RESILIENT RISK MANAGEMENT MODEL OF SUSTAINABLE SMART CITIES

by

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Dedication

I dedicate this dissertation to my mentor and guide throughout the Doctor of Business Administration (DBA) journey, Dr. Sasa Petar. Your unwavering support, insightful guidance, and encouragement have been instrumental in shaping this research and my academic growth. Your expertise and commitment have inspired me to strive for excellence, and I am grateful for the invaluable lessons learned under your mentorship.

To my husband, Dilshan, and our two children, Shirin and Yashan, I dedicate this thesis with profound gratitude. Your patience, understanding, and constant encouragement provided the foundation for my academic pursuits. Dilshan, your unwavering belief in my abilities, and constant motivation fueled my determination. Shirin and Yashan, your love and understanding during moments of dedicated study were my greatest motivation.

Finally, I dedicate this dissertation to my parents, late mother, Mrs. Chhabi Das and father Mr. Dilip Kumar Das whose love and unwavering support laid the foundation for the person I am today. Their guidance and encouragement were my source of strength, and their love shaped my character and ambitions. Though my mother is no longer with us, her spirit lives on in every page of this work. Without her love and support, I would have never embarked on this academic journey or achieved what I have today. This dissertation stands as a tribute to their enduring influence on my life and a testament to the indelible mark my mother left on my heart.

Thank you for being the pillars of strength and inspiration in my academic journey.
With heartfelt gratitude,
Munmun Das

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My sincere appreciation extends to **Dr. Sasa Petar**, my mentor, for providing invaluable guidance and unwavering support throughout this academic expedition. His expertise has not only shaped the content of this research but has also been instrumental in fostering my overall scholarly development.

To my family—Dilshan, Shirin, and Yashan—my heartfelt thanks. Dilshan, his steadfast belief in my capabilities has been a motivating force. Shirin and Yashan, your understanding and love have been the pillars of support during the challenges of this journey.

In remembrance of my late mother, whose love and support laid the foundation for my present self, I pay tribute to her. Her enduring influence and love remain etched in my heart, and my academic pursuits would not have been possible without her.

Gratitude is extended to my sisters Mrs. Mithu Sen and Ms. Putul Santra, and my friends and colleagues who offered support, encouragement, and valuable insights. Your contributions have added depth to this work.

To all those who contributed, no matter the scale, to the realization of this dissertation, I extend my sincere thanks. Your collective support has been instrumental in bringing this achievement to fruition.

With profound appreciation,

Munmun Das

ABSTRACT

RESILIENT RISK MANAGEMENT MODEL OF SUSTAINABLE SMART CITIES

Munmun Das
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Dissertation Chair: ____________________________

Smart city risk management has emerged as a crucial area of focus in response to growing challenges in today's world. Environmental issues, global pandemics, and geopolitical instability have compelled more people to migrate to urban areas in search of safety, better healthcare, food security, education, and employment opportunities.

While cities offer these benefits, they also bring about new risks and operational challenges. This research addresses those risks, focusing specifically on supply chain management and corporate finance, two critical sectors that sustain the backbone of smart cities.

The study aligns with global Sustainable Development Goals (SDGs), emphasizing the use of advanced technologies like Artificial Intelligence (AI), Internet of Things (IoT), and Blockchain to build resilient urban systems. A mixed-methods approach was used to explore these sectors. Quantitative data was gathered through a 40-question survey

conducted over three months with urban professionals such as supply chain experts, educators, and corporate leaders. Qualitative insights were collected through hands-on prototype testing with stakeholders like ERP consultants, CFOs, and intercompany accountants.

Key challenges identified include demand-supply misalignment, high transportation costs, fragmented distribution channels, inefficiencies in inventory management, and the complexities of cross-border intercompany reconciliation. Additionally, the lack of unified digital platforms across multiple entities in the ecosystem increases operational risks. To tackle these issues, the research led to the development of innovative solutions. Swikriti, a blockchain-based supply-chain management solution with inbuilt quality control and certification platform, and ensures product integrity. It also delivers real time analytics predictions and dashboard, Digital Twin & simulations which facilitates in optimum decision making. Viniyog focuses on automating intercompany reconciliations, mitigating disputes, and improving financial transparency globally.

Both the solutions address major sustainable development goals (SDGs) like Decent Work and Economic Growth (Goal 8), Industry, Innovation, and Infrastructure (Goal 9), Reduced Inequalities (Goal 10), Responsible Consumption and Production (Goal 12), Climate Action (Goal 13).

The outcomes of this research highlight the transformative potential of deep-tech solutions in mitigating urban risks. By addressing these pressing challenges, this study contributes significantly to sustainable smart city innovation. The study offers a pathway for cities to *operate more efficiently and equitably in the future. It also sets the foundation for further studies on technology adoption across different urban sectors and demographics.*

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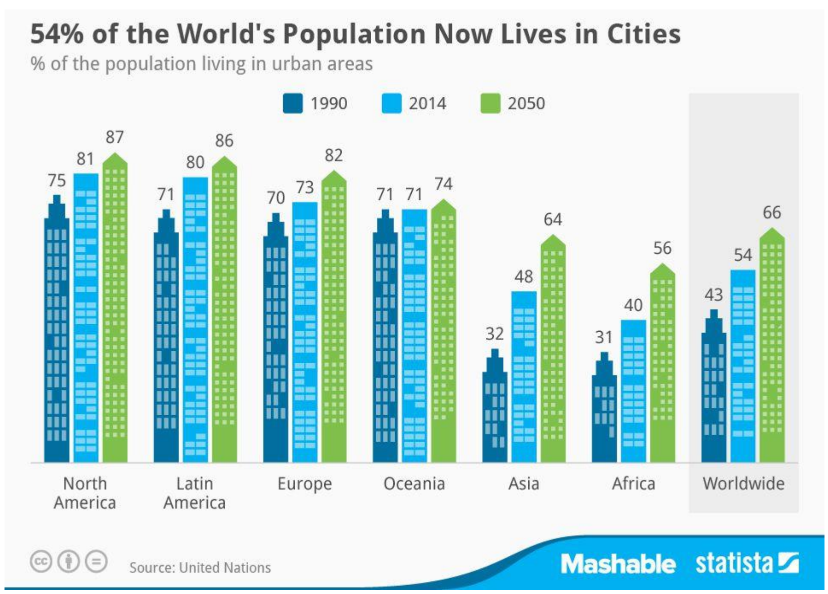
1.1 Introduction

United Nations - Department of Economic and Social Affairs predicts that approximately **68%** of the world's population will live in urban [1]cities by 2050[2]. Cities are the center of climate change and already represent **54%** of the global population and **70%** of greenhouse gas [3]emissions[4]. Along with this, natural calamities like floods, cyclones, heat waves, and earthquakes are some of the challenges to be dealt with by the cities[5]. The consequences of pandemics are also for cities.

Figure 1: UN Prediction of World Population Living in Cities by 2050



(Source: https://www.mphonline.org/urban-public-health)

[1] www.mdpi.com
[2] Source- https://population.un.org/wup/Publications/Files/WUP2020-F01-Report.pdf
[3] https://www.thehindubusinessline.com/
[4] Source- https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf, https://www.c40.org/deadline2020, https://wedocs.unep.org/handle/20.500.11822/19697
[5] Source- https://www.worldbank.org/en/topic/disasterriskmanagement/brief/urban-disaster-risk-management, https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-11-sustainable-cities-and-communities/targets/target-11-5.html, https://www.ipcc.ch/sr15/chapter/Chapter_8/

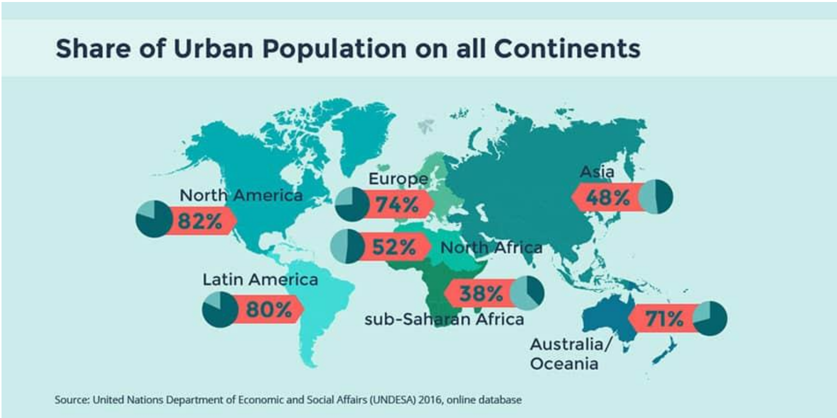
Figure 2: Share of Urban Population Worldwide

(Source: https://www.urbanet.info/world-urban-population/)

Table 1: Share of Urban Population of all Continents

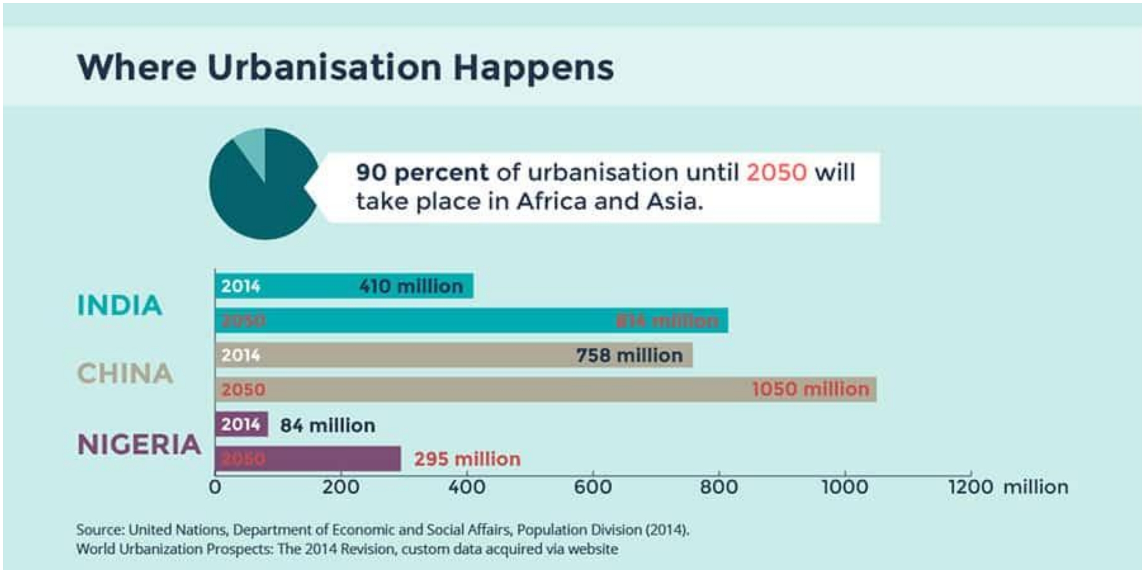
Continent	Urban Population
North America	82%
Latin America	80%
Europe	74%
Asia	48%
North Africa	52%
Sub-Saharan Africa	38%
Australia/Oceania	71%

Figure 4: Share of Urban Population by Continents



(Source: https://www.urbanet.info/world-urban-population/)

Figure 6: Countries witnessing the highest Urbanization



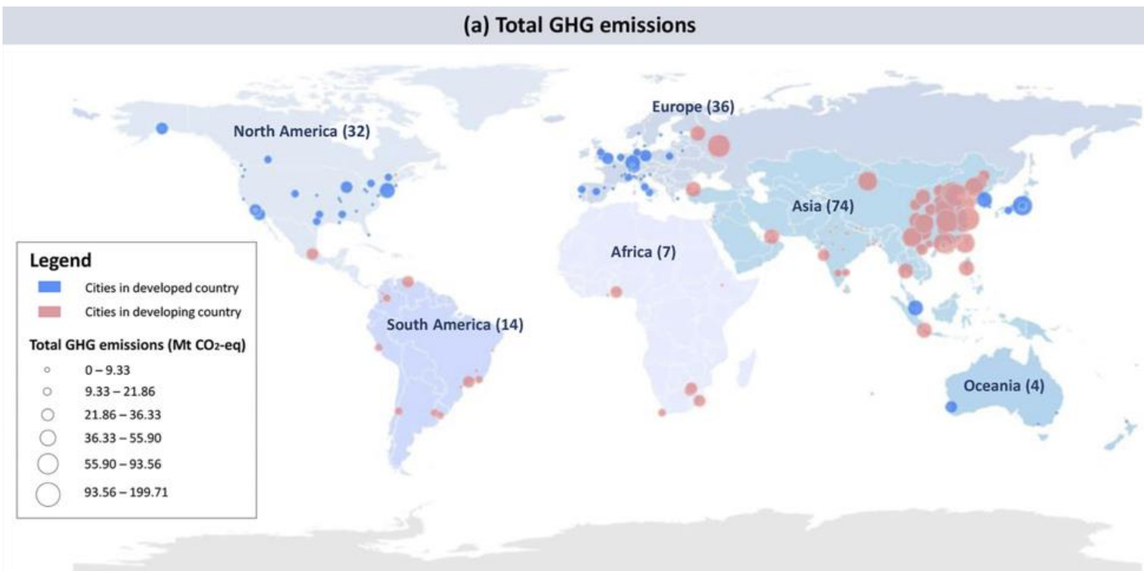
(Source: https://www.urbanet.info/world-urban-population/)

Figure 8: Cities with the highest growth rate

(Source: https://www.urbanet.info/world-urban-population/)

Urban regions are responsible for an astonishing 70% of greenhouse gas emissions. The importance of cities in the larger framework of climate change is highlighted by this statistic. As the world's population continues to increase, it is critical to address and mitigate cities' environmental footprints in order to promote resilient and sustainable growth. In order to make sure that cities not only handle growing populations but also actively work towards environmental sustainability, it highlights the critical need for creative solutions and intelligent urban planning.

Figure 10: Total GHG Emissions



(Source: https://news.mongabay.com/2021/07/chinese-cities-are-among-biggest-emitters-of-greenhouse-gases-study-finds/)

The **statistical figures of loss** due to natural calamities and pandemics in famous cities around the world can vary widely depending on the event, the location, and the time period. However, here are some examples of the loss caused by major natural calamities and pandemics in a few famous cities around the world:

- Hurricane Katrina, New Orleans, United States (2005):

Source: National Oceanic and Atmospheric Administration (NOAA) and National Hurricane Center

1,833 Estimated death toll	$161 Billion Estimated Economic Loss

- Typhoon Haiyan, Tacloban, Philippines (2013):

Source: Philippine government and United Nations Office for the Coordination of Humanitarian Affairs (OCHA)

6000-8000 Estimated death toll	$2.86 Billion Estimated Economic Loss

- Earthquake and tsunami, Tohoku region, Japan (2011):

Source: Japanese government and World Bank

15,899 Estimated death toll	$360 Billion Estimated Economic Loss

- COVID-19 pandemic, New York City, United States (2020-2021):

Source: New York State Department of Health and New York City Comptroller's Office

33,000+ Estimated death toll	$44.2 Billion Estimated Economic Loss

- COVID-19 pandemic, Mumbai, India (2020-2021):

Source: Indian government and Mumbai Municipal Corporation

15,000+ Estimated death toll	$5.73 Billion Estimated Economic Loss

Note that these figures are not comprehensive and may not represent the full extent of the loss caused by these events. Additionally, the economic loss estimates may not include indirect or long-term effects, such as the impact on mental health, social cohesion, or economic recovery.

Since everyone requires food, clean water, air to breathe, housing, and clean energy for their homes, cities must be designed to ensure that everyone's requirements are satisfied.

The following are the five main issues that cities face:

1) Resources (food, clean water, and clean energy) and Environmental Threats

2) Inequality (cities can be hubs for both social and physical inequality). Social inequality can manifest as differences in wealth, unequal access to healthcare and education, and other elements that fuel poverty and marginalization. Physical inequality can take the form of unequal access to public services and transportation, as well as unequal distribution of infrastructure like parks and other amenities.)

3) Technology divide

4) Social divide, and

5) Governance.[6]

The above problems have opened the doors to building technology-enabled sustainable smart cities. Consequently, spending on smart city projects is increasing over the years around the world. According to a survey it was approx. 608 billion USD in 2019 and will be increasing up to more than 1 trillion billion USD in 2025[7], so the investment is going to be seen in building smart cities.

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[6] https://www.weforum.org/agenda/2019/07/the-challenges-facing-cities-today/, https://www.forbes.com/sites/forbestechcouncil/2021/06/01/the-5-biggest-challenges-facing-cities-according-to-their-ctos/?sh=6e5d6d5e6c58, https://www.un.org/sustainabledevelopment/blog/2018/10/challenges-for-sustainable-cities/, https://www.governing.com/now/The-5-Biggest-Challenges-Cities-Will-Face-in-the-Future.html

[7] https://ww2.frost.com/news/press-releases/frost-sullivan-global-smart-city-market-outlook-2019-research-reveals-15-trillion-growth-opportunities-by-2025/

In 2013, the smart city market worldwide was about **$400 billion.** Since then, it has been growing quickly. By 2025, investments may exceed $1 trillion, which is a big rise in spending for smart city projects compared to earlier years.

Therefore, it is important to note that when investments are high and new technologies are used to tackle long-standing issues, risks at all levels will also significantly affect outcomes.

Technology is changing how we manage risks. Here are some ways technology is driving this change:

- **Better data collection and analysis:** Thanks to big data and analytics, organizations can collect and analyze large amounts of data to identify potential risks and make informed decisions.

- **Automation of risk management tasks:** Many risk management functions, such as compliance checks, can be automated with technology. Doing so can reduce human error and improve efficiency.

- **Predictive analytics:** This uses machine learning to identify patterns that may indicate future issues. It allows organizations to take preventive measures to minimize risks.

- **Real-time monitoring:** Using IoT sensors and other technologies, organizations can monitor assets and activities in real-time, helping them quickly spot and resolve problems as they arise.

- **Blockchain:** This technology enables the creation of secure, unchangeable records of transactions and data, which improves transparency and accountability in risk management.

Overall, technology gives organizations new tools and methods for managing risks, making them more proactive and efficient in identifying and reducing potential threats.

This study will explore the changes brought by the merging of Artificial Intelligence, the Internet of Things, and Blockchain in the creation and management of Smart Cities. It aims to understand the risks involved with this technology, referred to as "*TRINITY*," which highlights the blending of these three key technological areas that can improve human life quality. However, if misused, these technologies could lead to severe negative effects.

To manage these disruptive forces successfully, it is crucial to recognize risks at all levels, evaluate them for seriousness and likelihood, and create a contingency plan. This approach will ensure a strong disaster management framework and appropriate risk reduction strategies. The study will also look into how innovations are shifting the landscape for Risk Managers.

Leveraging IoT, blockchain, and AI can offer considerable benefits for smart cities. Nevertheless, it also brings certain risks.

The potential risks that could arise from the mix of technologies in smart cities are as follows:

- **Security risks:** With more connected devices and systems in a smart city, the chances of cyberattacks increase due to the higher number of potential security weaknesses. Hackers might exploit these weaknesses to access sensitive information, disrupt critical services, or cause physical harm.

- **Privacy risks:** If the large amounts of data produced by IoT devices and AI systems are not properly secured, there is a risk of privacy violations. Using facial recognition to monitor individuals in public places can lead to unauthorized surveillance concerns by governments or other entities.

- **Data bias:** The bias level in AI algorithms relies on how good and fair the training data is. If the data used to train these AI systems is biased, the AI will also show bias. This can lead to some groups being pushed aside in smart cities.

- **Transparency issues:** Blockchain is often said to improve transparency and accountability. However, using blockchain in a closed system with limited access can reduce transparency instead.

- **System breakdown:** In smart cities, many systems are interconnected. If one system fails, it can cause problems in others. This may result in issues like traffic jams, power outages, and safety risks for the public.

These are some potential risks that could arise from combining IoT, blockchain, and AI in smart cities.

1.2 Research Problem

The fast growth of cities and the rise of smart urban areas have caused many issues in managing city infrastructure, services, and related threats. By 2050, it is expected that over 68% of people will live in cities. This trend will need effective risk management methods to address environmental, social, and technical problems. Using technologies like blockchain, artificial intelligence (AI), and the Internet of Things (IoT) has the potential to change how enterprise risk management (ERM) works in smart cities.

However, even with the clear benefits these technologies provide, their use introduces new risks that need careful understanding and solutions.

To tackle this main issue, this study focuses on using smart solutions in specific areas, such as business management, banking, and supply chain oversight.

Blockchain technology has the potential to improve asset management systems by enhancing visibility and security when tracking real estate assets. This will result in a reduction in the number of unauthorised changes made to property records.

The combination of blockchain technology, the internet of things, and smart contracts backed by artificial intelligence can also contribute to increased efficiency in the supply chain and logistics industries.

When it comes to transportation networks, predictive warning systems that are powered by artificial intelligence have the potential to assist prevent financial losses, reputational harm, and hazards to human life.

The incorporation of blockchain technology into financial reconciliation systems has the potential to expedite banking procedures, hence lowering operating risks and increasing confidence.

To further reduce the likelihood of fraudulent activity in product quality certifications, a certification system that is based on blockchain technology can be of assistance.

This study's goal is to investigate how smart technologies can be effectively integrated into risk management strategies for businesses, especially in city settings. It aims to provide practical strategies for risk reduction by focusing on these specific applications.

1.3 Purpose of Research

The purpose of this research is to evaluate how advanced technologies such as blockchain, AI, and IoT can be included in enterprise risk management (ERM) plans in smart cities. As cities grow and smart technologies advance, managing city infrastructure, services, and related risks becomes increasingly complex. The global urban population is projected to reach 68% by 2050[8]. Developing innovative risk management systems will be key to addressing environmental, social, and technological challenges.

This research aims to achieve the following specific goals:

The main challenges faced in risk management in smart cities include:

- Identifying the unique environmental, social, and technological risks brought on by rapid urban growth and smart city development.

- Analyzing how these challenges affect urban infrastructure, services, and overall city governance.

- Evaluating the capabilities of blockchain, AI, and IoT in enterprise risk management (ERM).

[8] Sabyasachi Pramanik, Sandip Roy, Rajesh Bose. "Data Driven Mathematical Modeling in Agriculture: Tools and Technologies", River Publishers, 2024

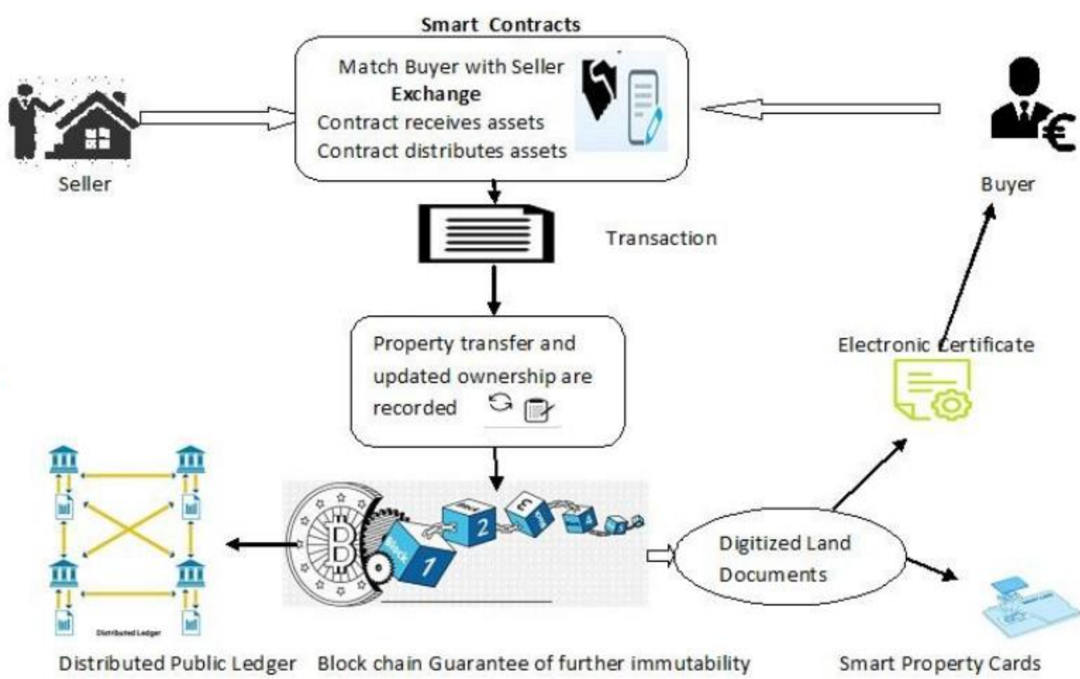
- Investigating how blockchain can enhance transparency, security, and efficiency across various urban sectors.
- Exploring how AI contributes to predictive analytics for informed decision-making and automating risk reduction.

- Assessing the role of IoT technology in facilitating real-time monitoring and data collection. of data, and prevent possible risks ahead of time.

- Create and build accurate use cases and applications:

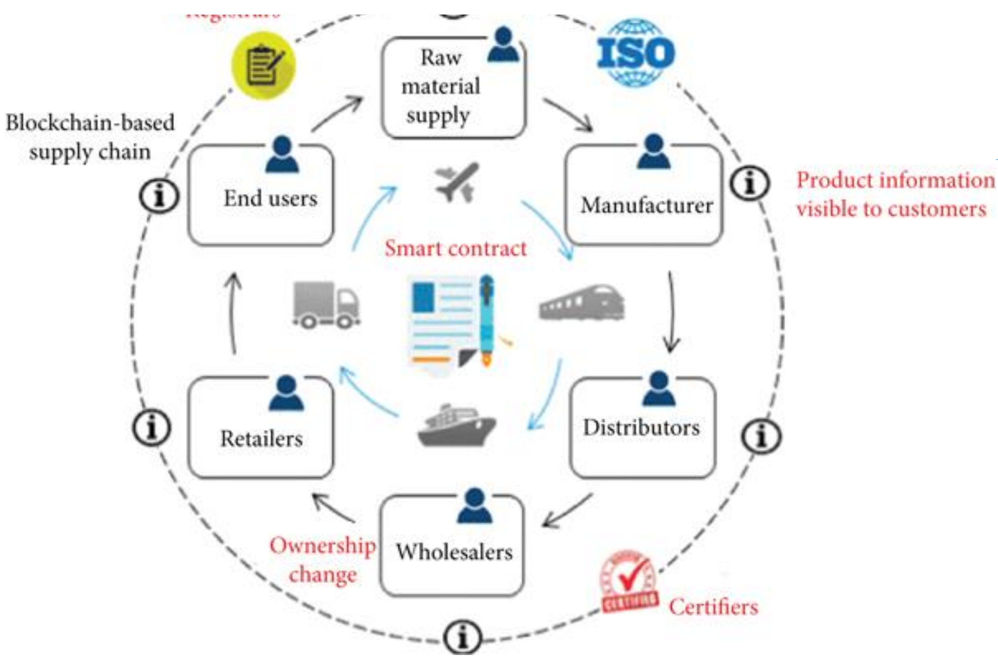
Corporate Governance: Evaluate how blockchain technology can improve clarity and safety in tracking real estate assets. This reduces risks linked to property titles and documentation in the real estate sector.

Figure 12: The Blockchain Based Property Registration Process



Supply Chain Management: Assess the advantages of utilising blockchain, Internet of Things (IoT), and artificial intelligence (AI)-enabled smart contracts to improve supply chain and logistics operations, enhance traceability, and reduce the risks associated with fraud[9] and inefficiency.

Figure 13: Blockchain & IoT based Supply chain system



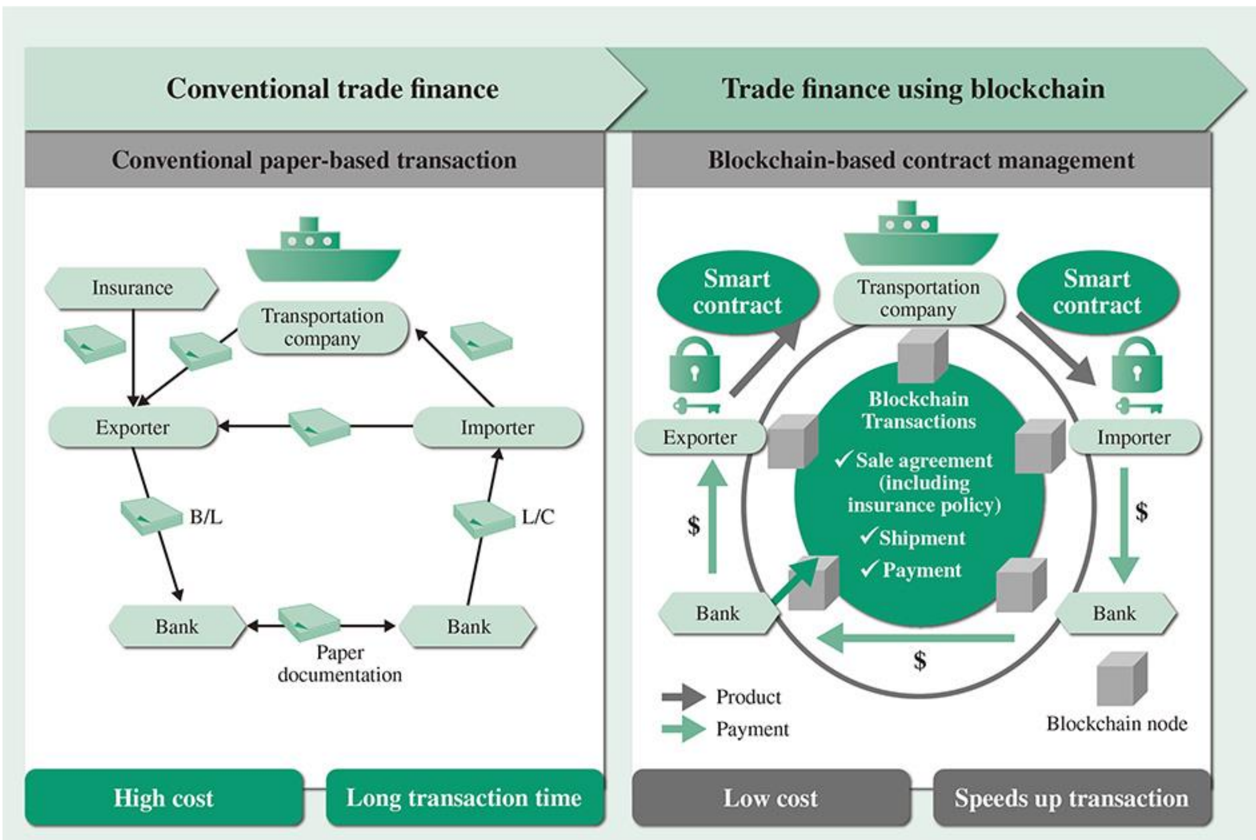
(Source: .0441)

(Source: https://www.softobotics.com/blogs/the-revolutionized-supply-chain-iot-and-blockchain/)

[9] "Industry 5.0 and Emerging Technologies", Springer Science and Business Media LLC, 2024

Corporate Finance: Examine the utilization of blockchain technology in financial reconciliation platforms within the banking sector to enhance banking procedures, diminish operational hazards, and fortify confidence.

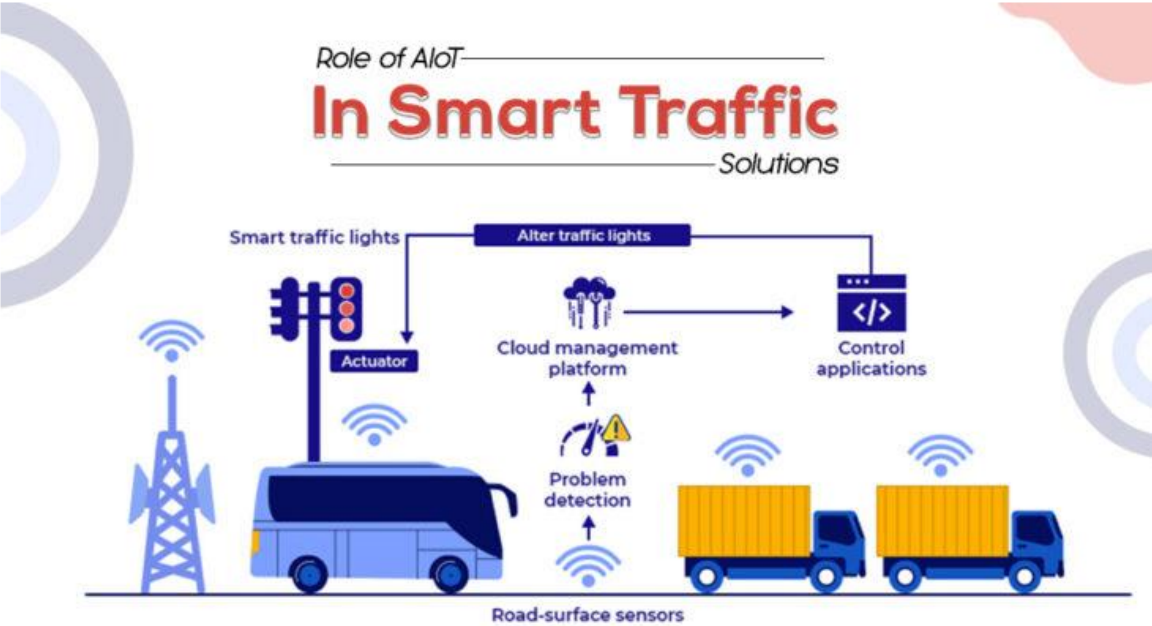
Figure 14: Conventional Trade Finance vs. Blockchain-based Trade Finance



(Source: https://www.hitachi.com/rev/archive/2017/r2017_01/103/index.html)

The purpose of this study is to evaluate the effectiveness of artificial intelligence-driven predictive alert systems in traffic and metro infrastructures for the purpose of minimising potential dangers to human life, minimising monetary damages, and protecting reputations against potential harm.

Figure 15: AI & IoT based Smart Road Traffic Solution



(Source: https://www.sunstreamglobal.com/role-of-aiot-in-smart-traffic-solutions/)

Product Quality Certification: Assess blockchain-based certification solutions to mitigate the risk of tampering with product quality certificates, guaranteeing their legitimacy and dependability.

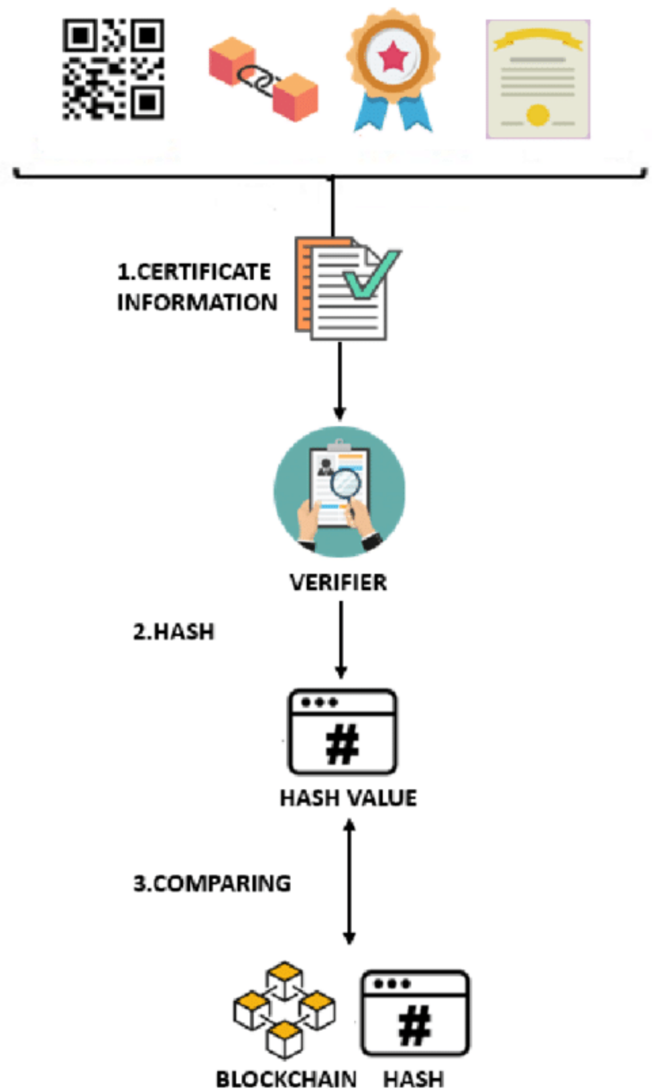


Figure 17: Blockchain based Product Test Quality Certificate Issuance

(Source:https://www.researchgate.net/figure/Digital-Certificate-Issue-Process-using-Blockchain_fig3_351356935)

Efficiently manage and mitigate any risks associated with state-of-the-art technologies:

Examine and evaluate the potential hazards that arise from the use of blockchain, artificial intelligence (AI), and Internet of Things (IoT) technologies in smart city settings.

Create comprehensive plans to evaluate and minimise these emerging hazards, guaranteeing the safe and effective usage of these technologies.

Suggest feasible solutions and frameworks:

Suggest practical strategies for incorporating blockchain, artificial intelligence (AI), and the Internet of Things (IoT) into business risk management (ERM) protocols.

Create robust frameworks to augment risk management in smart cities, specifically focusing on urban planners, policymakers, and business organizations.

The main objective of this research is to get a comprehensive comprehension of the efficient incorporation of cutting-edge technology into firm risk management protocols.

The aim is to offer pragmatic, empirically-supported strategies that may be embraced by urban planners, corporations, banks, and supply chain managers to reduce risks, enhance operational effectiveness, and advance sustainable urban development.

The objective of this research project is to expand the current understanding of smart city development and offer significant strategic insights to encourage innovation in reducing urban risks.

1.4 Significance of the Study

The importance of this study rests in its emphasis on incorporating state-of-the-art technologies to stimulate advancements in Smart City solutions. This is a thorough examination of the potential dangers related to urban planning and development, the generation of clean and sustainable energy, forecasts for air and soil quality, issues concerning traffic and public safety, innovative strategies employed by businesses, and progress made in areas such as education, healthcare, supply-chain management, and other aspects of urban society.

1.4.1 Improving the administration and maintenance of urban infrastructure

This study provides an in-depth examination of the distinct environmental, social, and technical hazards associated with growing urbanization. The report offers vital insights into how smart cities may implement more efficient and resilient governance structures by analyzing these problems and their effects on municipal infrastructure and services. This understanding assists urban planners and policymakers in creating more effective infrastructure and services that can endure and adapt to the challenges posed by increasing urban populations. Furthermore, given the rise in natural disasters caused by climate change as a result of greenhouse gas emissions, the study will play a crucial role in recognizing these hazards. Additionally, it will investigate the impact of artificial intelligence (AI) on predicting and managing disasters, providing improved suggestions and understanding for intelligent disaster management. Additionally, it will discuss the dangers of excessive dependence on AI, especially in cases when AI models are not constructed optimally, and provide methods for reducing these risks.

1.4.2 Enhancing Technological Implementations in Risk Management

This paper examines the potential of blockchain, AI, and IoT technologies to improve ERM in different urban sectors, offering practical insights into their implementation. Blockchain has the potential to greatly enhance transparency and security. AI can improve predictive analytics and decision-making capabilities. IoT can provide real-time monitoring and proactive risk management. These technological improvements can enhance risk management techniques in smart cities, making them more robust and efficient. They can effectively address unique hazards in each industry.

1.4.3 Creating use cases tailored to certain industries

The research focuses on developing precise use cases and applications in the areas of corporate governance, supply chain management, finance, transportation, metro systems, and product quality certification. This exemplifies how various technologies can efficiently alleviate risks, encompassing:

Asset management solutions that are based on blockchain technology have the potential to improve corporate governance by ensuring both transparency and security in the tracking of immovable assets. There is a reduction in the hazards that are involved with property titles and records because to this technology.

Supply Chain Management: The use of blockchain, Internet of Things (IoT), and Artificial Intelligence (AI)-enabled smart contracts helps optimize supply chain operations by improving traceability and minimizing instances of fraud and inefficiencies.

Blockchain technology in financial reconciliation platforms has the potential to optimize procedures, mitigate operational risks, and enhance confidence in the banking sector.

AI-driven predictive warning systems for traffic and metro systems can effectively reduce financial losses, protect reputation, and mitigate hazards to human life.

Product Quality Certification: Utilizing blockchain-based systems can guarantee the genuineness and dependability of product quality certificates, effectively avoiding any unauthorized alterations.

1.4.4 Managing Emerging Hazards Linked to Cutting-Edge Technologies

The paper also examines the unique hazards presented by implementing blockchain, AI, and IoT in smart city settings. The study examines and evaluates these emerging dangers, and then formulates comprehensive solutions to minimize them, therefore assuring the safe and effective utilization of these technologies. Ensuring the long-term profitability of smart city initiatives is essential for preserving public trust.

1.4.5 Offering pragmatic solutions and frameworks:

The study's objective is to offer practical suggestions and create models that urban planners, policymakers, and commercial organizations may implement to improve risk management in smart cities. Implementing these pragmatic measures can effectively reduce hazards, enhance operational efficiency, and foster sustainable urban development. This research adds to the existing information on the development of smart cities and provides valuable strategic insights that might stimulate innovation in urban risk management.

