Blockchain and Artificial Intelligence in Sustainable City: Can These Technologies Create Sustainable Cities and Communities?

Author: Muhammad Hamza
University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT,

Blockchain and Artificial intelligence (AI) are the most cutting-edge technologies and will reshape how people work, interact and live. The integration of both the technologies can lead decentralization. Blockchain has the potential to transform the activities of our everyday lives which include, automating payments and provide access to shared ledger, transactions, and logs in a decentralized manner which is secure and trustable. Moreover, Blockchain smart contracts make it possible for participants to govern transactions without any third party or intermediary involved. On the other hand, AI enables machines to make intelligent decisions and develop self-learning capabilities which can make predictions based on the analytical data available on the Blockchain. In this paper, the existing literature and seminal work on the development of Blockchain and AI integration in Sustainable City is reviewed. Furthermore, the paper explores the existing Blockchain and AI applications for SMART City and discusses the open challenges of utilizing Blockchain and AI for SMART Cities through the lens of Sustainable Development Goal; 11 (Sustainable Cities and Communities).

This paper discusses the Blockchain-AI integration in SMART Cities and its impact on the Society, Economy, and Environmental dimension, plus analyze the findings. Adding onto that, the paper analyzes the implications of Blockchain and AI technology by accessing the targets and indicators of the United Nations Sustainable Development Goal 11 (Sustainable Cities and Communities). Thus, seeking an answer to the research question: Is Artificial Intelligence integrated Blockchain technology aiding to achieve the United Nations Sustainable Development Goal of Sustainable Cities and Communities (SDG 11)? The reader is given a holistic assessment of whether Blockchain-AI integration in Sustainable City enabling or hindering the targets of Sustainable Development Goal 11 of sustainable cities and communities.

Graduation Committee members: Dr. Agata Leszkiewicz and Dr.Amini Velashani

Keywords
Blockchain, Artificial Intelligence, Machine learning, Sustainable City, SMART City, Sustainable Development Goal 11, Sustainable Cities and Communities.

1. INTRODUCTION

In this paper the research is done on Artificial Intelligence integration in Blockchain and its impacts on sustainable development. The expression "Blockchain-AI" is used in the article to refer to the Blockchain and Artificial Intelligence (AI) technology integration. Blockchain-AI and its impacts on sustainable development are not explored, the paper focuses on Blockchain-AI impacts in relation to the SDG goal of Sustainable Cities and Communities (SDG 11). The current lack of empirical study on the Field of Blockchain integrated AI in relation to sustainable development considering the above-mentioned UN development goal signal a need to direct research in this area.

Blockchain is referred to as a new era of the Internet of things (IoT), developed in the year 2008 by an anonymous group or person called "Satoshi Nakamoto" (Di Pierro, 2017). Blockchain is a public ledger where transactions are recorded and agreed upon by all users in a distributed network maintained by a network of public computers (Dinh & Thai, 2018). Whereas Artificial Intelligence (AI) has the ability of the system to learn itself from recognizing data patterns to make predictions, the algorithm is adapted to new data to improve capability over time (Chavali, Khatri & Hossain, 2020). Blockchain is enabling organizations to share data across borders in a trustable way and by giving AI access to this data greater value and better insight are provided that was not possible before (Chavali, Khatri & Hossain, 2020).

1.1 BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE RELATIONSHIP WITH SUSTAINIBILITY

Research in the Blockchain-AI is emerging and maturing. Blockchain is enabling sustainable development in many different forms for instance increasing the efficiency and transparency of the supply chain. The technology also promotes and incentivize circular economies, reduce information asymmetry in resource management, facilitating access to finance, improving monitoring, improving disaster preparedness, and enabling geospatial platforms (PricewaterhouseCoopers, 2018). The Blockchain-AI is inevitable as both technologies deal with data and value. Blockchain provide trustable platform for secure storage volume and distribution of the data because of decentralized ledger. Whereas the AI help analyze the data and produce insight that is useful in decision making (Ahmed et al., 2022). AI has the potential to act as an enabler for the UN Sustainable Development Goals as AI can enable smart and low-carbon cities with a range of interconnected technologies, for instance, electrical autonomous vehicles and smart appliances which will affect the consumption of electricity and AI also promote the use of renewable energy by enabling smart grids that is the potential of energy network to accurately predict when to redistribute power pertaining to the demand and supply of electricity (Vinuesa et al., 2020).

1.2 SUSTAINABLE DEVELOPMENT GOAL: 11 (SUSTAINABLE CITIES AND COMMUNITIES)

The section starts with background information on Sustainable Development Goal (SDG 11), The concept of sustainable development is referred to as development in the present that meets the needs of the current generation without compromising the ability of future generations to meet their needs (UNESCO.ORG, 2022). The growing population in urban areas is predicted to reach 6.5 billion by 2050, and the rising boom in urban migration has led to megacities in the developing world, and with the rising population, slums are becoming a feature of the urban cities (UNDP.ORG, 2022). To reach Sustainable Development Goals, transformation is required in the way urban cities are managed and built. Making cities more sustainable entails developing job and business possibilities, providing secure and affordable housing, and constructing resilient societies and economies. It entails investing in public transportation, establishing green public areas, and promoting participatory and inclusive urban planning and management (UNDP.ORG, 2022).

The current development in sustainability has extended the focus from economic benefit to how the solution to society problems can be designed to be economically viable but at the same time not compromising on the environmental sustainability and social responsibility. The United Nations formulated 17 Sustainable Development Goals with a vision of combating the global challenges in a cohesive way. For this research SDG 11 (Sustainable Cities and Communities) is selected because the Blockchain, Internet of things (IoT), and Artificial intelligence is being used as the most dominant technology application in the Smart Cities (Sharif and Pokharel, 2022). The rapid technology changes and development bring opportunity to achieve the United Nation 2030 agenda and the Sustainable Development Goals. The emerging technologies have the potential to reduce poverty, promote energy access and efficiency, support structural economic transformation and combat diseases (Department of Economic and Social Affairs, 2018; UNCTAD, 2017a). Blockchain-AI can have adverse or favorable impacts on (SDG's) Sustainable Development Goals, and the Blockchain-AI is strongly related to the goals of (Sustainable cities and communities). This is an emerging field due to the fact that the technology is advancing drastically nowadays, hence the debate is whether this integration is enabling the SDGs or resisting it. Thus, I will be analyzing the negative and positive impacts of this integration of Blockchain-AI on the SDG 11 and find out if the negative overweighs the positive or vice versa and if the technology is aiding to achieve the SDG 11.

1.3 RESEARCH GAP

The contribution of this paper is to present an inclusive review of the Blockchain-AI technology impact on the United Nations Sustainable Development Goal SDG 11 (Sustainable Cities and Communities). The main aim is to provide the reader with a comprehensible overview of the emerging Blockchain-AI technology's impact on sustainable and smart cities.

