuss blockchain technology and its expected impact on smart cities in this paper. A significant development in technology, blockchain is made up of a number of core standards and technologies. We especially look at the question of how blockchain technology could contribute to urban growth. We developed our conceptual framework and research ideas after carefully reviewing the literature. The process of smarting cities has determined Fourteen application areas for blockchain technology: (1) Smart electronic voting; (2) Smart healthcare; (3) Smart home; (4) Smart property management; (5) Smart transportation; (6) Smart Logistics and Supply Chains; (7) Smart Education; (8) Smart Factory, (9) Smart Mobility, (10) Smart grid, (11) Intelligent Traffic Systems, (12) Smart agriculture, (13) Energy Consumption Tracking and (14) Carbon Footprint Tracking. We look at recent developments in several fields, highlight the importance of blockchain technology and make recommendations for future research directions.

***Keywords*:** Blockchain, Smart cities, Electronic voting, Smart healthcare, Smart logistics, Smart education, Smart grid, Smart agriculture.

I. INTRODUCTION

Growing urbanization constitutes one of the primary reasons for the present enormous population rise in the world. Cities have been experiencing a lot of stress over the past few decades because of problems related to this situation. Numerous economic, social and environmental problems brought on by urbanization have a big influence on human civilization. According to a United Nations estimate, about 70 percent of people on Earth will live in cities by 2050, up from 55 percent in 2018 [1]. Urbanization enhanced people's standards of life in a number of areas, including transportation, education, healthcare, financial stability, working conditions and lifestyle [2]. The rapid rise of urbanization has given rise to a number of problems, including waste management, pollution, traffic jams, the depletion of nonrenewable resources and the challenge of maintaining social equity [3]. The concept of a "smart city," which is an intelligent effort to encourage sustainable urban expansion and an innovative answer to the issues and difficulties mentioned above [4], was introduced in this study. Numerous smart city and urban sustainability initiatives have been put forth in the last ten years [5]. They provide strategies to help urban leaders make decisions, take action, and assess city growth in the direction of a future that is more sustainable [6]. A smart city's physical infrastructure, institutional infrastructure, social infrastructure and financial structure are its four primary constituents.

According to [7], smart cities are those that integrate technological advancements to improve the environment, resource management, general well-being, finances, government services and urban expansion. Smart cities aim to improve all facets of urban life by utilizing current and emerging digital technologies. Transforming the delivery of essential services like healthcare, education, housing, transportation, power, water, infrastructure, monitoring, and law enforcement is one of the main goals of smart cities [8]. By using technology to integrate social, commercial and physical amenities, smart cities help address the issues of growing urbanization and population expansion [9]. Smart cities will become more intelligent, linked, instrumented, habitable, safe, environmentally friendly and adaptable as a result of recent technological developments like blockchain, artificial intelligence (AI), and the Internet of Things (IoT). These technologies are being used to create an environment that is easy to use and makes it easier for different digital services and devices to engage with one another. We discuss each field, show how block chain technology can play an important part in building smart cities and conclude each section with one or more research propositions.

II. BLOCKCHAIN TECHNOLOGY

One of the latest and most significant innovations and cutting-edge developments that is now having a big impact on the workplace is Blockchain technology. It is an unowned collection of time-tagged, irreversible information files that are updated by a group of computers. The data is organized into blocks that are linked to one another and secured by concepts from cryptography, like chains. Blockchain is very useful since it is dispersed rather than controlled by a single person, its data is cryptographically safe. Its unchangeability implies that no one can change the data it contains and its transparency enables tracking at any point of time, according to [10].

Blockchain is a public, decentralized digital ledger that records transactions across multiple computers. It helps in producing a long chain by linking to and validating the earlier block. Since each exchange is publicly documented and confirmed, it provides a high level of transparency. No one can alter any data published in to the Blockchain. It accomplishes this by demonstrating that the data is accurate and unaffected. By revealing a database's susceptibility to attack and keeping data on networks instead, blockchain

increases reliability. It offers an excellent structure for competing with well-established businesses and creating new and creative commercial models [11], [12].