Advocating for the development of cities in a manner that is environmentally friendly and can be maintained in the long term.

The objective of this research is to encourage sustainable urban development by using innovative technologies in ERM processes. The research aims to improve the ability of smart cities to withstand and recover from challenges by offering solutions that are supported by evidence and can be adopted by different groups involved. This can result in enhanced resource utilization, an elevated standard of living for urban inhabitants, and enhanced readiness for forthcoming difficulties.

1.5 Research Purpose and Questions

1.5.1 Purpose of the Research:

The main aim of this research is to investigate and assess the incorporation of cutting-edge technologies, specifically blockchain, artificial intelligence (AI), and the Internet of Things (IoT), into enterprise risk management (ERM) strategies in the context of smart cities. The objective of this study is to comprehend how these technologies can be utilised to tackle the intricate issues presented by the swift growth of metropolitan areas and the establishment of intelligent cities. The project aims to offer practical answers for reducing hazards, improving operational efficiency, and fostering sustainable urban development by examining these areas. The primary objective is to provide frameworks and techniques that can be implemented by urban planners, policymakers, and commercial organisations to enhance risk management and guarantee the resilience and sustainability of smart cities.

1.5.2 Relevant Questions:

How might technologies mitigate the challenges linked to the swift urbanization demand worldwide?

This question seeks to examine the impact of technology and non-technological advancements in addressing the difficulties caused by the rapid increase in urban populations and the resulting pressure on infrastructure and services.

How can state-of-the-art technologies be utilised to develop intelligent solutions for practical issues?

This question aims to examine the integration of blockchain, AI, and IoT into many areas of urban management in order to provide intelligent and efficient solutions for challenges like traffic management, resource allocation, and public safety.

What are the potential hazards linked to various stages of smart city development?

This inquiry aims to ascertain the environmental, social, and technical hazards that emerge at different phases of smart city development, starting from the initial design and implementation to the long-term operation and maintenance.

How can one proactively identify, evaluate, and forecast these risks before they materialise into real-life occurrences?

This inquiry explores the strategies and technologies that can be employed to proactively detect and evaluate risks, as well as forecast potential future risks to prevent their manifestation into tangible occurrences.

What are the potential hazards linked to the incorporation of sophisticated technologies in smart cities?

This inquiry explores the precise hazards associated with the implementation of blockchain, AI, and IoT technologies, encompassing cybersecurity vulnerabilities, apprehensions regarding data privacy, and the possibility of technological malfunction.

What strategies can be employed to minimise or reduce ethical issues while evaluating technology for developing smart solutions?

This inquiry examines the ethical ramifications of employing sophisticated technologies in intelligent urban areas, with a specific emphasis on discerning and alleviating ethical hazards to guarantee the responsible development and implementation of technical solutions.

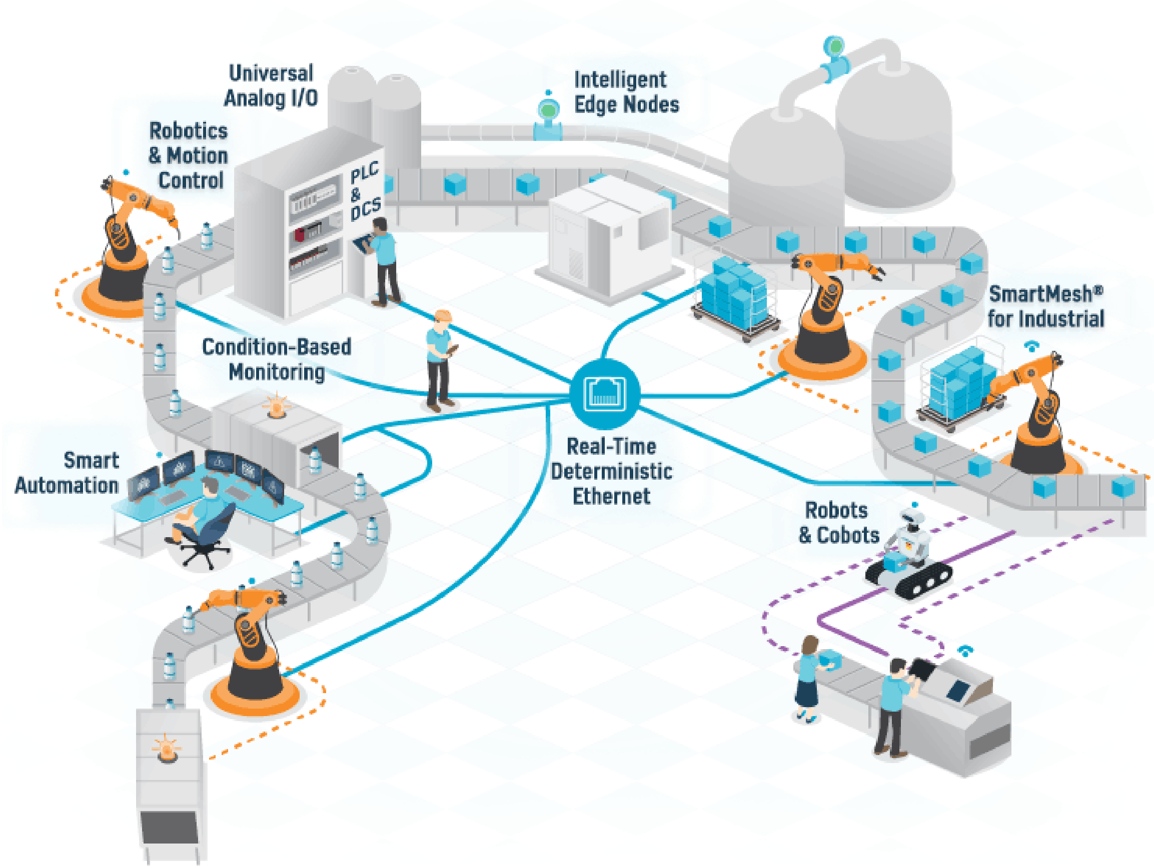
What methods can be used to examine and advance sustainability in this research?

This inquiry investigates the potential of research to enhance comprehension and advocacy for sustainability in smart cities, guaranteeing that technological progress results in enduring environmental, economic, and social advantages.

How might the integration of sustainable practices and the collaboration between humans and machines serve as the foundational principles for Industry 5.0?

This inquiry explores the significance of sustainable practices and the seamless integration of human and machine endeavours in the advancement of Industry 5.0, emphasising how these components can foster innovation and effectiveness in forthcoming urban settings.

Figure 19: Industry 4.0



(Source: https://www.linkedin.com/pulse/introduction-industry-40-pranesh-a-g/)

The transition from Industry 4.0 to Industry 5.0 signifies a change from a solely technology-focused model to one that prioritizes human-centeredness and sustainability. Within the framework of smart cities, this shift centres on the integration of cutting-edge technologies while prioritizing the improvement of human welfare and the promotion of sustainable urban development.

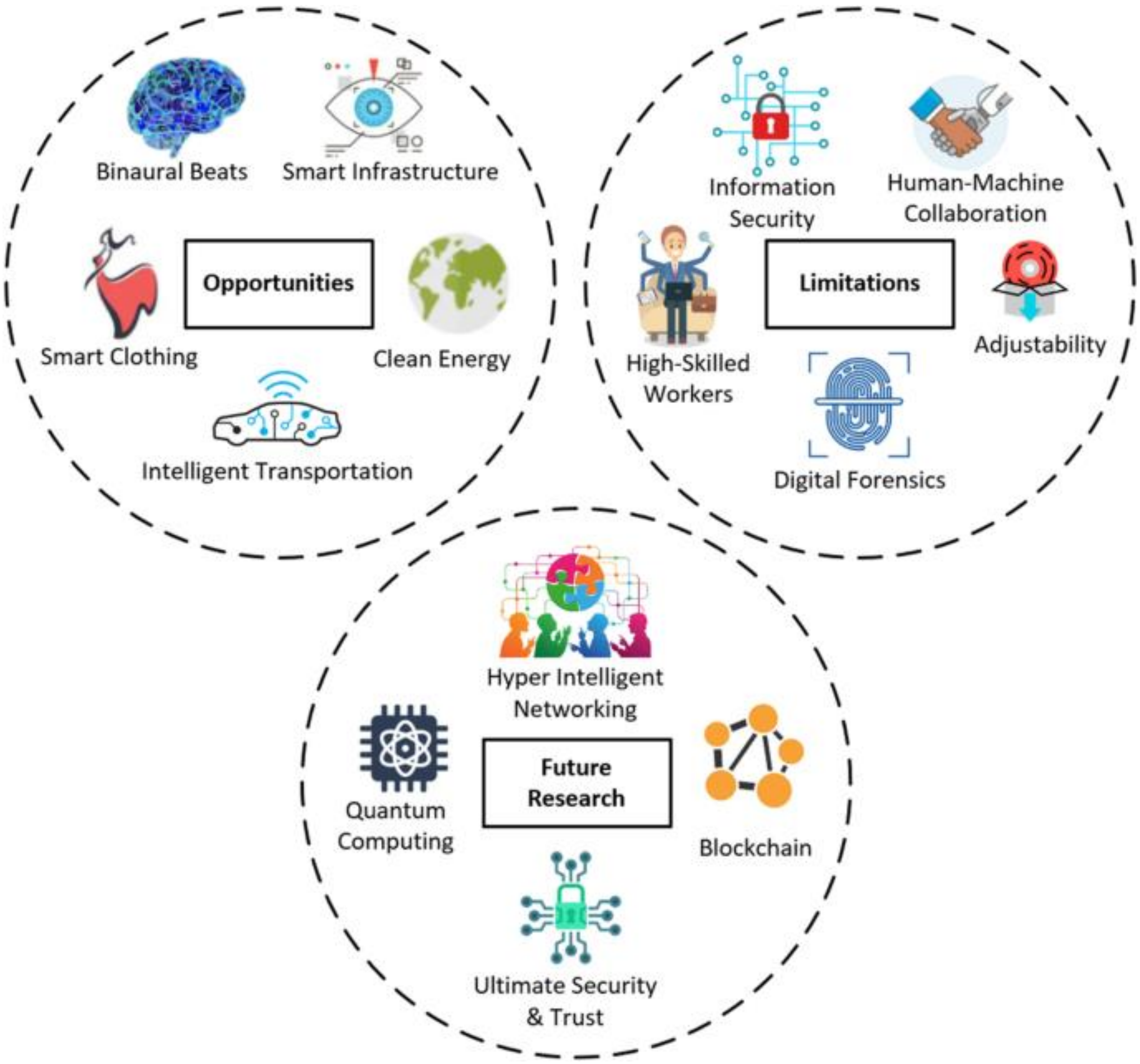


Figure 21: Industry 5.0 - Human Centric Solutions & Sustainability

(Source: https://journalofcloudcomputing.springeropen.com/articles/10.1186/s13677-022-00314-5)

What are the possible effects of AI-powered predictive analytics on urban risk management?

This inquiry aims to examine the capabilities of AI-powered predictive analytics in anticipating potential hazards and facilitating well-informed decision-making to mitigate the escalation of such risks into tangible problems.

How might blockchain improve the clarity and protection of urban governance?

This inquiry explores the capacity of blockchain technology to offer unchangeable records and transparent procedures that can improve the responsibility and security of urban governance systems.

How might IoT contribute to the immediate monitoring and proactive control of urban risks?

This inquiry explores the potential of IoT devices for ongoing data gathering and immediate monitoring to enable proactive risk management in urban settings.

What are the potential applications of smart technology in enhancing public safety and emergency response in smart cities?

This inquiry examines the utilisation of artificial intelligence (AI), Internet of Things (IoT), and blockchain technology to enhance public safety measures and optimise the effectiveness of emergency response systems.

The study is to gain a thorough understanding of how new technologies might be included into ERM strategies to establish smart cities that are resilient, efficient, and sustainable. The findings will provide vital knowledge and effective strategies for urban planners, legislators, and commercial organisations to improve risk management and support the successful growth of smart cities.

CHAPTER II:

REVIEW OF LITERATURE

2.1 Theoretical Framework

2.1.1 Conceptual Foundations:

Morozova, Irina & Yatsechko, Stanislav (2022) discuss the hazards associated with the development of smart cities and strategies for their mitigation. Their research indicates that the development of smart cities relies not only on technology but also on social factors. The correlation between smart cities and quality of life is evident, as enhancements in living standards facilitate the development of smart cities, and vice versa. This research depicts smart cities as socio-technological eco-systems where corporate social responsibility (CSR) is significant for sustainable urban development.

Moreover, their research indicates that the COVID-19 pandemic had no impact on the advancement of smart cities, especially pertaining to Sustainable Development Goal (SDG) 3 (Good Health and Well-being).

Dziatkovskii (2022) discusses the integration of AI and blockchain in smart cities. It addressing issues such as traffic congestion, trash management, and air quality. The paper highlights how AI may address issues by enhancing traffic flow, forecasting repair needs, and conserving energy. Blockchain is presented as a technology to ensure secure and transparent transactions. It facilitating energy trading and urban infrastructure. The research identifies AI and blockchain as essential technologies for proper administration and efficiency in smart cities.

Al Sharif and Professor (2021) examine the integration of ICT in smart city initiatives. He emphasises its possibility to enhance urban living through enhanced transportation, energy efficiency, and sustainability. The document outlines numerous elements essential for the advancement of smart cities and the associated risks, both technical and non-technical. The authors emphasise the necessity of identifying and mitigating these vulnerabilities for the efficient governance of smart cities. The authors emphasise that sophisticated technologies such as IoT, AI, and blockchain are important for the systematic operation of these cities.

Nguyen and Hallo (2022) propose a methodology for risk management in the governance of smart cities. He emphasises the necessity for comprehensive risk management across several urban functional sectors. The research perceives smart cities as complex systems encompassing components such as transportation, energy, healthcare, and education, with technology as the focal point. The authors contend that effective governance must comprehend the interrelation of these components and mitigate risks. They recognise technological, organisational, and societal risks, while emphasising governance structures that adjust to external influences and feedback to achieve optimum results.

Ahmed et al. (2022) examine the amalgamation of blockchain and artificial intelligence (AI) in transforming the development of sustainable Internet of Things (IoT) applications for smart cities. The article emphasises how these technologies facilitate efficient data management, secure transactions, and a solid framework for smart city infrastructures. This study focusses on a multi-tier blockchain framework designed to augment IoT applications across several sectors of smart cities, including energy, healthcare, transportation, and manufacturing. This integration seeks to improve sustainability and operational efficiency, also ensures data security through distributed systems.

Ariyachandra and Wedawatta (2023) examine the increasing significance of digital disaster risk management systems due to the rising frequency and severity of natural catastrophes. They illustrate Digital Twin (DT) technology, which creates a digital replica of physical assets that concurrently updates with the genuine object throughout its lifecycle. The authors elucidate that Smart Cities (SCs) utilise information and communication technology (ICT) to augment the efficiency of urban systems, including transportation, energy, and infrastructure. The integration of Digital Twin (DT) and Smart City (SC) technologies in Digital Twin Smart Cities (DTSCs) enhances disaster management through analysis and forecasting of potential events. This improves preparedness, reaction, and restoration efforts.

Nguyen, Han-Khanh. (2022) analyses the vulnerabilities present in supply chains within Vietnam's retail sector, emphasising supermarkets that have experienced important expansion and competitiveness, especially as a result of the COVID-19 epidemic. This study talks about three analytical models—SERVQUAL, binary logistic, and Grey models—to establish a comprehensive three-part framework. This framework examines the historical, current, and prospective aspects of supermarket business operations. The author identifies the key elements influencing consumer satisfaction and provides supermarket managers with strategic recommendations to enhance operational efficiency and mitigate supply chain risks.

Ullah et al. (2021) propose a Technology-Organization-Environment (TOE) framework for risk management in the administration of sustainable smart cities. This framework addresses the complex issues arising from the interplay of technology, organisational dynamics, and external variables. The framework delineates 56 distinct risks associated with smart city governance, categorised into three groups: technological risks (encompassing IoT networks, user safety, and public internet management), organisational risks (addressing data security and cloud management), and external risks (related to governance, environmental, and integration challenges). The TOE framework provides a systematic approach for managing these risks through continuous processes of identification, assessment, monitoring, and planning.

Ghosh, Akash; Gaddam, Prathik Kumar; Jadhav, Priyanka; Nallapuneni, Bhargavi; and Bajpai, Anshika (2023) emphasise the necessity of integrating artificial intelligence (AI) with blockchain technology to address challenges in 6G-enabled Internet of Things (IoT) applications. This study presents a novel architecture that integrates artificial intelligence with blockchain to enhance security and efficiency. It emphasises the execution of a "green AI" approach, designed to harmonise urban management solutions with the objectives of sustainability, equity, and efficiency in smart cities. The suggested framework aims to rectify the shortcomings of conventional AI methodologies, advocating for a comprehensive and sustainable approach to the advancement of smart cities.

Mumtaz, Hina & Ali, Mushtaq. (2024) clarify that the increased focus on environmental sustainability has led to the emergence of Green Fintech, which employs Artificial Intelligence (AI), the Internet of Things (IoT), and Big Data analytics to promote sustainable finance and enhance waste management. Through the utilisation of AI, financial institutions can analyse extensive datasets to reveal opportunities for sustainable investments, enhance resource efficiency, and detect environmental risks. IoT technologies boost waste management through real-time monitoring and improved collection, recycling, and disposal techniques. Blockchain-based smart contracts facilitate transactions, guarantee compliance, and promote environmentally sustainable practices in finance and waste management.

Chauhan and Sahoo (2024) examine the potential amalgamation of AI, blockchain, and IoT to advance sustainability objectives. Research indicates that AI can boost resource management, optimise energy use, and improve overall system efficiency. Simultaneously, blockchain enhances openness and accountability inside supply chains. IoT sensors gather real-time data on environmental concerns, aiding cities in optimising traffic flow, enhancing energy efficiency, and facilitating sustainable water management. These technologies collectively offer several alternatives for sustainable development.

Irfan et al. (2024) examine the enhancement of transparency and security in global supply chains through the integration of blockchain, IoT, and AI. This integration seeks to enhance traceability, efficiency, and risk management throughout supply chains. Blockchain ensures safe, immutable records; IoT delivers real-time data throughout the supply chain; and AI enhances operational efficiency and identifies anomalies. These three technologies can enhance the transparency, efficiency, and security of global supply chains.

Sandner, Groß, and Richter (2020) examine the significance of the convergence of Blockchain, IoT, and AI in the forthcoming phase of digital transformation. This integration facilitates creative business models in which autonomous agents, such as sensors, robotics, and vehicles, function as independent economic entities. The Internet of Things collects data, blockchain secures financial transactions and identity verification, and artificial intelligence improves decision-making, enabling these systems to autonomously manage operations, optimise performance, and conduct transactions.

Rajawat, Goyal, Kumar, and Singh (2024) introduce an innovative AI-based approach to enhance the security of blockchain networks, emphasising vulnerabilities associated with Sybil and DDoS attacks. Despite its innovation, blockchain has challenges stemming from these concerns. The researchers aim to mitigate these hazards with AI methodologies. Utilising Long Short-Term Memory (LSTM) for sequence learning and Self-organising Maps (SOM) for pattern recognition, they provide a novel methodology designed to identify and mitigate security vulnerabilities, hence enhancing blockchain networks.

Dutta, P., Choi, T.-M., Somani, S., & Butala, R. (2020) reviewed the role of blockchain technology in supply chain operations. The review covers 178 articles to study how blockchain can change various supply chain tasks like tracking origins, rethinking business processes, and boosting security. The research speaks about the opportunities, social effects, existing technologies, trends, and challenges of using blockchain in supply chains. It looks into blockchain's potential across sectors like shipping, manufacturing, auto, aviation, finance, technology, energy, healthcare, agriculture, food, e-commerce, and education. The goal is to give insights and set a future research path for further studies. in the new field.

Homaei, H., Homaei, M., & Caro, A. (2024) examines how artificial intelligence (AI) can improve the cybersecurity of digital twin technology in different industries. The work discusses the advantages of digital twins like faster speed, better accuracy, and greater efficiency in analyzing, designing, optimizing, and evolving systems. The research also highlights the security issues linked to moving towards cyber digitization, pointing out the risk of cyber threats due to insufficient information and security measures. Furthermore, it looks at the close relationship between digital twins and AI tools; indicates that their integration may strengthen the cybersecurity of digital platforms. This research acts as a guide for those interested in cybersecurity and digital safety.

The study by **Publication, S. (2020)** titled Blockchain Technology: A Driving Force in Smart Cities Development discusses how Blockchain Technology can improve the creation and running of Smart Cities. Key points include:

- Smart Cities: Intended to enhance citizens' lives by providing better facilities, environment, health services, and business ease.

- Role of Technology: Information technology infrastructure and online transactions are essential for Smart City functioning.

- Blockchain Technology: Suggested as a way to enable secure and trustworthy online transactions. It helps in preventing disorder in Smart City functions.

- Research Focus: Looks at Blockchain-based methods for Smart Cities, their likely effects, and how they can enhance the safety and reliability of operations.

- Proposed Framework: A safe framework based on Blockchain Technology for Smart Cities that identifies areas and processes that could benefit from this tech.

The study aims to tackle concerns regarding the trustworthiness and security of online transactions in Smart Cities. It proposes Blockchain as a method to improve overall development and operational effectiveness.

This work by **Rotuna, Carmen & Gheorghita, Alexandru & Alin, Zamfiroiu & Smada, Dragoş (2019)** analyzes how blockchain technology can be used to create smart cities. It shows blockchain's potential to solve challenges in urban areas like security, transparency, and efficient resource use. The research proposes a model for a Smart City ecosystem using Self-Sovereign Identity (SSI) authentication and smart contracts between citizens, entities, and governments. It also covers areas where blockchain might be useful, such as digital identity, IoT security, private communication, and self-driving cars. The objective is to help local projects utilize blockchain for public sector communication and transactions.

This study by **Palaiokrassas, Georgios & Skoufis, Petros & Voutyras, Orfefs & Kawasaki, Takafumi & Gallissot, Mathieu & Azzabi, Radhouene & Tsuge, Akira & Litke, Antonios & Okoshi, Tadashi & Nakazawa, Jin & Varvarigou, Theodora (2021)** looks at merging blockchain technology with the Internet of Things (IoT) and security frameworks to form a unified system for data sharing and collection in smart cities. The main points are:

- Blockchain and IoT Integration: Suggests using blockchains as shared ledgers to tackle data collection and distribution issues in smart city IoT networks.

- Smart Contracts: Smart contracts facilitate processes in the network, ensuring secure and effective data transactions.

- Data Protection: Combining blockchain with the InterPlanetary File System (IPFS) offers data security through anonymity and shared storage.

- IoT Data Marketplace: Proposes an IoT blockchain marketplace where objects and people can exchange value using virtual currencies for data and services.

- Cross-Border Trial: The marketplace is tested through a cross-border pilot trial involving Santander and Fujisawa, checks its interoperability, efficiency, and data protection.

- Sensing-as-a-Service: This paper presents Sensing-as-a-Service (S2aaS) model, allowing data sharing between suppliers and users.

- Security and Performance: The goal is to effectively address security and performance challenges by using blockchain and IoT advancements.

The research shows that combining blockchain, smart contracts, and IoT can set up a secure and efficient data marketplace for smart cities.

Lee, J. (2018) studied how blockchain tech affects sustainability in manufacturing. The key points are:

1. Blockchain Benefits: The research shows that blockchain brings real-time clarity and cost reductions for manufacturers.

2. Mechanisms: It looks at how blockchain is currently used in finance and supply chains to explain the benefits.

3. Theoretical Model: The paper compares manufacturing profits in two managerial games in a duopoly; indicates that blockchain can boost profitability and market competitiveness.

4. Sustainability: Findings indicate that blockchain's transparency and cost efficiency improve manufacturing sustainability.

The study is structured in these ways:

- Previous research on blockchain and its background.

- The necessity of blockchain for real-time transparency and cost cutting.

- Methods for lowering costs and increasing profits in manufacturing via blockchain.

- Discussion on blockchain's pros and cons for manufacturers.

In summary, the research shows that blockchain can notably boost manufacturing profitability and sustainability through greater transparency and cost savings.

The research titled "Internet of Things and AI-based optimization within Industry 4.0 paradigm" by **Mikołajewski et al. (2024)** examines integrating IoT and AI in Industry 4.0. The highlights are:

1. Methods: A systematic literature review from January 2017 to March 2023 focused on terms like IoT, IIoT, Industry 4.0, ML, and AI.

2. Review Results:

- Industry 4.0 focuses on customer-oriented production, notably affected by the COVID-19 pandemic.
- Contemporary industry aims for minimal human involvement, boosting efficiency via systems like EdgeSDN-I4COVID.
- Cyber-physical systems (CPS) are key to Industry 4.0, linking smart machines and control systems.
- AI methods enhance resource use, lower energy use, and reduce carbon footprints.
- Smart sensors and preventive maintenance are essential for critical operations.

3. Applications:

- IoT and AI find application across fields such as agriculture, forestry, livestock, and waste management.

- Technologies related to Industry 4.0 have been crucial during the COVID-19 pandemic for food supply chain continuity and efficient waste management.

4. Challenges:
- IoT device security is a major concern due to limited resources and different IoT protocols.
- The construction sector falls behind in adopting Industry 4.0 technologies compared to rail and forestry.

5. Future Directions:
- Focus on sustainability and energy saving.
- Integrating AI in industrial processes to enhance planning, optimization, and maintenance.
- Creating greener solutions with a lower carbon footprint.

The study "Visibility in complex supply chains. Platform, governance, tensions" by **Wycislak (2021)** discusses the connection between supply chains. visibility and business performance. It shows the problems and advantages of using real-time visibility platforms in supply chains. The study looks at several important points:

- Introduction: Talks about the unclear connection between supply chain visibility and business performance, stressing organizational obstacles to visibility.

- Platform and Real-time Visibility: Looks into the theory and practical use of real-time visibility platforms; concentrates on the difficulties of data integration and the function of digital industrial platforms.

- Platform Governance: Studies governance rules for digital platforms, covering participation rules, interaction methods, and conflict resolution, and how they affect competitive edge.

- Tensions: Discusses the conflicts in platform governance, like finding a balance between openness and control, from managing teamwork and rivalry to creating ecosystem value.

- Conclusions: Advises checking the abilities and readiness of supply chain partners before utilizing a real-time visibility platform; highlights the need for onboarding and compliance.

Vishal Ranaware (2019) conducted a study that investigates the potential applications of blockchain technology in the view of smart cities. It demonstrates how blockchain technology may be utilised to enhance various aspects of smart city infrastructure, which includes but not limited to private data sharing, smart contracts, citizen participation, the economy and employment opportunities, health, education, property registration, renewable energy, waste management, and safety. The findings of this study highlight the capacity of blockchain technology to deliver solutions that are transparent, immutable, and secure, hence improving the effectiveness and sustainability of metropolitan regions.

The research conducted by **Alasbali and colleagues (2022)** investigates the challenges and potential solutions associated with integrating blockchain technology into Internet of Things (IoT) networks in smart cities. It points out the necessity of standardisation and inter-operation among networks, databases, and application programming interfaces (APIs) in order to achieve urban goals. The study proposes a blockchain architecture that is hosted on the cloud as a solution to address issues of data storage, scalability, and security. This study intends to increase the connection and efficiency of smart cities enabled by the Internet of Things (IoT); it also assures that transactions are secure, autonomous, and verifiable. It discusses the development of a standard foundation for blockchain technology.

Khanna et al. (2021) conducted a study that analyses the possibilities that blockchain technology offers for the development of smart cities. It explores the ways in which blockchain technology, which is a distributed ledger that is both decentralised and permanent, might be utilised to address urbanisation challenges; increase citizen participation. The purpose of this study is to conduct a literature review in order to identify important areas in which blockchain technology has the potential to improve e-governance. These areas include boosting transparency, security, and efficiency in urban management. Besides, it discusses the integration of blockchain technology with other technologies such as the Internet of Things (IoT), artificial intelligence (AI), and cloud computing in order to construct cities that are more efficient and sustainable. At the end of the study, a comprehensive analysis of the advantages and disadvantages of implementing blockchain technology in smart cities is presented. The importance of blockchain technology in promoting innovation; enhances the quality of life for citizens.

In the article that was published in **2020 by I. J. R. A. S. E. T.,** the author investigates how blockchain technology might be used to address concerns regarding privacy and security in the Internet of Things (IoT). It highlights the vulnerabilities of Internet of Things devices, such as their low computational power, storage capacity, and network capacity, which contribute to their susceptibility to threats. In the paper, it is explained how the inherent characteristics of blockchain, such as immutable ledgers and decentralised systems, may enhance the security of the Internet of Things (IoT), prevent unauthorised data access, and guarantee the integrity of data. In addition to this, it highlights unresolved challenges and suggests potential topics for further research in order to improve the way blockchain technology interacts with Internet of Things (IoT) devices.

The research that was conducted by **Makhdoom and colleagues (2019)** and titled "PrivySharing: A Blockchain-based Framework for Integrity and Privacy-preserving Data Sharing in Smart Cities" investigates the use of blockchain technology to enhance the privacy and security of data in smart cities. They propose a method that they call PrivySharing, which divides the blockchain into multiple channels for different kinds of data, such as those pertaining to wellness, intelligent vehicles, and financial matters. This method safeguards the confidentiality of data through the use of private data gathering and the establishment of access control rules within smart contracts. In addition, the system incorporates a reward system known as PrivyCoin, which is designed to motivate users to submit data. The research highlights the manner in which the framework satisfies the standards of the General Data Protection Regulation (GDPR) of the European Union, as well as its function in protecting against potential security concerns.

The research conducted by **Aldribi and Singh (2022**) investigates the development of a decentralised and scalable solution for smart cities through the utilisation of blockchain technology. The Internet of Things (IoT), fog nodes, smart contracts, and the Inter-Planetary File System (IPFS) are all components that are incorporated into this system in order to enhance the effectiveness and longevity of smart city networks. The research focusses on three public sectors: healthcare, water supply, and power, and it demonstrates significant improvements in performance when implemented in a scalable environment. In comparison to the traditional centralised approaches, this decentralised approach offers superior performance, scalability, and security, making it an excellent choice for the development of smart cities in the time to come.

According to the findings of **Rahman et al. (2022),** a multi-layered blockchain-based platform is recommended for smart cities in order to preserve the integrity of Internet of Things data and to facilitate blockchain inter-operation. The growth of the Internet of Things has made data management more difficult in these domains. Because of the centralised nature of the cloud systems that are now in use, they are not considered to be trustworthy. For the purpose of addressing these concerns, they suggest a decentralised structure of blockchains that they refer to as Blockchain-of-Blockchains (BoBs). The purpose of BoBs is to ensure that data integrity is maintained and that operations between the various smart city sectors run smoothly. In order to investigate the capabilities of this concept, it is put to the test by utilising Hyperledger Fabric and Ethermint as a starting point.

The research by **Hidayati (2020)** investigates mixing Fog Computing (FC) and Blockchain to boost the efficiency and security of Internet of Everything (IoE) services in smart cities. The suggested Blockchain and Fog-based Architecture Network (BFAN) seeks to cut energy use and latency; while providing security through encryption and authentication. By handling data closer to users, this structure solves challenges like security, platform independence, support for multiple applications, and resource management. Simulation results show that BFAN performs better than current frameworks in energy efficiency, reduced latency, and security features for smart city applications.

The study by **Das et al.** looks into how blockchain could change Intelligent Transportation Systems (ITS) in smart cities; improves security, privacy, and interoperability. It reviews different blockchain applications in ITS, for example: secure data transfer, smart contracts for self-driving cars, and decentralized transport service marketplaces. The study also highlights the barriers to blockchain in ITS, such as scalability and high processing power needs; it offers performance insights based on key ITS metrics. Furthermore, it discusses future ITS security needs as well as showcases opportunities for research to advance smart cities.

The study by **Ivanišević, Stojan & Ciric, Zoran. (2019)** looks at literature to find key factors for using blockchain in smart cities. It shows how blockchain tech can change business models by making data systems better. The study looks into technical issues, changes needed in business models, and why community cooperation, laws, and user involvement are crucial for successful blockchain use in smart cities. The aim is to give insights into more factors that affects the success of blockchain projects in this area.

The work by **Ivanišević, S., Ivić, A., & Ćirić, Z.** studies using blockchain in smart cities, focuses on performance metrics. The goal is to create a useful framework to improve the implementation by looking at the best areas for application, key success factors, and performance metrics. Using the Delphi method, experts reviewed and suggested performance indicators, pinpointed the five most critical ones for blockchain in smart cities. The research also emphasizes blockchain's ability to boost security, transparency, and efficiency in urban information systems inspite of hurdles like limited resources and data access.

The research by **Bai, Y., Hu, Q., Seo, S.-H., Kang, K., & Lee, J. J** examines putting blockchain tech into smart city governance, with a focus on maintaining urban infrastructure. It suggests a new public participation consortium blockchain system aimed at getting citizens involved in decision-making. This system has a hybrid blockchain setup with a randomly chosen verifier group from the public to oversee transactions. It also presents a private-prior peer-prediction truthful verification method to stop collusion and a

Stackelberg-game mechanism to encourage ongoing public involvement. Detailed simulations show the system's effectiveness compared to other models.

The research by **Ciric, Zoran, Sedlak, Otilija & Ivanišević, Stojan. (2020)** looks into how blockchain tech can be used in smart city information systems to improve security and sustainability. It reviews current studies to find weaknesses in existing systems and contrasts them with blockchain benefits. The findings suggest that blockchain can help fix these weaknesses by boosting security, privacy, and network availability in smart cities. However, it stresses the need for more research to build a full framework for blockchain use in smart cities.

The study **by Cheikhrouhou, Omar, Ichrak, Amdouni, Mershad, Khaleel, Ammi, Meryem, & Nguyen Gia, Tuan. (2022)** offers a thorough review of blockchain solutions to improve cybersecurity across various smart city applications, such as smart healthcare, transportation, agriculture, supply chain management, smart grids, and smart homes. It discusses the advantages and disadvantages of current solutions, defines security needs for each application, and connects these solutions to those needs. Furthermore, it provides future research directions and serves as a key resource for researchers in cybersecurity, blockchain, and smart cities.

Publication, F. O. R. E. X. (2022) reviews security and privacy issues around IoT-Blockchain technology in smart cities. It points out that smart cities, using modern technologies like IoT, cloud computing, and big data, face big data protection challenges due to sharing large amounts of data. The study looks at how smart cities are set up. How blockchain enhances security and privacy, and the various problems. It speaks about the uses of blockchain in such settings. It ends with discussion on future issues and suggests ways to better data security in smart cities.

The paper by **Ahmed, S., Shah, M. A., & Wakil, K. (2020)** reviews the application of blockchain in smart cities. It looks at how blockchain can handle problems for example: security, privacy, and trust by offering a decentralized, unchangeable, and clear system. The study points out the pros of blockchain, like better security, privacy, and cooperation, etc, along with the challenges faced in its use in smart cities. The goal is to encourage more researches and dialogues on blockchain's ability to enhance smart city living.

The paper by **Xiao, Xiao-Yong & Jin, Lin & Kateb, Faris & Aldeeb, Hooreya. (2021)** discusses how to use blockchain with big data for urban governance. It shows that the features of blockchain—like decentralization, resistance to tampering, and privacy etc.—that can help tackle concerns about data quality, trustworthiness, and privacy in city management. By using blockchain, cities could boost data handling, improve urban research precision, and promote smart city growth, leading to better urban governance.

The paper by **Ivanisevic, S. (2019)** looks at how blockchain can be used in smart city information systems. It studies how blockchain can solve security, reliability, and availability problems in traditional systems used in smart cities. The paper reviews academic literature and real-world examples to pinpoint effective blockchain uses in different areas like smart economy, smart governance, smart mobility, smart environment, and smart living. The aim is to enhance sustainability and set up a structure for using blockchain-based information systems in smart cities.

The paper by **Singh, Charu. (2023)** examines the role of blockchain in creating smart city ecosystems. It shows how blockchain can improve security, openness, and efficiency etc. in various sectors, for example: smart banking, pollution monitoring, energy control, and self-driving cars etc. The study stresses that blockchain can help build a sustainable and lively smart city through secure data handling, real-time information access, and better citizen services.

The paper by **Wong, P. F., Chia, F. C., Kiu, M. S., & Lou, E. C. W. (2020)** explores the role of blockchain in developing smart sustainable cities. It points out that blockchain can tackle security issues that come with many connected devices in smart cities. The research focuses on five main areas for blockchain use: smart governance, smart mobility, smart asset management, smart utility, and smart logistics. It presents a plan for implementing blockchain into smart city development to boost sustainability and improve quality of citizens' life; focuses more on the benefits of decentralization, transparency, and solid data protection.

The paper by **Alnahari, Mohammed & Ariaratnam, Samuel. (2022)** researches the incorporation of blockchain technology into smart city infrastructure. It discusses how blockchain can streamline operations, increase transparency, security, and reduce data fragmentation. The paper looks into blockchain applications in sectors like energy, transport, water, construction, and government. It also deals with regulatory challenges from this new technology and suggests approaches for applying it in smart cities to enhance infrastructure management and sustainability.

The paper by **Wycislak, S. (2021)** investigates how blockchain could transform supply chain management. It shows how blockchain can improve economies. Coordination can happen with distributed ledgers, cryptocurrencies, smart contracts, and decentralized groups. This study shows how blockchain can make supply chains better by giving real-time updates and unchangeable records, that improves visibility, trust, efficiency etc. It also mentions problems of using blockchain, like needing new skills and shared standards; highlights uses and benefits etc., as well as automated processes, clearer operations, lower expenses.

The research by **Shannon, H., Fermat, Q., and Sundan, Bose (2024)** looks at how using AI for predictive analytics can strengthen infrastructure reliability in smart cities integrating big data and IoT tech. It offers a framework that brings together real-time data from different IoT devices and uses machine learning to foresee infrastructure issues that fine-tune maintenance plans. Success stories in transportation, utilities, and emergency services etc. showcase how predictive analytics can change; how cities make proactive decisions and use resources.

The work by **Oladejo, Abayomi, and Fatunmbi, Iyanuoluwa (2024)** studies how fast data analysis, machine learning, and IoT tech can boost the efficiency and sustainability of smart cities. By analyzing real-time info from sensors, traffic systems, and energy networks, predictive models can enhance traffic control, cut energy use, and optimize public services. The study includes examples from top smart cities worldwide, stressing the economic, environmental, and social problems of data-led city management. It also points out privacy, safety, and infrastructure, growth issues, etc. suggesting ways to ensure equal access to smart city solutions for everyone.

The research by **Cong, Yuxin, and Inazumi, Shinya (2024)** looks at urban growth and infrastructure resilience challenges in Japan; especially how smart city ideas can help with problems like land subsidence and liquefaction, made clear after the 2011 Great East Japan Earthquake. It assesses the current situation and the lack of geo-information and communication tech in Japan's smart cities. The study uses advanced tech like smart sensing and predictive analytics through kriging and ensemble learning to improve geotechnical investigation and urban planning accuracy. By examining data from Setagaya in Tokyo, predictive models are created to accurately find the depth of crucial support layers for urban infrastructure. The findings reveal that ensemble learning is better at estimating the depth of these layers.

Two methods have been introduced to predict unseen geographic data and create digital maps for the construction industry to aid in developing smart cities. This research is beneficial for real-time data analysis, helping the government in urban planning, allowing construction firms to assess risks, and offering real-time geographic information and hazard alerts to individuals through mobiles and other platforms. As per the researchers' understanding, this is the first time predictive analysis of geographic info has been done using geographic data, big data technology, machine learning, integrated learning, and AI.

The **2024 study titled "Big Data and Advanced Analytics for Smart Mobility: Collection and analysis of large-scale transportation data"** investigates how big data and advanced analytics can transform transport systems into smarter and more sustainable solutions. It discusses advanced analytical methods like machine learning, deep learning, spatial and temporal analysis, and optimization techniques etc. to improve traffic management. detecting odd events, and forecasting problems. The report points out uses like smart traffic control, various transportation plans, tailored mobility services, and eco-friendly transportation assessment. It also talks about issues like merging data, moral challenges, and needing teamwork across different fields, aiming to offer useful information for specialists and scholars in smart mobility.

The research by **Allam, Z. (2019)** looks at combining specific technologies in city areas, with a focus on Smart Cities. It shows how using sensors and Big Data via the Internet of Things (IoT) can change; how cities are built and run, provides fresh economic chances.

The paper stresses that while Artificial Intelligence (AI) and Big Data can really improve cities, it is important to balance tech progress with sustainability and livability. The authors suggest a plan that merges AI with essential aspects of Culture, Metabolism, and Governance to support the effective rollout of Smart Cities, aligning with Sustainable Development Goal 11 and the New Urban Agenda. This plan aims to assist policymakers, data experts, and engineers in boosting urban livability and economic development through AI and Big Data.