The existing literature review published in the context of Blockchain-AI lacks a comprehensive view of these technologies enabling sustainable developments. The literature published is in the context of the ecological footprint of Blockchain for e.g., focuses on the high energy consumption of power-intensive mining equipment for the bitcoin proof of work mechanism.

The existing studies are lacking a fully comprehensive view of all risks associated with smart city operations and planning. The complete assessment of all risks is important for the success of achieving the sustainable city goals and will reduce challenges of smart city projects from all the different aspects such as technology, security, and privacy, political, environmental, managerial, and user trust and adoption (Sharif and Pokharel, 2022). Although researchers have discussed the citizen's interaction with smart city technologies and services. However, only a limited number of studies have been done on the governance, standards, and privacy issues of technologies in smart cities. Therefore, detailed research is required in this aspect of smart cities to have a comprehensive understanding of smart cities at a holistic level (Sharif and Pokharel, 2022).

Another research gap concerns the public Blockchain as all users' identity and every transaction is publicly available for anyone to see therefore the data is vulnerable to attack. Further research is needed as miners' computational network is not protected therefore a strategy needs to be developed to protect the hashing power of the miners (Shinde, Patil, Kotecha and Ruikar, 2021).

1.4 PAPER OUTLINE

Considering this paper review, section 1 presents an overall overview of the introduction to Blockchain-AI technology and its relationship with sustainability. The section is followed by explaining the Sustainable Development Goal (SDG11) background, the research gap, and the research question.

In Section 2, Intensive review of the background of Blockchain-AI technology existing applications are discussed in relation to sustainable cities, then the section is followed with accessing the technology from a critical lens.

In Section 3, For the methodology this paper incorporates a qualitative research strategy to conduct a periodic and qualitative synthesis of the available literature on the impact of Blockchain-AI on the UN's Sustainable Development Goal of Sustainable Cities and Communities (SDG 11).

In Section 4, Blockchain-AI application for sustainable city and the challenges are discussed. In section 5, Blockchain-AI application is discussed based on three categories society, economy and environment and evaluation of SDG:11 targets are presented. Lastly, in section 5 the paper provides a conclusion and the direction for future research.

1.5 RESEARCH QUESTION

Is Artificial Intelligence integrated Blockchain technology aiding to achieve the Sustainable Development Goal of Sustainable Cities and Communities (SDG11)?

Based on the research question, the research sub-questions are as follows:

What are the benefits of Blockchain and AI integration?

What are the Blockchain-AI challenges?

2. OVERVIEW OF MAIN CONCEPTS

2.1 BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE BACKGROUND

The fundamental idea of Blockchain is based on shared and distributed ledger technology, unlike traditional records maintained by a single bank or organization, the Blockchain ledger is maintained by a network of public computers, each of which adds new entries that are visible to everyone (Di Pierro, 2017). The emerging Blockchain technology use case is widespread including cross-border payments, Internet of Things (IoT), Smart contracts, Supply chain management, and financial data management (Zīle & Strazdiņa, 2018).

Most of the AI-systems developed today are specialized systems that use data from database to make accurate predictions (Chavali, Khatri & Hossain, 2020). Blockchain-AI has enabled the use of decentralized AI applications and algorithms which provide access to secure, trusted, shared platforms of logs, knowledge, and decisions. These platforms provide a trail of records taken by AI before, during, or after the learning or decision-making process. AI depends on the data to adapt, learn, and make decisions. Machine learning works better if data collected is from a reliable, trusted, and secure source. Blockchain act as a distributed ledger on which data is stored and transacted in a way that is cryptographically signed and validated (Salah, Rehman, Nizamuddin & Al-Fuqaha, 2019). Therefore, when smart contracts are used for machine learning algorithms to make decisions or predictions then the outcomes of these decisions are trustable and undisputable (Banafa, A.,2020). Blockchain enables AI to store scalable data and provide an audit trail of data as this enhances the integrity of decisions that AI provides. AI can also comprehensively scan, understand, and correlate data at high-speed bringing new insights to Blockchain-based businesses.

Moreover, Blockchain enables AI to provide more actionable insights, manage data sharing and create a transparent and trustworthy data economy by giving access to the large volume of data within and outside the organization. Blockchain-AI have also enabled efficient automation by increasing the speed and efficiency of business processes for e.g. The AI model integrated into smart contracts can evaluate expired products, recall the products, and execute transactions automatically by reordering products, making payments, selecting the most sustainable shipping methods, and restocking of stocks by following a set threshold set on smart contract (IBM.com, 2022). Blockchain-AI is used in several industries e.g., healthcare where insight is provided from patient data and patterns, storing patient data and electronic health records on the Blockchain improves the processes and provides greater privacy for patient data. The life sciences sector is using Blockchain-AI to improve traceability of the drug supply chain and increase the success rate of clinical trials by cupelling advanced data analysis with a decentralized framework for clinical test trials making it possible to increase data integrity, transparency, patient tracking, consent management and automation of trial participation and data collection (IBM.COM, 2022). In the financial services sector, Blockchain played an important role by removing intermediary parties, improving transactions efficiency, and reducing the cost of transactions for e.g., consider the loan process where the applicant grants permission to use records stored on the Blockchain to access the application, the trust in data and automated process of assessing applications help to assess application faster and improve customer satisfaction (IBM.com, 2022). The Supply chain industry has used Blockchain-AI to replace the paper-based process with digitalization by making data shareable, and by adding automation to execute transactions, for e.g., manufacturers are tracking emission data on the product (IBM.com, 2022). The Blockchain-AI -assisted solutions are being developed for efficient energy management, Blockchain is used for peer-to-peer energy trading as in the decentralized peer to peer energy trading trust deficit is an important factor. Blockchain provide energy trading with the decentralized and distributed ledger which enable enhancement in energy trading by making it simpler, transparent, and secure (Otoum & Mouftah, 2021). AI-based energy solutions provide energy consumption data on equipment and specify the energy cost by equipment which enables consumers to track their appliance's energy consumption and control the energy cost. The Blockchain-AI energy system has been adopted by Brooklyn Microgrid which uses Ethereum smart contracts and the Byzantine Fault tolerance consensus method to enable consumers to sell their electricity directly to their neighbors (Otoum & Mouftah, 2021).

3. SYSTEMATIC LITERATURE REVIEW METHODOLOGY

This paper incorporates a qualitative research approach in order to undertake a periodic and qualitative synthesis of the existing literature related to the topic of Blockchain-AI impact on the United Nations Sustainable Development Goal 11 (SDG11). The qualitative analysis was preferred over the quantitative analysis because of the nature research topic. I will review, analyze, and evaluate the research process and findings of the relevant seminal work. The papers will be assessed, and selected literature material will be critically analyzed. In this regard, the paper will be based on the synthesis of relevant and credible journal articles, and other studies from for instance Google Scholar, Elsevier, and Jstor. The literature material will be collected by search based on keyword search query. I will analyze the articles which are updated and reflect the present development in the research topic area of Blockchain-AI.