Most people think that blockchain can significantly contribute to the long-term growth of the global economy, improve people's quality of life, and eventually lead to significant improvements in the society in which they live. Blockchain has the potential to significantly improve quality of life and allay the previously listed urbanization issues when combined with ICT, AI, and IoT intelligent services [13], [14]. The main features of blockchain that make it appropriate for use in the creation and administration of smart city infrastructure are confidentiality, mutual reliance, performance, and integrity. A blockchain can be used to record a variety of transactions in smart cities. Smart contracts enable the automatic interchange of data and the execution of intricate legal processes. Blockchain provides a greater level of autonomy for carrying out intelligent operations throughout the operational process of the smart city through the use of smart contracts and decentralized apps.

Figure: Blockchain Technology as a Driver for Smart City Applications.

III. ROLE OF BLOCKCHAIN IN SMART CITY APPLICATIONS

1. Smart electronic voting

In a smart city, e-governance aims to automate the governance process through the adoption of ICT. Voting is a democratic way of choosing leaders of the people at all three levels of government. The ethical behavior of the government employees conducting elections is the sole aspect that affects voting on paper. Other disadvantages of ballot-based voting include low participation by voters, substantial costs, labor-intensiveness, anomalies, pre-poll tampering, faked vote compilation and ease of inserting fraudulent ballot papers. Election processes have recently become beset with anomalies, conspiracy and poor administration, even in many of the industrialized countries. Electronic voting, or "e-voting," is a feasible alternative to conventional ballots since it offers tamper-proof voting thanks to digitalization. Compared to conventional paper-based voting, remote electronic voting offers the advantages of real-time processing and counting purposes, lower mistake rates and possible environmental benefits. Electronic voting is based on digital technologies. Instead of utilizing physical votes, software systems use biometrics to verify voter's identities. However, this voting process is vulnerable to hacking and manipulation attacks on both the user and system levels.

A decentralized network which is immune to single points of breakdown and centralized control is provided by Blockchain. A private key is available to every individual on the blockchain, allowing them to electronically sign transactions and add it to the append-only electronic record. These blockchain features could be used in scalable e-voting that utilizes blockchain technology. A wallet with a private key for polling-day validation may be provided to each voter taking part in blockchain-based electronic voting. A coin gets added into the wallet every single time a poll is held and it may only be utilized once when casting a vote for a supported candidate [15]. The system protocol can be developed to allow voters to be validated while maintaining their confidentiality as long as the vote is counted. A blockchain-based digital voting solution may be regarded rigging-proof because of its privacy and transparent properties. Considering the fact that Blockchain provides a transparent, fast and secure way to verify identities and vote. Low public acceptableness, technical difficulties like the blockchain scheme's adaptability and storage problems, end-user security and privacy concerns, resistance from people who would benefit from the inefficient voting system, like dishonest politicians and a lack of digital literacy among the general population are the main barriers to its widespread implementation.

Although several countries have adopted electronic voting, there are still significant security and vulnerability concerns. The primary reason blockchain offers solutions is because of its unique features, which include openness decentralization, irreversibility, nondisclosure, and the lack of a third-party requirement [16], [17]. Several electronic voting platforms created by governments in numerous countries are critically analyzed by academics in [18]. A. B. Ayed proposed a blockchain architecture for voting via the internet, or "i-voting," which provides truthfulness, legitimacy, dependability and privacy. The blockchain is going to have multiple branches. A particular transaction which is extended to the foundation block—the first block in each branch—will have the identity of the applicant included in it. The votes cast for the respective candidate are going to be represented by the blocks on the branch that were initiated by the foundation block of that contender. For the final total, votes from all branches—including orphan blocks inside a branch—are counted. Votes are safeguarded once they are cast and stored as transactions in the blockchain network. However, the primary disadvantage of the proposed method is that voters may act maliciously during the voting process. Regarding this, the Australian digital democracy group MiVote provides a blockchain-based online voting system for a variety of political activities, such as voting and reforming policies. The Blockchain-based technology aims to provide an extensive record of all transactions and instruct voters on how they can hold politicians responsible for their acts.

2. Smart healthcare

Blockchain has many potentials uses in the healthcare sector, including help to build a framework

which provides transparency of health data, techniques for analysis, consistency of results and increased trust in the clinical health benefit chain in smart cities [19]. They could thereby drastically reduce the price of creating novel drugs, testing supplies and healthcare services [20]. Data-driven healthcare systems have emerged as a result of a substantial rise in the sheer amount of information about patients being sent between insurance organizations and medical professionals. Because of this, healthcare providers are handling and creating vast volumes of sensitive data which requires strict privacy and access control [21]. Blockchain technology has a number of advantages for intelligent healthcare.