The research by **Qiu, R. G., Zu, T., Qian, Y., Qiu, L., & Badr, Y. (2018)** looks into how mixing physical and social sensing can improve transportation services in smart cities. It concentrates on using big data tools to enhance city mobility management and functions. By merging real-time info from sources like Citi Bike and Twitter, the study shows how a digital platform can lead to smarter and greener urban transport services. The research highlights the need for both physical and social sensing in building efficient, eco-friendly, user-friendly city services.

The study by **Nica, Elvira & Popescu, Gheorghe & Poliak, Miloš & Kliestik, Tomas & Oana, Sabie. (2023)** reviews recent discussions about digital twin tools, spatial thinking methods, and multi-sensor merging technology in sustainable city governance networks. It examines how predictive modeling methods, deep-learning sensing technologies, and large urban data shape immersive connected virtual areas in digital twin cities. This research looks at whether data-driven smart urban planning needs visual recognition tech, monitoring tools, and simulation-based digital twins etc. It also checks how blockchain-based digital twins, smart infrastructure sensors, and live IoT data support urban computing tech, ultimately seeking to clarify how these technologies help smart city governance and improve Internet-of-Things-based environments.

The study by **Elngar, A. (2019)** investigates the combination of blockchain technology (BT) and machine learning (ML) to boost the safety and efficiency of smart apps. It shows how BT's decentralized database guarantees data security and confidentiality, while ML's data analysis can tackle security problems like majority attacks and double-spending. The study reviews various ML methods such as Support Vector Machines (SVM), clustering, and Deep Learning (DL) algorithms, etc. and their use in smart apps like Unmanned Aerial Vehicles (UAVs), Smart Grids (SG), healthcare, and smart cities. It also discusses future research hurdles and presents a case study to showcase the real-world application of these technologies.

The study by **Tripathi, G., Ahad, M. A., & Paiva, S. (2020)** explores how IoT technologies can be used in healthcare within smart cities, stressing the need to create a secure and privacy-conscious "Smart Medical System (SMS)" framework. It highlights the advantages of IoT in real-time monitoring, patient info management and spotting problems, while needing data protection and privacy. The suggested setup uses Mobile Edge Computing (MEC) for instant analysis and blockchain for keeping data safe, with the goal of improving effectiveness and dependability in healthcare systems within smart city contexts.

The paper by **Asgari, M., & Nemati, M**. looks at how blockchain can be used in smart water systems. It examines ways blockchain can better water management by increasing data security, clarity, and effectiveness. The research is organized into three main sectors: Smart Water Systems, Water Quality Monitoring, and Storm Water Management. It also considers the technical, organizational, social, and institutional obstacles that might slow down blockchain use in water management.

The research by **Yigitcanlar, T., Desouza, K., Butler, L., & Roozkhosh, F. (2020)** examines how artificial intelligence (AI) might help in building smart cities. The study reviews 93 articles and sorts the results into the main areas of smart city growth: economy, society, environment, and governance. The findings indicate that AI in smart cities is a growing area, focusing on technologies, algorithms, and applications in business, data analysis, education, energy, environmental care, health, land use, security, transport, city management etc. sectors. It points out the lack of research on AI risks and the necessity for more study on future challenges. This paper seeks to help researchers by showing potential future research topics.

The mix of blockchain and artificial intelligence (AI) has received much focus due to its ability to improve security, efficiency, and productivity in unstable and complicated business situations.

The paper by **Charles, Vincent & Emrouznejad, Ali & Gherman, Tatiana. (2023)** reviews the current trends in blockchain and AI in supply chains, focusing on three essential questions: current studies on their mix, existing examples, and future research paths. The review shows that blockchain and AI can better supply chain strength, speed, cost-effectiveness, and traceability. Even though the integration is still early, these technologies hold the potential to transform supply chain management by enabling strong data sharing, predictive insights, and process automation without a central authority. This review aims to assist future research and practical uses in this area.

The study by **Yitmen, Ibrahim. "Integration of Blockchain and Digital Twins in the Smart Built Environment Adopting Disruptive Technologies—A Systematic Review." Sustainability, 2023** looks into combining blockchain and digital twins (DT) for improved lifecycle data management in buildings. It reviews 86 research papers to underline enabling technologies like AI, IoT, and Big Data analytics, discussing their potential, challenges, and integration abilities. The results show that merging these technologies can solve individual challenges and enhance smart building environments. The study also presents a model for merging these technologies into a cohesive system for better lifecycle management in the construction field.

The research by **Yarime, M. (2019)** analyzes how smart technologies can tackle issues in the woody biomass supply chain, especially in Japan. It emphasizes the importance of woody biomass in sustainable energy and its ability to cut emissions, boost economic growth, and strengthen energy security. Despite its promise, the woody biomass supply chain deals with technical and social issues. The study indicates that smart technologies could increase transparency, efficiency, and accountability in the supply chain, addressing concerns such as Transportation infrastructure, biomass quality management, business model integration, stakeholder relationship management, and local community development are important areas of study. The findings come from expert interviews and indicate that combining smart technologies with woody biomass supply chains can help achieve sustainability goals and guide energy policy in academia, industry, and government.

Chanda, M. (2022) presents an overview of smart cities, concentrating on how IoT communications can improve city management and services for residents. It discusses the concepts, features, and uses of smart cities, stressing the importance of IoT devices in forming systems that unite various sensors and ICT technologies. The study covers technology trends like machine learning and blockchain, addressing their uses, challenges, and possible solutions for smart cities. It also looks at cloud and fog IoT ecosystems and security and privacy concerns, offering a model for smart city mega-events. The paper ends by discussing how new technologies could shape the future of smart cities, underlining the need for reliable and robust systems.

Park, J.-ho et al. (2019) examine how to combine cognitive computing with the Internet of Things (IoT) to manage the vast amounts of data produced by smart city applications. They suggest a Cognitive IoT-based smart city network (CIoT-Net) structure that uses cognitive computing to analyze data from different smart city applications, aiming to tackle issues related to scalability and flexibility. The study highlights using AI and big data analysis for this model and identifies potential research challenges and opportunities. It stresses the advantages of cognitive computing in enabling personalized, human-like interactions and solutions in areas like healthcare and smart transportation.

Ch, M. H. (2020) reviews methods for energy generation in smart water systems, focusing on how urban water distribution can recover hydraulic energy and generate electricity. It discusses new technologies such as cyber-physical systems, digital twins, and blockchain, as well as methods like network dynamics and geometric deep learning. The paper also considers adding micro-turbines and pumps as turbines to boost energy recovery, manage leaks better, and enhance network resilience. Future research aims at highlighting digital water as a vital framework for effective and sustainable water network management.

2.1.2 Relevant Studies

Morozova, Irina & Yatsechko, Stanislav (2022) gives a view by organizing global experiences in smart city growth. It shows that smart cities help not just SDG 9 (Industry, Innovation, and Infrastructure) but also affect SDG 1 (No Poverty) and SDGs 11–13 (Sustainable Cities, Responsible Consumption, and Climate Action). By putting corporate social responsibility at the center of smart city management, the research argues that businesses are important in city planning and growth. This detailed investigation opens up for more study as in how businesses and entrepreneurship could affect smart city development.

Dziatkovskii's work connects to a wider range of studies about smart cities using new technologies to solve urban problems. For example, AI is used for traffic management and prediction to improve city functions and cut pollution. Blockchain is important for keeping data clear, especially in waste management and energy. The use of waste-to-energy in Europe's circular economy is another case of how these technologies support sustainable city growth.

The literature reviewed by **Al Sharif and Professor (2021)** discusses the growth of smart cities since the 1990s, highlighting the role of advanced ICT in tackling today's urban issues. This study links with earlier research on IoT, AI, and blockchain, showing these tools are key to managing urban infrastructure, energy, and public services. It also looks at tools and methods for risk assessment in smart cities, especially technical risks like data security, privacy, and operational issues. This ammends to previous studies on governance and planning required for smart city success factors.

The research by **Nguyen and Hallo (2022)** talks about smart city projects from 2010 to 2021; focuses on how risks are managed in different areas. It notes that technological and organizational risks are largely studied, however, social risks are less explored. This risk management perspective is placed within literature that perceives smart cities as linked systems; addressing challenges of managing various subsets i.e. subsystems. The study also reviews governance models shaped by outside factors like legal and environmental issues, etc. studying qualitative content analysis of 31 significant papers.

Ahmed et al. (2022) enhances understanding of AI, blockchain, and IoT by discussing existing literature that shows their real-world use in smart cities. The authors suggest a conceptual model that uses IoT devices, cloud computing, and AI to manage large data amounts and keep results in decentralized cloud systems using blockchain. The structure includes physical, data, network, consensus, incentive, smart contract, application layers etc. to support sustainable IoT frameworks. Practical uses involve smart healthcare, energy control, smart homes, industrial automation, etc. aiming to minimize environmental effects while boosting efficiency.

The work of **Ariyachandra and Wedawatta (2023)** reviews 312 titles and abstracts, alongside 72 full papers, to give a thorough view of the growth of DTSCs for disaster risk management. The authors review the intelligent technologies in DTSCs, such as big data and sensor networks, etc. and examine their advantages in increasing disaster resilience. These findings indicate that DTSC-dedicated disaster risk management can deliver real-time support. data, guess possible disaster effects, in order to organize rescue and do recovery tasks better. Yet, the use of DTSC technologies is still changing, with real-world uses needing more study and growth.

The research by **Nguyen, Han-Khanh. (2022)** shows increasing research on supply chain risk management, especially linked to customer happiness in retail grocery stores. The SERVQUAL model looks at service quality factors, while the binary logistic model studies how customer age, education, and income relate to their chance of using supermarket services again. The Grey model forecasts supermarket success from 2021 to 2024. Four key factors—product quality, staff, safety, and facilities—were found to directly impact customer satisfaction, while age, education, and income played roles in customer actions. This broad approach builds a strong base for improving service quality and managing risks well.

The work by **Ullah et al. (2021)** is based on reviewing 796 articles and points out risks in smart city management by sorting them into TOE layers. It notes rising global investment on smart city tech and stresses the need to focus on sustainability in city management. The framework builds on previous studies about ICT-based smart city management; merges advanced technology with governance. Leveraging ongoing risk management makes it useful for both researchers and field experts seeking to reduce risks in smart city projects.

Ghosh et al. (2023) assesses the performance of their proposed AI-focused Blockchain (AI-BC) system using both qualitative and quantitative methods. Their research shows that this new combination outperforms current methods in performance tests. The study also reviews existing work on AI and smart city use, identifying trends that support the need for an integrated method that emphasizes security, sustainability, and fair solutions in urban areas.

Mumtaz & Ali (2024) present a new mix of AI, IoT, and Big Data Analytics in Green Fintech to tackle sustainability problems. Their study investigates how AI and IoT improve financial and waste management, even while smart contracts refine payment systems to ensure clarity. Big Data Analytics helps stakeholders gain insights from complex data; facilitates better decisions in harmony with sustainable development goals.

The inquiry by **Chauhan & Sahoo (2024)** shows how AI, blockchain, and IoT are crucial for sustainability. Their analysis critically reviews how AI betters' energy efficiency and resource use, blockchain boosts supply chain transparency, and IoT enables immediate monitoring for better resource handling. The authors suggest using these technologies to create a more sustainable future, even while focusing on ethical governance, data safety, and cooperation etc. across sectors to tackle present implementation issues.

The investigation by **Irfan et al. (2024)** uses comparative text analysis of academic literature, industry reports, and case studies to look into the impact of these integrated technologies in various sectors and regions. The analysis detects patterns in the use of blockchain, IoT, and AI in supply chain management, highlighting how these technologies work together to improve supply chain transparency, decrease fraud, and protect sensitive information. The results underline the significance of this technological integration for enhancing supply chain functions, particularly in risk management and operational productivity.

The study of **Sandner, Philipp & Groß, Jonas & Richter, Robert. (2020)** discusses some practical examples, including a smart lamp that works on its own using blockchain for identity and payment while using AI for upkeep and optimization. Blockchain is noted for securing and standardizing data from IoT devices, leading to better privacy, security, and interoperability. AI helps by improving data management and scalability, and blockchain smart contracts automate business tasks, allowing for smooth device and system interactions.

The work of **Rajawat, Anand & Goyal, S & Kumar, Manoj & Singh, Thipendra P. (2024)** uses social network analysis and tests the SOM+LSTM method in a simulated blockchain setting. LSTM networks help predict event sequences with past data; SOMs improve pattern recognition to spot possible threats. The results show a significant improvement in identifying Sybil and DDoS attacks; responds faster than traditional security methods. The algorithm adjusts to new attack methods; offers a long-term solution for blockchain security.

The research from **Dutta, P., Choi, T.-M., Somani, S., & Butala, R. (2020)** shows that blockchain technology can greatly change supply chain (SC) operations in many industries. It points out several key aspects:

Better Security and Transparency: Blockchain’s decentralized and unchangeable nature ensures secure transactions, lowering chances of fraud and mistakes.

Increased Efficiency: Automation of tasks with smart contracts and distributed ledgers facilitates SC operations run more smoothly and saves costs.

Broad Applicability: Blockchain can be used in different sectors like shipping, manufacturing, automotive, aviation, finance, technology, energy, healthcare, agriculture, food, e-commerce, education, etc.; improves visibility and management of business processes.

Challenges and Future Research: Even with its potential, blockchain has challenges like usability, security, privacy, costs, etc. The study suggests more research to tackle these issues and find new uses for blockchain in SCs.

The research from **Homaei, H., Homaei, M., & Caro, A. (2024)** looks at how artificial intelligence (AI) can improve the cybersecurity of digital twin technology in different industries. It points out the advantages of digital twins, including better speed, accuracy, and efficiency, etc. in system analysis and design. The research also discusses security problems that come with moving to cyber digitization and highlights risks from cybercriminals due to inadequate information and security norms. It further explores how digital twins and AI tools interact; suggests that integrating them can enhance cybersecurity for digital platforms. This research serves as guidance for those studying cybersecurity and digital protection.

The study **Publication, S. (2020). Blockchain Technology: A Driving Force in Smart Cities Development** finds that Blockchain Technology is a strong tool that can greatly improve the creation and function of Smart Cities.

The main points are as follows:

• Secure Transactions: Blockchain makes online transactions safe and reliable, essential for Smart Cities' operations.

• Wide Application: Blockchain works well in various fields like insurance, governance, supply chain management, and healthcare.

• Future Potential: Blockchain is likely to keep expanding into more sectors, becoming a leading option for digital transactions.

• Proposed Framework: The research suggests a secure structure based on Blockchain. Technology used in Smart City services shows it can adapt and has possibilities for future use. The study shows how Blockchain Technology can change Smart Cities to be more effective, safe, and dependable.

Research by **Rotuna, Carmen & Gheorghita, Alexandru & Alin, Zamfiroiu & Smada, Dragoş. (2019)** finds urban growth creates new challenges for public infrastructure. As cities grow and change services, management gets more complicated. To tackle these issues, cities need to become smart by using digital technologies to enhance urban services for people. Blockchain, which started with cryptocurrencies, can greatly assist in city management. A Smart City using blockchain has benefits like better efficiency through automated citizen interactions, improved resource allocation, and less fraud. The study notes it's important to ensure new applications work with existing systems to maximize urbanization benefits. With blockchain, cities can build a decentralized system that boosts security, openness, and citizen involvement in decisions.

The study by **Treiblmaier, Horst & Rejeb, Abderahman & Strebinger, Andreas. (2020)** suggests blockchain can significantly aid smart city development.
Key points include:

• Improved Efficiency: Blockchain can enhance various city systems, such as healthcare, logistics, and energy.

• Transparency and Security: This technology ensures better transparency and safety in data handling and transactions.

• New Applications: Blockchain can be utilized in areas like e-voting, administration, and education, improving services and citizen participation.

• Research Framework: The study offers a detailed framework to direct future studies on blockchain use in smart cities. Overall, it highlights the potential of blockchain to transform urban settings and presents a plan for its use in smart cities.

In the research by **Palaiokrassas, Georgios & Skoufis, Petros & Voutyras, Orfefs & Kawasaki, Takafumi & Gallissot, Mathieu & Azzabi, Radhouene & Tsuge, Akira & Litke, Antonios & Okoshi, Tadashi & Nakazawa, Jin & Varvarigou, Theodora. (2021),** the integration of blockchain with IoT and security measures can establish a secure and efficient data market for smart cities. The proposed method combines blockchain, smart contracts, and the Inter-Planetary File System (IPFS) to manage data collection, sharing, security issues etc. within IoT networks. A trial between Santander and Fujisawa confirmed the system's efficiency, security, interoperability. This research points to the promise of the Sensing-as-a-Service (S2aaS) model for facilitate secure data exchanges in smart city settings.

Lee, J. (2018) finds blockchain technology can boost profits and competitiveness in manufacturing by providing real-time transparency and costs saving; ensures the industry's sustainability. The study's model shows companies that use blockchain can earn more than those that do not because of its cost-saving and transparency benefits. The findings also relate to smart city risk management with the help of blockchain, AI, and IoT. are indeed relevant. The transparency and savings of blockchain technology can be used in smart city projects to boost efficiency, lower costs, and better decision-making. Linking blockchain with AI and IoT can improve data accuracy, security, and real-time monitoring, etc. all of which are vital for managing risks in smart cities.

The research by **Mikołajewski and others (2024)** shows the potential of combining machine learning (ML), blockchain, and the Internet of Things (IoT) in smart cities. This mix tackles the challenges of modern cities by using ML for data insights and predictions, while blockchain offers a secure, decentralized way to keep data safe. Together, these technologies improve city management and enhance security and privacy in connected environments.

In relation to managing risks in smart cities, this study explains how these technologies can support autonomous and sustainable urban infrastructure. It also discusses challenges like scalability, privacy, and ethical issues, which are important for moving smart city projects forward. Thus, the study is significant for smart city risk management that involves blockchain, AI, and IoT.

The study **"Visibility in complex supply chains. Platform, governance, tensions" by Wycislak (2021)** looks at how supply chain visibility relates to business performance. It points out that organizational issues, not just technology, are major obstacles to visibility. It also covers the use of a real-time transportation visibility platform and how it affects supply chain management.

While mainly focused on supply chains, the insights can apply to smart city risk management using blockchain, AI, and IoT. The focus on real-time visibility, data integration, and platform governance, etc. can improve transparency, efficiency, and security in smart city systems. The study's findings about managing tensions and governance can help address the complexities and risks that come with smart city technologies.

The research by **Ranaware (2019)** investigates the mix of machine learning (ML), blockchain, and the Internet of Things (IoT) in smart cities. It shows how these technologies can solve the challenges of modern urban areas by improving data analysis and ensuring data safety through a decentralized system. This combination aids in better urban management and enhances security and privacy in connected cities. The study also talks about challenges like scalability, privacy, and ethical issues, etc. and suggests future research paths.

In summary, this study is important for smart city risk management that includes blockchain, AI, and IoT, as it offers insights into building resilient and sustainable urban frameworks.

The study by **Alasbali et al. (2022)** looks into the difficulties and solutions for using blockchain technology in IoT-based smart city applications.

The key findings are as follows:

1. Challenges: The study points out multiple issues in creating IoT-driven smart cities, including security risks, interoperability of different nodes, data management, scalability of various IoT networks, etc.

2. Suggested Solution: To tackle these issues, the research recommends a standardized, intermediary cloud-based blockchain model for IoT networking. within smart cities. This

model seeks to fix important gaps by allowing transactions that are autonomous, unchangeable, and undeniable.

3. Relevance to Smart City Risk Management: The results are very important for smart city risk management since they aim to improve security, interoperability, and data management using blockchain, AI, and IoT technologies.

The suggested model looks to build a more secure and efficient smart city foundation by using these technologies.

The research by **Khanna et al. (2021)** states that blockchain technology, when combined with AI and IoT, can greatly improve how smart cities are managed and governed. The main results show that the decentralized, secure, and verifiable nature of blockchain makes it suitable for many e-governance tasks in smart cities. The study points out four main areas where blockchain can offer significant advantages: energy trading, smart healthcare, e-voting, and supply chain management. These integrations can improve transparency, security, efficiency, and citizen engagement in urban management.

In terms of risk management, the study says that blockchain, along with AI and IoT, can tackle various issues smart cities encounter, like data privacy, security, and effective resource management. This combination can supply real-time data, boost decision-making, and ensure the integrity and trustworthiness of urban systems.

Publication, I. J. R. A. S. E. T. (2020) looks into how blockchain technology can tackle security and privacy issues in IoT systems. It notes that IoT devices typically have limited computing resources, storage, network capacity, etc. making them vulnerable to attacks. Integrating blockchain can improve security by providing a decentralized, unchangeable ledger; ensures data integrity and trust among IoT devices.

The study concludes that while blockchain can resolve many IoT issues, like data integrity and privacy protection, some problems are still not addressed, which includes the need for better anonymity and risks of user tracking through public keys. Yes, the findings are significant for smart city risk management supported by blockchain, AI, and IoT. The study's findings on improving IoT security via blockchain can be useful for smart city systems, guaranteeing secure and trustworthy data management across various urban applications.

The research by **Makhdoom et al. (2019) introduces "PrivySharing,"** a blockchain-based framework designed to maintain the integrity and privacy of IoT data sharing in smart cities. This framework tackles vital issues of data privacy and integrity by splitting the blockchain network into different channels, each handling specific data types (like health, smart vehicles, smart energy, and financial data). Access control rules in smart contracts and private data gathering further enhance user data security. Moreover, the framework meets important standards in the European Union General Data Protection Regulation (EU GDPR); ensures personal data is collected and processed with user approval; gives users control over their data. The framework also includes strong security measures, such as dual security for the REST API (API Key and OAuth 2.0), safeguards against false data injection and Sybil attacks, and a transparent and auditable network operation.

The research is very relevant to smart city risk management since it tackles crucial issues of data privacy, integrity, and security in IoT settings using blockchain technology. It offers a thorough solution that guarantees user data is protected and managed properly while complying with regulatory mandates and building trust in smart city projects. The framework's scalability, effectiveness, and reward system are potential benefits. system where users share their data with stakeholders adds to its ability to address smart city data management issues.

The research by **Aldribi, Abdulaziz & Singh, Aman. (2022)** finds that a decentralized and scalable solution using blockchain can effectively create sustainable smart-city networks. By combining IoT, fog computing, trusted chains, smart contracts, blockchain, the Inter-Planetary File System (IPFS), etc. deep techs, the model shows marked improvements in performance, scalability, and distribution. Tests with 1500 devices and over 10,000 records reveal a performance improvement of 77.44%. This study is pertinent to smart city risk management integrating blockchain, AI, and IoT. It tackles the problems of centralized data processing and provides a decentralized alternative that boosts security, processing, and storage capabilities, suitable for public services like electricity, water supply, and healthcare.

The research by **Rahman, Mohammad & Chamikara, M.A.P. & Khalil, Ibrahim & Bouras, Abdelaziz. (2022)** suggests that the proposed hierarchical blockchain system, called Blockchain-of-Blockchains (BoBs), successfully maintains the integrity of IoT data and encourages interoperability in smart city networks. By using Hyperledger Fabric and Ethermint for this model, the findings show that BoBs effectively tackle issues linked to centralized cloud-based management, giving a decentralized option that enhances transparency and traceability of data. This study is highly relevant for managing risks in smart cities powered by blockchain, AI, and IoT, offering a solid solution for data maintenance and interoperability challenges, ensuring secure data management across smart city entities.

The work by **Hidayati, D. N. U. R. U. L. (2020)** finds that the proposed Blockchain and Fog-based Architecture Network (BFAN) greatly improves the performance of smart city applications by cutting energy use and latency while enhancing security through blockchain. This architecture protects sensitive data through encryption and authentication, making it crucial for smart city risk management utilizing blockchain, AI, and IoT. Simulation results show that BFAN is more energy-efficient, scalable, and secure than existing options.

The research by **Das, D., Banerjee, S., Chatterjee, P., Ghosh, U., & Biswas, U.,** concludes that blockchain can significantly improve the security, privacy, and interoperability of Intelligent Transportation Systems (ITS) in smart cities. It underscores blockchain's ability to enable secure data sharing, smart contracts for autonomous vehicles, and decentralized marketplaces for transportation. While there are challenges like scalability and the need for high processing power, blockchain can create new business models and drive innovation in transport services. The results are relevant to smart city risk management using blockchain, AI, and IoT, as addressing security and privacy needs can alleviate risks related to data handling in smart cities, reinforcing a complete risk management strategy.

The work by **Ivanišević, Stojan & Ciric, Zoran. (2019)** identifies key factors for the successful launch of blockchain initiatives in smart cities. It points out that blockchain, while innovative, should be seen as a crucial aspect of current data frameworks rather than an entirely new paradigm. It stresses the need for improvements in blockchain design to enhance scalability, decrease latency, and boost capacity for smaller devices. This information is useful for smart city risk management powered by blockchain, AI, and IoT, as it sheds light on the technical aspects at play. limitations and needed improvements for making blockchain work better. The research highlights that a strong community and a network that adds value are important for blockchain projects to succeed.

The research by **Ivanišević, S., Ivić, A., & Ćirić, Z.** says that we can better use blockchain in smart cities by looking at certain performance measures. The paper found five main performance measures for blockchain success in smart cities:

• Satisfaction of end-users

• Growth of the user base over time

• Budget management

• Time management

• Completion of the project on schedule

These measures are key for understanding how well blockchain projects are working in smart cities.

In terms of smart city risk management using blockchain, AI, and IoT, the research points out that blockchain can boost security, transparency, and reliability in smart city information systems. This can reduce risks related to data integrity, privacy, and system uptime.

The research by **Bai, Y., Hu, Q., Seo, S.-H., Kang, K., & Lee, J. J.** suggests a new blockchain system for public input in maintaining infrastructure in smart cities. This system gets citizens involved in decision-making and allows them to see all administrative actions in real-time. By using a mixed blockchain setup, a group of citizens chosen at random is used to verify transactions. Additionally, a private-verification method is put in place to deal with collusion by public verifiers. This aims to improve transparency and trust in maintaining urban infrastructure, tackling the challenges of public participation in smart city governance.

The research also details an incentive system based on game theory to boost public involvement. Simulations show that this blockchain system outperforms other versions, showing its potential to change how smart cities are managed. This study is crucial for managing risks in smart cities using blockchain, AI, and IoT, as it offers a full solution to enhance citizen participation and enhance the efficiency, resilience, and sustainability of urban services. With advanced technologies, this system aims to consistently improve citizens' lives and contribute to smart city growth.

The research by **Ciric, Zoran & Sedlak, Otilija & Ivanišević, Stojan. (2020)** titled "Implementation of Blockchain Technology in the Smart City" looks into how blockchain can boost the security and sustainability of smart city information systems (IS). It identifies weaknesses like privacy, security, and availability in current smart city IS, comparing them to the advantages of blockchain technology. The study concludes that blockchain's distributed nature can improve security and transparency greatly, while its ability to connect can boost network availability. However, it also points out that more research is needed to create a framework for blockchain use in smart cities, including identifying key success factors and performance measures.

In short, this study is very important for managing risks in smart cities using blockchain, AI, and IoT. It offers useful insights into how blockchain can lower risks and enhance the sustainability and security of smart city systems. Using blockchain can greatly improve the efficiency and security of various subsystems like e-government, payments, and data storage, making it a solid answer to the problems modern smart cities face.

The research by **Cheikhrouhou, Omar & Ichrak, Amdouni & Mershad, Khaleel & Ammi, Meryem & Nguyen gia, Tuan. (2022)** state that blockchain tech could really help with the cybersecurity of smart city. The study looks at existing blockchain solutions and shows how blockchain can help with security in smart health, smart transport, smart farming, supply chains, smart grids, smart homes etc. The authors talk about the good and bad sides of these solutions, set out security needs for each smart city application, and link these solutions to those needs. They also suggest where research could go in the future, making it useful for researchers in cybersecurity, blockchain, and smart cities.

When thinking about smart city risk management with blockchain, AI, and IoT, this study is quite relevant. It details how blockchain can work with other technologies to boost security and make smart city systems more resilient. By focusing on specific security needs, the study shows how blockchain can reduce risks and enhance the overall security of smart cities. This makes it an important resource for anyone working on smart city technologies.

The study by **Publication, F. O. R. E. X. (2022)** claims that while smart cities bring many benefits through tech like IoT, cloud computing, and big data, they also struggle with data protection and privacy due to lots of data sharing. The research shows how blockchain could tackle these issues by offering a secure and decentralized system for data integrity and trust. Blockchain can improve the security and privacy of smart city solutions through transparent transactions, automatic decisions, and preventing unauthorized access.

This finding is quite relevant to managing risks in smart cities using blockchain, AI, and IoT, as it emphasizes the need for blockchain to lessen security and privacy risks in these environments.

The study by **Ahmed, S., Shah, M. A., & Wakil, K. (2020)** finds that blockchain tech could greatly aid in developing Smart Cities by overcoming challenges like security, immutability, interoperability, decentralization, privacy, and trust. It points out barriers in the Smart City sector and looks at how blockchain can help overcome them. The study also emphasizes the advantages of blockchain, such as offering a secure and transparent space for smart city applications.

Yes, the results are important for smart city risk management with blockchain, AI, and IoT. The study shows that blockchain can enhance security, privacy, and data integrity, enabling secure communication, secure transactions etc. without needing middlemen. This makes blockchain a critical tool for handling risks in smart city projects.

The research by **Xiao, Xiao-Yong & Jin, Lin & Kateb, Faris & Aldeeb, Hooreya. (2021)** titled "Modernisation of urban governance: An approach of 'Blockchain + Big Data'" looks at mixing blockchain with big data to better urban governance. The authors say that blockchain's features—like autonomy, decentralization, resistance to tampering, openness, and anonymity—can really improve the quality and collection of urban big data. By ensuring data authenticity and trustworthiness, blockchain can fix issues around data credibility, interpretative power, information integrity, access, and user privacy. The study concludes that creating a big data management system on blockchain can boost urban governance. of intelligent cities and advance urban management capabilities.

This study is relevant for managing risks in smart cities using blockchain, AI, and IoT. Combining these technologies can improve urban management by offering secure, decentralized systems that ensure data accuracy and trust. Blockchain boosts the privacy and safety of urban data, while AI and IoT provide enhanced data analysis and forecasting abilities. Together, they can develop strong and sustainable smart city systems, tackling the challenges of today's urban settings and enhancing overall urban governance.

The research by **Ivanisevic, S. (2019)** finds that blockchain technology has great potential to improve the safety, dependability, and accessibility of smart city systems. By solving major issues and weaknesses in traditional structures, blockchain can deliver a strong solution for overseeing smart city infrastructure. The research stresses the need to combine blockchain with other technologies like AI and IoT to shape a more secure and effective urban space. This combination can help lessen risks linked to data security, privacy, and system dependability, making it a useful tool for managing smart city risks.

The study also points out the necessity for more research to create a complete plan for using blockchain-based information systems in smart cities. The benefits are evident, but the authors note that actual applications are limited, especially in government-related areas of smart cities. There is a call for continued investigation of blockchain’s uses in different smart city sectors, such as smart economy, smart governance, and smart mobility, to fully tap into its potential for enhancing urban sustainability and resilience.

The study by **Singh, Charu. (2023)** titled "Ecosystem of Smart City Using Blockchain Technology" looks into how blockchain technology can be included in developing smart city ecosystems. It shows how blockchain can improve safety, transparency, and efficiency in diverse smart city tasks like smart banking, tracking pollution, smart energy systems, smart parking, and self-driving cars. The study emphasizes that blockchain can create a secure and unchanging record of data and transactions, building trust and accountability among stakeholders. It also considers how blockchain addresses security issues and allows the merging of different technologies in smart cities.

The results of this research are very significant for managing risks in smart cities through blockchain, AI, and IoT. Merging these technologies can help reduce risks related to data security, privacy, and working together. By using blockchain's decentralized and clear nature, smart cities can ensure safe data sharing and management, lowering the chances of cyberattacks and data leaks. Furthermore, combining AI and IoT with blockchain can enhance real-time monitoring and decision-making; further improves the resilience and sustainability of smart city systems. Ultimately, the study offers important insights on how blockchain, AI, and IoT can work together to build secure and efficient smart city ecosystems.

The research by **Wong, P. F., Chia, F. C., Kiu, M. S., & Lou, E. C. W. (2020) concludes** that adding blockchain technology to smart city frameworks can greatly improve the management and sustainability of urban areas. The findings highlight five main areas where blockchain can be effectively used: smart governance, smart mobility, smart asset management, smart utility, and smart logistics. By utilizing the decentralized and secure nature of blockchain, these areas can experience better transparency, efficiency, and safety. For example, blockchain's capabilities can enhance... secure governance can be done by using blockchain, improving transportation with better ticketing and ride-sharing, and optimizing utilities by tracking energy and water use. The research shows blockchain, mixed with IoT and AI, can solve security issues from many connected devices in smart cities. Old cybersecurity methods do not work well for the big networks in these cities. Blockchain offers a strong security method through its permanent and decentralized records, protecting data and stopping unauthorized access. This mix not only helps with security but also aids in sustainable development by improving resource use and lowering environmental damage.

The research by **Alnahari and Ariaratnam (2022)** determines that Blockchain tech can improve smart city infrastructure by providing transparency, safety, and efficiency in areas like energy, transport, water, construction, and government. Using Blockchain makes processes easier, cuts costs, and reduces data issues, making it a useful tool for urban challenges needing less human input. However, the research also warns about setbacks related to regulations because of a lack of knowledge in governing organizations, which can result in confusion and uncertainty in solving problems.

Regarding smart city risk management involving Blockchain, AI, and IoT, the study is quite relevant. Blockchain's decentralized and secure ledgers are vital for keeping data safe and intact, crucial for managing risks in smart cities. Combining Blockchain with AI and IoT can set up a strong system for real-time data analysis, automated decision-making, and fast responses to city issues. This connectivity can improve the resilience and sustainability of smart cities, enabling better risk management related to infrastructure, cybersecurity, and resources.

The study by **Wycislak (2021)** titled "Blockchain Opportunities in Supply Chain" investigates how blockchain can transform supply chain management. It demonstrates how blockchain can improve visibility, trust, and efficiency in supply chains by supplying live updates and unchangeable transaction records. Wycislak discusses a blockchain-based platform that solves issues like limited visibility and unreliable data in transport networks. Using blockchain, this platform enables complete transaction visibility, automates handling exceptions, and boosts the performance and transparency of transport services.

Although primarily centered on supply chains, the findings are significant for smart city risk management powered by blockchain, AI, and IoT. The benefits of better visibility, trust, and automation from blockchain can also apply to smart city systems, tackling problems like data security, privacy, and effective resource management. Integrating AI and IoT with blockchain can improve urban management even further, allowing for timely decision-making and increasing the resilience and sustainability of smart cities. Hence, the study's recommendations on blockchain's potential can guide ways to handle risks and enhance the efficiency of urban systems.

The research by **Shannon, Fermat, and Sundan (2024)** titled "AI-Driven Predictive Analytics in Smart Cities: Enhancing Infrastructure Resilience Through Big Data and IoT" looks into how AI predictive analytics can work with big data and IoT to strengthen infrastructure in smart cities. The authors present a framework that utilizes real-time data from This research looks at different IoT sensors and applies machine learning to foresee infrastructure issues and improve maintenance plans. The success of this method is shown through examples in transport, utilities, and emergency services, showcasing its ability to encourage timely decisions and better resource use in cities.

This study is relevant to smart city risk management that uses blockchain, AI, and IoT. By combining predictive analytics with IoT information, the system enhances the capability to spot and reduce risks linked to city infrastructure. Machine learning makes sure the system adjusts to fresh data and changing situations. Meanwhile, blockchain offers a secure way to manage and share data among many users. The mix of these technologies can greatly boost the durability and effectiveness of smart city infrastructures, helping them face the difficulties of modern urban life.

The research by **Oladejo, Abayomi & Fatunmbi, Iyanuoluwa (2024)** finds that bringing together blockchain, AI, and IoT is key for increasing the effectiveness, safety, and sustainability of smart cities. Using machine learning for data analysis allows cities to greatly improve their IoT systems' intelligence. Blockchain creates a secure, decentralized setup for ensuring data trustworthiness, addressing the challenges of today's cities. This combined approach enhances urban management, strengthens security and privacy, and supports smart city infrastructure that is independent, strong, and sustainable.

The results indicate that merging these technologies in smart cities is vital for tackling issues like scalability, privacy, and ethics. The study highlights potential uses and future research paths that are important for progressing smart city projects. By grasping these factors, cities can boost effectiveness, urban sustainability, and resilience, thereby enhancing residents' quality of life. This thorough approach to smart city risk management is highly pertinent and offers a valuable guideline for scholars and practitioners in this area.

The study by **Cong, Yuxin & Inazumi, Shinya (2024)** concludes that the use of advanced technologies such as smart sensing, kriging for predictions, and ensemble learning greatly increases the accuracy of geotechnical investigations and city planning. Analyzing data from Setagaya, Tokyo, they created predictive models to determine the depth of foundational layers vital for city infrastructure. The findings underline the advantages of ensemble learning in predicting these depths, offering a more dependable base for urban development. This technique not only boosts the precision of geotechnical assessments but also helps build urban infrastructures that are resilient to natural disasters like earthquakes.

While this study focuses mainly on predictive analytics and geotechnical investigations, its outcomes are strongly connected to smart city risk management. Using real-time geographic data and hazard alerts through mobile devices aligns with smart city technology principles, including blockchain, AI, and IoT. These technologies can further enhance the predictive models by ensuring data authenticity, enabling decentralized data processing, and offering real-time information. Therefore, the methods and findings of this research can be successfully applied to smart city risk management, making urban areas safer and more prepared for environmental challenges.

The **2024 study on Big Data and Advanced Analytics for Smart Mobility** finds that integrating these technologies... Big data and advanced analytics can improve efficiency, sustainability, and user experience in transportation systems related to smart mobility solutions. These technologies can change how we handle traffic management, plan for multiple transportation modes, offer personalized mobility services, and analyze sustainable transportation practices.

The study indicates that for smart city risk management, which includes blockchain, AI, and IoT, these findings are important. Advanced analytics methods like machine learning, deep learning, spatial and temporal analysis, and optimization can help predict and address potential risks. Furthermore, the focus on data integration, interoperability, and ethical considerations aligns with blockchain's principles for safe and transparent data management. Collaboration across disciplines and engaging stakeholders as mentioned in the study are also essential for effectively implementing smart city initiatives that use AI and IoT.

In **Allam's study (2019),** it is pointed out that while AI and Big Data have great potential for urban growth, it is vital to balance tech progress with sustainability and livability. The framework proposed stresses including cultural, metabolic, and governance aspects to succeed in smart city development in line with Sustainable Development Goal 11 and the New Urban Agenda. In terms of smart city risk management with blockchain, AI, and IoT, the study underscores the importance of a comprehensive strategy that weighs these technologies against sustainability and livability. This strategy could make smart cities more resilient and adaptable, improving their ability to manage risks and enhance urban living conditions.

Qiu et al. (2018) discusses integrating physical and social sensing to boost smart city mobility services. The study shows how big data can be used to gather, process, and analyze real-time information from platforms like Citi Bike and Twitter. Their prototype illustrates the advantages of merging physical and social sensing for better city mobility management. It emphasizes the need for a combined approach to build a digital ecosystem that enhances urban services and sustainability.

Although the primary focus is on smart city mobility, the findings are also relevant for risk management using blockchain, AI, and IoT. Utilizing big data technologies and real-time data processing can strengthen smart city operations and management. By employing these technologies, cities can better track and respond to different risks, improve service delivery, and ensure a more sustainable and resilient urban environment.

Nica et al. (2023) conclude that digital twin simulation tools, spatial cognition algorithms, and multi-sensor fusion are vital in sustainable urban governance. Their findings show that virtual navigation, geospatial mapping, and IoT-connected sensors enable effective smart urban governance. These technologies, together with digital twin simulation and data visualization, enhance sustainable urban governance by improving urban data fusion and decision-making.

As for its relevance in smart city risk management using blockchain, AI, and IoT, the study suggests that these technologies are essential. to making highly connected online spaces in digital twin cities. Systems that use blockchain for digital twins, smart infrastructure sensors, and live IoT data help urban computing technologies, which support smarter, sustainable city strategies. By blending these technologies, we can check and sense city environments, which is key for handling risks and keeping smart cities strong.

The research by **Elngar, A. (2019)** shows that applying Machine Learning (ML) with Blockchain Technology (BT) can boost the security and resilience of smart apps from various threats. Using standard ML methods like Support Vector Machines (SVM), clustering, and bagging, along with Deep Learning (DL) techniques like Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM), the research reveals how these technologies can spot and reduce risks in blockchain networks. The merger of ML and BT gives accurate outcomes, making smart apps tougher and safer.

In smart city risk management, the results from this study are very relevant. It looks at how ML and BT can be used in many smart tools, such as Unmanned Aerial Vehicles (UAVs), Smart Grids (SG), healthcare, and urban environments. By improving data safety and privacy through decentralized databases and consensus methods, and tackling new security challenges like majority attacks and double-spending, these technologies can greatly increase the trustworthiness and precision of smart city systems. Thus, the study is a useful guide for building stronger and safer smart city structures powered by blockchain, AI, and IoT.