The PRISMA approach is selected to improve the systematic review and meta-analysis of the selected literature material. The PRISMA is an interactive process of review and is based on a 27-item checklist (Moher et al., 2009, 2015). The PRISMA approach includes the use of flow diagrams which help the researcher in the screening, eligibility, and inclusions of the literature review process. The reason for selecting this approach is that it provides the standards and guidelines on how the literature review should be structured and analyzed (Snyder, 2019). The PRISMA approach will also help to make sure the relevant and credible literature review sources are collected in light of the research topic which enhances the transparency and objectivity of the research paper.

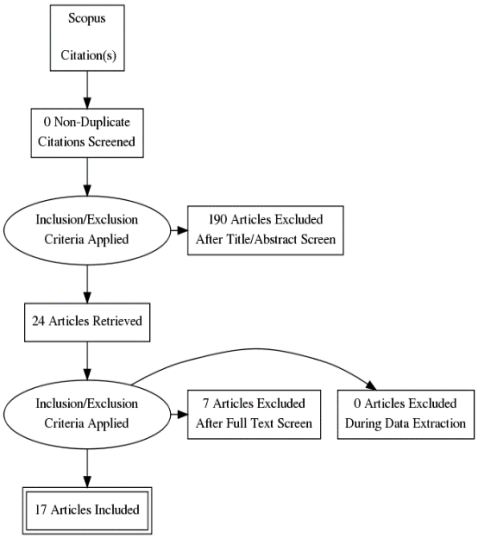

Fig 1. Systematic review of Blockchain-AI on Sustainable City.

3.1 IDENTIFICATION

The first step of the approach is to identify and select relevant literature that will be included in the research literature review. The literature sources will be extracted from Google Scholar, Elsevier, and Jstor because the platforms provide credible databases that include a comprehensive portfolio of scientific journals and peer-reviewed articles. Considering the emerging field of Blockchain-AI literature data will also be collected from case studies and credible news publications to perform an analysis of the selected UN Sustainable Development Goal: 11 of sustainable cities and communities.

3.2 CRITERIA AND SEARCHED KEYWORDS

The articles for the literature review are searched based on the following keywords (TITLE-ABS-KEY (("Blockchain" OR "Cryptocurrency" OR "Digital currency")) AND TITLE-ABS-KEY (("Artificial Intelligence" OR "Intelligent system" OR "Machine learning" OR "Robotics" OR "expert system")) AND TITLE-ABS-KEY (("Sustainable city" OR "SMART City" OR "Connected city" OR "Digital city" OR "Eco-city" OR "Green city"))) and the search will be limited to Blockchain-AI impacts on the United Nations Sustainable Development Goal 11 of sustainable city and communities.

3.3 SCREENING

Based on the searched keywords a total of 216 documents were retrieved and all the retrieved documents were published between the year 2 017 to 2022. The retrieved documents were including articles, books, and conference papers.

The screening activity was performed by setting criteria for excluding the papers for instance E1: Articles not published in English, E2: Duplicate articles, and E3: Articles published between the year 2017 to 2022.

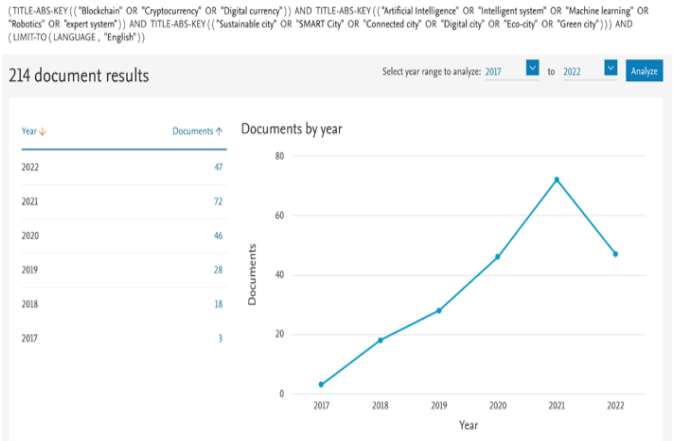

Fig 2: Literature review keyword search analysis

After applying the exclusion criteria, a total of 214 documents were filtered out, and there is a spike in the number of publications between the years 2017 to 2021.

3.4 ELIGIBILITY AND INCLUSION

The last step of the PRISMA guideline is to set criteria for eligibility and inclusion of the literature material in the final sample. All papers will be assessed by carefully reading the abstracts and keywords and the final sample of literature material including papers that are related to the Blockchain-AI impacts on the selected UN Sustainable Development Goal: 11 of sustainable cities and communities, Blockchain-AI development in a sustainable city, and Blockchain impact on smart cities.

The United Nations targeted the 17 Sustainable Development Goals (SDG's) for 2030 agenda. However, for this research, I selected the UN SDG: 11 of Sustainable Cities and Communities

because of their relevance to the research topic of AI integrated Blockchain. The articles selected for the literature review of this research are summarized in appendix number 2.

3.5 DATA PROCESSING AND ANALYZING METHOD

The paper analyzes the selected UN SDG (11) of Sustainable Cities and Communities by grouping them into three groups namely Economy, Society, and Environment. This categorical grouping will allow to comprehensively analyze the impact of Blockchain-AI on the Sustainable Development Goal: 11.

The categorical groups are as follows:

3.5.1 *Society*: Refer to the community and society that will be impacted in a positive or negative way by the development of *Blockchain-AI.*

3.5.2 *Economy:* Refer to the industry sector that will contribute to economic growth, economic profits, and GDP growth of the country.

3.5.3 *Environment:* Refers to the natural surroundings.

The relevant article selection is an important aspect of the research paper; therefore, the first dimension is related to the nature of the article and the second dimension is related to the impact on SDG: 11, the articles will be analyzed if it is directly or indirectly connected with the selected UN SDG 11 and state impacts of the Blockchain-AI on UN SDG 11. As each paper can indicate impacts on a broader number of UN sustainable development goals. Therefore, after analyzing the selected sample of articles. I will assess if targets of SDG:11 is achieved by analyzing the impacts of Blockchain-AI technology on the selected SGD with the categories formulated above namely Society, Economy, and Environment.

Aspects Investigated	Dimension	Criteria For Selection
Nature of Article	Theoretical/empirical approach.	Abstract information and methodology used.
Impact on SDG: 11	Reference to SDGs.	The paper addresses SDG'S, Blockchain, and AI technology.
	The direction of impacts positive/negative.	The paper addresses the impact of Blockchain-AI technology on society, economy, and environment in relation to the SDG 11.