A blockchain-enabled system for healthcare, guarantees the accuracy and compatibility of health information, enhances the standard of insurance claim decision-making and provides excellent patient-centered services. In this way, blockchain can guarantee accuracy of data, accountability and access for everyone in addition to assisting in overcoming data security obstacles. By providing a common and unchangeable structure for information, blockchain technology also provides a data-management framework that makes it easier to control, store and trade disparate medical information about patients [22]. Along with the fundamental advantages of blockchain accessibility and consistency, it is also stated that blockchain technology may offer quick accessibility to health data. The fact that health records are stored in separated record-keeping systems throughout hospitals and different healthcare institutions (such as exchanges of medical information that provide shared patient records presents a serious problem because it prevents healthcare professionals from accessing available patient data in an emergency. Blockchain technology facilitates the advancement of smart healthcare systems by facilitating the easy access and transmission of medical records for patients, monetizing medical information for research purposes and consolidating and safeguarding health records [23].

Blockchain shows an excellent level of dependability in e-health services, that may be useful in providing a more personalized and efficient medical support. In healthcare settings, both patients and doctors have greater access to healthcare records and papers thanks to blockchain's secure decentralization of information about patients, which eliminates the need for centralized control [24]. Physicians can save numerous lives by identifying warning symptoms of dangerous illnesses early on thanks to quick access to health data. This is particularly crucial in densely populated places, as the recent catastrophic COVID-19 occurrences have shown. COVID-19 "makes a convincing case for the further integration of blockchain," according to the World Economic Forum (WEF). It can potentially replace today's valuable networks, which have been identified by an absence of connectedness and smooth exchange of information, because it can build transparent, compatible with one another and connected networks [25]. In an effort to combat the COVID-19 epidemic, Spanish researchers have tested blockchain technology to help medical professionals make better informed choices about isolation and social isolation. During this epidemic, savvy citizens' health data could be protected from malicious use and breaches of privacy by utilizing technology. Blockchain's collaborative features may also assist with COVID-19 patient tracking, hospital overburden reduction and healthcare procedure simplification. In this regard, previous scholarly studies have already demonstrated how blockchain, when paired with artificial intelligence (AI) and a geographic information system (GIS), can facilitate the quick spread of information regarding the outbreak of a pandemic and afterwards monitoring of individuals who test positive. Federated blockchain systems facilitate the rapid extraction of combined information from such an environment [26].

In general, blockchain-based technologies are currently being investigated for protecting data related to healthcare, overseeing pharmaceutical supply chains, encouraging clinical studies and information monetization, avoiding fraud in the medical field, enhancing public health monitoring and granting appropriate access to truly public and open geo-tagged data, according to [27]. Consequently, with the objective to provide residents with excellent medical treatment, the blockchain system offers healthcare stakeholders fresh opportunities to reevaluate their present operational methods. Authorities in smart cities, especially those in government, must use a great deal of discretion and take into consideration a variety of aspects related to the implementation of blockchain technology in the healthcare industry. Blockchain has the potential to boost public confidence in local authorities in nations where individuals receive funding from the government or publicly healthcare services at the local level. This is feasible since technology may be used by smart cities to modernize their medical facilities and build more flexible service networks.

3. Smart home

The term "smart home" describes the advanced use of wireless sensor networks (WSN), universal computing and information and communications technology (ICT) for intelligent management and administration, including lighting control, regulating the climate, security alarm control and entertainment system handling. Additionally, it has emergency alarm systems, restricted entry to stop cyber-physical dangers and a safety measure for identifying breaches [28]. A local network connects the gadgets in smart homes to the web so that a wall-hung terminal or desktop/mobile apps may track and supervise them remotely. The term "smart house" refers to the increasing integration and usage of many modern technologies using home WiFi networks in order to improve people's quality of life. Smart houses are a prime example of a highly sophisticated living space that offers greater comfort, simplicity, as well as security to its occupants. They make it possible to match the choices of the inhabitants with their home environments [29].