The study by **Tripathi, G., Ahad, M. A., & Paiva, S. (2020)** concludes that merging IoT, Mobile Edge Computing (MEC), and blockchain can largely upgrade healthcare in smart cities. By using these technologies, the suggested Smart Medical System (SMS) model provides real-time monitoring, safe data handling, and smooth healthcare delivery. MEC allows key processing to happen close to the source, lowering delays and enhancing response times. Blockchain helps protect patient information, ensuring its integrity and making it unchangeable. This mix of technologies builds a strong and safe healthcare system that can manage the huge data volumes from IoT devices and sensors well.

Regarding its significance for smart city risk management, the results of the study are very important. The SMS model takes on major issues like data privacy, security, and real-time processing, which are vital for handling risks in a smart city. By securing healthcare data capture, storage, and processing, the model reduces risks linked to data leaks and unauthorized access. Also, using blockchain gives a clear and fixed record of actions, further boosting the system's safety and reliability. In summary, this study provides a thorough way to combine advanced technologies for better risk management in smart cities.

The research by **Asgari, M., & Nemati, M.** indicates that blockchain, when combined with IoT and AI, has great promise for improving water management systems in smart cities. It points out three main application areas: Smart Water Systems, Water Quality Monitoring, and Storm Water Management. The study stresses that blockchain can enhance data safety, clarity, and faith in water management methods. However, it also notes various challenges, including technical, organizational, social, and institutional issues that must be resolved for effective use. These challenges encompass the necessity for long-term commitment and updated systems. organizational rules and knowledge.

In smart city risk management, the study is important. Using blockchain, AI, and IoT, smart cities can manage water more effectively and securely, which is essential for durability and strength. These technologies can support on-the-spot watching, forecast upkeep, and better decision-making, thus reducing dangers related to water shortage, quality, and stormwater issues. This overall method can improve the operation and reliability of smart city systems.

The study by **Yigitcanlar, T., Desouza, K., Butler, L., & Roozkhosh, F. (2020)** states that AI in smart cities is a new research area. The main emphasis of the literature is on AI tools, methods, and their current and future uses. AI in smart cities mainly focuses on business improvement, data study, education, energy, environmental care, health, land use, security, transport, urban management, etc. Yet, there is little academic study on the dangers of using AI widely, and potential changes AI may bring to cities and societies are not well studied.

Regarding smart city risk management with blockchain, AI, and IoT, the study points out AI's possible advantages for creating smarter cities, yet it does not specifically talk about using blockchain and IoT for risk management. Thus, while the study offers good information on AI uses in smart cities, it does not fully address the dangers or the role of blockchain and IoT here.

The study by **Yitmen, Ibrahim, titled "Integration of Blockchain and Digital Twins in the Smart Built Environment Adopting Disruptive Technologies—A Systematic Review" (Sustainability, 2023),** states that combining blockchain and digital twins (DT) with supportive technologies like AI, ML, IoT, cloud and edge computing, and Big Data analysis can significantly improve building lifecycle data management. The review of 86 studies shows that research in this area is still developing and highlights the need for practical methods to find and validate the true capabilities of these technologies. This tech integration can resolve individual challenges, making a more cohesive and efficient system for enhancing the built environment.

Concerning smart city risk management, the findings of this study are very important. Using blockchain, AI, and IoT can boost data security, transparency, and efficiency in smart cities. By utilizing these technologies, smart cities can better manage risks tied to data leaks, system issues, and other weaknesses. The study's descriptive model gives a way to understand how these technologies can come together, providing useful insights for building strong and secure smart city systems.

The study by **Yarime, M. (2019)** indicates that incorporating smart technologies into the woody biomass supply chain can effectively tackle both technical and social problems in Japan. These issues involve transportation systems, biomass quality control, business model adjustments, managing stakeholder relationships, and boosting local communities. The study mentions that better transparency, sharing information, accountability, automation, maximizing value, etc. are key to overcoming these hurdles. By using smart technologies, the woody biomass supply chain can become more efficient, clear, and sustainable, ultimately aiding in cutting emissions, enhancing economic growth, and ensuring energy security. This study's findings also relate to smart city risk management supported by blockchain, AI, and IoT. The integration of smart technologies in woody biomass supply chain shows how these tools can improve transparency, efficiency, and accountability, all key for managing risks in smart cities. Blockchain can secure and clarify transactions, AI enhances supply chain tasks, and IoT delivers real-time data for improved decisions. By implementing these technologies in woody biomass supply chains, the study gives useful insights on how smart city projects can solve similar issues and reach sustainability goals.

The study by **Chanda, M. (2022)** finds that using new technologies like IoT, machine learning, and blockchain can greatly boost the effectiveness and strength of smart cities. It stresses the need for these technologies to better city management, resident services, and overall security and privacy. The work also notes the promise of cloud and fog IoT systems in managing IoT devices and setups. Regarding smart city risk management, it suggests that blockchain applications can create more reliable and robust systems, effectively handling security and privacy issues. Thus, these findings are quite relevant for managing risks in smart cities using blockchain, AI, and IoT.

The study by **Park, J.-ho, Salim, M. M., Jo, J. H., Sicato, J. C. S., Rathore, S., & Park, J. H. (2019)** presents a Cognitive Internet of Things (CIoT)-based smart city network (CIoT-Net) design to tackle scalability and flexibility issues in dealing with vast amounts of data from smart city applications. By utilizing AI and big data analysis, the design seeks to guarantee quick responses and effective data management. While it shows the potential of cognitive computing for smart city operations, it also notes research challenges and opportunities for the proposed setup. Although the study does not directly discuss smart city risk management using blockchain, AI, and IoT, the discussed principles and technologies could be relevant and integrated to enhance data management and quick decision-making in these urban areas.

The study by **Ch, M. H. (2020)** finds that urban water distribution systems have great potential for recovering energy, which can support smart cities' zero-net energy goals. By combining technologies like micro-turbines and pumps as turbines, along with pressure reduction valves, hydraulic energy in water systems can be converted into electricity. This strategy not only aids in energy creation but also improves leakage management and overall network resilience. The paper emphasizes that digital water technologies, such as cyber-physical systems, digital twins, and blockchain, etc. are crucial for the future of Water Distribution Systems (WDS).

In terms of smart city risk management, these findings are very relevant. Incorporating advanced technologies like blockchain, AI, and IoT in digital water systems can create a solid framework for monitoring and enhancing water distribution networks. This complete, data-focused method can boost urban infrastructure's resilience and efficiency, reduce risks tied to water distribution, and advance sustainable development in smart cities. By using these technologies, cities can manage resources better, lower energy use, and strengthen overall urban resilience.

The study by **Charles, Vincent & Emrouznejad, Ali & Gherman, Tatiana. (2023)** you pointed out emphasizes the important advantages of combining blockchain and AI in supply chains, such as improving information and process resilience and allowing for quicker, more cost-effective operations. Delivery of goods and making product tracking better. The study shows that this joining can create safer, faster, and more productive businesses, especially in tricky and unclear situations. About its importance for smart city risk management using blockchain, AI, and IoT, the findings and advantages mentioned in the research can be used. The better information strength, more efficiency, and improved tracking can help create stronger and quicker risk management in smart cities. Using these technologies, smart cities can handle problems related to buildings, public safety, and managing resources, making the urban setting stronger and more efficient.

2.1.3 Gaps in Existing Research

The study by **Morozova, Irina & Yatsechko, Stanislav (2022)** offers useful insights about smart city risks and corporate duty, yet some gaps persist:

- Tech Use: The research does not analyze much how advanced tech, like artificial intelligence (AI), Internet of Things (IoT), and blockchain can be used in smart city management to improve city efficiency and strength.

- Citizen Involvement: There is not much talk about how public participation and views affect the growth and success of smart cities. Learning to boost community involvement could provide practical ideas for city planners.

- Comparative Studies: There is no analysis comparing smart city models around the world. Doing this could help find global best practices and shared issues, aiding policymakers and industry members.

- Economic Effects: The paper does not look closely at the economic effects of smart city projects, like their influence on local businesses, job creation, and economic growth in regions.

- Climate Change Response: The study does not adequately explore ways smart cities can address climate change, mainly through sustainable infrastructure and green tech initiatives.

- Governance Policies: There is not enough analysis of how different government policies and laws impact smart city development. Future studies could evaluate how governance styles affect the successful implementation of smart city plans.

- Long-Term Studies: The research lacks long-term studies on the effects of smart cities on social, economic, and environmental aspects.

The study by **Dziatkovskii (2022)** does not sufficiently explore risks or limits of tech in smart city systems. While it points out the pros of AI and blockchain, the following issues are noted:

- Waste Cutting: The main focus is on managing and recycling waste instead of cutting waste production at its starting point.

- Old Systems Integration: There is little discussion on how to include or phase out older systems like traditional incineration plants for AI and blockchain solutions.

- Central Authority vs. Blockchain: The article does not investigate deeply the need for blockchain in areas where reliable central authorities exist, like air quality control, indicating blockchain may not be necessary in all cases.

- Tech Over-focus: The study fixates on AI and blockchain without looking into other possible tech or non-tech solutions that might better tackle urban issues.

Even with thorough coverage in the study by **Al Sharif and Professor (2021),** some gaps still appear in the literature:

- Social Issues: While tech and non-tech risks are noted, the paper does not explore social risks linked to smart city tech, like public involvement, community trust, and possible inequalities.

- Complete Risk Study: The paper talks about single risk dimensions but lacks a full risk assessment framework that merges both tech and non-tech risks.

- New Tech: The study emphasizes established tech like IoT, AI, and blockchain but does not consider the potential impacts of newer tech, like quantum computing, on smart city frameworks.

- Real-World Cases: There is a lack of real-world case studies showing the implementation and struggles faced by smart cities in various areas, which could offer more useful insights for future planning.

Several gaps are found in the study by **Nguyen and Hallo (2022):**

- Social Risks: While tech and organizational risks are well-studied, social risks like public participation, inequality, and social inclusion are not thoroughly examined. smart city governance as these technologies are currently underutilized.

- Framework Development: The existing frameworks for smart city governance need improvement. Current models require updates to handle new challenges in urban management.

- Data Protection: Issues regarding data protection are not adequately addressed. The necessity for frameworks that prioritize user privacy and security in smart city systems is evident.

- Stakeholder Engagement: There is a lack of engagement among various stakeholders in the governance process, which affects the decision-making necessary for effective smart city management.

In the work by **Ahmed et al. (2022),** several gaps are noted:

- Tech Growth: While the joining of AI and blockchain appears beneficial, there is a need for better understanding and integration with other tech systems such as cloud and edge computing.

- Energy Use: The high energy needs for AI and blockchain in IoT systems challenge sustainability goals. More focus on energy-efficient computing is essential to lessen carbon emissions from smart city initiatives.

- Security Concerns: Despite blockchain's advantages for security, there are ongoing challenges tied to data privacy and user authentication in IoT contexts. Clear-cut solutions for these issues are still required.

- Regulatory Needs: The absence of uniform regulations complicates the implementation of smart city technologies. Future studies should focus on creating governance strategies that adhere to legal and ethical standards.

Ariyachandra and Wedawatta (2023) pinpoint several obstacles in employing Digital Twin Smart Cities (DTSC):

1. Complexity: The addition of DTSCs raises complexity in managing disaster risks, which complicates execution.

2. Interoperability: Disaster management systems struggle with interoperability and resource sharing, disrupting effective response during emergencies.

3. Funding Issues: Ongoing financial support for training and maintaining systems is key for DTSC project longevity but acquiring reliable funding is challenging.

4. Social Data: There is a need for improved techniques to assess human behaviors during disasters to better inform crisis decision-making.

Nguyen, Han-Khanh (2022) points out several limitations for future research:

1. Small Sample: The research sample was limited relative to the broad customer demographic of supermarkets, risking the findings' representativeness.

2. Seasonality: The investigation ignored seasonal changes in supermarket operations, like fluctuations during holiday periods.

3. Lack of Comparisons: No analysis was made between various supermarket chains, which could have better illustrated service quality and customer satisfaction trends within the industry.

Ullah et al. (2021) highlight various deficiencies in research concerning the risks of smart city governance, notably:

- Integration Issues: There is a need for further studies on how technologies like AI, IoT, and blockchain can be effectively merged into smart city governance. Smart city systems focus on working together and good data sharing.

- Security and Privacy: There is not enough research on advanced security methods to keep connected systems safe from cyber attacks and protect user data.

- Regulatory Frameworks: The study shows a need for better rules to control risks that come with using new technologies in smart cities.

- User Trust and Acceptance: There is a lack of research on how to gain trust and ensure that users accept new technologies, emphasizing the importance of clear information and ethical practices.

Even with progress, the study by **Ghosh et al. (2023)** reveals some important gaps, such as:

- Security and Privacy: Current systems do not have enough safeguards to protect data security and privacy when using AI, IoT, and blockchain together.

- Scalability Issues: Many solutions find it hard to grow efficiently to deal with the large amounts of data from IoT devices.

- Interoperability Challenges: The absence of smooth interoperability between different technologies makes integration and operation difficult.

- Energy Consumption: High energy use is still a big problem, especially for blockchain and AI technologies.

The work of **Mumtaz, Hina & Ali, Mushtaq. (2024)** points out key gaps in combining AI, IoT, and blockchain technologies:

- Security and Privacy: Current frameworks often do not have strong protections for data integrity and privacy with these combined technologies.

- Scalability: Many systems have difficulty scaling properly due to the large amounts of data from IoT devices.

- Interoperability Issues: Smooth integration across various technologies and platforms is a major hurdle.

- Energy Consumption: The high energy use, especially in blockchain and AI operations, is an ongoing challenge for sustainability.

Chauhan, Megha & Sahoo, Deepali. (2024) highlight several issues blocking full integration of these technologies:

- High Implementation Costs: The costs to start and maintain AI, IoT, and blockchain systems are high, especially in areas with limited funds.

- Technical Complexities: Merging AI, IoT, and blockchain with current systems raises significant technical issues, particularly concerning compatibility and standards.

- Data Privacy and Security: Protecting data privacy and safeguarding against cyber threats are crucial due to the large amounts of data involved.

In the study of **Irfan et al. (2024),** challenges for integrating these technologies in global supply chains include:

- Interoperability Issues: Achieving smooth communication and data sharing between blockchain, IoT, and AI is a major challenge.

- Scalability Concerns: Managing the vast amounts of data from IoT devices and processing it through AI and blockchain in global supply chains is a significant problem.

- Data Privacy and Security: Ensuring sensitive supply chain data is safe from cyber threats and unauthorized access requires strong security measures.

- Regulatory Compliance: Dealing with complex legal and regulatory systems in different areas creates major barriers to implementation.

Sandner, Philipp & Groß, Jonas & Richter, Robert. (2020) pinpoint several crucial gaps in understanding and utilizing these technologies:

- Integration Challenges: Many current studies look at blockchain, IoT, and AI separately. More research is needed to see how to integrate them smoothly and enhance their benefits across industries.

- Scalability and Efficiency: The limits of blockchain scalability and the performance of AI algorithms in IoT settings need further exploration. to be focused on promoting broader adoption and practical application in real-time scenarios.

- Data Privacy and Security: Strong data privacy and security measures are still a concern, especially in IoT networks where sensitive data is collected and shared frequently.

- Regulatory and Standardization Issues: There is a requirement for standardized protocols and regulatory guidelines to facilitate the merging of these technologies, ensuring they work together and comply across different fields and locations.

Several issues exist in applying the suggested AI-driven algorithm in the study by **Rajawat, Anand & Goyal, S & Kumar, Manoj & Singh, Thipendra P. (2024):**

- Computational Costs: Training LSTM models in relation to large-scale blockchain transaction data can be costly in computing resources. Future research might look into more efficient models or methods like hardware acceleration to cut costs.

- Model Interpretability: AI models, particularly neural networks such as LSTM and SOM, face criticism for their "black box" nature. Increasing the clarity and interpretability of these models could reveal why particular transactions are identified as security threats.

- Adaptability: While the model can respond to new attack methods, regular retraining may be necessary. Creating more adaptable models that need less frequent retraining could enhance flexibility.

- Scalability: As blockchain networks grow, effectively managing and analyzing increasing data volumes becomes vital. Future research could aim to advance the scalability of the proposed algorithm to work with larger datasets.

The study by **Dutta, P., Choi, T.-M., Somani, S., & Butala, R. (2020)** regarding blockchain tech in supply chain operations uncovers several gaps, especially in relation to the smart urban movement:

- Integration with Smart City Infrastructure: Research on the smooth integration of blockchain with existing smart city systems to improve urban services is limited.

- Scalability and Interoperability: Many studies ignore the issues surrounding the scaling of blockchain solutions and ensuring compatibility with technologies utilized in smart cities.

- Data Privacy and Security: Despite blockchain's reputation for security, more investigation is needed to see how it can solve particular privacy issues in urban smart settings.

- Regulatory and Governance Challenges: The legal framework for blockchain in smart cities is still lacking. Research is needed to explore how regulations can be structured to promote blockchain while aligning with local and global laws.

- Economic and Social Effects: There is insufficient understanding of the wider economic and societal consequences of using blockchain in smart cities, including impacts on jobs, city planning, and community involvement.

- User Acceptance and Knowledge: More research is necessary to grasp the elements affecting user acceptance of blockchain technologies in urban environments, along with developing methods to boost awareness and acceptance.

The study gap in the research by **Homaei, H., Homaei, M., & Caro, A. (2024)** in the context of Smart City Risk Management largely concerns these areas:

- Comprehensive Understanding of Risks: Numerous individual studies on smart city risks exist, but a complete understanding of these risks is not yet available. A systematic review is essential to identify the sources, trends, and categories of risks in smart city studies.

- Focus on Social Risks: There has been inadequate attention given to social risks in smart city research. While studies from countries with established smart cities typically highlight social risks, overall, this area is still underexplored.

- Integration of Risk and Change Management: There is a pressing need for frameworks that connect risk management with change management processes. management practices to manage and lessen social risks in smart city development projects.

- Privacy and Security Concerns: A full look into privacy, security, and risk concerns in smart cities is still required. This involves grasping the complexities and tackling the important issues associated with these elements.

The paper **Publication, S. (2020). Blockchain Technology: A Driving Force in Smart Cities Development** highlights several gaps regarding Smart Cities:

- Integration Difficulties: Smart Cities depend on multiple technologies that must merge effortlessly. The absence of standards may cause compatibility problems and separate systems that cannot effectively communicate.

- Security Issues: It is essential to secure online transactions and data. Any flaw can cause major disruptions and possible fraud, disrupting the trust and reliability of Smart City services.

- Scalability Problems: As Smart Cities expand, the IT systems must expand as well. This involves managing more data, additional users, and extra services without losing performance or security.

- Data Management: Handling and securing large amounts of data created by Smart Cities is a big challenge. Ensuring data integrity, availability, and privacy while blocking unauthorized access is crucial.

- Technological Adjustment: Current IT systems may not be entirely compatible with new technologies like Blockchain. Upgrading systems to support these technologies can be expensive and slow.

- Regulatory and Compliance Challenges: Introducing new technologies in Smart Cities must follow different laws and standards. Dealing with these regulatory items can be complicated and may delay the acceptance of new solutions.

- User Acceptance and Awareness: For Smart Cities to succeed, residents should understand and trust the technologies being used. Teaching citizens about the benefits and safety of technologies like Blockchain is vital for broad acceptance.

Fixing these gaps is key for the effective development and running of Smart Cities, making sure they are efficient, safe, and helpful for all inhabitants.

The study **Rotuna, Carmen & Gheorghita, Alexandru & Alin, Zamfiroiu & Smada, Dragoş. (2019)** notes several gaps in community risk research concerning Smart Cities:

- Lack of Complete Risk Analysis: Although many studies address the advantages and uses of blockchain in smart cities, there is not enough thorough analysis on the potential risks and challenges linked to its use. This includes security weaknesses, privacy issues, and possible data misuse.

- Compatibility Issues: The study points out the urgent need for more research on how blockchain systems can work together with current city infrastructure.

Achieving smooth integration and compatibility is vital for the successful launch of smart city technologies.

- Scalability and Efficiency: More investigation is needed into how scalable and efficient blockchain solutions are within smart cities. As urban areas grow and connected devices increase, blockchain systems must cope with the added demands without losing efficiency.

- Regulatory and Legal Problems: The study mentions the need for additional research about the laws and regulations concerning blockchain use in smart cities. This covers matters regarding data ownership, privacy laws, and the legal effects of smart contracts.

- Social and Ethical Concerns: There is a research gap concerning the social and ethical concerns of using blockchain in smart cities. This includes effects on citizen privacy, the risk of greater surveillance, and the ethical factors of automated decision-making systems.

- Economic Feasibility: The study indicates that additional research is required to determine the economic feasibility of using blockchain solutions in smart cities. This should include evaluations of costs and benefits, funding strategies, and the possibilities for partnerships between the public and private sectors.

These gaps point to a necessity for a multidisciplinary approach in smart city exploration, which involves working together across fields like technology, urban planning, policy-making, and social sciences to tackle the intricate problems and dangers linked to smart city advancement.

The study by **Treiblmaier, Horst & Rejeb, Abderahman & Strebinger, Andreas (2020)** discusses how blockchain can improve smart city growth. A brief summary is as follows:

- Smart City Definition: The study characterizes a smart city as one that utilizes information technology to address urban issues and enhance the quality of life for residents.

- Blockchain's Role: Blockchain is noted as a key technology driving smart cities, providing various technologies and protocols.

- Areas of Application: Nine main areas are mentioned where blockchain could be advantageous:

    - Healthcare
    - Logistics and supply chains
    - Mobility
    - Energy
    - Administrative services
    - E-voting

- Factories
- Homes
- Education

• Research Framework: A detailed review of literature is performed, along with a framework and research suggestions to direct future studies in these areas.

The paper points out the potential of blockchain technology to transform urban progress and offers a detailed structure for its use within smart cities.

The research by **Treiblmaier, Horst & Rejeb, Abderahman & Strebinger, Andreas (2020)** identifies several points needing attention:

- Complete Risk Assessment: Although many studies exist on specific risks of smart cities, a complete assessment that includes all risk types (organizational, social, and technological) is missing.

- Social Risks: There is a significant lack of research into social risks tied to smart cities. Most existing studies concentrate on technological and organizational issues, while social concerns like privacy and inequality are not well examined.

- Risk and Change Management Integration: There are few studies that look at how to merge risk management with change management strategies to develop a framework for controlling and reducing risks in smart city initiatives.

- Long-Term Studies: There is a demand for long-term studies that monitor how risks evolve as smart cities grow. This would offer better insights into risk changes and effective management.

Filling these gaps can aid in crafting more effective risk management strategies for smart cities, underpinning their sustainable and secure advancement.

The study by **Palaiokrassas, Georgios & Skoufis, Petros & Voutyras, Orfefs & Kawasaki, Takafumi & Gallissot, Mathieu & Azzabi, Radhouene & Tsuge, Akira & Litke, Antonios & Okoshi, Tadashi & Nakazawa, Jin & Varvarigou, Theodora (2021)** identifies several shortcomings regarding smart cities:

- Scalability and Storage Challenges: The study recognizes that storing vast amounts of data on blockchain can create scalability and performance problems. This is a major issue for smart cities that produce large data volumes from various sensors and devices.

- Interoperability: The study proposes a universal data collection and distribution system, but achieving smooth interoperability among different IoT systems and platforms remains difficult. Smart cities often incorporate many technologies and standards, complicating integration.

- Data Privacy and Security: While the study discusses data protection via blockchain and IPFS, full assurance of data privacy and security in a decentralized setup is still a pressing issue. The study emphasizes the need for additional research. Research on privacy-preserving tools and secure identity management is ongoing.

- Trust and Authentication: Gaining trust between different players in a smart city is very important. The study proposes blockchain-based identity management systems; however, problems like identity wallet leaks and changes in identity create risks that require attention.

- Economic and Social Incentives: The study suggests a marketplace for exchanging IoT data, but the economic and social reasons for joining this marketplace need more analysis. It is key to understand what drives people and organizations to share data and how to compensate them fairly to make the marketplace successful.

- Regulatory Compliance: Meeting rules like GDPR and APPI is essential for using blockchain solutions in smart cities. The study discusses efforts to comply with these laws, but ongoing research is crucial to adapt to changing regulations.

These gaps show a need for ongoing research and development to unlock the benefits of combining blockchain and IoT in smart cities.

Lee, J. (2018) discusses how blockchain can improve transparency and cut costs in manufacturing. However, there are gaps that need more study. Current research mainly centers on theories and case studies in finance and supply chains, leaving a lack of evidence in manufacturing. The effects of blockchain on small and medium-sized enterprises (SMEs) in manufacturing are also not well explored. Furthermore, long-term sustainability and scalability of blockchain solutions in manufacturing, especially regarding energy use and integration with current systems, need deeper examination. Filling these gaps will help understand blockchain's role in promoting sustainability in manufacturing.

The work of **Mikołajewski et al. (2024)** discusses advancements in Industry 4.0, IoT, and AI but identifies gaps in research that need addressing. One key issue is the integration of different IoT platforms. Many IoT solutions work independently, causing inefficiencies and data issues. Research needs to create standardized methods for smoother communication and data sharing among IoT systems. Additionally, stronger cybersecurity is necessary to protect IoT networks from complex attacks, including the development of predictive AI models for quick threat detection. The environmental effects of IoT devices and Industry 4.0 technologies also require focus, with research aiming for sustainable and energy-efficient solutions to reduce the carbon footprint. Addressing these issues is vital for the successful and sustainable rollout of Industry 4.0.

Lastly, Wycislak, S. (2021) examines visibility in complicated supply chains and identifies significant gaps. While real-time visibility platforms show potential, obstacles remain, particularly in organization, such as silos and reluctance to share information, along with a lack of incentive systems. Additionally, the unequal distribution of risks and rewards between freight forwarders and visibility platform owners creates tension that needs resolution. Addressing these issues calls for a thorough approach. looks at both tech and organization parts to boost supply chain view and performance.

The study by **Vishal Ranaware (2019)** talks about how blockchain tech can help in smart city growth, but it doesn't dig deep into real-world issues and limits of using blockchain in smart city projects. Specifically, the work misses points on scalability issues, how to connect with current systems, legal and regulatory problems, and the economic effects on different stakeholders. There is also a lack of actual data and case studies to back up the claimed advantages of blockchain in smart cities, which would improve future studies and real use.

The work by **Alasbali et al. (2022)** on smart city tech shows key progress in IoT and blockchain use, yet it uncovers a big problem with getting different systems to work together smoothly. Even though IoT and blockchain could change cities for the better, competition in tech leads to separate systems that block the full benefits of smart cities. This split makes it tough to gather and analyze data well, leading to issues in system safety, managing data resources, and scalability. While blockchain seems to solve issues of secure, clear, and decentralized dealings, its use in smart cities is still limited. To fix these problems, a common framework is needed to advance tech interoperability and use blockchain to build trust and efficiency in IoT-focused smart city setups.

The research by **Khanna et al. (2021)** about how blockchain helps e-governance in smart cities is detailed but misses some points. A big miss is the absence of real-world data and case studies that show how blockchain is actually being used in smart cities. The study talks about possible benefits and uses but needs more solid examples and trials to show how effective it is and what challenges might come up. Also, the study could look deeper into the social and economic effects of blockchain on different groups in smart cities and the barriers to getting it adopted, like legal issues, tech limits, and how the public feels about it. Filling these gaps would give a fuller view of blockchain's part in smart city development.

The study by **Publication, I. J. R. A. S. E. T. (2020)** shows blockchain's potential in solving security and privacy issues in IoT systems, but it also points out some gaps that need more attention. A major issue is that IoT devices have limited computing power, storage, and network bandwidth, making them easy targets for attacks and misuse. While blockchain can improve security with its unchangeable ledger and decentralized structure, combining blockchain with IoT still has hurdles like scalability, energy use, and the need for better consensus methods. The paper notes ongoing issues even after blockchain is put in place, showing that more research is necessary to fully grasp and tackle these hurdles in real applications.

The **proposed “PrivySharing” framework in the work of Makhdoom et al. (2019)** provides a solid solution for keeping IoT data private. However, there are still some issues to fix. A big issue is that the blockchain network needs to be more scalable. As the number of IoT devices and the data they generate grow, the blockchain might struggle to manage the high data flow and keep response times low. Also, the system relies on private data groups and rules for access that are built into smart contracts. This can make it complicated to manage and change these rules as the system changes. Moreover, the reward system called "PrivyCoin" for sharing data brings up concerns about whether the economic incentives might be misused. Finally, even though the framework meets the European Union's General Data Protection Regulation, it is vital to think about different data protection laws in other areas and make sure the system can adapt to those. Fixing these issues will be key for the "PrivySharing" framework to be widely accepted and successful over time.

The blockchain solution suggested for smart cities in the research by **Aldribi, Abdulaziz & Singh, Aman. (2022)** shows improvements in performance and scalability. Yet, this study mainly examines three public sector areas: electricity, water, and healthcare. This results in a gap in understanding how this solution can apply to other important areas like transportation, waste management, and public safety. While the performance evaluation looks at many devices and records, it fails to consider how sustainable the system is in the long run when put into existing city infrastructures. More research is necessary to look into these issues and ensure that this proposed model is applicable and strong enough for different urban settings.

In the research by **Rahman, Mohammad & Chamikara, M.A.P. & Khalil, Ibrahim & Bouras, Abdelaziz. (2022),** the proposed hierarchical blockchain platform tackles important issues related to ensuring IoT data integrity and achieving blockchain cooperation in smart city organizations. However, there is still a need for more research into the scalability and real-life use of these systems. The study shows promise with the integration of Hyperledger Fabric and Ethermint as a proof-of-concept, but more work is needed to assess the performance and security of Blockchain-of-Blockchains (BoBs) in large, diverse smart city settings. In addition, the ability of different blockchain networks to exchange transactions in a smart city context requires thorough investigation to ensure smooth and efficient data flow without sacrificing system integrity and transparency.

The research by **Hidayati, D. N. U. R. U. L. (2020)** on combining Fog computing and Blockchain technologies in smart city applications indicates potential benefits such as lower energy use, reduced latency, and better security. Nevertheless, there are still significant gaps in the research. Existing frameworks often face problems like platform compatibility, support for multiple applications, and efficient resource management. Additionally, how scalable these solutions are in real-world situations has not been thoroughly investigated. More research is required to overcome these problems and develop stronger, scalable, and flexible frameworks that can effectively meet the varied and changing demands of smart city applications.

In the paper by **Das, D., Banerjee, S., Chatterjee, P., Ghosh, U., & Biswas, U.,** blockchain technology has great potential to improve Intelligent Transportation Systems (ITS) in smart cities. However, there are significant research gaps that must be addressed. A major issue is the scalability of blockchain solutions to manage the large volume of data generated. amount of data made by ITS in real-time. The high computer power needed for blockchain tasks is a problem for broad use. More research is also needed on how to combine blockchain with current ITS systems and create standard rules to make sure they work together. Plus, the security and privacy issues of using blockchain in ITS need careful study to find and fix possible weaknesses. Fixing these issues will be key to using blockchain technology to change ITS and smart city uses.

Ivanišević, Stojan & Ciric, Zoran. (2019) in their paper find several key factors for making blockchain projects work in smart cities. But they see a big gap in knowing the specific problems and success aspects that are special to blockchain projects in smart cities. Even though the paper has a detailed review of current writing, it states that more real-world research is needed to confirm these factors and to find others that may come up when put into practice. This gap shows the need for deeper studies to find and tackle the special needs and challenges faced by blockchain projects in smart cities to make sure they are adopted and mixed well.

The study by **Ivanišević, S., Ivić, A., & Ćirić, Z.** on blockchain project rollout in smart cities shows a key gap in the current literature: the absence of a workable framework and guidelines for these rollouts. This gap brings uncertainty and issues to the process. While the study highlights good application areas, key success factors, and performance metrics, it shows that current research is scattered and often based on single examples rather than a complete, organized study. The small number of expert groups and limited data access further limit the research, which shows the need for wider, multi-case studies and more expert involvement to shape a solid framework for blockchain use in smart cities.

The research by **Bai, Y., Hu, Q., Seo, S.-H., Kang, K., & Lee, J. J.** proposes an inventive public participation consortium blockchain system for infrastructure care, but there is a significant research gap about how scalable and sustainable such systems can be long-term. The use of blockchain tech in smart city management needs a lot of computing power and energy, which could lead to environmental and cost problems. Furthermore, the efficiency of the suggested reward systems in various socio-economic areas has not been deeply studied. Future studies should aim at making blockchain solutions that use less energy and check how these incentive strategies work in various urban settings to support wider and sustainable use of blockchain public involvement systems in smart cities.

The work of **Ciric, Zoran & Sedlak, Otilija & Ivanišević, Stojan. (2020)** points out the potential gains of blockchain tech in boosting the security and sustainability of smart city information systems but finds a key gap in the real-world implementation framework. Specifically, there is a lack of detailed studies that give clear guidelines and methods for incorporating blockchain into current smart city setups. The research also does not tackle the scalability and compatibility issues that might come up during implementation. Future studies should work on creating a strong framework that includes practical steps, case studies, and best practices for effectively integrating blockchain tech in smart cities, making sure these systems can be scaled and used in various city settings.

The paper by **Cheikhrouhou, Omar, Ichrak Amdouni, Mershad Khaleel, Ammi Meryem, and Nguyen Gia Tuan (2022)** reviews blockchain solutions for smart city cybersecurity. However, it finds a major gap in applying and testing these solutions in real life. There are few studies that assess how effective and scalable blockchain technology is in different smart city scenarios. Moreover, the research overlooks issues about how blockchain can fit with current smart city systems and how various blockchain platforms can work together. Future work should aim to conduct actual pilot projects and create standard guides to facilitate the use and scalability of blockchain cybersecurity in smart cities.

Publication by F. O. R. E. X. (2022) also gives a detailed overview of smart city structures and blockchain's potential uses but points out a major lack of attention on real-world application and integration. There is a shortfall of studies assessing blockchain's effectiveness in various city settings, especially its role in protecting data and privacy. Additionally, it does not adequately cover scalability and interoperability challenges when merging blockchain with current smart city systems. Future research should prioritize pilot projects and develop standard frameworks to ensure smooth integration and scalability of blockchain solutions in smart cities, focusing on both technical and social-economic issues.

The study by **Ahmed, S., Shah, M. A., and Wakil, K. (2020)** reviews blockchain usages and benefits in smart cities, identifying a significant lack in real-world application and integration focus. Specifically, there is insufficient empirical research evaluating how effective and scalable blockchain is in different urban contexts. Furthermore, the study does not adequately address the challenges of integrating blockchain with existing smart city infrastructures. Future research should conduct real pilot projects and create frameworks that ensure the smooth and scalable implementation of blockchain solutions in smart cities, addressing technical and socio-economic factors.

The research by **Xiao, Xiao-Yong, Jin, Lin, Kateb, Faris, and Aldeeb, Hooreya (2021**) on improving urban governance through blockchain and big data highlights numerous gaps. While many benefits of blockchain for ensuring data trustworthiness and privacy are noted, studies that confirm these benefits in actual urban governance are lacking. The research mainly emphasizes technological elements, often ignoring the socio-political and economic impacts of these technologies in varied urban environments. Comprehensive frameworks are needed to address how blockchain can work with existing urban data systems and the scalability of these solutions in quickly advancing cities. Additionally, the ethical issues and potential risks associated with data privacy and security in blockchain urban governance are not sufficiently explored. Closing these gaps is essential for building effective, inclusive, and sustainable urban governance models.

Even though blockchain technologies show promise for enhancing security, issues, evaluating real-world applications, and establishing measurable success criteria for blockchain integration in supply chains. Current literature often emphasizes theoretical advantages without delving into actual outcomes and challenges faced during deployment. Also, the exploration of the cost, benefits, and overall impact of blockchain on supply chain efficiency is not sufficiently covered. Closing this gap is essential for advancing the effective use of blockchain technology in supply chain management.

The study by **Ivanisevic, S. (2019)** on issues of reliability and availability in smart city systems shows a noticeable lack in research. There are few thorough frameworks and empirical studies assessing how well blockchain solutions work in various smart city settings. Much of the existing literature emphasizes theoretical gains and individual cases, neglecting a complete evaluation of real-life uses, success factors, and performance measurements across smart city sectors. This signifies a clear need for additional research to create standardized frameworks that can help integrate blockchain into smart city systems efficiently, fulfilling the complex needs of urban areas.

Singh, Charu. (2023) discusses gaps in research regarding the blockchain technology ecosystem in smart cities. Despite the potential of blockchain for improved security, transparency, and efficiency, there's insufficient comprehensive research on its long-term effects and scalability. Moreover, the study does not adequately cover the challenges posed by the interoperability of different blockchain platforms and their integration with current smart city systems. More empirical evidence on the cost-effectiveness and practical viability of blockchain applications in various urban contexts is needed. Additionally, the societal and ethical effects of broad blockchain use in smart cities warrant further study to ensure equitable benefits for all residents.

Research by **Wong, P. F., Chia, F. C., Kiu, M. S., & Lou, E. C. W. (2020)** reveals a notable gap in understanding the practical application and scalability of blockchain solutions in smart city frameworks. While the theoretical advantages and possible uses of blockchain in governance, mobility, asset management, utilities, and logistics are highlighted, empirical case studies demonstrating successful large-scale implementations are missing. The compatibility of blockchain systems with existing urban infrastructures, along with the socio-economic effects of widespread blockchain use in smart cities, are insufficiently studied. It is vital to address these gaps for the creation of effective, scalable, and inclusive smart city solutions that utilize blockchain technology properly.

Alnahari, Mohammed & Ariaratnam, Samuel. (2022) point out a significant gap in research regarding the real-world application and scalability of blockchain technology in smart cities. Though the theoretical benefits are documented, there is a lack of empirical evidence showing successful large-scale implementations. Issues of interoperability between blockchain systems and existing urban infrastructure, as well as socio-economic effects of broad blockchain use in smart cities, require further exploration. Filling these gaps is important for developing effective, scalable, and inclusive smart city solutions leveraging blockchain technology.

Wycislak, S. (2021) examines opportunities for blockchain in supply chains and identifies a considerable divide between the theoretical capabilities of the technology and its practical application. While the scholarly discourse covers blockchain's potential uses in supply chain processes, there is a pressing need for detailed studies that connect expectations to successful field implementations. This includes recognizing practical challenges, assessing real-world applications, and setting measurable benchmarks for the success of blockchain integration in supply chains. Current literature tends to focus on theoretical benefits without adequately addressing actual outcomes and hurdles in deployment. Additionally, the exploration of costs, benefits, and overall impacts of blockchain on supply chain efficiency is lacking. Addressing this divide is critical for advancing the meaningful implementation of blockchain technology in supply chain management. Case studies and theoretical ideas look at challenges like visibility, trust, and efficiency in decentralized transport networks. The research highlights the need to explore how blockchain can fit into supply chain tasks to solve problems like limited visibility, dependence on informal methods, and the necessity for standard procedures.

The study by **Shannon, H., Fermat, Q., & Sundan, Bose (2024) shows** good progress in using big data and IoT tech to improve infrastructure in smart cities. Nonetheless, there is a clear gap in making these technologies work together with real-time adaptive systems that can react to unexpected events. Existing methods often focus on predicting maintenance and optimizing processes, but they usually can't adjust to sudden changes or crises. This gap indicates a need for more research into AI systems that can both predict issues and adapt automatically to new data, thus making smart city systems more resilient and responsive.

The research by **Oladejo, Abayomi & Fatunmbi, Iyanuoluwa (2024)** deeply examines using advanced data analytics, machine learning, and IoT tools to boost smart city efficiency and sustainability. However, it misses the socio-cultural effects of these technologies on urban communities. There is a lack of understanding on how real-time data analysis and AI choices can affect community involvement, public trust, and the inclusivity of smart city projects. The study also doesn't look enough at the long-term effects of data-driven urban management on social equality and the risks of widening digital gaps, which could worsen existing disparities. It's important to address these social factors to ensure that smart city solutions are both advanced and fair.

Meanwhile, **Allam, Z. (2019)** thoroughly examines AI and Big Data in Smart Cities but misses the social and cultural effects on urban residents. It does not adequately explore how adopting AI and IoT impacts community participation, public trust, and inclusiveness in cities. This research also overlooks the long-term results of data-driven urban management on social fairness and the risk of digital divides that may increase current inequalities. Understanding these social aspects is vital to guarantee that Smart City solutions are both technically advanced and socially responsible.

In another study, **Cong, Yuxin & Inazumi, Shinya (2024)** extensively look into smart city ideas and technologies to tackle urban development issues in Japan. However, it does not adequately analyze the socio-economic effects on local communities. There is a gap in comprehending how smart sensing and predictive analytics influence community involvement, public trust, and participation in urban planning. The research does not consider the long-term effects of using advanced geotechnical research and predictive models on social fairness and the risk of creating digital gaps. Addressing these economic and social aspects is essential to ensure smart city solutions are both advanced and equitable.