Fig.3: Literature review search criteria

4. DISCUSSION

4.1 BLOCKCHAIN APPLICATION FOR SMART CITIES

The traffic congestion in urban countries is constantly rising and to overcome the problem of traffic congestion traffic authorities can limit the total number of vehicles on the road. The permit will help limit the number of vehicles on the road and will motivate the road users to use an alternative form of transportation like cycling and public transport. The traffic permits can be tradable in the open market known as Tradable Mobility Pass (TMP), but the traffic permit is difficult to implement, although the Blockchain smart contracts can play an important role to increase the feasibility of the solution (Bagloee et al., 2021). The Ethereum Blockchain can make it feasible to build smart contracts that will enable a dynamic road toll system where the toll prices are higher during peak hours' time to reduce traffic congestion. The smart contract and en-route tradable permit can also help to give priority to emergency vehicles by setting higher costs on primary roads that will promote other road users to take alternative roads and improve the traffic flow on primary roads. Another use case of Blockchain is platooning of heavy trucks by lightning up several trucks at the same speed to maintain traffic flow which will reduce the chances of accidents that result in air drag and reduce the fuel consumption by 20% (Bagloee et al., 2021). In platooning real-time data about vehicle position speed, braking, and acceleration trajectory is stored where Blockchain can enable communication between vehicles and data infrastructure which is accessible as a transaction on the Blockchain (Bagloee et al., 2021).

The supply chain faces the challenge of real-time tracking of goods and Blockchain plays an important role in the supply chain as it increases trust and transparency between all actors involved in the supply chain. In the urban supply chain, the Blockchain enables the tracking and analysis of the supply chain by establishing real-time indicators to analyze the quality factor such as humidity and temperature. Moreover, in the situation of a health crisis or disease outbreak, the Blockchain can prevent the contamination of products from the urban environment. The Blockchain also helps in minimizing the cost associated with tracking and monitoring the supply chain.

Moving on, Blockchain has the potential to assist the government in the governance of smart cities. The government can use Blockchain technology to record income, expenses, and government contracts on the Blockchain which will increase transparency and reduce corruption (Wong, Chia, Kiu, and Lou, 2020). The Blockchain can also be leveraged in the voting process by using smart contracts the voter can cast vote once and this can be traced back to the Blockchain this will reduce the manipulation in the voting process and enhance transparency. Adding to that, Blockchain can provide a platform to centralize citizens identity in one place for instance the national identity, passport, and birth and death certificates of an individual can be linked to the Blockchain, and this will reduce the identity fraud (Wong, Chia, Kiu and Lou, 2020).

Considering Blockchain and the sharing car economy if combined have the potential to disrupt the existing giant companies like Uber and Airbnb. These companies are dependent upon the assets that are owned by other people and value is derived by connecting customers and service vendors. Blockchain can offer great enhancement to these digital platforms for the benefit of the service provider and the users who are using the services by eliminating the third-party agents and making the platform peer-owned and peer-run marketplaces. The problem with sharing economy is the problem of trust issue which can be resolved using Blockchain technology, for instance in ride sharing economy user's details (Vehicle registration and citizen number) can be stored in the Blockchain which will increase trust as the identity of drivers and customers can be easily verified (Wong, Chia, Kiu and Lou, 2020). Adding to that, Blockchain can create a more robust and efficient ticketing system for public transport by using cryptocurrency to purchase digital tickets online this will ease the

use of public transportation as users don't have to visit ticket desks and offices to use the public transport and the government can use the Blockchain to create an incentive system for using public transport for instance rewards tokens evenly distributed to the public transport users (Wong, Chia, Kiu and Lou, 2020).

Blockchain has a use case in property registration and transactions with the help of smart contracts property transactions can be stored in the smart contract it replaces the traditional paper agreements and intermediaries involved in the transaction. The use of smart contracts will eliminate the problem of double registries and fraud in property transactions. The Blockchain can also assist property developers as all approvals, reports, and building drawings can be stored on the Blockchain. This will also give a transparent overview of the project and aid in record keeping, the smart contracts can be developed to automate payments on completion of the work by builders and developers can leverage Blockchain technology to set schedules for building maintenance which can be assessed through Blockchain by the facility management team (Wong, Chia, Kiu and Lou, 2020).

In the energy sector Blockchain technology has the potential to eliminate energy retailers from the energy sector. The services offered by a retailer such as billing and metering electricity consumption can be replaced by Blockchain technology, The substitution of retailers with Blockchain can result in reduced electricity bills by up to 40%, and by connecting users to the energy grid the Ethereum Blockchain enables users to buy electricity at the cost they are willing to pay this will result in a stable supply of electricity and at a lower cost (Consensys, 2022). Moreover, the Blockchain can enable peer-to-peer energy trading between users as excess energy can be traded between participants reducing the control of central authorities such as wholesale retailers (Consensys, 2022).

4.2 BLOCKCHAIN-AI TECHNOLOGY BUILDING SUSTAINABLE CITY

The healthcare sector uses a large amount of data that requires a tremendous amount of computation, security, and management. The Blockchain and Artificial Intelligence (AI) framework enable the healthcare industry to assure the reliability and security of health reports and enable high computation power which also increases the data exchange between healthcare systems and insurance organizations.

Traffic optimization is essential to improve mobility as the transport sector contributes to 23% CO2 emissions and traffic congestion accounts for 3\4 of this. The Blockchain solution is proposed which ensures a secure, transparent, and decentralized platform for traffic optimization (Paiva et al., 2021). The solution is proposed for monitoring and analyzing the traffic using Unmanned Aerial Vehicles (UAV) which collects real-time video and artificial intelligence is used for processing and identifying moving objects. The IoT sensors are installed on road lines which collect data about traffic density, the data collected will help to reduce traffic congestion at intersections (Paiva et al., 2021). Furthermore, role of Blockchain in autonomous vehicles is emerging one of the benefits the Blockchain provides is the ability to store events in autonomous vehicles this data can be useful in case if an accident occurs (Paiva et al., 2021). The use of Blockchain and smart contracts can also be seen in firmware updates by manufacturers as the system is vulnerable to attacks the Blockchain ensures the integrity and authenticity of firmware updates. In autonomous vehicles, the use of vision-based artificial intelligence can be seen which allows vehicles to detect obstacles and enable them to avoid the obstacles (Paiva et al., 2021).

The Blockchain-AI -assisted solutions are proposed in the energy sector. The Blockchain is a decentralized and distributed ledger technology that is used for peer-to-peer energy trading by eliminating the intermediary energy broker (Otoum and Mouftah, 2021). Peer-to-peer energy trading gives more authority and control to the end user as users can control and manage electricity output. The AI-based energy solutions seem to have great potential as AI-based home assistant solutions provide energy consumption data on household equipment with a possibility to itemize energy costs (Otoum and Mouftah, 2021). PowerScout has adopted the AI model to predict future utility cost savings, as AI is predicting and making suggestions to clients when opting for clean energy technologies to power their homes (Otoum and Mouftah, 2021). The use case of AI seems promising in the energy sector as it has the potential to reduce power consumption because the AI provides users with data and insights over their power consumption on equipment therefore the users can significantly optimize their electricity consumption to reduce cost and AI is also playing an important role in selecting the clean energy sources which are vital for the sustainability of the energy sector.