Incorporating blockchain-based technologies into smart homes has many advantages. According to [30], blockchain can help with accountability and confidence in smart homes. In order to provide context-aware service provisioning, the technology enables homeowners to monitor all gadgets and sensors. Using ambient sensing, smartphone apps and Internet of Things sensors may easily produce data about person physiological conditions, utilization of energy, security protocols and behavior among users. Every piece of information can be stored on the blockchain and utilized for activities related to the economy of sharing [31]. Digital signatures may be applied to safely give every smart-home equipment a unique identification and to identify questionable activity. Blockchain's decentralized, visible and trustworthy features offer a special system for smooth communication and easy multi-platform information sharing amongst smart-home sensors, actuators and gadgets. Furthermore, the problem of compatibility amongst smart-home devices may be resolved by blockchain. This is

necessary for smart houses in smart cities to integrate, communicate and operate properly. Regarding this, [32] emphasize how important blockchain technology is for enabling communication between smart homes, increasing automated energy exchange in smart homes, and encouraging more environmentally friendly behaviors inside and outside smart cities. Blockchain holds great promise for resolving current problems that impede the widespread use of smart homes. As a result, with the goal to increase the intelligence of smart houses, smart-home architects must strengthen the technological viability of blockchain and its accessibility, to enhance the comfort of smart home residents.

4. Smart property management

Due to its immovable, diverse and essential asset nature, real estate is a profitable industry in the modern global marketplace. Real estate is the possession or renting of commercial, private and public properties. The term "smart real estate management" (SREM) describes the application of cutting-edge, modern innovations to the efficient commercial handling of real estate trading in a sustainable, user-centric, safe and private manner. In order to address the main issues facing the real estate sector, smart real estate (SRE) must embrace innovative disruptive technological solutions. By meeting the demands of relevant stakeholders, including customers, real estate agents, government agencies and lawmakers, under a common decentralized ledger, blockchain technology holds the potential to develop novel models of operation in the real state sector.

Blockchain offers a smooth way to address land registration issues and property fraud. It is possible to hash the land's geolocation and polygonal description, link them to the owner's ID and store them in a distributed ledger. Additionally, tracking an asset's whole possession history and validating and authenticating associated transactions are made possible by the immutable blockchain [33]. Purchasing real estate is yet another illustration of the difficulties, as it entails tedious and intricate transaction procedures that are complicated by various flaws or wrongful conduct (like double-selling, collusion and fake title deeds). Blockchain may be used to assist with prevent fraudulent conduct, boost productivity and accountability, enable tough ownership protection and decrease transaction delay and expense. An unchangeable record of property transactions can also be created using blockchain technology.

An ideal ecosystem for the efficient and digital administration of real estate investments for increased value creation is Evareium [34]. The Evareium platform's Ethereum ERC20-based currency, EVRM, is supported by real estate assets. It makes it possible for investors to make money passively without actively dealing real estate. By 2027, EVRM is expected to account for 10% of global GDP.

5. Smart transportation

Increased accessibility to updated transportation systems which are sustainable for the smart city and the ecosystem at large, as well as effective for users, is the goal of smart transportation. This is a crucial component of every smart city. In order to make existing public transportation efficient, secure, quick, practical, affordable, profitable and linked together, the Intelligent Transport System (ITS) combines the utilization of cutting-edge technologies like computers, networked sensors, wireless communications and electronics with contemporary management strategies and traffic management techniques. Traffic signal control systems, Speed Detection Camera System (SDCS) integration, automatic number plate identification, CCTV systems for continuous surveillance and traffic ticket administration systems are all part of the smart transportation system.

In order to assist transport administrators, enhance routing procedure strategies and schedules, prepare for different needs of travelers and increase productivity with respect to both environmental and sustainable development objectives, blockchain-based technologies could be used in combination with Internet of Things equipment and networks to provide ongoing real-time monitoring of automobiles and travelers [35]. In a fully decentralized fashion, the Byzantine Fault Tolerance (BFT) characteristic of blockchain may address the interaction and cooperation issues in cars, roadside linked equipment and infrastructure and pedestrian-owned smartphones for smart transportation systems. An internal financial system for ITS will be established thanks to blockchain's "double spending" resistance, which facilitates financial transactions eliminating the need for middlemen. Using an effective transportation system, which utilizes use of blockchain technology, users can securely spend money on their transportation needs.

6. Smart Logistics and Supply Chains

One of the most common subjects of smart-city designers is logistics in cities because of the constantly growing amount of transportation and several other distribution inadequacies. The way supply-chain and logistical processes operate in delivering products and services to consumers has been greatly impacted by the usage of cutting-edge technologies. Although many businesses have seen improvements in their skills, efficiency in operations and position in the marketplace as a result of the shift to a data-driven supply chains and logistics, smart logistics remains ill-prepared to deal with the sudden alterations in the business environment and majority of supply chains are not flexible enough to respond rapidly to shifting environmental and market circumstances.