Lastly, the research on **Big Data and Advanced Analytics for Smart Mobility (2024)** gives a detailed view of key concepts and uses of big data in transportation. and analytics in smart mobility doesn't fully consider how these technologies affect different urban groups socio-economically. There’s a lack of understanding about how smart mobility solutions impact community involvement, public trust, and equal access in transportation planning. The research also doesn’t look at the long-term effects of data-driven transport systems on social equity or the risk of increasing digital divides, which could worsen existing inequalities. It's important to tackle these socio-economic aspects to make sure smart mobility solutions are not just advanced but also fair and inclusive.

Qiu, R. G., Zu, T., Qian, Y., Qiu, L., & Badr, Y. (2018) researched using big data platforms and analytics to improve mobility services in smart cities, making progress in blending physical and social sensing. However, there's still a lack of understanding about how to apply these technologies in real-time urban settings. While combining physical and social sensing has been examined, how these systems can scale and adapt to quickly changing urban environments needs further study. Additionally, using advanced machine learning to predict and control urban mobility in real-time is still just beginning. Future work should aim to create sturdy, adaptable frameworks that can respond dynamically to the changing needs of smart cities, making mobility services efficient and able to handle urban complexities.

Even with developments in predictive models, deep-learning sensing technologies, and big urban data for digital twin cities, **Nica, Elvira & Popescu, Gheorghe & Poliak, Miloš & Kliestik, Tomas & Oana, Sabie (2023)** found a gap in how these technologies can fit into existing urban infrastructures. There's a pressing need for studies that delve into the scalability and real-time usage of digital twin simulation tools, spatial cognition algorithms, and multi-sensor fusion tech in varied urban areas. Moreover, the ethical issues and data privacy risks linked with the use of blockchain-based digital twins and real-time IoT data in urban computing must be explored further to ensure smart city governance is both sustainable and secure.

Even with the exciting potential of blockchain technology (BT) and machine learning (ML) for better data security and privacy, **Elngar, A. (2019)** identified a significant gap in researching how these technologies can be practically used and scaled in real applications. Comprehensive studies need to address issues concerning data reliability and sharing in ML to enhance accuracy in BT-based smart applications. Furthermore, exploring ethical concerns and potential security risks, such as majority attacks and double-spending, is crucial to ensuring the resilience and trustworthiness of these systems across various smart applications, including UAVs, smart grids, healthcare, and smart cities.

In spite of significant strides in IoT-based healthcare solutions, **Tripathi, G., Ahad, M. A., & Paiva, S. (2020)** found an essential gap in ensuring patient data's security and privacy. While current technologies provide useful applications like real-time monitoring and patient data management, they often neglect the weaknesses related to data transmission and storage. The integration of technologies like Mobile Edge Computing (MEC) and blockchain is necessary to enhance security and address existing vulnerabilities. that enhance data security and privacy. Yet, robust frameworks are still needed to manage and protect the large amounts of sensitive medical data from IoT devices. Future studies should aim to create secure and privacy-preserving healthcare systems that fit well within the smart city framework while keeping patient information safe and confidential.

The research by **Asgari, M., & Nemati, M.** points out gaps in blockchain technology's use in water management systems. Although the benefits of blockchain are noted, there are few comprehensive studies about real-life implementation issues. More research is needed on long-term planning for water management, updates to policies, and gaining necessary knowledge and expertise. The study also identifies technical, organizational, social, and institutional challenges that could slow down the adoption of blockchain, and these areas need more exploration for successful implementation.

Yigitcanlar, T., Desouza, K., Butler, L., & Roozkhosh, F. (2020) discuss AI in smart cities, revealing several gaps. Despite significant attention on AI technologies and their uses, there are not enough detailed reviews on the subject. Limited scholarly work exists that examines the risks of broader AI use and the disruptions it might cause in cities. Furthermore, current research does not sufficiently explore the long-term effects of AI on smart city development regarding economy, society, environment, and governance. These gaps underscore the need for more research to explore AI's role in advancing smart cities.

Yitmen, Ibrahim's research, "Integration of Blockchain and Digital Twins in the Smart Built Environment Adopting Disruptive Technologies—A Systematic Review," points to gaps in integrating blockchain and digital twins (DT) for building data management. Though interest in enabling technologies like AI, ML, IoT, cloud computing, and Big Data is growing, practical methods to reveal their true potential and integration are lacking. While combining these technologies seems promising for addressing individual challenges, additional research is necessary to create models demonstrating effective integration in smart built environments, indicating further investigation is needed into practical uses and integration techniques.

Yarime, M. (2019) examines woody biomass supply chains and smart technologies, revealing notable gaps. Despite awareness of the role of woody biomass in sustainable energy and the mention of smart technologies in supply chain management, the two areas are not well combined. Specifically, there are few comprehensive studies on how smart technologies can tackle technical and social challenges within woody biomass supply chains. More research is essential to develop practical approaches and models demonstrating these technologies' potential to enhance transparency, efficiency, and sustainability in woody biomass supply chains.

Chanda, M. (2022) studies smart cities and IoT communications, identifying several gaps. Even though there is much discussion around merging technologies like machine learning, blockchain, and cloud and fog IoT systems, there is a clear lack of in-depth studies. This text discusses practical use and mixing of tech in real smart city settings. Also, it says more studies must focus on strong models that include safety and privacy issues, helping make smart cities more trustworthy and stronger. These missing parts show a need for more investigation into real uses, ways to mix, and long-term effects of new tech on smart city growth.

The study by **Park, J.-ho, Salim, M. M., Jo, J. H., Sicato, J. C. S., Rathore, S., & Park, J. H. (2019)** on smart city use of cognitive computing and AI shows many gaps. Even though there's a lot said about data analysis with cognitive computing, there aren't enough complete studies about how to scale and flexibly use data gathered in smart cities. More research should find practical methods to manage data from millions of sensors effectively and implement it across cognitive computing applications for quick responses. These issues underline the need for more study on practical uses and ways to combine data in smart city applications.

The study by **Ch, M. H. (2020)** on smart cities and energy use with zero net shows gaps as well. There is much focus on building energy needs and renewable options about smart power grids, but not much look into getting hydraulic energy from city water systems for electricity. More research is also needed to find practical ways to include new tech like cyber-physical systems, digital twins, and blockchain into smart water systems. These gaps indicate a need for more study on energy recovery methods and a complete, data-centered way to manage and operate water networks.

The research by **Charles, Vincent & Emrouznejad, Ali & Gherman, Tatiana (2023)** about mixing blockchain and AI in supply chains finds many gaps as well. Despite the focus and many studies on this idea, there isn't enough detailed research on how to bring these technologies into practice in the real world. More studies should explore how to mix blockchain and AI well to boost resilience, improve efficiency, and increase product traceability in changing and complex business situations. Also, further study is necessary to spot possible challenges and find ways to tackle them to gain full benefits from blockchain and AI in supply chains.

2.1.4 Research Assumptions

This research by **Morozova, Irina & Yatsechko, Stanislav (2022)** starts with some theoretical ideas and beliefs that shape the hypothesis:

1. Tech Improvements and City Efficiency: It is believed that new technologies (like AI, IoT, and blockchain) will improve city efficiency, lowering risks and operational problems.

2. CSR and Sustainable Growth: The study assumes that companies, through CSR activities, play a key role in promoting sustainable smart city growth, in addition to public sector contributions.

3. Smart Cities and Living Quality: The research suggests a connection between smart city development and quality of life, where improving one will enhance the other.

4. Global Pandemic Effects: It is suggested that global health crises, like COVID-19, do not greatly hinder smart city progress, particularly related to health-focused sustainable development goals (SDGs).

5. Policy Impact: The study believes that policies are essential for smart city development, and that proper policy alignment can boost urban sustainability and resilience.

These ideas will help shape the research hypothesis, which aims to explore how technological innovations, CSR, and government policies help reduce risks and foster sustainable urban growth.

The study by **Dziatkovskii (2022)** suggests that using AI and blockchain will make city infrastructure and waste management smarter and more effective. It assumes that these technologies will offer sustainable solutions without fully considering potential issues, like difficulties in moving from old systems or the need for oversight in certain areas.

Moreover, it takes for granted that using AI and blockchain is always good for smart cities, overlooking the risks of their use or other methods that may work just as well.

The research by **Al Sharif and Professor (2021)** assumes that adding Information and Communication Technology (ICT) into smart city designs will enhance living conditions by tackling transport, energy, and resource management problems. It also believes that IoT, AI, and blockchain are the main required technologies for smart cities. The study presumes that understanding and managing risks will ensure smart cities operate smoothly and safely. However, it does not consider new technologies or the wider social effects of smart city tech on community involvement and public trust.

The work by **Ahmed et al. (2022)** assumes that the combination of blockchain and AI will be vital for future smart city development, especially for creating sustainable IoT networks. It believes that layered systems will offer a secure and efficient base for smart city uses. It also thinks that the decentralized nature of blockchain will improve data security and trust in smart city systems. However, this paper acknowledges that issues like energy use, security risks, and the need for strong regulations must be addressed to realize the full benefits of this tech combination.

Ariyachandra and Wedawatta (2023) assume that Digital Twin and Smart City (DTSC) technologies will keep advancing and be important in managing disaster risks by providing precise, real-time data and predictive insights. The paper further suggests that solving current issues related to technical interoperability, complexity, and sustainability will enable better disaster management strategies. Lastly, it implies that future improvements in social sensing will contribute to better outcomes. comprehensive disaster response methods that enhance city resilience to natural disasters.

Nguyen, Han-Khanh (2022) suggests that broadening the research sample and considering seasonal factors will yield better insights into consumer habits and supermarket success. It is also believed that comparing different supermarket chains will increase the relevance of the results and deepen the understanding of service quality and supply chain uncertainties. Additionally, the study assumes that the three-dimensional framework insights can help supermarket leaders create better business strategies, especially during ongoing issues like the COVID-19 crisis.

The work by **Ullah et al. (2021)** insists that a layered approach to risk management can greatly improve smart city governance. They assume that the Technology, Organization, Environment (TOE) framework can be a foundation for thorough risk evaluations by factoring in technological, organizational, and external elements. The framework also assumes risk management within smart cities is a continuous process that must adapt to new technologies, such as 5G and blockchain. Furthermore, it is presumed that by tackling these risks, smart cities can enhance citizen safety and privacy, while promoting sustainable development.

Ghosh et al. (2023) argues that improving security measures, creating scalable solutions, setting interoperability standards, and advancing energy-efficient algorithms are crucial for solving current issues. By focusing on these areas, the aim is to help develop integrated systems that sufficiently support smart city applications while ensuring safety, privacy, and environmental sustainability.

Mumtaz, Hina & Ali, Mushtaq (2024) state that filling these gaps includes:

- Developing better security measures to protect data.
- Creating scalable solutions to manage the growing data from IoT systems.
- Setting interoperability standards for smooth communication between AI, IoT, and blockchain technologies.
- Designing energy-saving algorithms to minimize the ecological footprint of these integrated systems, fulfilling sustainability targets.

Chauhan, Megha & Sahoo, Deepali (2024) present recommendations such as:

- Interdisciplinary Efforts: Teams from different fields must work together to tackle the social, economic, and environmental aspects of these technologies.

- Field Research: Implementing trials and extended studies to evaluate the real-world effects and feasibility of combining AI, blockchain, and IoT.

- Ethical Frameworks: Creating strong guidelines for data governance to confront matters like data ownership, consent, and bias in algorithms, ensuring ethical technology use.

- Affordable Implementation: Finding ways to lessen financial challenges through supportive policies, funding opportunities, and investing in research.

Irfan et al. (2024) proposes the following:

- Standardization Measures: Formulating industry standards for secure data sharing and interoperability across blockchain, AI, and IoT systems.

- Improved Security Protocols: Using advanced encryption and verification methods to safeguard data and maintain supply chain integrity.

- Responsible AI Practices: Promoting transparency and fairness in AI decision-making and addressing potential biases.
- Trial Programs: Launching practical pilot projects to evaluate these integrated technologies, measure their effectiveness, and improve broader strategies for implementation.

Sandner, Philipp & Groß, Jonas & Richter, Robert. (2020) Here are some areas for further study to tackle these issues:

- Integration: Investigate how to combine blockchain, IoT, and AI more effectively to unlock their full capabilities.
- Scalability: Find new ways to enhance blockchain scalability and improve AI performance in IoT systems.
- Privacy and Security: Develop stronger methods for data privacy and security to protect IoT networks from cyber threats.
- Standards and Regulations: Formulate standard protocols and regulations to encourage the use of these combined technologies across various industries, boosting innovation and trust among users.

The research by **Rajawat et al. (2024)** believes that merging LSTM (Long Short-Term Memory) and SOM (Self-Organizing Map) networks will boost the discovery of security risks and help predict future threats. It assumes that AI methods can strengthen blockchain's response to changing attack techniques. The research also suggests that, if proper computational resources are available, this approach could be applied on large blockchain networks without sacrificing performance or security.

Dutta et al. (2020) points out several key areas for future study relating to blockchain in supply chain (SC) operations:

- Emerging Technologies: Look into how blockchain can work together with IoT, AI, and big data to improve SC effectiveness and visibility.

- Scalability: Explore ways to enhance blockchain scalability for processing a high volume of transactions in real-time SC activities.

- Interoperability: Create standards to ensure different blockchain platforms can work together and integrate with existing SC systems.

- Security and Privacy: Research better cryptographic methods and privacy solutions to mitigate concerns in blockchain-based SCs.

- Regulations: Examine how regulatory policies affect blockchain integration in SCs and suggest frameworks that promote innovation while ensuring compliance.

- Economic and Environmental Analysis: Evaluate the economic advantages and environmental footprint of blockchain in SCs, looking at cost-effectiveness and sustainability.
- User Behavior: Investigate what factors drive user acceptance of blockchain in SCs and create strategies to build trust among stakeholders.

- Specific Applications: Conduct detailed research on blockchain use in industries like healthcare, agriculture, and manufacturing to uncover particular challenges and possibilities.

- Governance Models: Study various governance models for blockchain networks to ensure fair and open decision-making.

- Long-term Studies: Carry out extensive studies to measure the effects of blockchain on supply chain efficiency and its development over time.

The research by **Homaei et al. (2024)** regarding smart cities shows many exciting avenues for investigation. Here are important areas for researchers:

1. Sustainability: Explore how green IoT and eco-friendly technologies can contribute to building sustainable smart cities.

2. Data Analysis: Develop advanced data analysis and machine learning approaches to process the large volumes of data produced by smart city systems. 3. Security and Privacy: Improve the security and privacy for smart city projects, tackling data safety and cyber threats.

3. Interoperability and Standardization: Formulating standard frameworks and protocols to guarantee compatibility among various smart city systems and technologies.

4. Citizen Engagement: Finding ways to boost citizen involvement and participation in smart city projects, ensuring technologies align with resident needs and preferences.

5. Urban Planning and Management: Using smart city technologies to enhance urban planning and management, including traffic control, waste disposal, and energy usage.

6. Health and Well-being: Examining how smart city technologies affect public health and wellness, like the use of IoT in healthcare and emergency services.

The study by **S. (2020)** discusses Blockchain Technology's role in Smart City Growth and suggests future research areas:

1. Implementation and Testing: The suggested secure setup based on Blockchain Technology must be put into practice and tested in real situations to check its performance, speed, flexibility, and compliance with cybersecurity.

2. Enhancements and Adaptations: Future research should aim to improve the suggested structure to be more suited for specific Smart City services. This involves adjusting the architecture to fit various application needs.

3. Scalability and Integration: Researching how to expand the Blockchain-based framework to meet the increasing demands of Smart Cities and how to integrate it with current IT systems and other new technologies.

4. Cost-Benefit Analysis: Performing a thorough cost-benefit assessment to grasp the financial effects of using Blockchain Technology in Smart Cities, including possible savings and investment returns.

5. User Acceptance and Education: Looking into ways to boost user acceptance and knowledge of Blockchain Technology among Smart City residents and stakeholders, involving educational efforts and easy-to-use interfaces.

6. Regulatory and Compliance Issues: Analyzing the regulatory and compliance challenges related to deploying Blockchain Technology in Smart Cities and suggesting ways to address these issues.

7. Interoperability: Studying methods to ensure compatibility between different Blockchain systems and other technologies in Smart Cities to create an efficient ecosystem.

These future research areas outlined by **Rotuna, Carmen & Gheorghita, Alexandru & Alin, Zamfiroiu & Smada, Dragoş. (2019)** aim to solve current gaps and challenges, ensuring that Blockchain Technology can be properly used to improve Smart Cities' development and functioning.

The future research scope in smart cities and risk management is broad and encouraging. Here are some main areas where further study and growth may be useful:

1. Advanced Data Analytics and AI:

- Using AI and machine learning to forecast and reduce risks in real time.
- Creating algorithms to examine large data from IoT devices for better risk evaluation and decision-making.

2. Cybersecurity Enhancements:

- Strengthening smart city infrastructure security against cyber threats.
- Applying advanced encryption and blockchain technologies for secure data sharing and storage.

3. Interoperability and Integration:

- Ensuring smooth integration of new technologies with current urban infrastructure.
- Developing standards and protocols for compatibility among various smart city systems and devices.

4. Sustainable and Resilient Infrastructure:

- Designing smart city solutions that prioritize environmental sustainability and resilience to natural disasters.

- Looking into green IoT tech to cut down energy use and lessen impact on the environment.

5. Regulatory and Legal Structures:
   - Setting up broad regulatory rules to tackle the legal and ethical issues around smart city tech.
   - Making sure data privacy and protection laws are enforced to keep citizen information safe.

6. Citizen Involvement:
   - Boosting citizen involvement through participatory platforms and clear governance.
   - Creating tools to engage citizens in decision-making and risk management.

7. Economic Feasibility and Funding Sources:
   - Finding new funding approaches and partnerships between public and private sectors for smart city projects.
   - Performing cost-benefit assessments to guarantee the economic feasibility of smart city efforts.

8. Social and Ethical Aspects:
   - Tackling the social and ethical issues of smart city tech, such as privacy worries and the digital divide.
   - Making sure all citizens have fair access to smart city resources.

By concentrating on these topics, future studies can aid in building smarter, safer, and more adaptable urban spaces that successfully handle risks and enhance the living standards of residents.

The potential research directions from **Treiblmaier, Horst & Rejeb, Abderahman & Strebinger, Andreas. (2020)** regarding blockchain tech in smart cities are broad and hold promise. Below are key areas for further study and development:

1. Merging with New Tech: Future studies should examine how blockchain can connect with other new technologies like IoT, AI, and big data to improve smart city capabilities.

2. Scalability and Compatibility: Tackling scalability and compatibility issues for blockchain systems in smart cities is vital. Research should aim to provide solutions for smooth integration and strong performance.

3. Security and Data Privacy: Improving the security and privacy of blockchain applications in smart cities is essential. Future inquiries can look into advanced cryptographic methods and privacy-preserving strategies.

4. Rules and Oversight Structures: Crafting detailed regulatory and governance frameworks for blockchain use in smart cities is necessary. Studies may work on policies that balance innovation with safety and privacy.

5. Sustainable Progress: Investigating how blockchain can aid in the sustainable growth of smart cities, focusing on energy management, waste cutting, and environmental monitoring, is a promising research focus.

These topics show the capacity of blockchain tech to transform smart city growth and tackle various urban difficulties.

The future directions of this research - **Palaiokrassas, Georgios & Skoufis, Petros & Voutyras, Orfefs & Kawasaki, Takafumi & Gallissot, Mathieu & Azzabi, Radhouene & Tsuge, Akira & Litke, Antonios & Okoshi, Tadashi & Nakazawa, Jin & Varvarigou, Theodora. (2021)** include several encouraging areas:

1. Scalability Solutions: Developing better methods to manage the vast amounts of data produced by IoT devices in smart cities, ensuring blockchain systems can grow efficiently without loss of performance.

2. Compatibility Improvements: Establishing standards and protocols to enhance interoperability among various IoT systems and blockchain platforms, enabling smooth integration and data sharing.

3. Security Upgrades: Researching innovative privacy techniques and secure identity systems to better protect data and user privacy in decentralized settings.

4. Economic Frameworks: Looking into economic and social motivators for joining IoT data marketplaces, ensuring fair rewards and fostering broad acceptance.

5. Regulatory Alignment: Adapting continually to the changing regulatory landscape will be necessary. Regulatory frameworks need to ensure compliance with data protection laws like GDPR and APPI, and tackle any new legal issues that come up.

6. Real-World Uses: More use of blockchain and IoT in smart city applications, like traffic control, energy management, and public safety, is needed to show practical benefits and promote further innovation.

7. User Experience Enhancements: Improving user interfaces and overall experiences for people in the IoT data marketplace is vital to make it more user-friendly and accessible.

By focusing on these areas, the research can help create stronger, safer, and more efficient smart city systems, using blockchain and IoT technologies fully.

Future research suggested by **Lee, J. (2018)** should look at how blockchain can improve urban resilience and sustainability in smart cities. By using blockchain's transparency and cost benefits, researchers should study how distributed ledger technology works for crucial urban systems like energy grids, transport networks, and public services. This includes looking into how blockchain can enhance data security, make processes smoother, and build trust among various parties. Moreover, comparing blockchain effectiveness in different smart city uses and its role in risk management strategies is essential. This research will provide important ideas for optimizing smart city systems and making them strong against different risks.

Future research on IoT and AI-based optimization within the Industry 4.0 framework by **Mikołajewski et al. (2024**) should aim to improve the integration and interoperability of smart systems across industries. This includes creating advanced machine learning methods and AI tools to enhance maintenance, energy use, and quick decision-making. Additionally, exploring cyber-physical systems (CPS) and digital twins for simulating and improving industrial processes can lead to better productivity and safety. There should be a strong focus on addressing cybersecurity issues and making IoT networks more secure against threats. Using these technologies can lead to stronger, more efficient, and sustainable industrial settings.

The research by **Wycislak, S. (2021)** on smart city risk management can concentrate on incorporating advanced technologies like AI and IoT for better real-time visibility and predictive analysis, ensuring strong cybersecurity to safeguard data, and enhancing disaster resilience with smart technologies. It should also look into sustainable urban development, consider social and ethical aspects, and build effective governance frameworks. Emphasizing interoperability standards and new business models will be important for seamless integration and economic sustainability in smart city projects.

Future research from **Vishal Ranaware (2019)** on smart city risk management can look into merging advanced technologies like AI and IoT for better real-time visibility and predictive analysis, ensuring strong cybersecurity measures for data protection, and enhancing disaster resilience using smart technologies. It should also focus on sustainable urban development, address social and ethical issues, and develop effective governance frameworks. Highlighting interoperability standards and innovative business strategies will be crucial for economic sustainability and smooth integration of smart city efforts.

The future research of **Alasbali, N., Azzuhri, S. R. B., Salleh, R. B., Kiah, L. M., Shariffuddin, A. A. A. S. A., bin Nik Mohd Kamel, N. M. I., & Ismail, L. (2022)** about managing risks in smart cities looks very promising. As smart cities grow, using blockchain with IoT can improve safety, privacy, and how urban systems work together. Future studies might look into creating general rules for blockchain-based IoT networks to make data sharing and communication better across different platforms. Also, looking into better encryption techniques and decentralized ways of verifying identities will be important to reduce cybersecurity risks and keep data safe. Using predictive analytics and AI tools can help find weaknesses early and make resource distribution more efficient for dealing with risks. By exploring these areas, the research can help build strong, safe, and effective smart city environments that enhance urban living.

The future research of **Khanna, A., Sah, A., Bolshev, V., Jasinski, M., Vinogradov, A., Leonowicz, Z., & Jasiński, M. (2021)** about managing risks in smart cities looks extensive and encouraging. As smart cities continue to develop, combining blockchain with IoT can enhance security, privacy, and how urban systems connect with each other. Future research could aim at creating standard protocols for blockchain-based IoT networks to improve data sharing and communication on various platforms. Exploring better encryption and decentralized identity verification methods is also crucial to combat cybersecurity threats and maintain data integrity. Implementing predictive analytics and AI-driven risk assessment tools might help identify weaknesses and allocate resources efficiently for proactive risk management. Addressing these aspects can aid in developing resilient, secure, and effective smart city systems that benefit urban residents.

The future research of **Publication, I. J. R. A. S. E. T. (2020)** in smart city risk management looks broadly promising. As smart cities grow, combining blockchain with IoT can greatly enhance the security, privacy, and interoperability of urban systems. Future studies could work on standard protocols for blockchain-based IoT networks to make data sharing and communication smoother across platforms. Investigating advanced encryption techniques and decentralized authentication methods will be essential for reducing cybersecurity risks and ensuring data protection. Utilizing predictive analytics and AI-driven tools can help spot potential risks and improve resource allocation for preventive management. By exploring these areas, the research can support the development of resilient, secure, and effective smart city models that boost urban living standards.

The future research of **Makhdoom, I., Zhou, I., Abolhasan, M., Lipman, J., & Ni, W. (2019)** in smart city risk management is broad and promising. As smart cities evolve, mixing blockchain technology with IoT can improve security, privacy, and communication between urban systems. Future research might investigate creating standardized rules for blockchain-based IoT networks for smoother data sharing and interaction across several platforms. Additionally, looking into improved encryption and decentralized verification methods will be vital for reducing cyber threats and maintaining data integrity. mechanisms will be important for reducing cybersecurity risks and keeping data safe. Using predictive analytics and AI tools for risk assessment can help spot weaknesses and use resources better to manage risks ahead of time. By focusing on these aspects, the research can help build strong, secure, and effective smart city systems that enhance life quality for city dwellers.

The future research directions of **Aldribi, Abdulaziz & Singh, Aman. (2022)** in smart city risk management include making better security measures to protect key systems from cyber threats, combining IoT and blockchain for better disaster response, and using predictive analytics for pre-emptive risk management. Following regulations, creating standards for system compatibility, and raising public awareness are essential. Also, concentrating on sustainability and strength, along with protecting privacy, will make smart cities safer and more effective, allowing them to adapt easily to new challenges.

The future research directions of the study by **Rahman, Mohammad & Chamikara, M.A.P. & Khalil, Ibrahim & Bouras, Abdelaziz. (2022)** regarding smart city risk management are extensive and hopeful. By using the Blockchain-of-Blockchains (BoBs) framework, smart cities can improve their defenses against data leaks, cyber threats, and service disruptions. The decentralized nature of BoBs keeps data safe and clear among different city departments and services, lowering the risk of a single point of failure found in centralized systems. Also, the compatibility of various blockchain networks under the BoBs structure can enable smooth data sharing among different smart city participants, leading to better responses during emergencies. This method boosts the security of smart cities while building trust among the public and stakeholders through a strong and clear data management system.

The future research directions of the study by **Hidayati, D. N. U. R. U. L. (2020)** regarding smart city risk management are extensive and hopeful. As smart cities grow, combining Blockchain and Fog computing can greatly improve risk management. Future studies can aim at creating stronger and more adaptable frameworks that deal with the complex and changing aspects of smart city settings. This involves enhancing the resilience of IoE applications against cyber threats, ensuring data protection, and efficiently using resources to avoid system overloads. Moreover, blending advanced machine learning with Blockchain and Fog computing can provide predictive analytics for early risk management, enabling city leaders to foresee and handle potential issues before they become serious. By continuously improving these technologies, smart cities can reach higher standards of security, efficiency, and sustainability, ultimately enhancing the life quality of their residents.

The future research directions of **Das, D., Banerjee, S., Chatterjee, P., Ghosh, U., & Biswas, U.** in smart city risk management include investigating the role of blockchain technology in improving the security and resilience of urban systems. This involves creating decentralized structures for real-time threat monitoring and response, such as cyber-attacks, natural disasters, and infrastructure issues. By exploiting blockchain's secure and clear nature, researchers can establish strong mechanisms for data integrity and trust management, making sure critical information is shared safely among involved parties. Also, applying smart contracts can help automate emergency responses. response rules, simplify resource use, and enhance how city services work together. Upcoming research should also look into the scalability and compatibility issues of blockchain to ensure it can be effectively used in large smart city settings.

The future work of **Ivanišević, Stojan & Ciric, Zoran. (2019)** can focus on how blockchain technology fits into smart city risk management systems. As smart cities grow, they encounter many risks like data leaks, cyber threats, and operational problems. The decentralized and unchangeable nature of blockchain can boost security and clarity in smart city activities, helping to reduce these threats. Future studies should aim to find and analyze essential success factors for blockchain use in smart cities, including following regulations, working well with current systems, and getting user support. By tackling these issues, the research can aid in creating strong and secure smart city systems that use blockchain technology to handle risks well.

The future work of **Ivanišević, S., Ivić, A., & Ćirić, Z.** regarding smart city risk management appears promising and varied. As blockchain technology advances, its role in smart city systems can greatly improve risk management tactics. Future research might concentrate on creating broader frameworks that use blockchain's security aspects to lessen risks linked to data breaches, cyber-threats, and unauthorized access. Moreover, looking into how blockchain can be used for real-time checks and reports of city systems can offer a clear and reliable event record, helping speed up responses and recoveries during crises. More studies could also examine how blockchain can simplify risk evaluation, enhance decision-making using decentralized agreement methods, and promote better teamwork among different participants in the smart city network. By focusing on these points, future research can help build stronger and safer smart cities that can effectively handle and reduce risks.

The future work of **Bai, Y., Hu, Q., Seo, S.-H., Kang, K., & Lee, J. J.** in smart city risk management holds great potential. As blockchain technology evolves, its use in smart city structures can greatly improve risk management strategies. Future studies could aim to create strong frameworks that make use of blockchain's security benefits to tackle risks from data breaches, cyber-attacks, and unauthorized entries. Further exploration into using blockchain for real-time checks and reporting of city infrastructure can ensure a clear and unchangeable record of occurrences, aiding faster responses in emergencies. Additional studies might also look into how blockchain can make risk assessment easier, enhance decision-making through shared consensus processes, and encourage better cooperation among different players in the smart city field. By focusing on these aspects, future research can help build more resilient and secure smart cities that can effectively address and manage risks.

The future work of **Ciric, Zoran & Sedlak, Otilija & Ivanišević, Stojan. (2020)** regarding smart city risk management is extensive and encouraging. As smart cities grow, integrating blockchain technology can greatly improve the resilience and security of urban information networks. Future research should aim to develop clear frameworks for using blockchain solutions to tackle specific risk management issues like data breaches. cyber attacks and system failures. Looking into the use of blockchain can help increase transparency, accountability, and trust among involved parties. Finding key success traits and performance measures will help future research give useful information to policymakers and planners for building safer, more sustainable, and effective smart cities. This research aims to not only reduce risks but also use blockchain to encourage innovation and enhance urban living quality.

The research path for **Cheikhrouhou, Omar & Ichrak, Amdouni & Mershad, Khaleel & Ammi, Meryem & Nguyen gia, Tuan. (2022)** in smart city risk management, especially concerning cybersecurity, focuses on using blockchain to tackle new challenges. As smart cities grow, their systems will become more complex and interlinked, requiring strong, scalable, and flexible security solutions. Future studies should create blockchain frameworks that offer immediate threat detection, automated responses, and better data protection. Researching quantum-resistant blockchain methods will be key for protection against potential quantum computing issues. Teamwork among schools, businesses, and government will be crucial to form standard protocols and promote the use of these advanced security measures, ultimately building secure smart city environments.

The research direction of **Publication, F. O. R. E. X. (2022)** on smart city risk management should work on building strong, scalable, and smart blockchain systems that effectively handle security and privacy issues. This should involve developing better consensus methods, smart contracts, and encryption to guarantee data reliability and privacy. Additionally, research should look into combining artificial intelligence and machine learning for better threat prediction and response, improving real-time tracking. There should also be a focus on creating standard protocols for data sharing and protection in various smart city uses, ensuring that they meet global data protection laws. By tackling these issues, future studies can significantly improve the safe and efficient function of smart cities, building public trust and enabling sustainable growth.

The future research area for **Ahmed, S., Shah, M. A., & Wakil, K. (2020)** in smart city risk management centers on using advanced blockchain tech to boost security, privacy, and trust. As smart cities grow, the data complexity will rise, requiring solid risk management plans. Future research should emphasize creating scalable blockchain solutions that can manage extensive data operations while assuring data security. Additionally, exploring blockchain's ability to automate risk evaluation and management with smart contracts can significantly lessen human mistakes and increase efficiency. Attention must also be paid to enabling different blockchain platforms to cooperate, leading to a cohesive and secure smart city system. By focusing on these points, future research can advance smart cities to withstand various cyber threats and operational challenges.

The research potential for **Xiao, Xiao-Yong & Jin, Lin & Kateb, Faris & Aldeeb, Hooreya. (2021)** in smart city risk management, using blockchain and big data together, is extensive and exciting. By incorporating blockchain into city data management systems, urban areas can boost the and reliable method for handling urban data, which is critical for efficient risk management. This blending may lead to stronger urban infrastructures that can better cope with emergencies and lessen risks tied to natural disasters, cyber threats, and other city issues. Moreover, blockchain's decentralized aspect can aid in clearer and more efficient communication among different parties, such as government bodies, businesses, and residents, thus boosting the overall governance and response of smart cities. Future studies might look into inventive uses of blockchain in areas like predictive analytics, real-time oversight, and automated response systems, helping to build safer and more sustainable city spaces.

Research to be conducted by **Ivanisevic, S. (2019)** on smart city risk management should aim to delve into how blockchain technologies can strengthen the stability and security of urban data systems. This involves exploring how blockchain could be used to create decentralized, unalterable records that protect data integrity and clarity, lowering the risks related to data breaches and cyber threats. Furthermore, studies should look at how blockchain can enable real-time tracking and automatic reactions to urban system failures, improving the dependability and availability of services. By carrying out practical studies and pilot initiatives within current smart cities, researchers can find best practices and create frameworks for effectively putting blockchain-based solutions into action, aiding in the establishment of more secure, efficient, and sturdy urban areas.

The research future for **Singh, Charu. (2023)** in smart city risk management looks broad and full of potential. As cities keep advancing and using new technologies, efforts will likely focus on boosting the stability and security of urban infrastructures. Future studies could investigate building stronger blockchain-based systems to maintain data integrity and security, especially in crucial areas like transportation, energy, and public services. There is also room to utilize artificial intelligence and machine learning for predicting and reducing risks linked with urbanization, such as environmental dangers, cyber threats, and infrastructure failures. By promoting teamwork across different fields and using new technologies, researchers can help develop safer, more efficient, and sustainable smart cities.

The research outlook of **Wong, P. F., Chia, F. C., Kiu, M. S., & Lou, E. C. W. (2020)** in smart city risk management should focus on combining advanced technologies like blockchain, AI, and IoT to strengthen the resilience and safety of urban infrastructures. This includes designing solid frameworks for real-time monitoring and predictive analysis to detect and reduce risks related to cybersecurity issues, resource shortages, and environmental threats. Moreover, investigating how decentralized systems can enhance clarity and trust in public services and examining blockchain's role in protecting data integrity and privacy in smart city contexts will be key. Cooperative efforts among lawmakers, tech experts, and urban planners are vital to producing adaptable and sustainable solutions that can manage the complexities of today's urban landscapes.

Alnahari, Mohammed & Ariaratnam, Samuel. (2022) see great potential in future research on smart city risk management with Blockchain technology. As smart cities continue to progress, using Blockchain can greatly improve risk management by offering a secure, clear, and dependable approach to managing urban data, which is essential for effective risk management. and unchangeable record for all dealings and data swaps. Future studies might look into making better Blockchain-based systems to tackle different city issues like cybersecurity risks, data leaks, and weak infrastructure. Using Blockchain's decentralized approach, cities could provide timely awareness and reporting of dangers, allowing quick actions against possible threats. Also, examining the joining of Blockchain with other new technologies such as IoT and AI might improve predictive analysis and automated risk handling. This complete method would not only boost the durability and safety of smart city structures but also promote more trust and teamwork among different parties, leading to more sustainable and efficient urban settings.

The prospective research focus of **Wycislak, S. (2021)** concerning risk management for smart cities, based on the current document, emphasizes using blockchain technology to improve clarity, safety, and efficiency in urban systems. Blockchain's decentralized characteristics can offer a strong structure for managing risks related to data leaks, cyber threats, and operational faults. By blending blockchain with smart contracts, cities could simplify and secure transactions, providing real-time oversight and responsibility in vital infrastructure and services. This could advance the robustness of urban settings, enabling them to endure and swiftly bounce back from disruptions, fostering sustainable and safe smart cities.

The future research possibilities of **Shannon, H & Fermat, Q & Sundan, Bose. (2024)** regarding smart city risk management are extensive and encouraging. By honing AI-based predictive analysis and incorporating advanced IoT technologies, cities can reach exceptional levels of infrastructure strength. Future tasks may target improving the precision and effectiveness of predictive models, including a wider range of data sources, and creating real-time adaptive systems that can react flexibly to new dangers. Moreover, applying these technologies to new fields like environmental monitoring, public health, and cybersecurity can greatly enhance the safety and sustainability of smart cities. This research opens doors for a proactive urban management style, where data insights lead to timely actions, improved resource usage, and ultimately, stronger and more livable city environments.

The future research potential of **Oladejo, Abayomi & Fatunmbi, Iyanuoluwa. (2024)** within smart city risk management is extensive and encouraging. By using advanced data analysis, machine learning, and IoT technologies, cities can identify and deal with potential risks early, like natural disasters, infrastructure breakdowns, and security issues. Gathering real-time data from various city systems will support predictive modeling and early warning systems, improving the city's resilience and response skills. Moreover, the research can develop flexible and scalable solutions that change with the city's needs, ensuring ongoing safety and sustainability. Tackling concerns regarding data protection and security will be essential, as it builds public trust and guarantees fair access to the benefits of smart cities. This all-encompassing method to risk management will enhance residents' quality of life while driving economic growth and environmental sustainability.

The future research areas for **Cong, Yuxin & Inazumi, Shinya. (2024)** in smart city risk management are broad and encouraging. By utilizing advanced technologies such as smart sensing, predictive analytics, and machine learning, upcoming studies can further enhance and extend the predictive frameworks created. in this study. The models can work in different geographic areas and urban settings, making geotechnical investigations and urban planning more precise and dependable. Also, using real-time data from sources like IoT devices and satellite images can help improve hazard predictions and risk assessments. This will allow governments, construction companies, and individuals to make better decisions, which will lead to safer and stronger urban areas. Moreover, creating easy-to-use applications and platforms that give real-time geographic data and hazard alerts can encourage citizens to join in risk management and disaster preparation efforts. This research sets the stage for a complete and active approach to smart city risk management, leading to better urban development that is both sustainable and resilient.

Looking ahead to research in **2024**, there is a focus on **Big Data and Advanced Analytics for Smart Mobility.** The collection and analysis of large transportation data relating to smart city risk management will center on combining big data and advanced analytics to boost predictive capabilities and resilience. Using machine learning and deep learning, researchers can create complex models for real-time risk assessment and predicting incidents, allowing for preventative actions against potential threats. Spatial and temporal analysis can help find vulnerable areas and improve resource use during emergencies. Moreover, better data integration and smooth communication between different smart city systems will improve coordinated responses to risks. Ethical issues and strong data governance will be key to maintaining public confidence and ensuring responsible data use. Working together across different fields and involving stakeholders will promote innovation and develop effective risk management strategies for safer, more resilient smart cities.

In the future research scope of **Allam, Z. (2019)** regarding smart cities and risk management, there are many opportunities ahead. As cities adopt AI and Big Data more, it is essential to create strong frameworks for assessing and managing risks. Future studies should aim to improve predictive analytics to anticipate and address urban risks such as natural disasters, cyber-attacks, and infrastructure failures. Furthermore, understanding the ethical concerns and privacy issues tied to widespread data collection and AI use will be important. Merging AI-driven risk management with sustainable urban planning can help develop smart cities that are resilient, adaptable, and secure, while also focusing on technological growth and human welfare. This comprehensive approach will assist in achieving Sustainable Development Goal 11 and the New Urban Agenda, creating cities that are not only smart but also safe and inclusive.

The future research path of **Qiu, R. G., Zu, T., Qian, Y., Qiu, L., & Badr, Y. (2018)** focuses on combining physical and social sensing in smart city risk management. The use of big data technologies allows for the collection, processing, and analysis of real-time data from sources like IoT devices and social media to gain a full understanding of urban dynamics. This blending can improve predictive analytics for risk assessment, helping city leaders to predict and reduce risks like natural disasters, traffic jams, and health crises. Additionally, developing advanced machine learning models can enhance the accuracy of these forecasts, leading to more effective and timely actions. The ongoing growth of this digital environment will ensure continued improvement in urban safety and management strategies. and efficiency of urban water management systems. The combination of blockchain's secure data handling with IoT's real-time monitoring and AI's analytical capabilities offers a chance for smart cities to respond better to water-related challenges. Future studies could consider developing methods to improve the tracking of water usage and enhance accountability, helping to prevent losses and promote conservation efforts. Also, the focus should be on creating smart contracts that automate and streamline water distribution, addressing issues swiftly as they arise. Collaborative efforts among tech developers, water management officials, and local authorities will be vital in crafting effective strategies that support sustainable water practices in urban settings. This systematic approach will ultimately improve not only water management but also overall public trust in city services. of these technologies can lead to improved efficiency in disaster response, infrastructure monitoring, and overall urban management. However, to achieve these advancements, urban areas must focus on overcoming technological and social barriers, as well as fostering collaboration among stakeholders to promote innovation.