Moving on, Brooklyn Microgrid has implemented Blockchain in the energy system where the Ethereum smart contracts and Practical Byzantine Fault Tolerance (pBFT) consensus mechanism is enabling users to directly sell their excess energy to their neighbors (Otoum and Mouftah, 2021). Another work was proposed where the electric vehicle charging service can be provided using smart contracts in a permissioned energy Blockchain system. The Blockchain with Internet of Things (IoT) device and AI can be used for efficient waste management. IoT sensors detects the accumulated waste with the help of sensors and alerts the waste management authorities to clean and dispose of the waste. This information can be stored on the Blockchain and accessible to all parties involved. Moreover, tracking all this information in real time it will help the authorities to schedule waste collection and select the optimum routes for waste collection vehicles (Wong, Chia, Kiu and Lou, 2020).

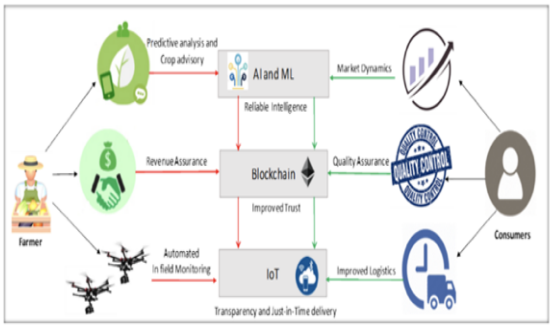

Fig.4: Intelligent precision farming with blockchain from Rehman et al, 2019.

In the agriculture industry Blockchain-AI technology integrated with IoT device it can help in crop selection, irrigation method selection, predict yield and to monitor the crop yield. Thus, this will reduce cost for farmers. Moreover, AI can predict the demand and output level which will optimize the supply chain and increase profit margins for all stakeholders in the agriculture industry (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019). The IoT sensors are installed in the farming fields to monitor the crop

nutrients level and the images that are captured by these devices can be used in monitoring the growth of crops. The AI can help IoT devices to improve the supply chain through predictive analysis which will help farmers to grow the crops according to the weather conditions and real-time data that is available from monitoring the crop growth. The statistical data produced can help the farmers take the most optimum decisions and plans can be tailored for each farmer based on factors like soil condition, weather, pest, and crop data on a real-time basis (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019). Blockchain can be used to store all transactions and ensure all stakeholders have access to this information and this will increase transparency and reduce the time that will be spent on the logistics of agricultural commodities (Salah, Rehman, Nizamuddin, and Al-Fuqaha, 2019).

A great potential of Blockchain technology combined with AI can be seen in the supply chain as these two technologies have the potential to automate the supply chain. AI-platforms, when combined with Blockchain have the potential to collect and combine data from point-of-sale systems, history of purchase information, identify data patterns and perform a predictive analysis which will help the companies to predict future demand, sales figures, return statistics and identify and prepare for potential issues earlier (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019).

4.3 BLOCKCHAIN-AI CHALLENGES

4.3.1 Privacy

Though Blockchain offers great benefits, however, the transaction is posted on an open ledger which is available for everyone to access. This aspect of Blockchain cause a privacy concern as personal and sensitive data is collected by IoT device and by posting this data on an open ledger leads to privacy concerns. This issue can be resolved by posting data on a private Blockchain, but this will limit the functionality of AI and the ability to predict accurate decision making and analytics because of the limited data that can be processed on the private Blockchain (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019).

4.3.2 Scalability and side chains

Scalability is the major concern for Blockchain as Bitcoin can process on average 4 transactions per second whereas 12 transactions per second can be executed on Ethereum. This concern is a serious issue that creates a barrier to widespread adoption of Blockchain as platforms like Facebook can process millions of transactions every second which include like, posts, and comments. Sidechains are a concept in a Blockchain that is used outside the main net to improve the transaction processing rate. However, the processing capability of the main net and sidechains are not comparable to Facebook and other platforms (Salah, Rehman, Nizamuddin, and Al-Fuqaha, 2019).

4.3.3 Blockchain security

The Blockchain decentralized aspect can be misused. Blockchain offers a great potential for IoT devices to process data and performs predictive analysis but the connected devices and the need for data sharing among devices and users the entire network can be vulnerable to cyber-attacks (Paiva, Ahad, Tripathi, Feroz & Casalino, 2021).

4.3.4 Smart contracts

The security of smart contracts is of key importance, and the safety aspects of smart contracts should be thoroughly investigated to make sure that there are no vulnerabilities in the code of the smart contracts. The DAO-platform had security vulnerabilities in its smart contract which resulted in the loss of 3.6 million ether, therefore, testing the smart contracts for security features is of key importance as the industry is growing (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019).

4.3.5 Standards and regulations

Blockchain technology standards and regulations are still in the development stage. The IEEE, NIST, ITU, and other standards bodies are developing standards for Blockchain governance. Besides that, at the local and global levels, governmental and institutional guidelines, rules, laws, regulations, and policies for Blockchain deployment and dispute resolution in the context of AI applications, and particularly for public Blockchain transactions involving financing and automated payments which involve cryptocurrencies, must be put in place (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019).

4.3.6 Governance

Developing and maintaining a digital Blockchain platform is difficult as it involves different stakeholders. Even if a private Blockchain is used issues such as the type of Blockchain (Hyperledger or Ethereum), where the Blockchain nodes will be located, and who is responsible to write the smart contracts arises. Adding to that, issues regarding the resolution of disputes, the selection of oracle, and government regulations also need to be considered (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019).

Adding to that, Blockchain-AI is a disruptive technology, and corporations around the world are promoting widespread adoption of Blockchain-AI as PwC predicts that AI will add 15.7 trillion to the world economy by 2030, and because of that Gross Domestic Product (GDP) will increase by 14%, and business value added by Blockchain technology will reach around $3.1 trillion by 2030 (bbvaopenmind.com,2022). However, Blockchain-AI has adverse effects on many external factors. To start off, the effect of Blockchain-AI on society as in the individuals, the individuals with jobs are threatened by this integration. This is due to the fact that nowadays most of these jobs are now automated and are replacing humans. The Blockchain industry is criticized for carbon footprint emission, and the adoption of Blockchain-AI will increase the risk of carbon emission as the technology is integrated into corporations (Verbeek & Lundqvist, 2021). Moreover, the individuals of society are also scared as they are concerned about losing their job. Adding to that, in general, the people of the society were concerned about how their personal information is being stored and is used for many purposes (Verbeek & Lundqvist, 2021). Thus, their privacy is being invaded through this new integration. Furthermore, through these integrated technologies, decision-making is also becoming automated, therefore, all the decisions are opaque and can lead to some sort of discrimination. Therefore, individuals are opposing it. Plus, it also has the power to use fake pictures and videos, and make them more realistic, thus losing the trust of society and changing the perspectives of individuals (Verbeek & Lundqvist, 2021).