Supply-chain and transportation operations in smart cities might work better thanks to blockchain technology. It can facilitate sharing of data and working together amongst the many logistics process parties [36]. Blockchain may be utilized by supply-chain participants to facilitate due diligence, improve the safety of IoT devices and effectively control the movement of products and services across different locations in the network [24]. Blockchain is seen to be essential for supply-chain integrity and transparency, allowing continuous monitoring of all company transactions and enhancing the quality of the finished products [37]. A completely open supply chain is a lucky way to lessen operational inefficiency, unpredictability and knowledge asymmetry in cities that are smart.

Blockchain facilitates the creation of smart cities by improving the efficiency of supply chains as well as the uniformity and transparency of items across their manufacturing and consumption cycles. Reliable supply chains and a diverse range of micro-industries with ever-changing business relationships are essential components of a future smart city. In the same manner, blockchain technology increases consumer confidence and fulfillment by enabling smart city users to monitor and determine the source of what they are selling [30]. The technology boosts the efficiency of traceback processes, stops fraudulent and counterfeiting [36] and streamlines a number of supply-chain management as well as logistics operations, including fulfilling orders, control of inventory and shipment of goods [30]. Blockchain provides an efficient way to coordinate papers, expedite clearance from customs and authorizations and cut down on processing time in the logistics sector,

according to [24]. Therefore, supply-chain partners may become more competitive, operations can be streamlined, logistics costs can be decreased and congestion in transportation inside city limits can be reduced by utilizing the clever advantages and benefits that blockchain offers.

7. Smart Education

One of the key markers and distinguishing characteristics of smart cities of tomorrow is education. Future workforce strategy depends on the accuracy of educational qualification records. Thus, the need for education is closely associated to the growth of intelligent cities. In addition, education and school quality in relation to local development and the combination of educational institutions and smart cities are critical to the quality and sustainability of smart cities [38]. Even though ICT is widely used in education, the digitization of school data has created concerns about confidentiality and safety of its internet-based storage [39]. The necessity to secure private data that is enhanced with important details including citizenship, immigration, monetary and social profiles collected by educational organizations has raised major issues for the education sector. Since big data and educational analytics have grown increasingly prevalent in higher education [40], issues over the usage of information about students have grown. [41] assert that the privacy of educational information systems is a crucial component that limits the caliber of information services and significantly impacts resource preservation and transmission. Blockchain offers an extremely safe architecture for managing massive volumes of data related to education. Since each person may hold and distribute their own electronic certificates over a peer-to-peer network, the system serves as a safe ledger for preserving educational records including student transcripts, degrees and certificates [22]. Higher education paradigms can be changed into sustainable platforms for continuous learning with the use of blockchain technology.

Academic achievements can be safely exchanged and certified thanks to the technological layer made possible by blockchain. [42], for instance, created a system that uses blockchain technology that would streamline verifying of people's educational achievements and to enhance confidentiality and management of their educational credentials when students complete an assignment or when foreign employers demand that they verify their educational achievements. The ability to automatically and instantaneously evaluate information about student achievement without requiring educational organizations to create, own, or award degree certificates is the main advantage of integrating blockchain technology into intelligent learning. Furthermore, by reducing the potential for ledger manipulation, blockchain improves information quality and dependability and fortifies the confidentiality of educational documents. Additionally, teacher’s and student’s faith in online educational service providers, evaluation techniques, credentials and training and proprietary information is bolstered by the secure nature of Blockchain. Enhancing the utilization of educational resources is also believed to need the implementation of a distributed, safe administration for universities system. Higher degrees of confidentiality would help students by enabling them making more knowledgeable choices regarding their academic pursuits, as blockchain guards against malicious attempts and information leaks [22]. By creating a data-secure environment in smart cities, blockchain technology enhances the authenticity of students' academic records, eases worry regarding security in the field of education and encourages community engagement and an awareness of community. Therefore, blockchain could potentially use to enhance the human element in smart cities by building better universities that provide educational environments and encouraging students' creative problem-solving and innovative thinking.