The research by **Yigitcanlar et al. (2020)** focuses on how AI can help manage risks in urban innovation for smart cities. It reviews current and potential uses of AI in areas like business operations, data analysis, education, energy use, environmental care, health services, land management, security, transportation, and urban governance. The study aims to find gaps in the literature about the risks of AI and to examine the disruptions it might cause in city settings. By reviewing 93 studies, it intends to offer insights for building smarter cities while emphasizing the importance of managing AI-related risks to support sustainable urban development.

The study by **Yitmen (2023)** looks at combining blockchain with digital twins (DT) for risk management in smart cities, which shows great potential. As cities grow more complex, merging these technologies can establish a strong system for real-time monitoring and risk reduction. Blockchain offers a reliable way to ensure data accuracy and transparency, essential for trust in urban management. On the other hand, digital twins create realistic models of city operations, helping stakeholders foresee and tackle risks like disasters and infrastructure issues. Using AI, IoT, and big data, this combination can improve decision-making, resource efficiency, and resilience to unexpected occurrences, aiding in the sustainable growth of smart cities.

Future research by **Yarime (2019)** should explore how smart technologies can enhance risk management in the supply chains of woody biomass to support smart cities. This includes investigating how real-time data, IoT, and blockchain can increase efficiency and transparency in biomass logistics, thus reducing supply chain risks. Further studies should look into how these technologies can improve resource use, ensure biomass quality, and boost cooperation among stakeholders. Focusing on these factors can help create resilient urban energy systems that align with larger smart city goals and climate resilience efforts.

Chanda (2022) envisions future research in smart city risk management to involve advanced technologies like AI, machine learning, and blockchain for better predictive analytics and immediate decision-making. By applying these technologies, cities can develop stronger risk management strategies capable of identifying and reducing threats, ranging from natural disasters to cyber threats. Moreover, integrating these technologies can enhance the efficiency of responses to disasters and improve infrastructure oversight. IoT devices and sensors will help in monitoring and collecting data continuously, giving insights into city dynamics and weaknesses. Future studies should work on making smart city systems more secure and protecting privacy so that the large amounts of data are safe from breaches or misuse. The main aim is to build resilient and sustainable smart cities that can handle risks while keeping residents safe and well.

The future research areas of **Park, J.-ho, Salim, M. M., Jo, J. H., Sicato, J. C. S., Rathore, S., & Park, J. H. (2019**) in smart city innovation and risk management are broad and promising. They include better data analytics and AI use for predicting needs and personalizing services; creating adaptive systems for scalability and flexibility; strong security and privacy protections; sustainable development with smart energy management; increased citizen participation through smart governance; better disaster response and resilience; and promoting innovation through partnership and funding. These focuses can greatly aid in making cities smarter, safer, and more sustainable.

The future focus of **Ch, M. H. (2020)** in smart city risk management should be on using advanced digital technologies like cyber-physical systems, digital twins, and blockchain to make urban water systems more resilient and efficient. By utilizing these technologies, cities can create better models for energy recovery, like using micro-turbines and pumps as turbines to convert excess hydraulic energy into electricity. Also, applying network dynamics and deep learning can enhance leakage control and system resilience. A comprehensive, data-driven approach to managing water networks will help achieve zero-net energy use and ensure sustainable urban infrastructure in smart cities.

The future study from **Charles, Vincent & Emrouznejad, Ali & Gherman, Tatiana. (2023)** on blockchain and AI in supply chains, especially in smart city contexts and risk management, looks promising. As smart cities develop, having secure, quick, and transparent supply chains is vital. Blockchain can ensure solid records and improve traceability, while AI can enhance logistics and predict potential problems. Together, they can improve risk management by identifying weaknesses and enabling quick responses. This approach can lead to smarter and stronger urban systems that use resources better and deliver services faster, ultimately improving life for city residents.

2.2 Theory of Reasoned Action

The Theory of Reasoned Action (TRA), made by Fishbein and Ajzen, explains how beliefs, attitudes, intentions, and actions are linked. TRA suggests that a person's intention to act is influenced by their attitude toward it and the social norms around them. This concept is the foundation of this study, which examines what participants believe and intend regarding the use of new technologies like Blockchain, Artificial Intelligence, and Internet of Things in Smart City developments and Risk Management.

For this research, a survey was conducted over three months. Participants responded through an online platform. The purpose of the survey was to gather information about key elements related to the TRA framework. The findings are displayed in Table 2 below.

Refer to the Survey Questionnaire and Response in the Appendix C: Interview Guide Section.

In the context of the **Theory of Reasoned Action (TRA)**, the survey questions are grouped into three categories: **Attitude**, **Subjective Norms**, and **Behavioral Intention**. The alignment of the survey data with these categories are shown as follows:

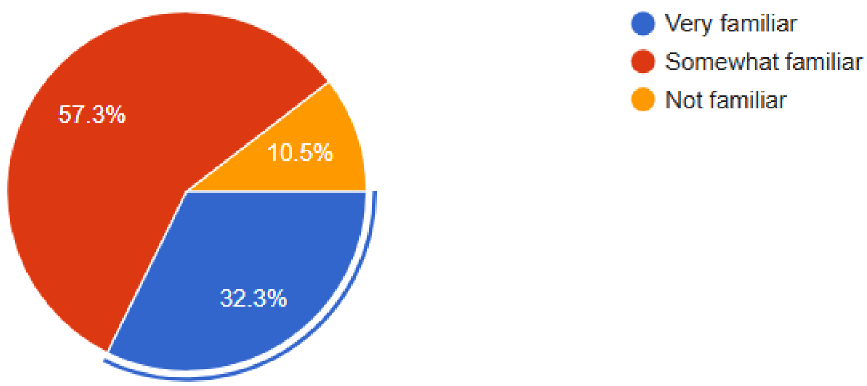
1. Attitude

Attitude refers to an individual's perception either positive or negative in performing a set of actions. Questions that reflect perceptions, or opinions about the technologies in Smart Cities would fall under this category.

Survey Questions grouped under Attitude:

- **Familiarity with Smart City Concepts and Technologies:**
    - "How familiar are you with the concept of Smart Cities and the technologies (AI, Blockchain, IoT) that enable them?"
    - *(57.3% are somewhat familiar, 32.3% are very familiar)*

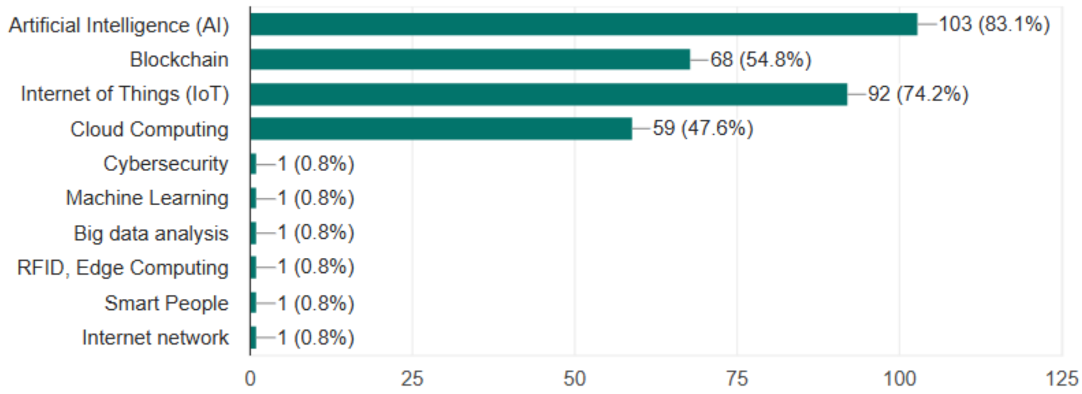
Figure 22: Familiarity with the concept of Smart Cities and the technologies (AI, Blockchain, IoT)



    - The result indicates the current level of awareness and acceptance. This further shapes attitudes toward adopting these technologies.

- **Crucial Technologies for Risk Management:**
    - "Which of the following technologies do you believe is most crucial for managing risks in a Smart City?"
    - *(AI: 83.1%, IoT: 74.2%, Blockchain: 54.8%)*

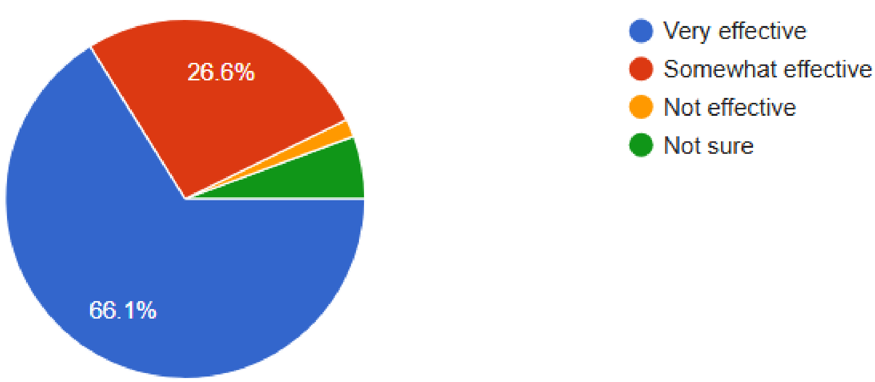
Figure 23: Most crucial technologies for Smart City Risk Management



- This reflects perceptions of importance and value associated with each technology.

- **Effectiveness of AI-Enabled Systems:**
    - "How effective do you think AI-enabled video surveillance and data analytics are in mitigating public safety risks in Smart Cities?"
    - *(66.1% Very effective, 26.6% Somewhat effective)*

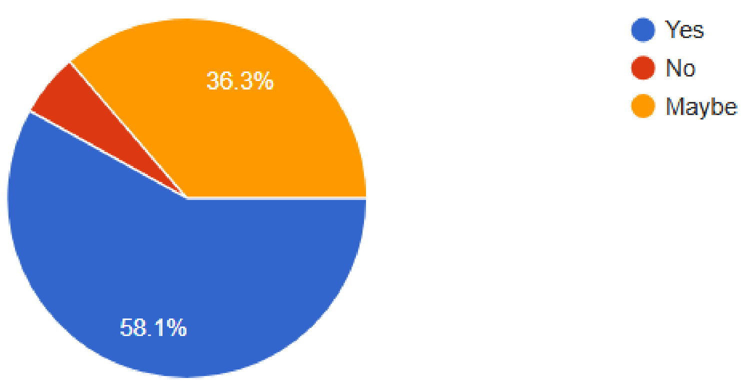
Figure 24: Effectivity of the AI-enabled video surveillance in mitigating public safely risks



- This indicates positive evaluation on leveraging AI enabled public safety applications.

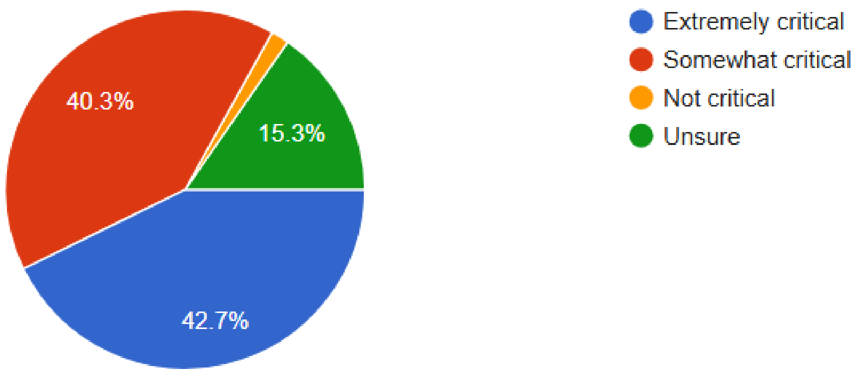
- **Perceptions of Blockchain for Public Safety and Transparency:**
    - "Would you trust a blockchain-based system to securely manage public safety data (e.g., crime reports, emergency response times)?"
    - *(58.1% yes, 36.3% maybe)*

Figure 25: Perception of Blockchain in Public Safety



    - "How critical is the role of blockchain in enhancing financial transparency and accountability in Smart City projects (e.g., smart contracts, automated financial transactions)"?
    - *(42.7% extremely critical, 40.3% somewhat critical)*

Figure 26: The role of Blockchain in financial transparency and accountability



- This highlights attitudes toward blockchain's role in solving specific Smart City challenges.

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2. Subjective Norms

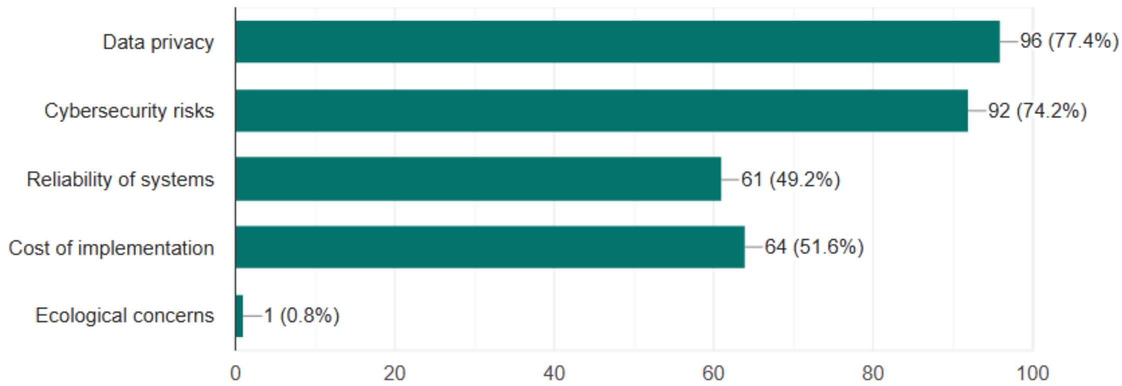
Subjective norms relate to the perceived social pressure to perform or not perform a behavior.[10] This is generally influenced by peers, community, or societal expectations.

Survey Questions grouped under Subjective Norms:

- **Concerns with AI and IoT:**
  - "What are your top concerns regarding the use of AI and IoT in public safety systems (e.g., surveillance, emergency response)?"
  - *(Data privacy: 77.4%, Cybersecurity risks: 74.2%)*

[10] https://www.researchgate.net/

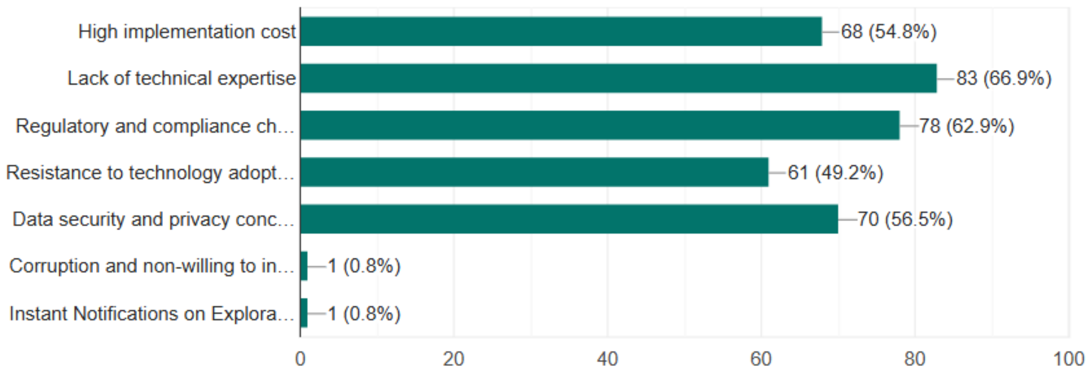
Figure 27: Top concerns regarding AI & IoT in Public safety systems



- The result reflects societal concerns and collective perceptions that influence behavior, such as trust in technology.

- **Barriers to Adoption:**
    - "What do you see as the most significant barrier to adopting AI, Blockchain, and IoT technologies for risk management in Smart Cities?"
    - *(Lack of technical expertise: 66.9%, Regulatory challenges: 62.9%, Data security concerns: 56.5%)*

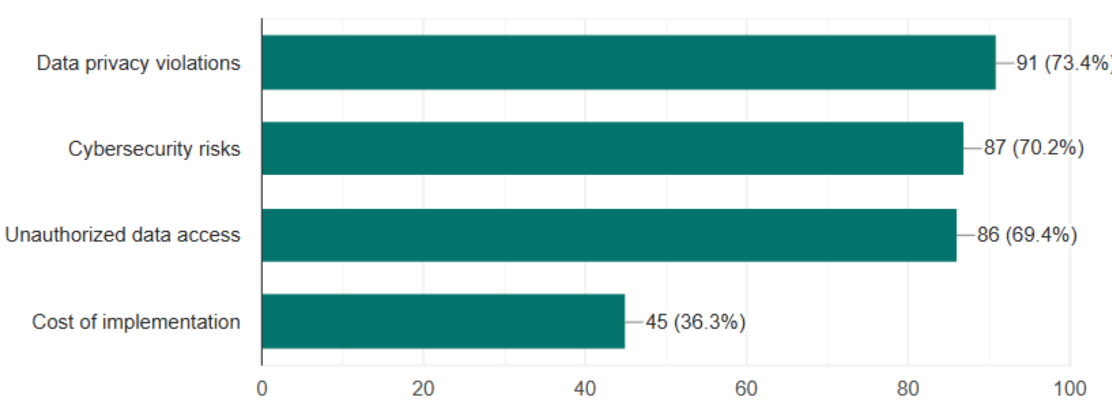
Figure 28: Barriers to Adoption of AI, IoT & Blockchain



- This indicates external social and institutional pressures that shape norms and expectations.

- **Education Sector Risks:**
  - "What concerns do you have regarding the use of AI and Blockchain for managing student data in Smart City educational institutions (e.g., privacy, data accuracy, security)?"
  - *(Data privacy violations: 73.4%, Cybersecurity risks: 70.2%)*

Figure 29: Concerns regarding use of AI & Blockchain in education



- This demonstrates collective societal apprehensions regarding technology integration in education.

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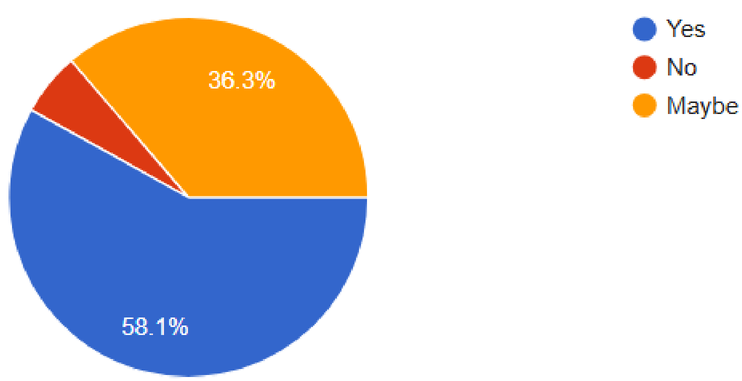
3. Behavioral Intention

Behavioral intention refers to the likelihood of performing a specific behavior. This reflects an individual's readiness or willingness to act.

Survey Questions grouped under Behavioral Intention:

- **Blockchain Trust for Public Safety:**
  - " Would you trust a blockchain-based system to securely manage public safety data (e.g., crime reports, emergency response times)?”
  - *(58.1% yes, 36.3% maybe)*

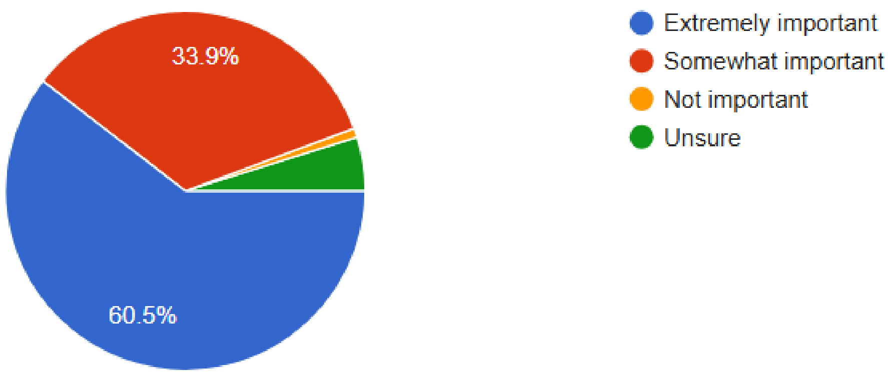
Figure 30: Trust for Blockchain in Public Safety



  - This indicates the willingness of individuals to adopt blockchain for this purpose.

- **Adoption of IoT in Energy and Agriculture:**
    - "How important do you consider IoT and AI in managing risks related to smart grids (e.g., power outages, energy theft, peak load management)?"
    - *(94% consider IoT extremely or somewhat important for energy)*

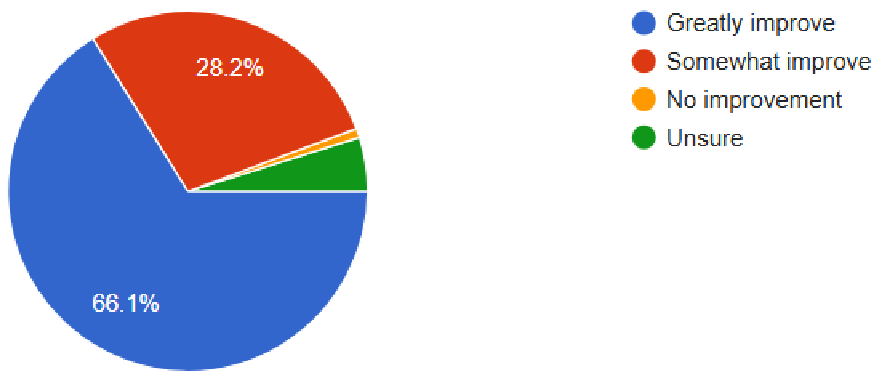
Figure 31: Adoption of IoT in energy



    - This reflects participants' intentions to prioritize IoT for addressing critical risks.

- **Supply Chain Risk Management:**
    - "To what extent do you believe that AI and IoT can improve supply chain risk management in Smart Cities (e.g., real-time tracking, predictive analytics)?"
    - *(AI and IoT: 66.1% greatly improve, 28.2% somewhat improve)*

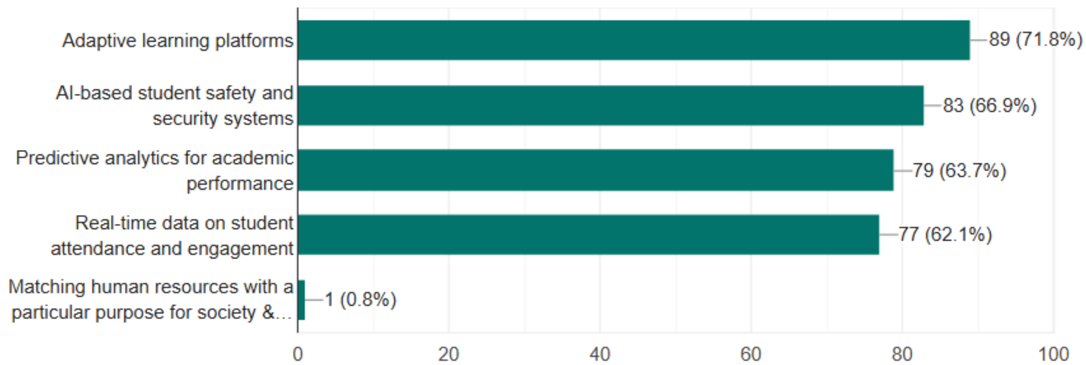
Figure 32: Trust on AI & IoT in improving supply chain



- This indicates participants' readiness to consider these technologies for supply chain challenges.

- **Adaptive Learning Platforms in Education:**
  - " Which of the following AI-enabled tools can most effectively manage risks in the education sector of Smart Cities?"
  - *(71.8% effective)*

Figure 33: AI-enabled tools that can most effective manage risk in education sector



This reflects intentions to support or adopt these platforms in the education sector.

2.2.1. Mapping the TRA Framework:

Table 2: Mapping of Theory of Reasoned Action (TRA) Framework to Actual Survey Data

TRA Component	**Survey Themes/Questions**
Attitude	Familiarity with Smart City technologies, Importance of AI/Blockchain/IoT, Effectiveness of AI-enabled systems.
Subjective Norms	Concerns about AI/IoT, Barriers to adoption, Data privacy and cybersecurity issues, Education sector risks.
Behavioral Intention	Willingness to trust blockchain, IoT importance in energy/agriculture, AI adoption in education and supply chain.

CHAPTER III:

METHODOLOGY

3.1 Overview of the Research Problem

The current study looks at risk management in smart cities, which is a new topic because urbanization, technology, and sustainability are growing quickly. The fast rise in urban population, expected to reach **68 percent of the global population by 2050**, creates coordinated risks that can make these systems work better.

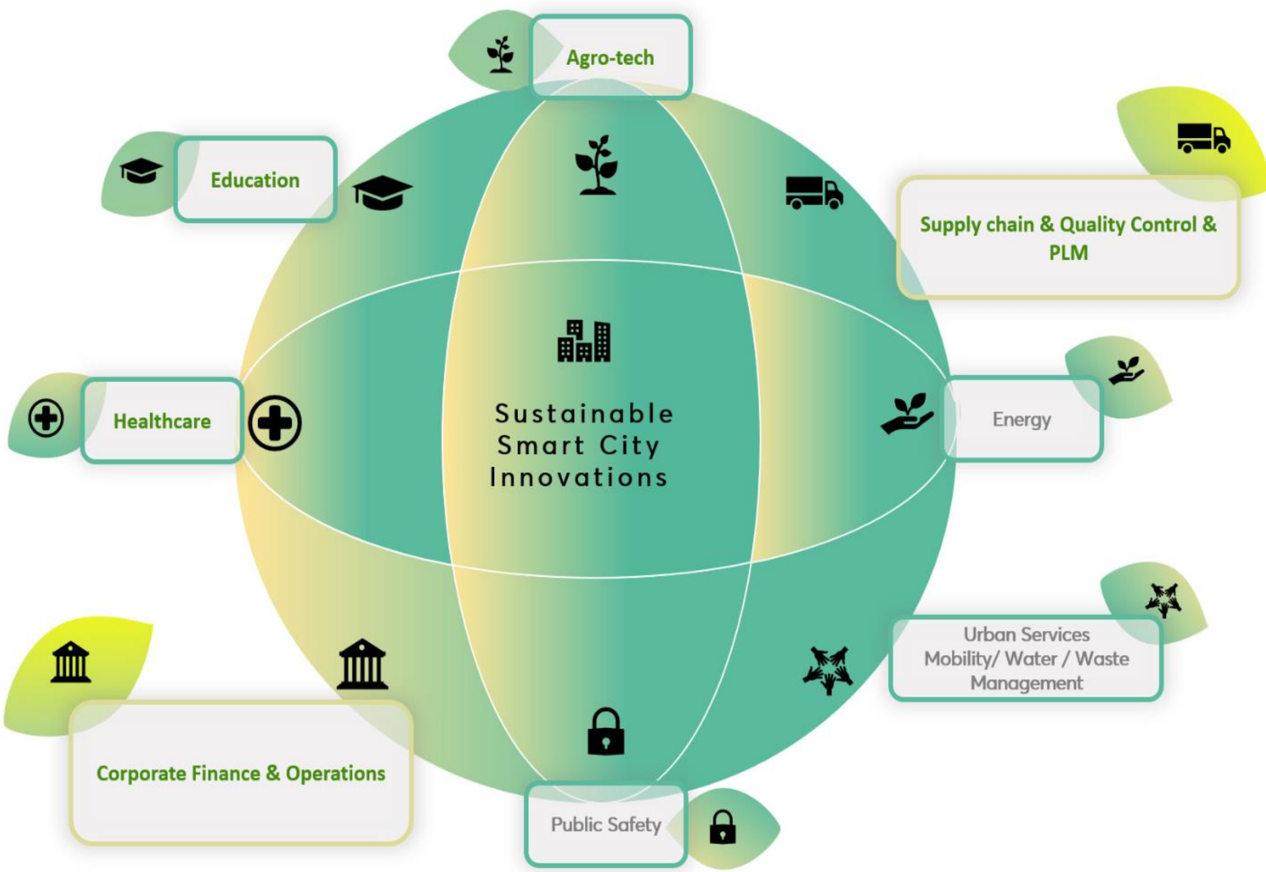
Traditional risk management methods are struggling to deal with many challenges, especially those related to environmental, social, and technological issues. As urbanization accelerates, smart urban planning is essential.

Thinking of Smart Cities requires a focus on the basics. Cities are constructed from smaller parts—business operations, water systems, energy, agriculture, healthcare, education, and supply chains. Logistics, public safety, and waste management are also very important.

Each of these areas has specific issues. For example, poor risk management in water supply can cause shortages or pollution. In healthcare, risks can slow down services or threaten patient safety. Disruptions in supply chains can stop the flow of necessary goods, affecting whole communities.

Managing risks in all these areas is very important. By solving these issues at the basic level, we can build a stronger, more resilient city. Once these smaller parts are stable, we can expand to citywide management. This approach will help the whole system work better, sustainably, and with fewer interruptions. It's crucial to establish a strong foundation before aiming for greater heights.

Figure 34: Sustainable Smart City - Micro Units



3.2 Narrowing the Focus: Diving Deep into Critical Sectors

A city's intelligence depends on how well its main parts work together. While every sector matters, two are very critical for research and innovation: supply chain and industry operations. This is particularly true in a global context.

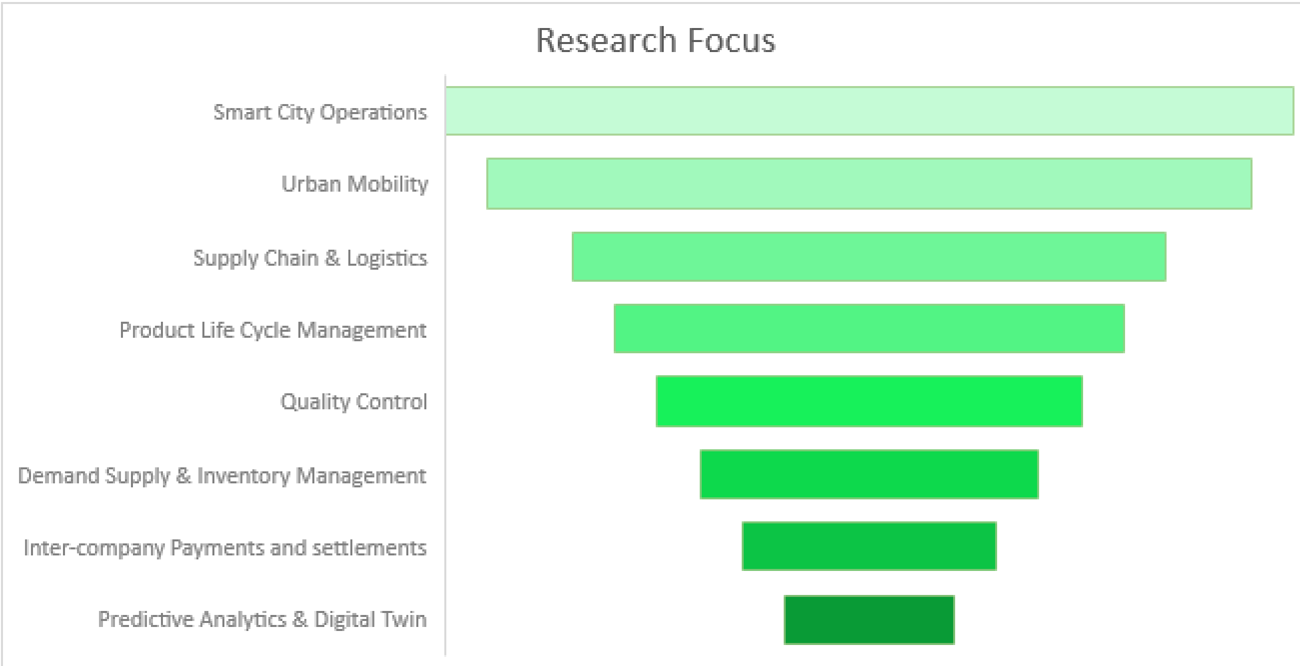
The supply chain is essential. Any disruption here can have big effects. Costs of goods can increase sharply. There could be shortages of critical medicines, food, or necessary crops. Such problems can impact city functions and daily life significantly.

When disruptions occur across borders, the problems multiply. Governments have to deal with complex laws and regulations. Geopolitical tensions can rise, leading to delays and distrust. Trade policies, changes in currency value, and national security issues become relevant. These disruptions affect not only one city but can impact whole global systems.

Specifically, the risks associated with transactions between businesses and supply chains pose basic challenges. Global business operations, foreign transactions, and complicated relationships increase these risks. As smart cities grow, there is a rising need for better systems that can handle these risks effectively and quickly.

Thus, this research seeks to explore the use of modern technologies like blockchain, artificial intelligence (AI), and the Internet of Things (IoT) in Enterprise Risk Management (ERM) frameworks. These technologies could enhance risk management efficiency, provide better transparency, and create stronger structures.

Figure 35: Narrowing the Focus: Diving Deep into Critical Sectors



3.3 Operationalization of Theoretical Constructs

Talking about the theoretical constructs in the research focus areas of supply chain, mobility, and industry operations; let's further delve deeper into these critical sectors. The supply chain is the backbone of any business operation, but it has its own set of problems & challenges. These issues can cause inefficiencies, delays, and increased costs. Let's explore some key pain points and the associated risks, particularly in sectors like aerospace and defense, pharmaceuticals, and organic food manufacturing.

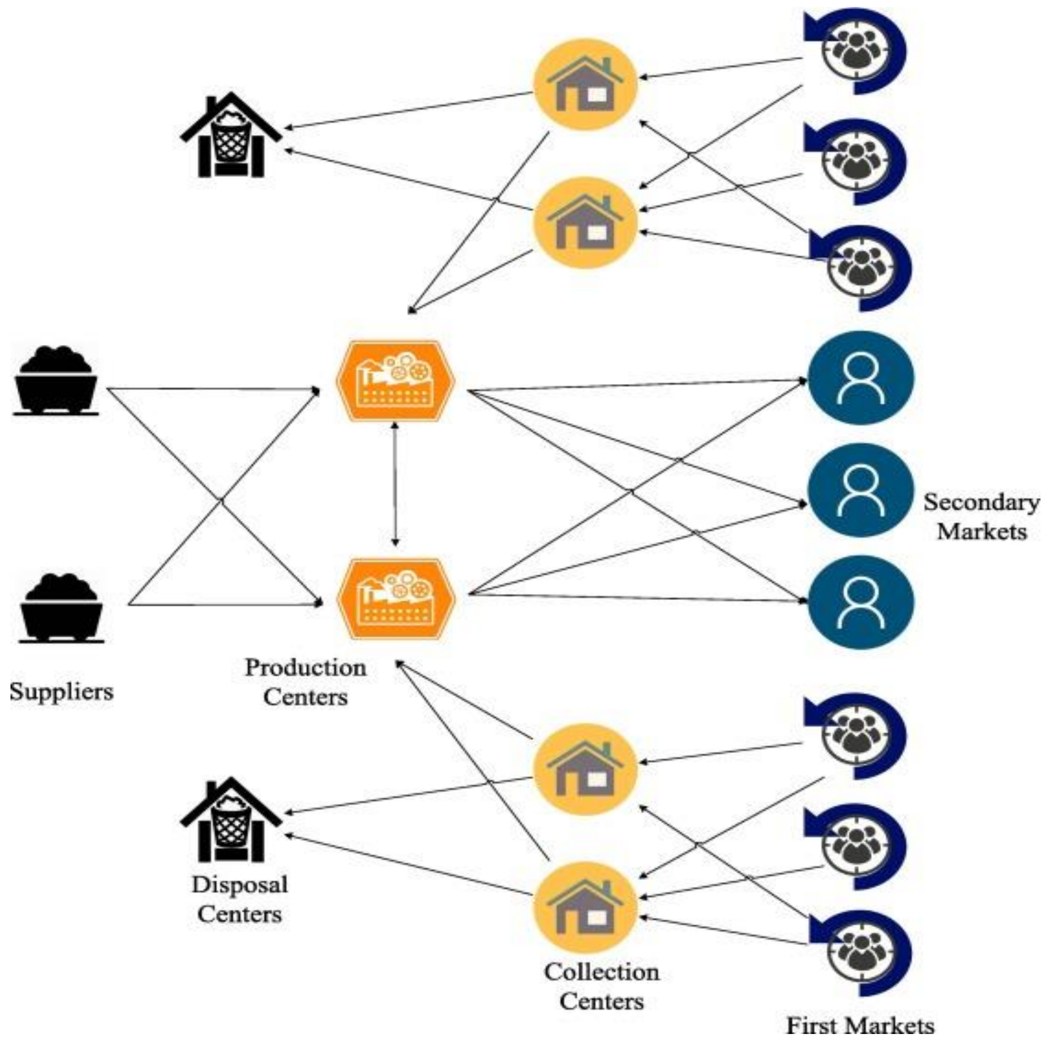


Figure 36: Non-linear Supply Chain Ecosystem

3.3.1 Demand-Supply Misalignment:

One of the biggest challenges in the supply chain is matching demand with supply. Overestimating demand can lead to overproduction and waste, while underestimating it results in stockouts and customer dissatisfaction. In sectors like pharma, a mismatch can mean shortages of life-saving drugs. In aerospace, delayed delivery of key parts can halt production lines for months. For organic food chains, overstocking leads to spoilage and losses, while shortages affect retail commitments.

3.3.2 Minimizing Transportation Costs:

Transportation is one of the highest costs in the supply chain. Efficient logistics planning is essential to keep these costs under control. For aerospace and defense, transporting heavy equipment and parts globally requires careful route and cost analysis. Similarly, in pharma, maintaining a cold chain for sensitive drugs like vaccines increases costs. Organic food supply chains must also ensure minimal transport times to maintain freshness while keeping costs low.

3.3.3 Best Route Decisions

Choosing the best route for transportation is another critical factor. Poor route planning can lead to delays and increased fuel consumption. For example, in defense, delays in shipping equipment can disrupt military readiness. In pharma, a delayed route can compromise drug quality if temperature-sensitive shipments are exposed to fluctuating conditions. Organic food chains risk product spoilage, especially for perishable items.

3.3.4 Distribution Channel Setup and Greenfield Analysis

Setting up efficient distribution channels is key to ensuring that products reach the right place at the right time. Greenfield analysis helps determine optimal locations for warehouses and distribution centers. In aerospace, this could mean setting up hubs near manufacturing plants or ports. For pharma, it’s about proximity to hospitals or retail pharmacies. In organic food, distribution centers must be close to farms and urban centers to reduce transit times. Poor decisions here can lead to increased costs, delays, and inefficient operations.

3.3.5 Product Life Cycle Management

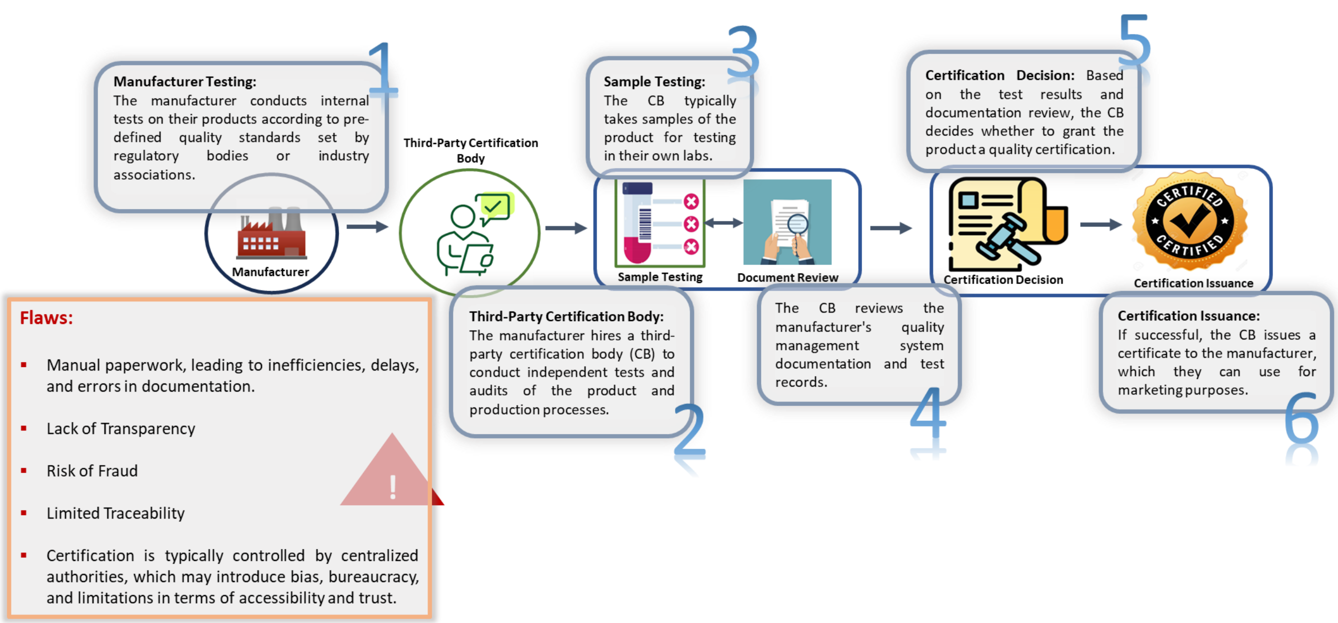
Managing a product through its lifecycle—from design to disposal—is essential. For aerospace, outdated parts can’t be used in advanced systems, leading to high replacement costs. In pharma, expired drugs pose risks to patient safety and require careful disposal. Organic food products have short lifecycles, making timely distribution critical to avoid waste. Inefficiencies in managing these lifecycles can result in financial and reputational losses.