5. SDG: 11 (SUSTAINABLE CITIES AND COMMUNITIES) TARGETS EVALUATION ON THE THREE PILLARS OF SUSTAINABLE DEVELOPMENT.

In this section, I will analyze the findings of this papers derived from literature review of the seminal work. The section starts by

exploring the findings of the paper by looking at the implication of the Blockchain-AI technology on the society, economy, and environment dimension. The classification allows to provide an overview to the reader about the general areas of influence of Blockchain-AI. Furthermore, the paper precedes with implication by discussing the implication of the technologies by looking at the Sustainable Development Goal 11 (Sustainable Cities and Communities) targets set by the United Nations. Lastly, A comprehensive viewpoint is presented to the reader if the Blockchain-AI in Sustainable City is enabling or hindering the targets of Sustainable Development Goal 11 of sustainable cities and communities.

5.1 SOCIETY

Referring to the table in appendix 1, Through the AI technology, the target no. 11.2 can be achieved, which is basically to reduce the pollution by promoting the use of public transport. Blockchain-AI technology development in the transport infrastructure is seen to be acting as an enabler for the target 11.2 of Sustainable Development Goal: 11 of Sustainable Cities and Communities by providing improved accessibility to the public transport for people, and by increasing the road safety and making the transport network more sustainable. This target can be achieved by installing IoT sensor on the road lines to attain estimates on the number of cars commuting through a specific road, the sensor would help us gather areas where there is more traffic and then we can promote public transport at a cheaper rate to persuade the people to opt for public transport rather than commuting individually in their personal cars. Moreover, the toll charge in that area could also be increased, so that the people would choose public transport to reduce their overall transport cost. Thus, this will result in individuals opting for public transport and the aim of reducing the carbon emissions generated through vehicles.

Moreover, AI act as an enabler for low carbon economy and supports the creation of sustainable city (SDG 11) by making changes to process in different industry sectors and services, for instance, food, health, water, and energy services (vinuesa et al., 2020). The range of interconnected technologies such as electric autonomous vehicles and smart appliances can help consumers to reduce their carbon emissions. The Blockchain-AI is being used to monitor and reduce the traffic congestion by integrating IoT sensors on roads and by using (TMP) Tradable Mobility Permit (Bagloee et al., 2021). The technology is also supporting developments in ride sharing economy by improving the element of trust as the driver's information is stored on Blockchain which is verifiable by other parties using the service (Wong, Chia, Kiu and Lou, 2020). Moving on to the development in improving the public transportation network, the technology provides solution such as digitalizing the ticketing systems and establishing a reward system to incentivize public transport users which will help to promote the use of public transportation and reduce carbon emissions. The Blockchain-AI also benefit consumers by creating new changes in the energy sector that were not possible before, the decentralized peer-to-peer energy trading and itemizing the cost of equipment that the AI analytics produce helps the users to reduce energy cost and significantly reduce the CO2 emissions. Thus, all the implementation of Blockchain-AI discussed above leads to reducing environmental footprint and helps to achieve the SDG 11 goal target 11.2.

Referring to appendix 1, another use case of Blockchain-AI equipped with IoT devices is that it creates an efficient waste management system for waste collection. This is enabling the SDG 11 goal target number: 11.6 by paying attention to municipal and other waste management system and by supporting efficient waste management system (Wong, Chia, Kiu and Lou, 2020).

As seen in appendix 1, the target 11.3 which is about urban planning of areas in order to compete with the growing population, can be achieved through Blockchain-AI implementation. The urban planning comprises of designing the infrastructure of a land to make it convenient for humans to live in that area. Through the Ethereum Blockchain, it will be quite feasible to build smart contracts within the area, and they will help the road toll system operate and reduce the traffic congestion in that new area. As through that technology, the authorities will be able to attain information on the traffic congestion and, during peak times when the traffic is at its highest, the toll prices will rise. The timings will be determined by analyzing for a few months and identifying the peak timings through the data gathered. Then later the authorities implement on it and release the schedule of toll prices for every day. Moreover, the smart contract will identify the emergency vehicles and provide them with an alternative route with less traffic, the data of traffic on different routes will be captured through satellites and sensors. Thus, it will result in improvement in traffic flow. Adding onto that, the government can implement on platooning, this will help us reduce the number of accidents that can occur within an area; therefore, it will be a part of urban planning.

There are some negative consequences of the AI on society as advanced AI technology require massive computational resources which can be accomplished by large data centers which are energy extensive for instance as Blockchain has many advantages, but the energy use of Bitcoin cryptocurrency consumes a large amount of electricity which is comparable to the electricity demand of an entire country, and this will have a negative impact on the United Nation Sustainable Development Goals. The information commission technology is expected to represent 20% of global electricity consumption by 2030 and the electricity consumption of ICT is recorded to be 1% now (Vinuesa et al., 2020). Therefore, as the AI use case emerges it is important to promote the renewable energy-based data centers which will reduce the emission levels. Moreover, another threat of AI is to human rights as people have limited information about the use of data processed by AI and the consequences it may have on their lives.

On the other hand, the introduction of these technologies has increased the new challenges such as privacy concerns as sharing personal data on the Blockchain and between devices poses a risk of the entire network vulnerable to attack and breaches. For instance, the use case of Blockchain-AI in the healthcare industry enables sharing of patient records, medicine dosage, and other useful data on the Blockchain which is vulnerable to breaches. The emerging technology has several benefits, however, as the technology is automating processes and increasing efficiency which implies that it can have a devastating effect on society leaving people unemployed in several industries.

5.2 ECONOMY

The technological advancement that AI brings provide have a positive impact on the number of SDGs. The positive impact of AI is related to increasing productivity whereas the negative impact is mainly based on inequalities that the AI creates in the economy. The markets in the future will be supported by data analysis and analytics. However, these resources may not be available in low-income and developing countries thus this will

significantly increase inequalities. The advancement that AI technology brings means that existing jobs will be replaced, and people will be required to learn new skills (Vinuesa et al., 2020).