8. Smart Factory

One of the most important components of smart cities is smart factories. Introducing hyper-efficient production that is appropriate for highly competitive surroundings and volatile market situations is at the heart of the "smart factory" concept. To create smarter and customized products, a smart factory consists of a group of sensors and self-governing systems that can self-optimize and make decisions on their own [43]. There are many obstacles in the way of implementing smart manufacturing. For example, both regular and unexpected repairs, as well as sudden malfunctions and process incidents, continue to occur in a number of facilities. The hazards associated with cyberattacks; industrial espionage [44] and inaccurate production data may be increased by working within intelligent manufacturing facilities.

The capacity to handle enormous volumes of information is essential to the effective functioning of smart factories, claim [45]. To do this, blockchain technology can offer reliable decentralized administration, monitoring and control of all IoT devices and machinery utilized in smart factories. Blockchain may offer greater speed and efficiency for data transfer, safe automation in industries and the operation of manufacturing machinery over unstable networks. Blockchain may transform smart factories quicker, more adaptable and equipped to handle various manufacturing planning and scheduling choices in extremely volatile operating situations. In particular, the technology is helpful for predictive maintenance, automated problem diagnosis and remote updating of software during manufacturing [23]. As blockchain technology may result in significant reductions in expenses by means of predictive maintenance and accountability of materials collected for production, it may serve as a useful solution in the operation and upkeep of manufacturing facilities where there is a significant reliance on sophisticated electro-mechanic equipment. Blockchain simplifies autonomous workflows and resource sharing across industrial Internet of Things devices, allowing factory personnel to focus on manufacturing procedure monitoring [46]. Manufacturing procedures are becoming more automated and self-sufficient thanks to the integration of blockchain technology and innovative manufacturing technology. In the same vein, blockchain-based decentralized sharing of information can help production data analysts create accurate forecasts, ongoing process controls and real-time responses in addition to supporting security for on-chain smart-factory data [47].

9. Smart Mobility

The intelligent movement of residents is a fundamental aspect of smart cities. The accessibility and readily available nature of contemporary, environmentally friendly transportation systems are enhanced by efficient mobility. According to [48], smart mobility, made possible by smart technology, can result in more intelligent and efficient transportation systems in the future. Smart mobility necessitates the creation of safe, effective, and clean public transportation. For any modern city, managing its transportation infrastructure has proven to be a difficult undertaking. The creation of novel and environmentally friendly modes of transportation is made possible by the

incorporation of blockchain technology to intelligent mobility. In this connection, [30] note out that the usage of blockchain-based and IoT-integrated systems allows constant monitoring of both individuals and vehicles. This may act as the foundation for a variety of machine-learning algorithm-based apps and services, such as creating transport schedules, predicting commuter demand in various city locations and allocating driver shifts in a way that balances people's needs with mode of transportation demands.

Blockchain technology can help smart city planners build an effective transportation system that lets residents look for and make payments for services directly. According to Rahman et al. [49], the technology may be used to reliably record and preserve detailed information about the driver and the vehicle profile, preserving an exhaustive and unchangeable record of repairs, collisions and exchanges. The reliability of public transit can be enhanced by blockchain-based intelligent transportation solutions. Additionally, they promote car-sharing programs and allow for variable rates for insurance depending on driver behavior data (such as speed and braking habits) [23]. Additionally, blockchain applications support a private and intelligent transportation environment. By guaranteeing a more sustainable, reliable, secure, economical and adaptable mode of transportation which is capable of meeting the ecological, cultural and financial needs of future generations as well as present, it can improve citizen mobility inside smart cities. By enabling municipal transportation decision-makers optimize scheduling and routing methods, take into account the diverse demands of inhabitants and enhance environmental sustainability, blockchain-based apps can also significantly improve smart mobility for residents.

10. Smart grid

A smart grid is a contemporary electrical grid that has been innovated for maximum reliability and effectiveness. The transmission lines, electrical generators, renewable energy sources, intelligent appliances, sensing devices and smart meters make up the smart grid, which is in charge of producing and distributing electricity under electronic supervision [50]. In contrast to the conventional electrical distribution system, smart grids add sensing, surveillance, communication, evaluation, visualization, calculation, control, automation, diagnostics, maintenance and repair capabilities. The main goals of the smart grid are to reduce losses of energy, satisfy consumption with an adequate supply and improve grid dependability, cost-effectiveness, sustainability and operational effectiveness.