3.3.6 Quality Control and Certification

Figure 37: Quality Control Stages

Ensuring consistent quality and obtaining the necessary certifications are non-negotiable in these industries. For aerospace, a single faulty part can lead to catastrophic failures. In pharma, non-compliance with regulatory standards like FDA approval can result in fines or product recalls. Organic food chains must adhere to strict certification processes to maintain consumer trust and market access. Poor quality control can lead to safety risks, regulatory penalties, and loss of market credibility. [11]

Figure 38: Traditional Quality Control - Associated Flaws



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11 Image Source: https://pawlafashion.com/quality/

3.3.7 Inventory Management

Balancing inventory levels is a constant struggle. Holding too much inventory ties up capital and increases storage costs, while holding too little results in stockouts. For defense, having an excess inventory of spare parts might seem safe but could result in obsolescence. For pharma, overstocking medicines that have short shelf lives leads to wastage. Organic food chains face similar challenges, as perishable items can spoil quickly if not sold in time.

3.3.8 Warehouse and Raw Material Supplier Management

Managing warehouses and raw material suppliers is another pain point. Warehouses must be located strategically, and suppliers must be reliable. In aerospace, storing large components requires significant space and security. In pharma, warehouses must meet strict temperature and humidity controls. Organic food warehouses must ensure clean and pest-free environments. Poor supplier relationships or inadequate warehouse conditions can lead to production delays and quality issues.

3.3.9 Risks Across These Pain Points

Every one of these challenges comes with associated risks:

Aerospace and Defense: Delays in part deliveries can jeopardize national security. Faulty components can lead to mission failure or loss of life.

Pharma: Supply chain disruptions can lead to shortages of essential medicines, affecting public health. Regulatory non-compliance risks hefty penalties.

Organic Food: Delays or quality issues can break trust with consumers, affecting sales and brand reputation.

The interconnected nature of global supply chains means that one weak link can disrupt the entire operation. For cross-border supply chains, geopolitical tensions, varying regulations, and currency fluctuations add more complexity. Addressing these pain points with data-driven insights, automation, and advanced technologies is critical to ensuring smooth and resilient supply chain operations.

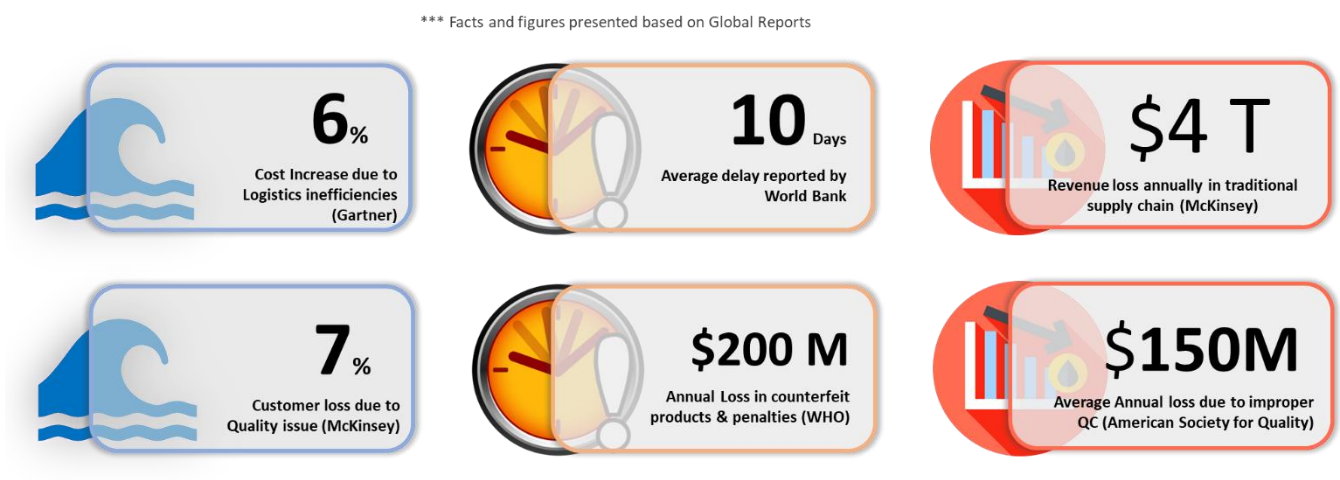


Figure 39: Facts and Figures from Reports published globally- SCM & QC Losses

3.3.10 Corporate Finance - Impacts

When we talk about all these supply chain operations, we also have to consider the added challenges of cross-border payments and settlements. These transactions often occur between various entities like vendors, suppliers, and distributors. The risks here are significant, especially when it comes to intercompany reconciliation and transactions between related parties.

3.3.11 What is Inter-company reconciliation in the context of supply chain?

Intercompany reconciliation refers to the process of matching and confirming transactions between different entities within the same corporate group or supply chain network. For example, a manufacturer might sell parts to a distributor, and the distributor might owe money. Reconciliation ensures that the amounts recorded by each party align, preventing discrepancies.

By Accounting definition: Intercompany Reconciliation (ICR) is the process of matching and verifying financial transactions between two or more entities within the same parent company.

If a company has multiple subsidiaries, they often exchange goods, services, or money. These transactions must balance correctly in both companies' books.

A **Related Party Transaction (RPT)** is a deal, arrangement, or transaction made between two parties who have a pre-existing relationship (e.g., family ties, shared ownership, or management control).

These parties are often referred to as **"related parties"** under the Companies Act, 2013 in India, and their transactions must comply with regulations to avoid unfair advantages or financial manipulation.

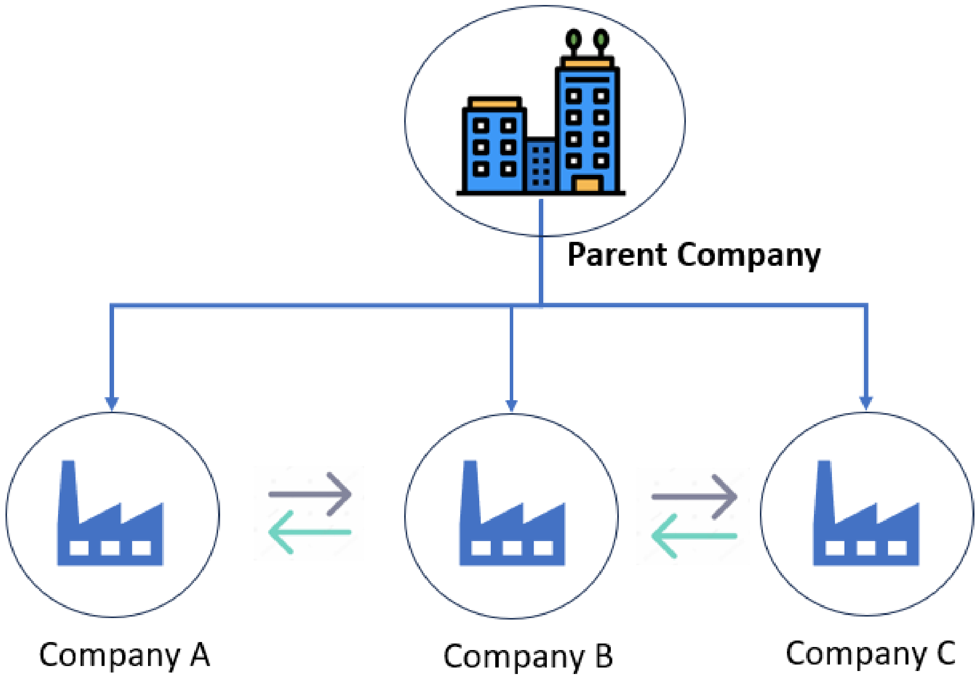


Figure 40: Inter-company Transactions

Related Parties (RP):

Defined by regulations like the Companies Act, focusing on legal, ownership, or governance connections (e.g., director-to-company, relative-to-company relationships). Transactions must comply with legal requirements such as arm's length pricing and regulatory reporting.

Who are Related Parties?

According to Section 2(76) of the Companies Act, 2013, [12]related parties include:

- ✓ Directors or their relatives

[12] https://www.mca.gov.in/Ministry/pdf/CompaniesAct2013.pdf

- ✓ Key managerial personnel (KMP) or their relatives
- ✓ Any firm, private company, or public company in which a director or KMP or their relative is a partner, director, or holds significant control or interest
- ✓ Any person on whose advice or direction, a director or KMP acts
- ✓ Subsidiary, holding, or associate companies

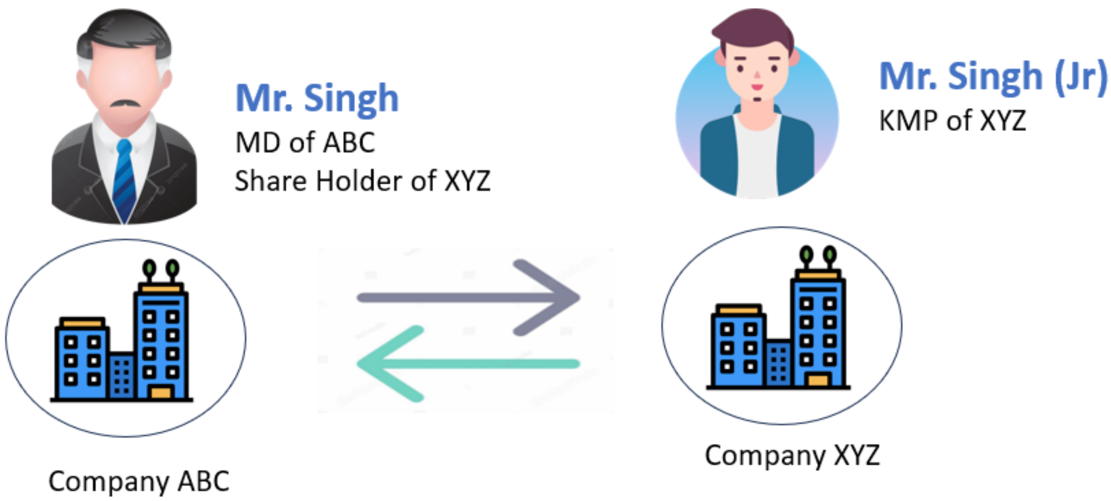


Figure 41: Example of Related Parties Transaction

Inter-Related Parties (IRP):

A broader concept that includes companies connected through corporate ownership (e.g., parent and subsidiaries) but does not necessarily fall under the strict legal criteria of RP.

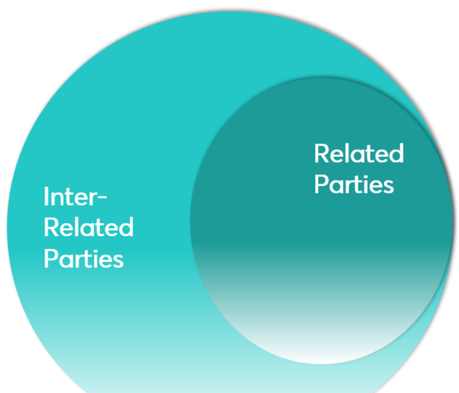


Figure 42: Inter-related parties vs Related parties Transactions

Transactions may be part of normal business operations within a corporate group (e.g., inventory transfers between subsidiaries).

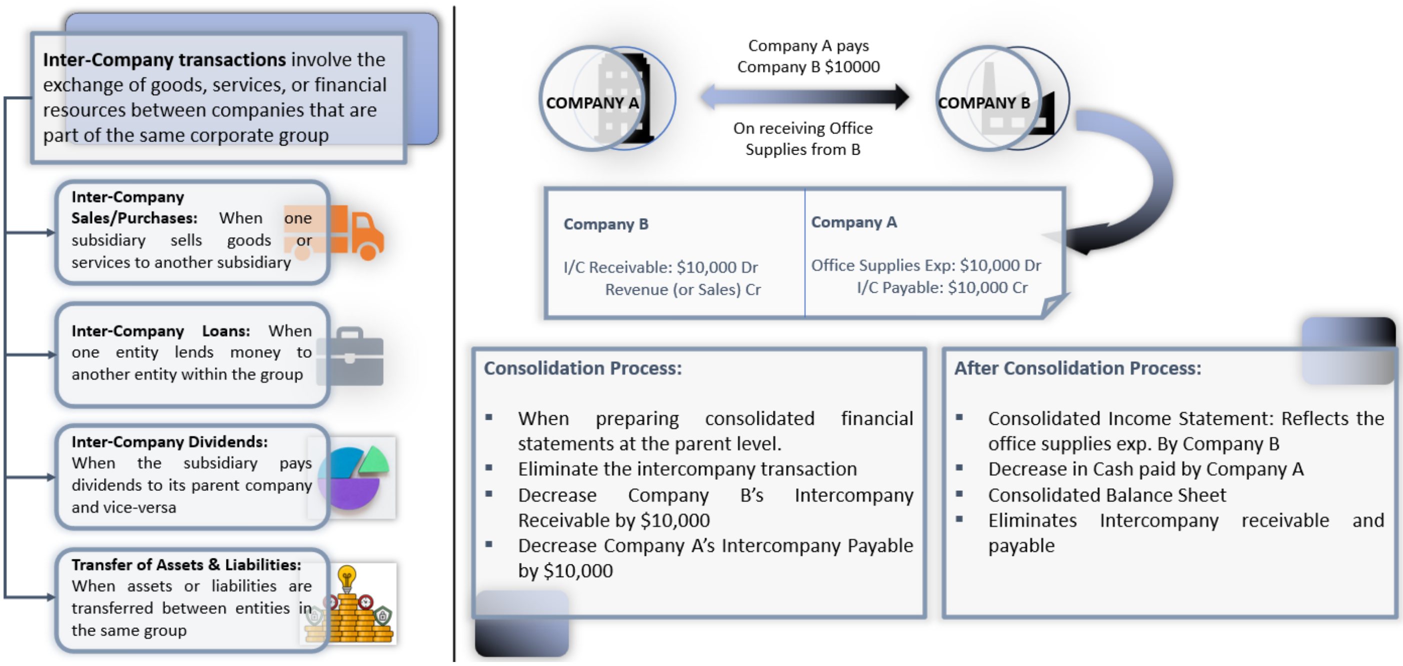


Figure 43: Inter-company reconciliation Process

3.3.12 Risks associated with Inter-company transactions

These intercompany transactions pose risks because multiple parties are involved, and their records need to match. If there are errors, it could lead to financial losses, delays, or disputes. For instance, a supplier might claim they were paid, but the buyer's records show otherwise. This misalignment can cause friction and even lead to legal issues.

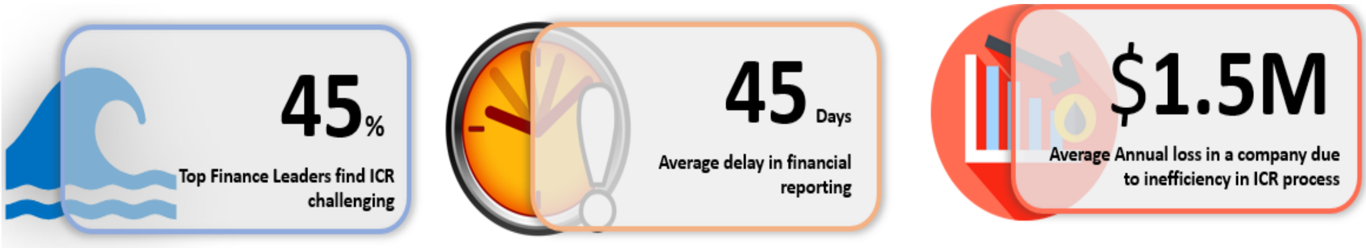


Figure 44: Big 4 Reports on Losses occurring in inefficient ICR

3.3.13 Scams and past issues

In the past, there have been several high-profile scams involving intercompany transactions. Some companies inflated sales or misreported payments to boost their financial standing. This happened when the reconciliation process wasn't transparent or rigorous enough. Without proper checks, it becomes easy for fraudsters to take advantage of the system.

Figure 45: Global Inter-company transaction scams

3.3.14 ERP system challenges

Another layer of risk comes from the fact that different entities in the supply chain often use different ERP (Enterprise Resource Planning) systems. These systems might not communicate well with each other, leading to mismatches in financial records. When entities cannot sync their data, reconciliation becomes even more complicated. This issue is further magnified in cross-border transactions, where currency conversions, tax laws, and trade regulations also play a role.

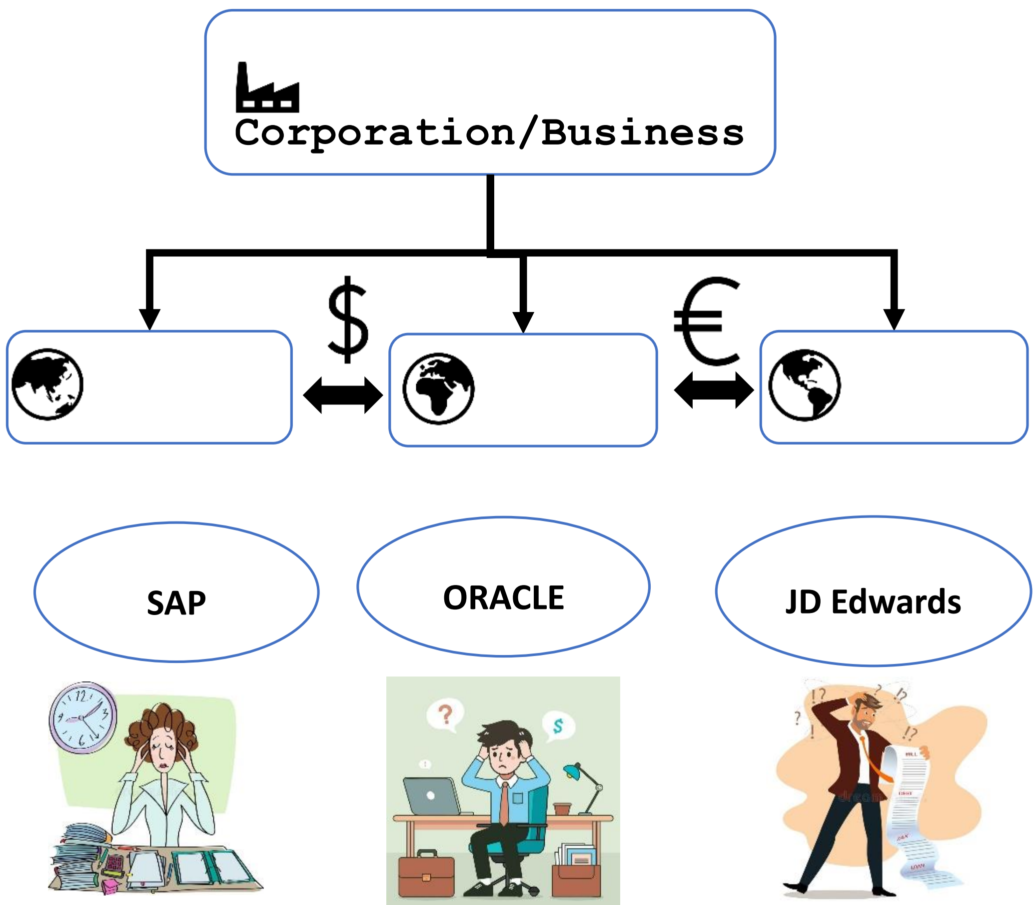


Figure 46: Entities using different ERPs

3.3.15 Unified ledger issue

Trying to bring all these separate records together into a unified ledger is difficult. Each ERP system is built differently and may not be designed to handle complex, global supply chains. This means extra time and effort are spent reconciling data. Additionally, this increases the chances of human error and discrepancies.

3.3.16 Key Problems faced in Inter-company reconciliation process:

- Failure to eliminate inter-company transactions can lead to an overstatement of assets, revenues, and profits in the consolidated financial statements.

- Proper documentation of inter-company transactions is crucial for transparency and audit purposes.

- Financial Statements should disclose related party transactions, and notes should provide details about the nature and extent of these transactions.

- Directly impact companies by causing delays in financial reporting and decision-making.

- The delays can lead to missed business opportunities and strained relationships with stakeholders.

- Inaccurate reconciliation may result in financial discrepancies, damaging trust and credibility

Cross-border payments and intercompany reconciliation in the supply chain are risky. These risks come from discrepancies in records, different ERP systems, and even fraudulent activities. Addressing these challenges is crucial for maintaining trust and smooth operations across all entities in the supply chain.

3.4 Research Purpose

The purpose of this research is to create innovative solutions for managing risks in smart cities. The focus is on using cutting-edge technologies like AI, IoT, and Blockchain. With this goal in mind, I worked on developing visionary deep tech solutions. I started with ideation, built minimum viable products (MVPs), and prepared these solutions for launch.

I architected two key platforms: **Swikriti** and **Viniyog**. Each has a unique purpose and addresses critical challenges in its own way.

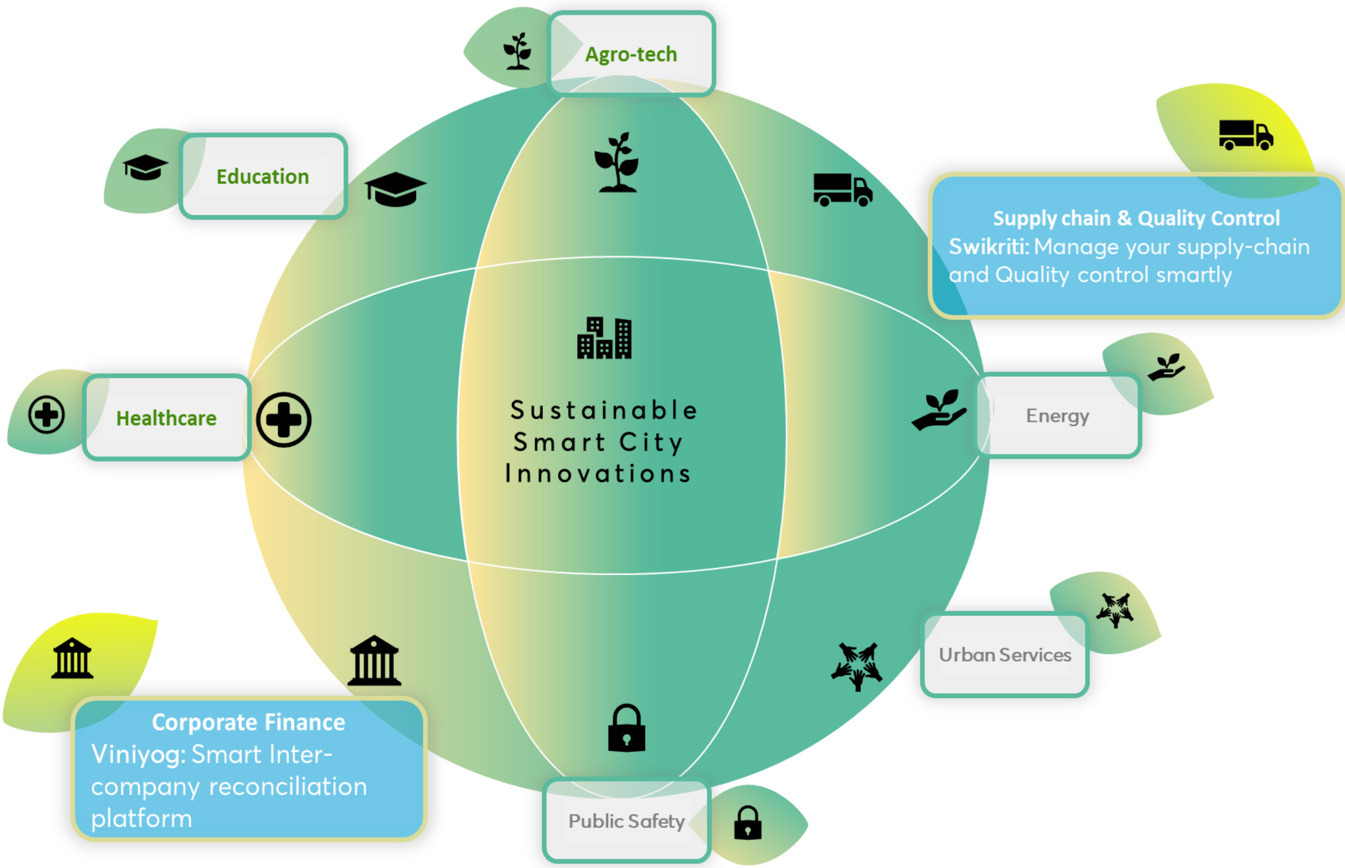


Figure 47: Introducing flagship innovations: Viniyog & Swikriti

3.4.1 **Swikriti** – A Smart Chain Solution

Figure 48: Swikriti - A Smart Supply chain Solution

Swikriti focuses on ensuring product integrity across the supply chain. It brings transparency, trust, and efficiency by tracking a product's entire lifecycle. It's the **one stop solution** solving **Nine**

Critical pain points and mitigating supply chain risks

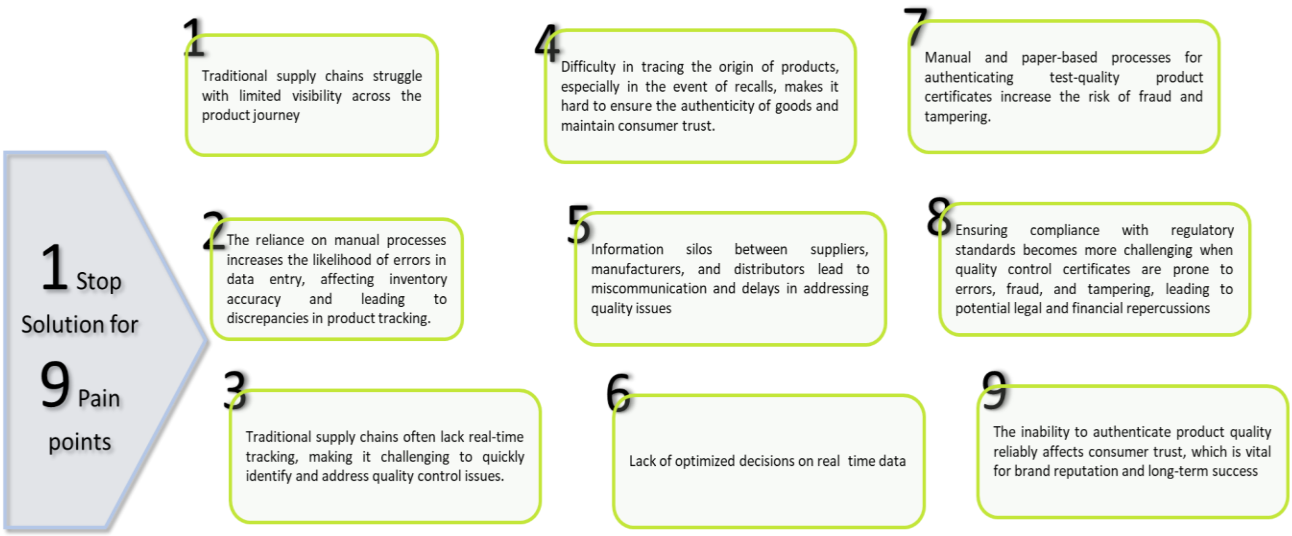


Figure 49: Introducing Swikriti- A One Stop Solution for Nine Critical Risks/pain points

The solution uses blockchain to certify authenticity and record every step.

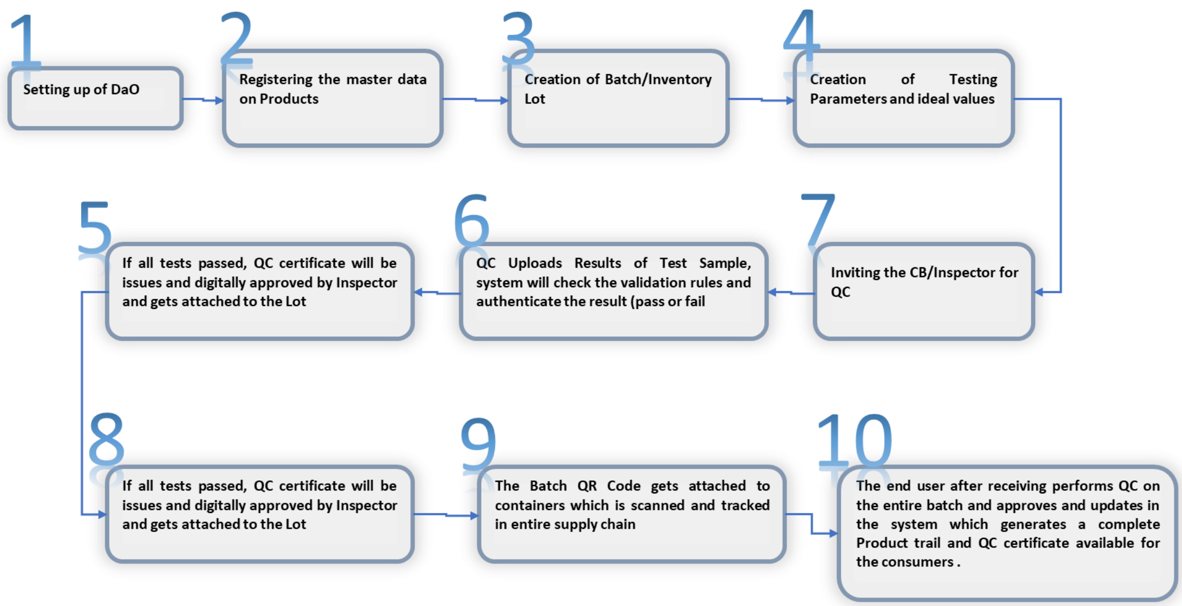


Figure 50: Blockchain based Supply-chain & Product Quality Certification – Process Flow – SWIKRITI

Swikriti leverages real time data & predictive analytics for better forcasting and decision making based on the real time data.

Figure 51: Different types of supply chain analytics

3.4.2 Role of Supply chain Analytics:

Demand Forecasting: Uses historical data and trends to predict future demand, reducing stockouts and excess inventory.

Inventory Optimization: Balances inventory levels to meet demand without overstocking, minimizing holding costs.

Supplier Performance Analysis: Evaluates supplier reliability, quality, and delivery times, improving supplier relationships and decision-making.

Risk Management: Identifies potential disruptions in the supply chain and enables proactive risk mitigation.

Cost Reduction: Analyzes costs across the supply chain to find areas for savings, such as transportation, warehousing, and procurement.

Operational Efficiency: Identifies inefficiencies and bottlenecks, enables process improvements to increase throughput.

Logistics and Transportation Optimization: Improves route planning, fuel efficiency, and reduces transit times, minimizing shipping costs.

Quality Control: Monitors product quality across the supply chain to ensure consistency and compliance.

Customer Satisfaction: Enhances service levels by reducing delays, improving delivery accuracy, and increasing order fulfillment rates.

Sustainability and Compliance: Tracks and reduces the environmental impact of supply chain activities, ensuring adherence to regulatory standards.

Swikriti introduces **Digital Twin technology**. This means every physical product has a digital replica. The twin records real-time data about the product's condition, movement, and ownership. This is especially important for industries like organic food, pharma, and aerospace, where quality and certification are critical.

3.4.3 What is Digital Twin?

- A digital twin is a virtual representation of a physical object, system, or process.
- Mimics real world entity in terms of its attributes, behavior and interactions.
- Usually created using data from sensors, IoT devices, and other sources along with advanced modelling and simulation techniques.

[13]

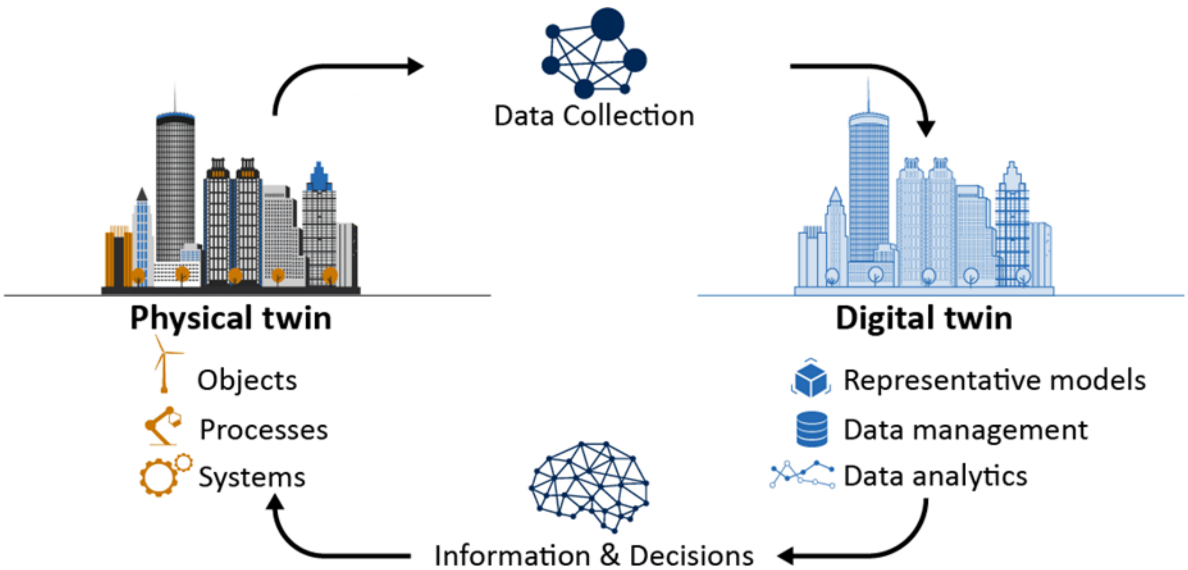


Figure 52: Digital Twin

There are various types of digital twin, but currently I am building the twins of Supply chain network and Network of Networks (NoN)

- Product
- Process
- Company
- Supply chain network
- Network of Networks (NoN)

[13] Source: https://www.gao.gov/products/gao-23-106453

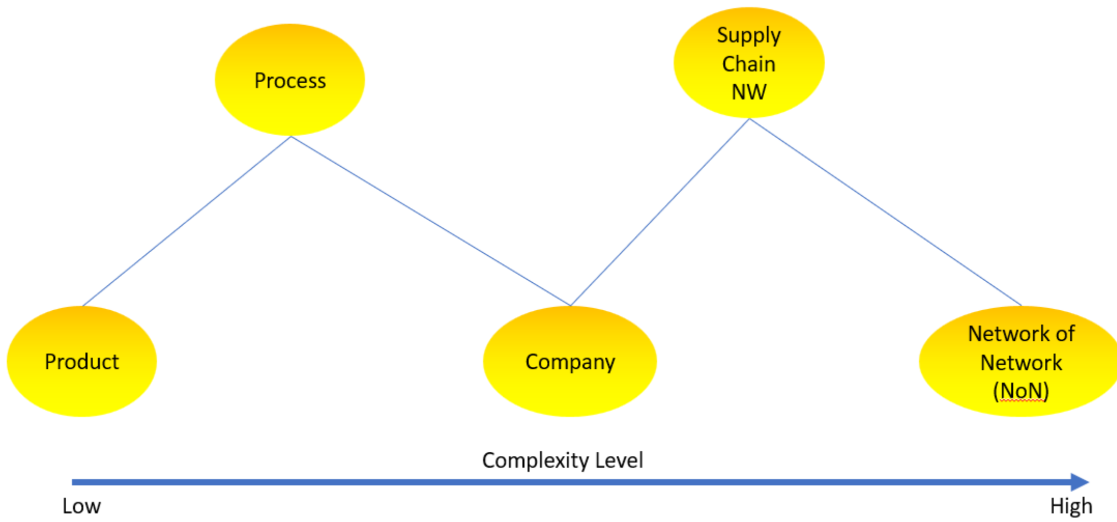


Figure 53: Types of Digital Twin

The platform also integrates with IoT sensors to monitor product storage conditions like temperature and humidity. This reduces risks like spoilage or damage during transit. Swikriti offers a seamless way to ensure that the product reaching the end user is exactly what it claims to be. So the different enablers of a digital twin is shown as follows:

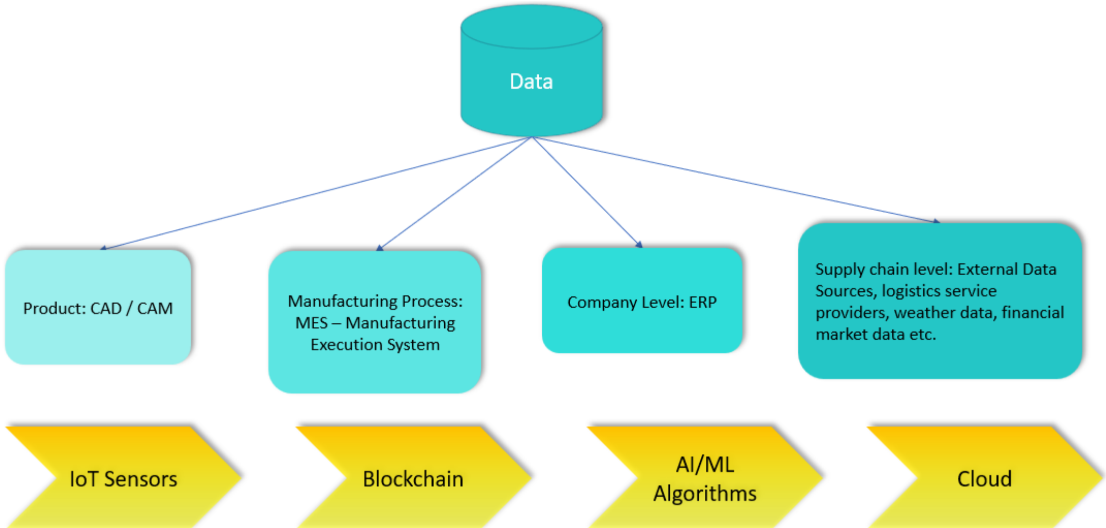


Figure 55: Digital Twin Enablers

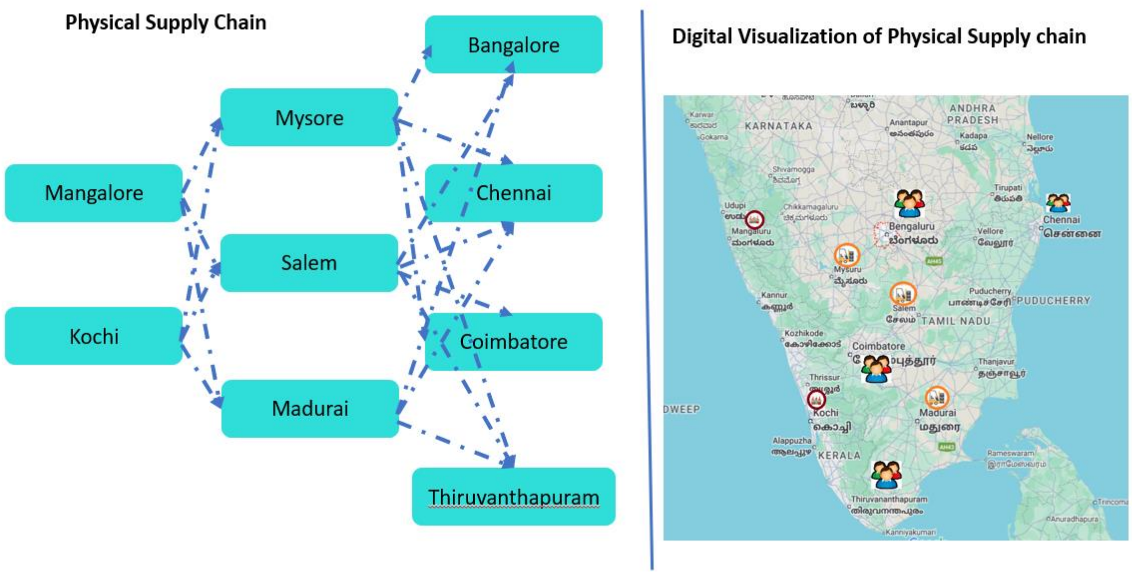


Figure 54: Physical Supply chain vs Digital Visualization of Physical chain

3.4.4 Advantages of Swikriti's Digital Twin

- Enhanced Visibility and Real-Time Tracking
- Predictive Maintenance and Asset Optimization
- Demand Forecasting and Inventory Optimization
- Enhanced Scenario Planning and Risk Management
- Improved Sustainability and Waste Reduction
- Faster and More Effective Decision-Making
- Enhanced Collaboration and Communication
- Better Customer Experience and Service Levels
- Cost Savings through Process Optimization
- Scalability and Flexibility
- Enhanced Traceability with Blockchain Integration

3.4.5 Swikriti: Mitigating Risks Through Quality Control and Certification

Swikriti reduces risks by using blockchain for quality control and certification. It ensures that every product in the supply chain is tracked and verified at each stage.