Referring to appendix 1, the target 11a can be achieved as the application of Blockchai-AI in agriculture sector is benefiting the farmers and helping to reduce the gap between the developed and undeveloped territories of the country. The AI analytical capabilities help farmers in crop selection, irrigation, and monitoring. Furthermore, The IoT sensors installed in farm field help farmers to monitor crop nutrition level with the help images captured. The AI predictive analysis help farmers to select crop according to the weather conditions which optimize the farming yield (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019). All this information being stored on the Blockchain increases trust and ensure all stakeholders have access to all information in a transparent manner. Therefore, the application of Blockchain-AI in agriculture sector ensures territorial development in the rural areas on the country as the farmers are equipped with advance tools and technologies which ensure higher farming yields and profit margins (Salah, Rehman, Nizamuddin and Al-Fuqaha, 2019. Thus, this further creates a positive economic link between urban and rural aeas of the country.

However, Blockchain-AI is a new emerging technology and possess the following challenges:

5.2.1 Governance

Governance is not just about mitigating the security risks of these technologies but also about that these technologies can be deployed within a legal framework and their full potential is utilized. The regulations on Blockchain-AI are not clear, and the industry is not regulated by public authorities, therefore, the government should establish a proper framework, standards, and policies to govern these emerging technologies (Probst, Pedersen, and Dakkak-Arnoux PwC, 2017).

5.2.2 Unemployment

The biggest concern that emerges from the widespread adoption of AI is that it will replace the human workforce. A recent study conducted by the world economic forum predicts that 5 million jobs in 15 major developed countries will be replaced by AI. A total of 9% of jobs are at a very high risk of being automated where a new set of skills will be required by personnel to operate, maintain, and regulate technologies linked to AI and personnel will also be required to train people to work with AI technology (Probst, Pedersen and Dakkak-Arnoux PwC, 2017).

5.2.3 Cyber security threats

Automation and the use of IoT sensors increase the chances of the network being vulnerable to security breaches. AI-adoption requires companies to have a robust and stronger cybersecurity practice that will reduce the chances of data being compromised (Probst, Pedersen, and Dakkak-Arnoux PwC, 2017).

The advanced AI technology is unevenly distributed as advanced AI agricultural equipment may not be accessible to small farmers and this will create an increased gap between developed economies and undeveloped economies. On the other side, AI has the potential to mitigate the negative effects of inequality by using the simulation method to assess how virtual societies may react to inequalities (Vinuesa et al., 2020).

5.3 ENVIRONMENT

AI advancement helps in understanding climate change and its impact. The development in AI is leading to a low carbon economy by integrating renewable energy sources and increasing the efficiency of the existing energy system which is aiding to reduce carbon emissions. AI with help of a smart grid can increase the efficiency of different renewable energy sources that will match the electricity demand to the time when weather conditions such as sun and wind are suitable to create electricity at an optimum level (Vinuesa et al., 2020). The AI algorithm can also help automatically detect oil spills in the ocean (Vinuesa et al., 2020). Another benefit is that AI With the ability to handle enormous amounts of pictures in a relatively short period, neural networks and objective-oriented methodologies may be utilized to enhance the categorization of plant cover categories based on satellite images (Vinuesa et al., 2020). The above use cases of artificial intelligence and Blockchain technology is acting as enabler for SDG 11 target 11.6 by reducing the environmental impact of cities and moving on, the above use cases also act as enabler for target 11b of SDG 11 that is by developing integrated policies to mitigation and adaptation to climate change, and resilience to disasters. Lastly the technology act as enabler for target 11.5 as AI algorithm can assist in environment planning as discussed above. Therefore, the technology can help to reduce number of people affected by disasters, and water-related disasters.

Furthermore, in order to achieve target 11.4 which is about preserving the natural heritage, AI can play an integral role in preserving the natural habitat. The AI algorithm can help detect the oil spills in the ocean, thus instant action can be taken against it, and we can preserve the oceans from toxic compounds in the water, which will reduce the risk of severe health problem that can be caused by it. Plus, these AI algorithms can assist in recognizing desertification patterns across vast regions, providing information useful for environmental planning, decision-making, and management to avoid more desertification, or they can assist in reversing trends by identifying the key causes.

However, on the other hand, the AI benefits which help to achieve the goals on climate action can be undermined because of the high energy consumption of AI applications, and the emissions will significantly increase if non-renewable energy sources are being used to power these applications (Vinuesa et al., 2020).

The targets 11.1, 11.7, and 11c are not fulfilled as in the literature findings there was no application of Blockchain-AI technology in sustainable city found that helps to achieve the above-mentioned targets.

6. CONCLUSION AND FURTHER RESEARCH

The paper provided a detailed assessment of the advantages of convergence of Blockchain-AI technology in sustainable city and the challenges posed by these technologies that are limiting the widespread adoption of these technologies in the cities. Blockchain-AI convergence have superseding advantages which are pushing sustainable development in many different industry sectors and the country infrastructure. The Blockchain-AI benefits can be seen which are inclined towards making cities more sustainable and resilient. After carefully analyzing the literature related to the development in the Blockchain-AI technology, it can be interpreted that the technology is enabling and supporting the Sustainable Development Goal:11 targets of 11.2, 11.3. 11.4, 11.5, 11.6, 11a and 11b.

Blockchain-AI assisted us in achieving the SDG 11, however there were a few sub goals that were not affected through this integration. When talking about the sub goals that were positively affected through this technology, there are many existing operations of a city that can be improvised when merged with the Blockchain technology. To begin, Blockchain technology can help enhance the accessibility to the public transport, which was done by making it easier to book tickets online through any mode of payment (cash, card, and cryptocurrency), this will help us achieve the SDG 11 goal target of 11.2. Moreover, the introduction of an effective toll system through the integration of AI technology in reducing the traffic congestion, this can be done by gathering data of vehicles and interpreting the peak hours and varying the toll prices accordingly. Therefore, making us achieve the SDG goal 11.3. Adding onto that, SDG goal 11.4 can be achieved through the AI desertification program, which will recognize the pattern and help us come up with solutions beforehand. Plus, the AI algorithm can be used for environmental planning, which will help us protect the natural environment and avoid the impact of the disasters, leading to the resolution of the SDG goal 11.5, 11a and 11b. Lastly, by having access to the data, waste management can also be improved through tracking oil spills and other forms of waste. Resulting in the achievement of SDG goal 11.6. To wrap it up, the Blockchain-AI does not have any impact on the SGD goals 11.1, 11.7 and 11c.

On the other side, there are a few challenges that are faced while integrating Blockchain-AI together in making a city sustainable. To start off, the implementation of the entire technology is on a large scale, as we are trying to achieve the SDG goal 11 of making the entire city sustainable, therefore it will be a challenge to incorporate this technology in every operation of the city. Moreover, The Blockchain-AI require data of all the citizens of the city, there will be a huge risk of security as the data will be vulnerable and it can be leaked for malicious reasons. Plus, security would also be an issue due to the fact that this system of Blockchain-AI lacks governance. There is no authority that is officially controlling the system, thus making it decentralized as the power is in the hands of the users. Lastly, there are no formal rules and regulations set for the Blockchain technology, therefore it imposes a huge risk to implement it on an entire city without any formal rules and regulations.