In energy trading sectors, renewable energy sources (RES) including wind and solar electricity generation have brought in so-called prosumers. Inside the framework of the smart grid, local energy production for local consumption has minimal transmission loss. Blockchain enables energy trading between peers' infrastructure in the smart grid eliminating the need for an administrative body. Blockchain applications in the smart grid were covered by [51]. These included automated decentralized electrical delivery and distribution, real-time operational surveillance of the power grid, determining the most suitable spot for electric vehicles to be charged at an affordable rate, efficient and individualized energy exchange among prosumers, cyber-physical protection for the smart grid and accurate consumption analytics. A blockchain architecture was proposed by the researchers as the smart grid's cyber layer. For stable and dependable management of operations, aggregator-based blockchains and application-dependent blockchains are implemented.

11. Intelligent Traffic Systems

Blockchain technology can act as a bridge between the expanding Internet of Things (IoT), Intelligent Transportation Systems (ITS), and autonomous driving trends. An autonomous car that is listed as a Blockchain asset will always be in contact with other automobiles and traffic systems, making it a trackable asset [52]. A navigation system may deal with rush-hour traffic problems by directing traffic along other routes based on the data gathered, ensuring that every person's typical trip time stays the same. Furthermore, the Blockchain-powered communication system may steer cars that are about to crash and redirect traffic in a manner that avoids or lessens the impact if a vehicle loses grip and collides with other vehicles approaching [53].

12. Smart agriculture

Green development has emerged as one of the main objectives of smart, environmentally friendly urban growth in an effort to enhance a deteriorating environment overall. One of the biggest green developments in agriculture is the expanding utilization of energy from renewable sources. A novel system and strategy need to be established to create a favorable external environment enabling the creation of renewable energy sources in order to promote green agriculture. The possible future possibilities of the energy-efficient innovation ecosystem and blockchain-enabled smart agricultural coupling mechanisms are discussed by [54] and [55]. The suggested model calculates and evaluates the green energy innovation ecosystem's spatial collection, regional inequalities and geographical–temporal variations. The findings may be applied to smart agriculture in order to establish an ecosystem for renewable energy innovation centered around blockchain technology.

13. Energy Consumption Tracking

The secure data monitoring and preservation that Blockchain technology offers, that can be utilized applied in a variety of ways, is another tool that may be employed to promote sustainability. Real-time data collection and management, like tracking and reporting to users on their energy consumption, could be one of the applications [56]. The foundation of blockchain security of data is the notion that when data inputs are made, they cannot be changed and are simple to track, which leaves little to no opportunity for mistakes or oversights. Smartphone applications can notify users of their electricity consumption and related expenses serve as an example of how this Blockchain functionality might be integrated into the power system. Customers who check their electrical consumption in real time not just benefit from information transparency, but they also find it easier to set and maintain a usage limit. Customers may be given access to a number of extra interactive features through applications for smartphones.

14. Carbon Footprint Tracking

Monitoring the carbon footprint of energy equipment is one way that blockchain is being used to promote sustainability in power infrastructure [57]. Features of blockchain technology, like information storage and safety may be used for this. Since the total quantity of carbon created cannot be modified once it has been documented, data generation is guaranteed to be reliable. The

environmental effect of a product's carbon footprint may be studied and both the manufacturer and the consumer must have access to this information. Management or regulating services might set a price based on their carbon footprints or set a threshold above which a "carbon" tax would be applied in order to deter the usage of such appliances. People would become more conscious of how their behaviors affect the environment as a result. Implementing the tax after evaluating the products and raising their prices if a greater footprint is found could be an additional step to reduce the overall number of products in use. The supply-demand connection for these products may also shift as a result, leading to a sustainable future driven by blockchain technology [58].

IV. CONCLUSION

In this paper, we have discussed Blockchain as a new foundational technology for the operating system of smart cities. The implementation of blockchain technology with smart cities is still in its infancy. These ideas cover a wide range of systems and processes and are quite general. As technology further develops, more individuals embrace the ideas of smart cities and more people investigate the potential of blockchain technology, major innovations and achievements are anticipated in both disciplines in the near future. The complexity of governance and administration is increasing as cities grow and extend their services. Cities must thus change to meet the problems posed by these changes in the areas of the field of engineering, finances, society and the natural environment. To effectively handle the issues, cities need to become more intelligent. In conclusion, there are a lot of obstacles to overcome in the extensive research on implementing blockchain technology in smart cities. Although the network community gains from resolving the problems and going on. The purpose of this research is to give a concise introduction to blockchain technology while explaining how smart city issues could potentially be addressed with it. We hope that our research and discussion will help to further the development and application of smart cities.

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