6.1 Further research

Based on the review of this paper, there are few research directions that can be perused in the field of Blockchain-AI in sustainable city.

Internet of Things (IoT) is a dominant technology used in the sustainable city and has several applications in transportation, health, energy, waste management and in many other areas. The integration of IoT data with Blockchain-AI technology to enhance the sustainable city function is still lacking. The research can be channeled on shortcomings of cybersecurity and privacy challenges in sustainable cities (Sun, Yan & Zhang, 2016).

Blockchain-AI are the two most cutting-edge technologies and when integrated together require double computational resources for these technologies to function at their optimum. The future research direction can be based on optimizing resource utilization for these technologies (Shinde, Patil, Kotecha and Ruikar, 2021).

The research indicates that there is impact of non-technical risks on the success of sustainable city which is not explored. It is likely that the non-technical risks are more adverse and have impact on human behavior. Therefore, there is a need to mitigate the risks and reduce the impact of that risk. Moreover, further research can be directed to focus on researching on the non-technical risks and their implementation in sustainable cities. This will also necessitate research into the creation of risk management strategies that are appropriate for smart cities and versatile enough to be used in a variety of smart cities. A smart risk assessment tool can improve the security of systems in a smart city (Sharif & Pokharel, 2022).

7. ACKNOWLEDGEMENT

I would like to thank the University of Twente for providing the resources necessary to complete this research and I would like to gratefully thank my bachelor thesis advisors, Dr. Agata Leszkiewicz and Dr. Amini Velashani who supported me throughout the research by providing their valuable feedback and by guiding me to achieve the goal of this research.

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9. APPENDIX

9.1 APPENDIX 1: Sustainable Development Goal 11 Targets and Indicators

Target	Indicator	Findings
11.1: By 2030, ensure access for all to adequate, safe, and affordable housing and basic services and upgrade slums.	11.1.1: Proportion of urban population living in slums, informal settlements, or inadequate housing.	-
11.2: By 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.	11.2.1: Proportion of population that has convenient access to public transport, by sex, age, and persons with disabilities.	**AI and Blockchain integration bring improved accessibility to public transport, traffic safety and increase sustainability of road network.** **Autonomous vehicles** **Ride Sharing** **Tradable Mobility Permit (TMP)**
11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated, and sustainable human settlement planning and management in all countries.	11.3.1: Ratio of land consumption rate to population growth rate. 11.3.2: Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically.	**Increase efficiency of road toll system and reduce traffic congestion.**
11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1: Total per capita expenditure on the preservation, protection, and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)	**AI desertification pattern recognition and ocean oil spill detection application.**
11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11.5.1: Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population 11.5.2: Direct economic loss attributed to disasters in relation to global domestic product (GDP) 11.5.3: (*a*) Damage to critical infrastructure and (*b*) number of disruptions to basic services, attributed to disasters.	**AI algorithm for environment planning.**

Fig: 5: Sustainable Development Goal 11 Targets and Indicators

Target	Indicator	Findings
11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1: Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities 11.6.2: Annual mean levels of fine particulate matter (e.g., PM2.5 and PM10) in cities (population weighted)	**Blockchain and AI creating an efficient waste management system.** **AI algorithm automatic oil spill detection in the ocean.** **AI innovation in electricity smart grid for improve renewable energy infrastructure.**
11.7: By 2030, provide universal access to safe, inclusive, and accessible, green, and public spaces, in particular for women and children, older persons and persons with disabilities	11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age, and persons with disabilities. 11.7.2: Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months.	-
11.a: Support positive economic, social, and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	11.a.1: Number of countries that have national urban policies or regional development plans that (*a*) respond to population dynamics; (*b*) ensure balanced territorial development; and (*c*) increase local fiscal space	**AI and Blockchain innovation in agriculture sector.**
11.b: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	11.b.1: Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030 11.b.2: Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	**AI and Blockchain helps in increase adoption to climate change, improve environmental planning and increase resilience to disasters.**
11.c: Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.	-	-

Fig: 5: Appendix 1: Sustainable Development Goal 11 Targets and Indicators

9.2 APPENDIX 2: SUMMARY OF LITERATURE REVIEW RESEARCH.

Author	Year	Title
Vinuesa R, Azizpour H, Leite I, Balaam M, Dignum V, Domisch S, Felländer A, Langhans S, Tegmark M, Fuso, Nerini F	2020	The role of artificial intelligence in achieving the Sustainable Development Goals.
Phui Fung Wong, Fah Choy Chia, Mee San Kiu & Eric C.W. Lou	2020	Potential Integration of Blockchain Technology into Smart Sustainable City (SSC) Developments: A Systematic Review
Sharif, R. and Pokharel, S	2022	Smart City Dimensions and Associated Risks: Review of literature
Otoum Safa & Hussein T. Mouftah	2021	Enabling Trustworthiness in Sustainable Energy Infrastructure Through Blockchain-AI -Assisted Solutions
K. Salah, M. H. U. Rehman, N. Nizamuddin and A. Al-Fuqaha	2019	Blockchain for AI: Review and Open Research Challenges
B. Chavali, S. K. Khatri and S. A. Hossain	2020	Blockchain and AI Integration
Shinde, R., Patil, S., Kotecha, K. and Ruikar, K	2021	Blockchain for Securing AI Applications and Open Innovations
Verbeek, A., & Lundqvist, M	2021	Artificial intelligence, blockchain and the future of Europe: How disruptive technologies create opportunities for a green and digital economy
Kim, Seong-Kyu, and Jun-Ho Huh	2020	Blockchain of Carbon Trading for UN Sustainable Development Goals
Shinde, R., Patil, S., Kotecha, K. and Ruikar, K	2021	Blockchain for Securing AI Applications and Open Innovations
Banafa, A	2020	Blockchain technology and applications

Figure. 6: Summary of literature review research.

Author	Year	Title
Paiva, S., Ahad, M., Tripathi, G., Feroz, N., & Casalino, G	2021	Enabling Technologies for Urban Smart Mobility: Recent Trends, Opportunities and Challenges
Khaled Salah,, M. Habib Ur Rehman , Nishara Ni-zamuddin1 , And Ala Al-Fuqaha	2019	Blockchain for AI: Review and Open Research Challenges
Bagloee, S., Hesh-mati, M., Dia, H., Ghaderi, H., Pettit, C. and Asadi, M	2021	Blockchain: The operating system of smart cities. *Cities*
Dinh, T., & Thai, M	2018	Blockchain and AI : A Disruptive Integration.
Di Pierro, M	2017	What Is the Blockchain?
Zīle, K., & Strazdiņa, R	2018	Blockchain Use Cases and Their Feasibility

Figure. 6: Summary of literature review research.