One major risk it addresses is counterfeit products. Blockchain creates an unchangeable record, making it impossible to tamper with certifications. This ensures only authentic goods reach the market.

For industries like pharma, Swikriti minimizes the risk of fake medicines. It certifies the source and quality of drugs, protecting consumer safety.

In the organic food industry, it prevents false labeling. It verifies that the food meets organic standards throughout its lifecycle.

Swikriti also addresses supply chain fraud. Blockchain transparency makes it easier to detect discrepancies, like altered records or missing shipments.

The platform helps companies comply with regulatory standards. Certification data is stored securely and can be audited anytime. This reduces non-compliance risks.

Finally, it reduces the risk of disputes between parties. A single, tamper-proof source of truth eliminates misunderstandings about product quality or delivery.

Swikriti ensures trust, transparency, and accountability in every step of the supply chain.

Swikriti can be referred from the following links:
https://swikriti.shihaantech.com/
https://www.youtube.com/watch?v=rJlksfWhxAA

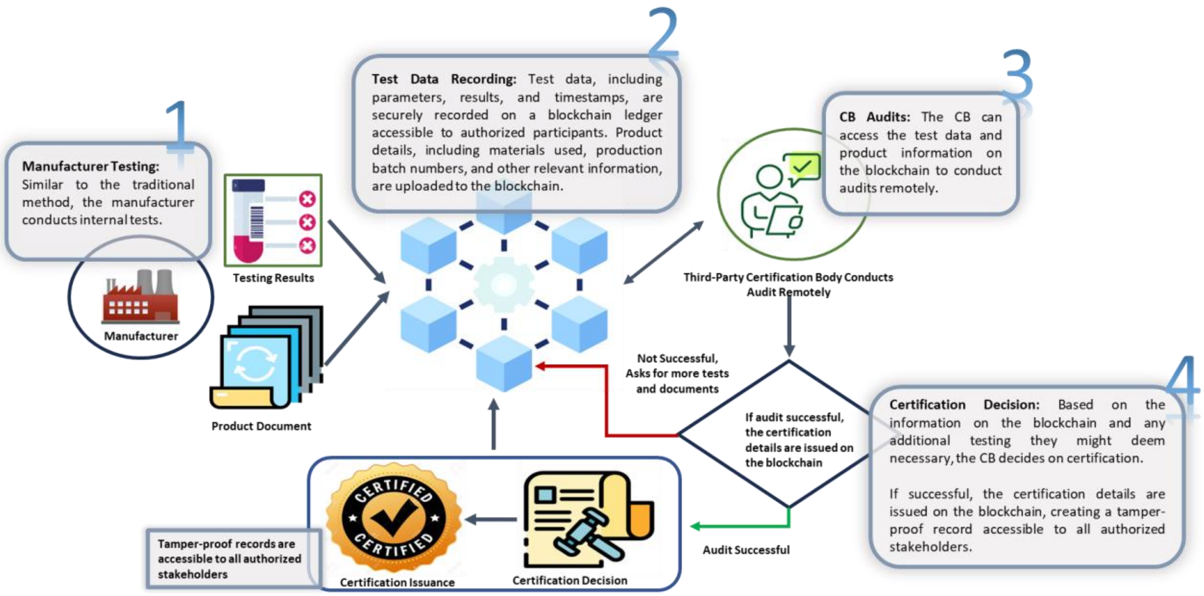


Figure 56: Swikriti- Blockchain based Quality Control & Product Certification

3.4.6 Blockchain & AI enabled Supply chain- Global Market Trends

The following trends clearly shows that how industries are inclined to using cutting edge technologies to reduce supply chain risks.

Figure 57: Global blockchain based SCM Market Trend

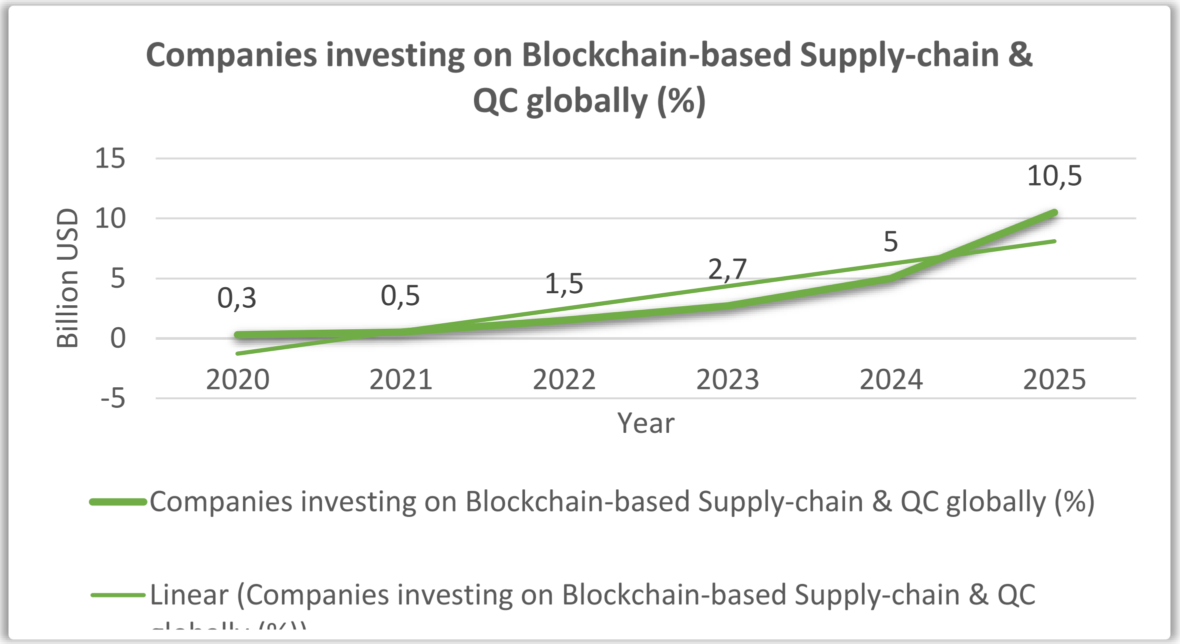


Figure 58:Companies investing on Blockchain-based Supply-chain & QC globally (%)

3.4.7 Swikriti- A Blockchain and AI based Smart Supply Chain Solution

As discussed as how Swikriti is solving the supply chain risks using cutting edge technologies like blockchian, artificial intelligence and internet of things, here are some actual product prototype images.

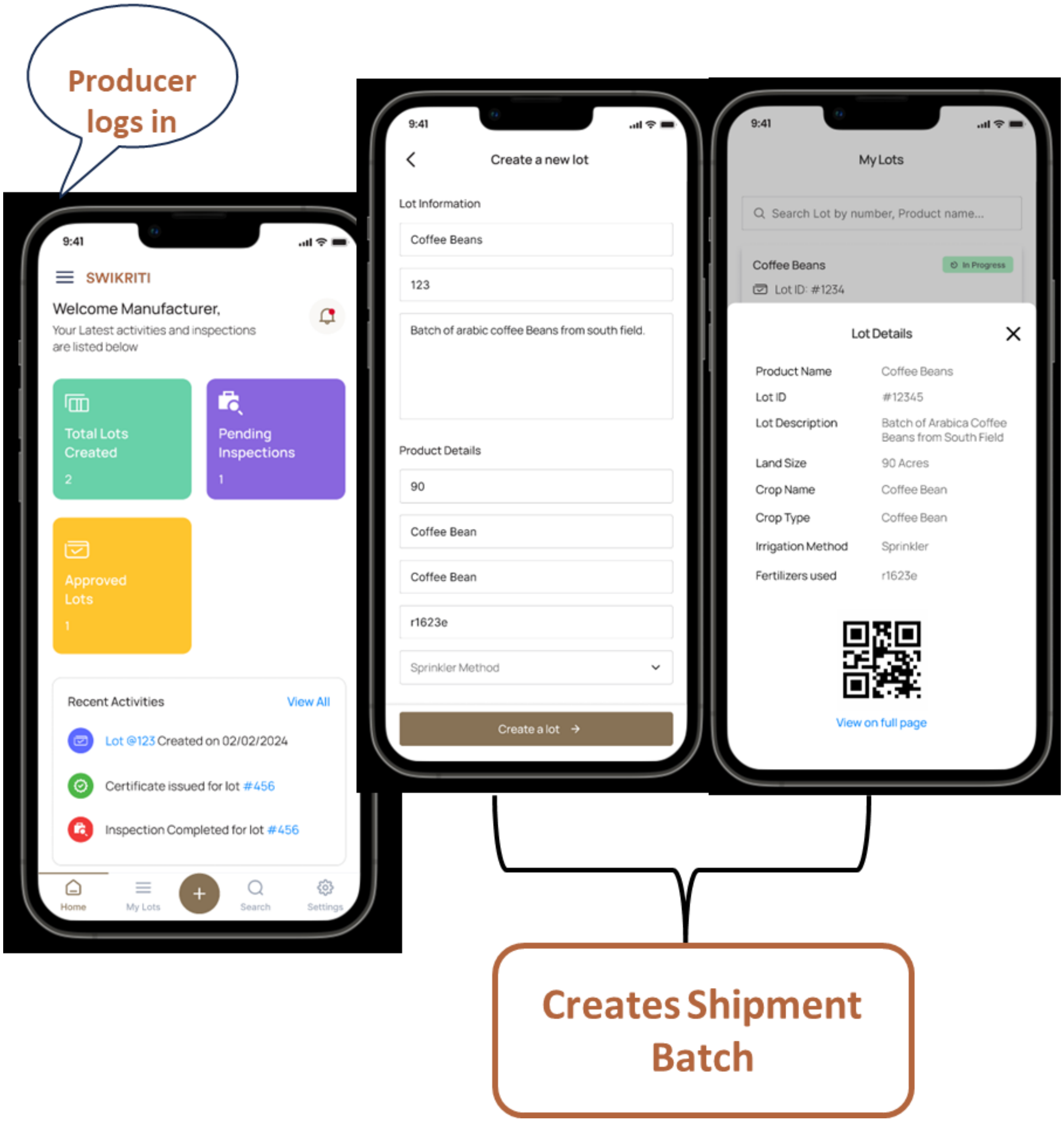


Figure 59: Swikriti - Actual Application Images

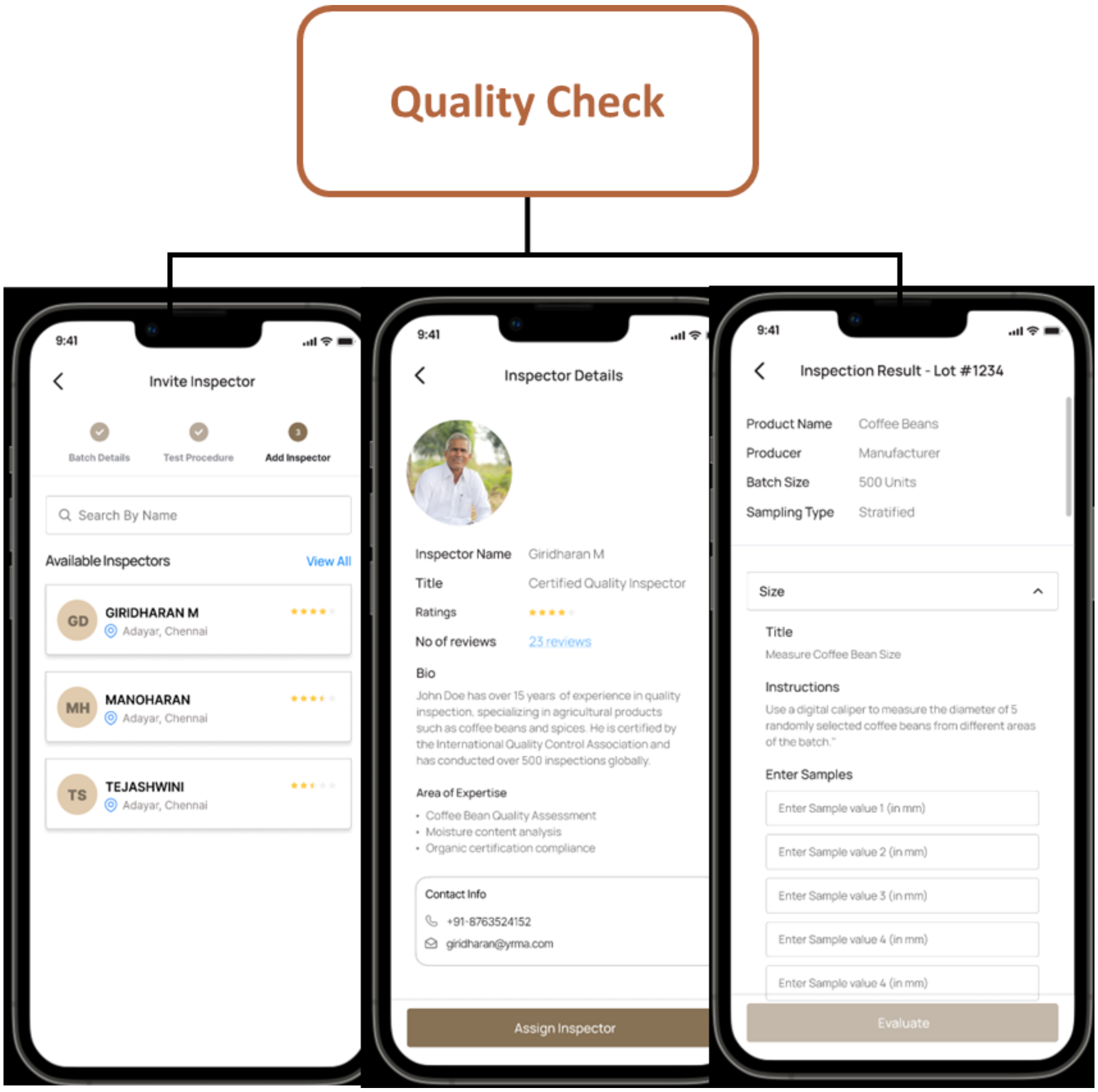


Figure 60: Swikriti: Actual application images

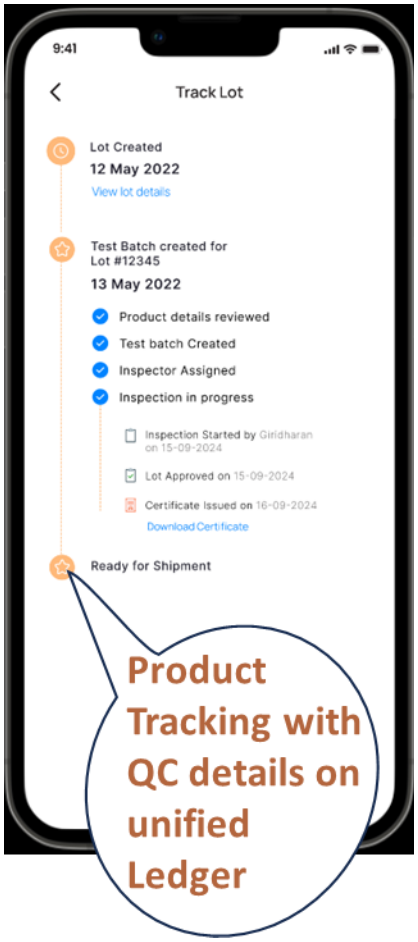


Figure 61: Swikriti- Actual application images

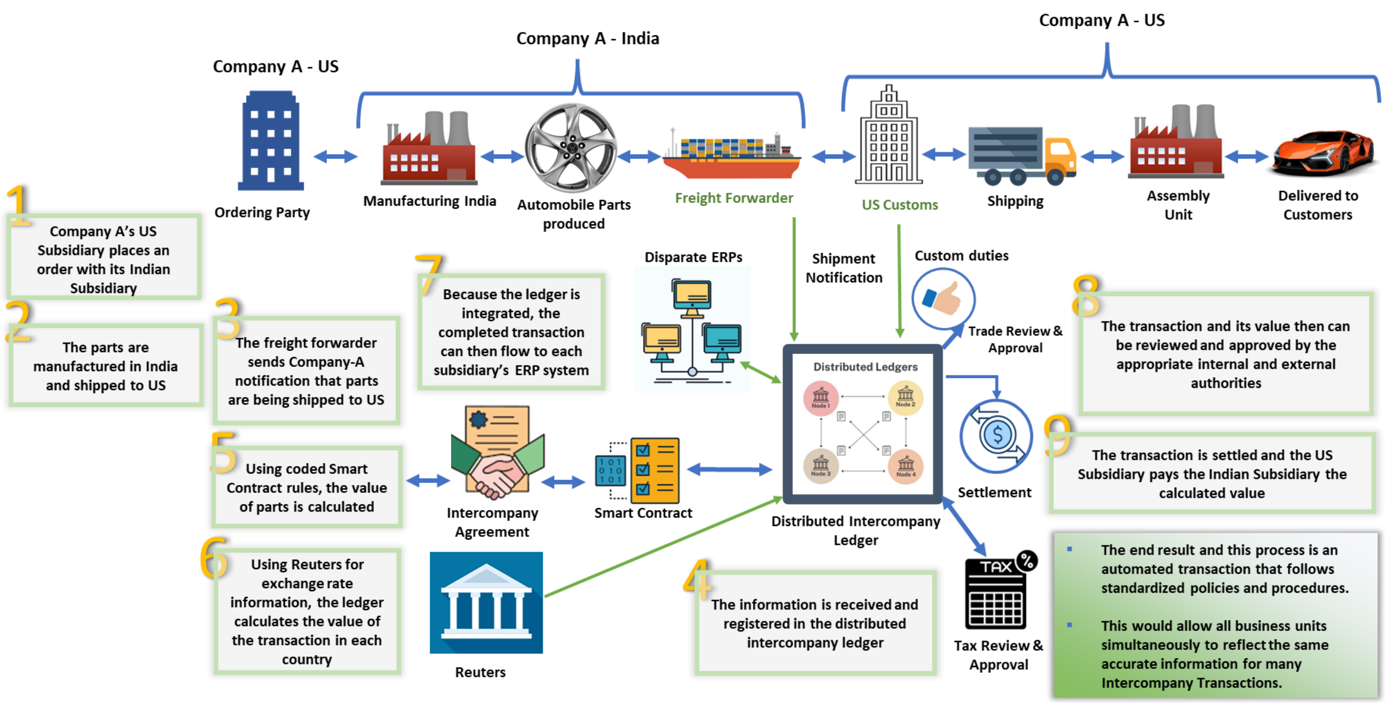
3.4.8 **Viniyog** – A Smart cross border Inter-company reconciliation platform

Viniyog tackles a major pain point in global business operations: intercompany reconciliation. It simplifies and automates the process of matching transactions between related parties.

Figure 62: Vimiyog - A Smart Intercompany Reconciliation platform

What makes Viniyog unique is its ability to work across different ERP systems. It uses AI-powered anomaly detection to identify mismatches or errors in records. The platform also integrates blockchain to create a unified ledger. This ensures transparency and accuracy.

Figure 63: Viniyog Process flow



Another standout feature of Viniyog is its built-in decision-making tools. These tools provide insights into financial operations, helping companies resolve disputes faster. It's designed to handle the complexities of cross-border transactions, including currency differences, tax laws, and compliance issues.

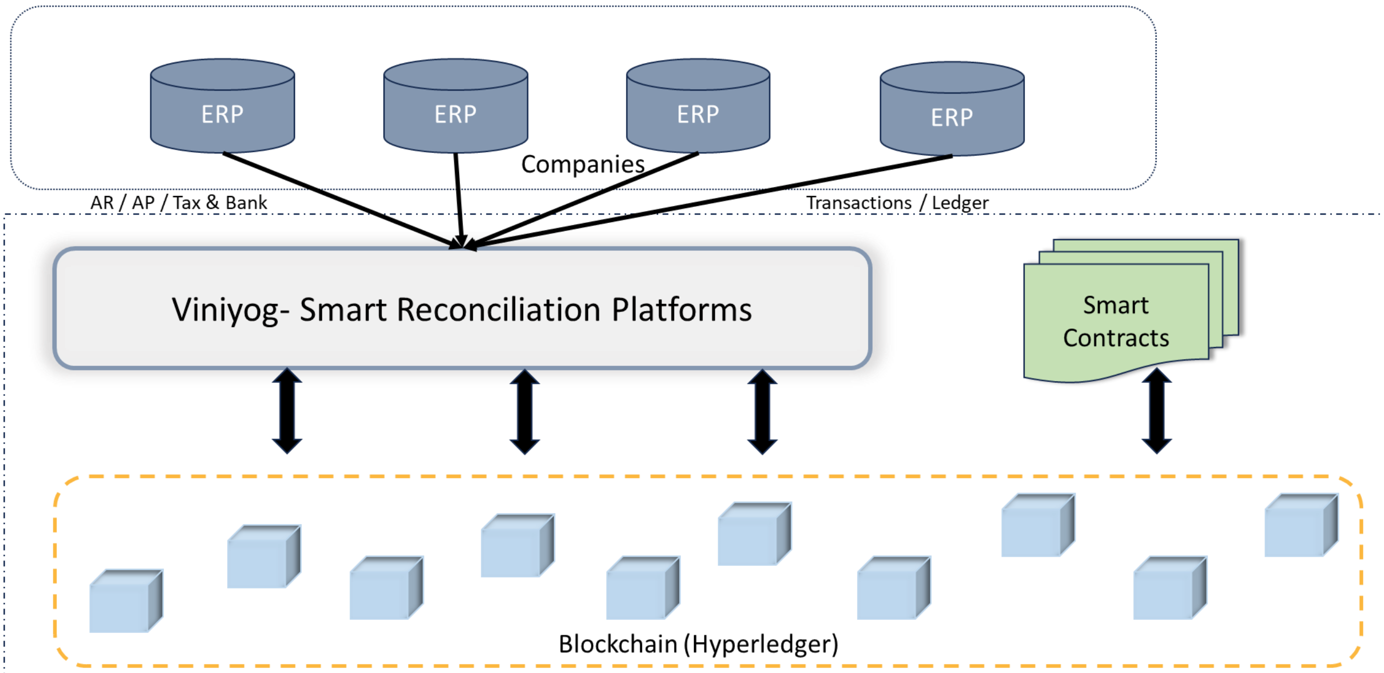


Figure 65: Data Flow and Execution in Viniyog

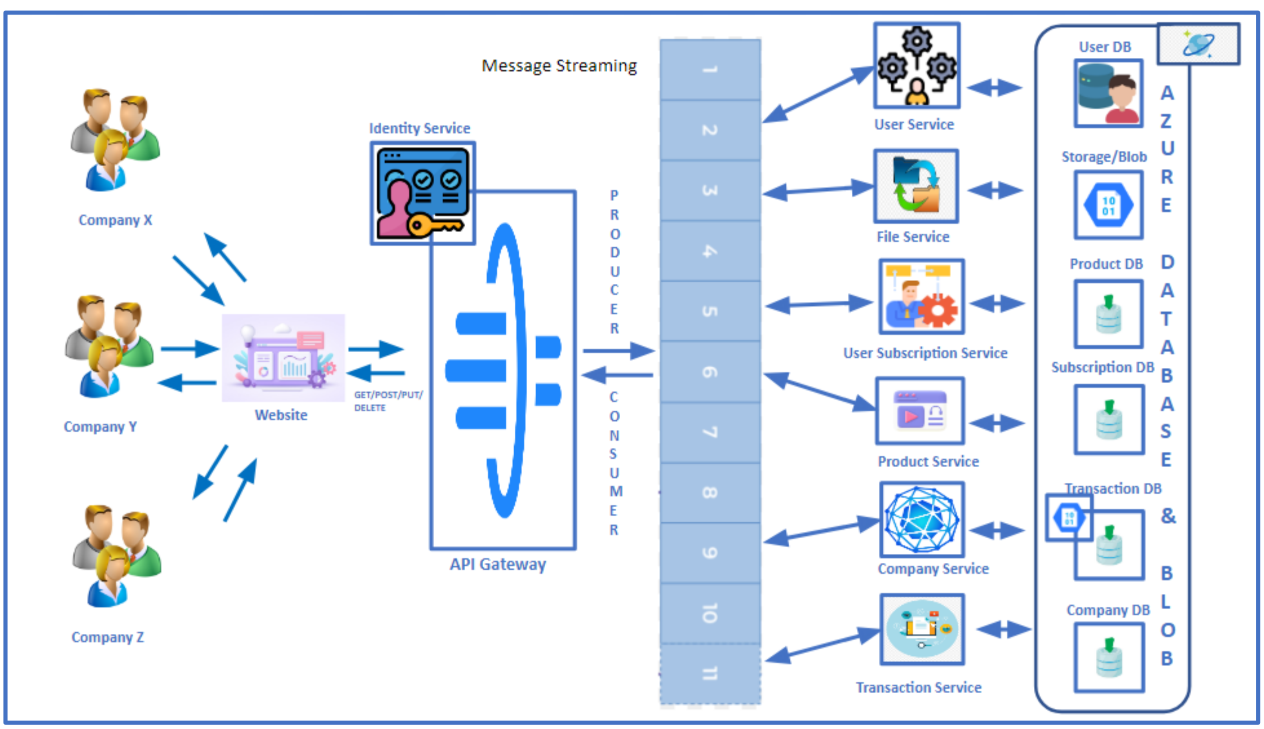


Figure 64: High Level Application Architecture

Both platforms are built with the vision of making operations smarter, more efficient, and less prone to risks. They are tailored to meet the demands of smart cities, where every process needs to work seamlessly for the greater good.

The global Market inclination for blockchain based Intercompany reconciliation platform:

Figure 67: Blockchain based ICR - Market Trends

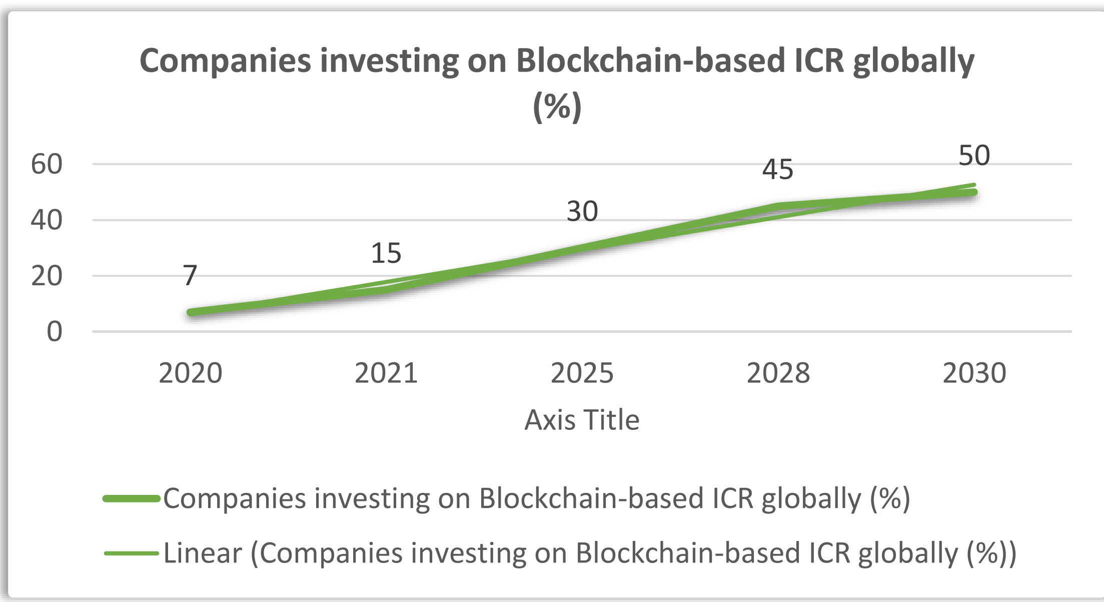


Figure 66: Companies investing on Blockchain-based ICR globally (%)

3.4.9 Viniyog- A Blockchain and AI based Smart Inter-company reconciliation platform

The Unique value proposition of leveraging deep technologies like blockchain, AI and IoT are as follows:

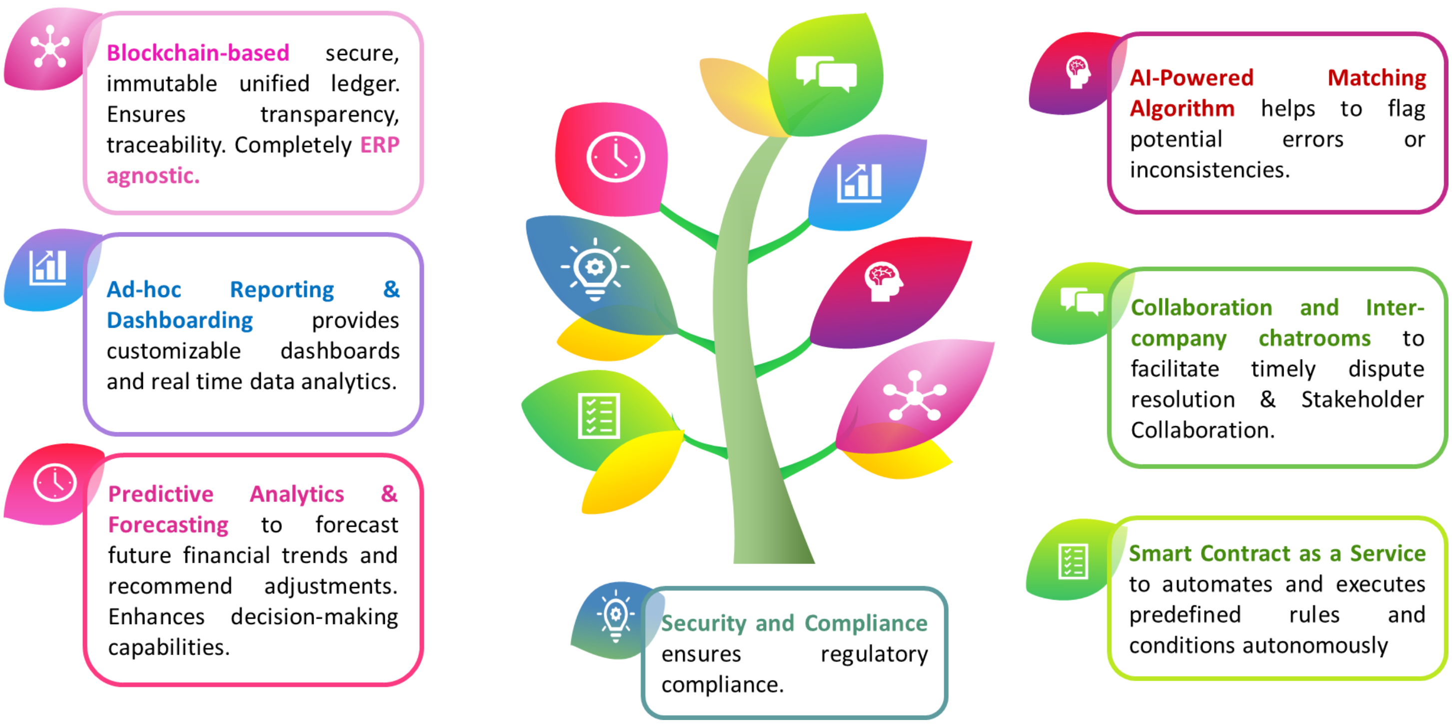


Figure 68: Unique Value Proposition of leveraging Deep Tech Solutions in mitigating Supply chain and Inter-company accounting risks

Viniyog can be referred from following links:

https://viniyog.shihaantech.com/

https://www.youtube.com/watch?v=Ebmtv6akx70

Moreover, the following images give an idea of the actual application.

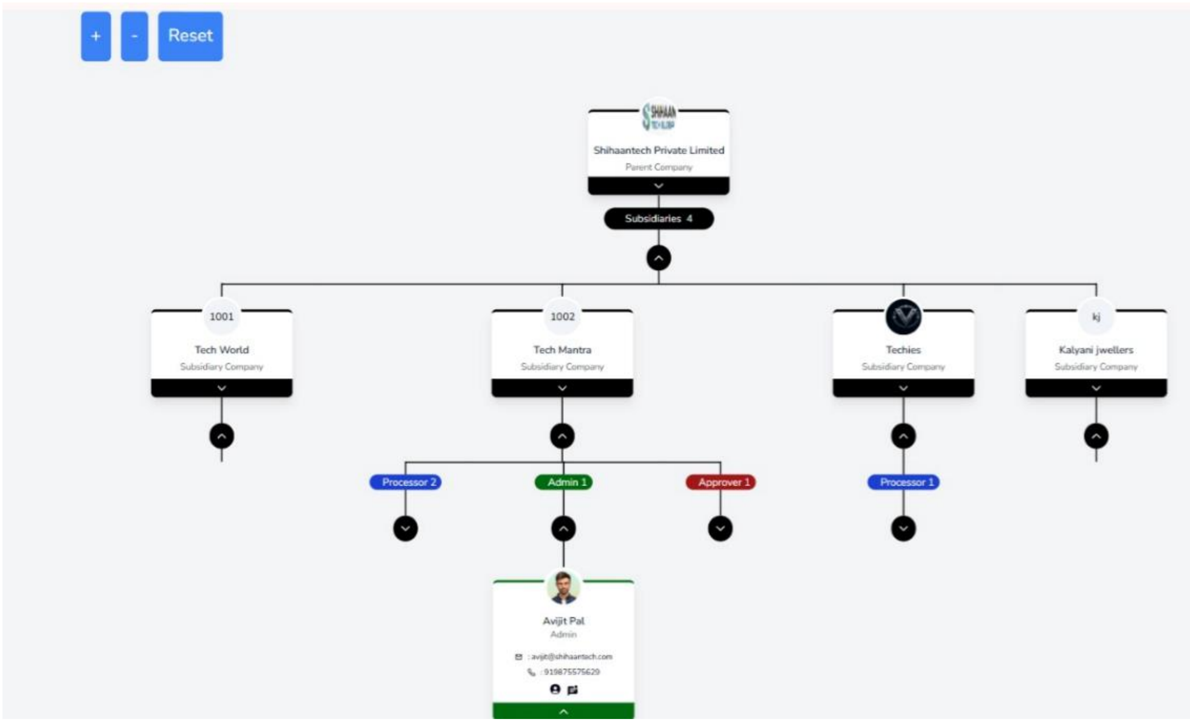


Figure 69: Decentralizes Autonomous Organization Structure of Inter-company

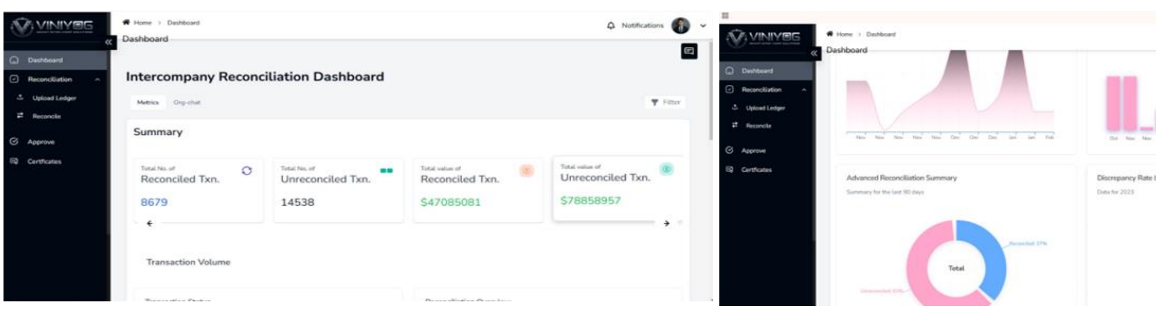


Figure 70: Viniyog - Dashboard

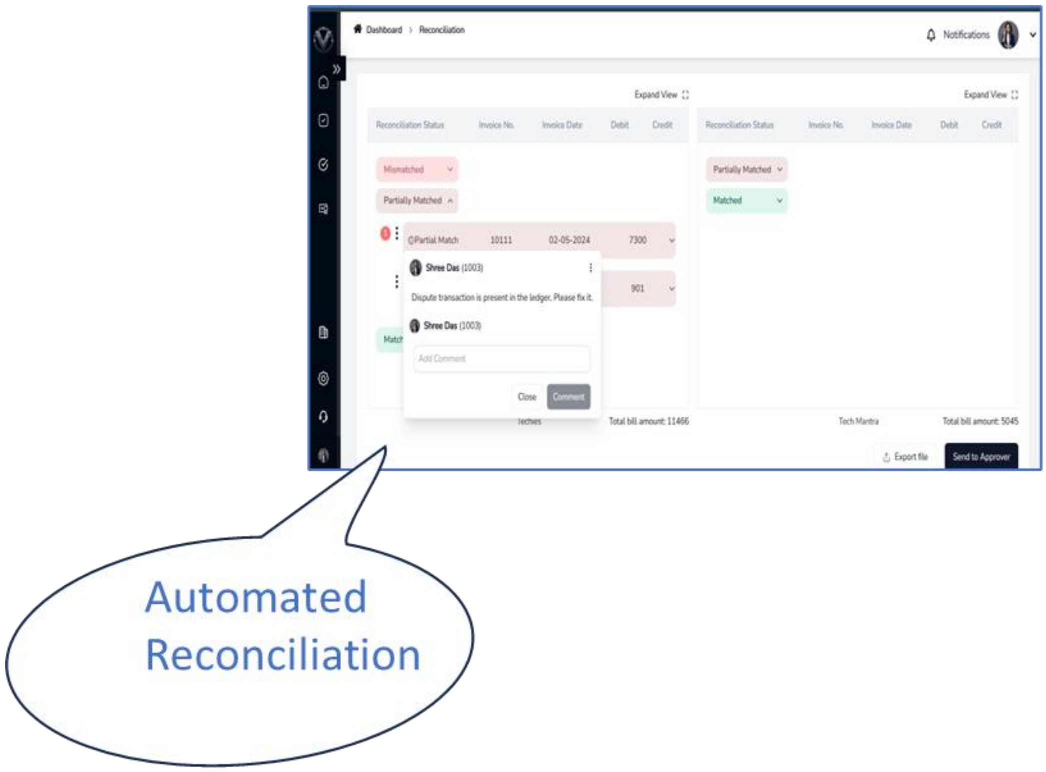


Figure 71: Viniyog: Automated Reconciliation

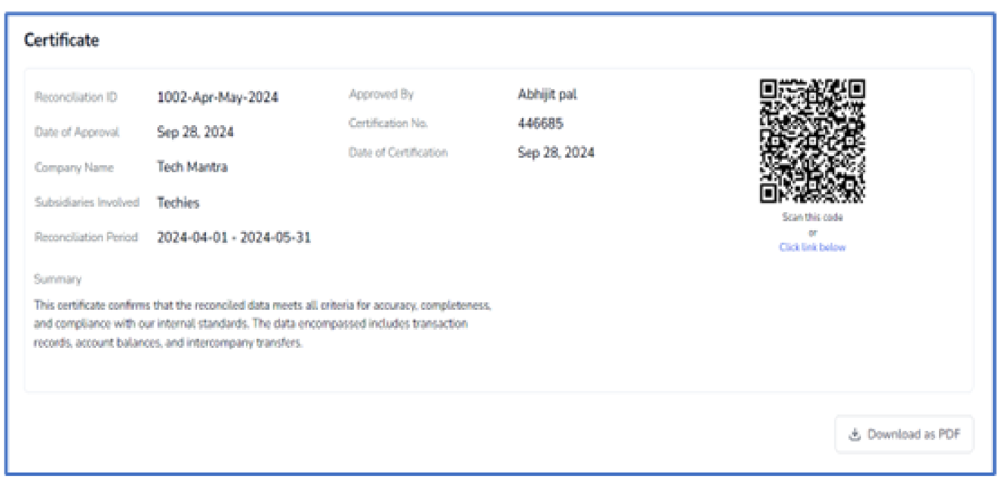


Figure 72: Viniyog - Reconciliation Auditor approved Certificate

3.5 Research Accomplishments:

The research began with a broad vision of managing risks in smart cities through deep tech innovation. It narrowed down to two critical sectors—**supply chain and corporate financial operations**—conducting detailed studies on risks and exploring how technology can offer smart solutions.

The work included analyzing industry trends, understanding pain points, and identifying gaps where innovation could create value. This led to designing and building minimum viable products, such as **Swikriti** and **Viniyog**, from ideation to launch. These products represent the culmination of the research, achieving its purpose of turning insights into practical, risk-mitigating solutions.

3.6 Research Question

The comprehensive research questionaire prepared for the survey to understnd the how people perceive the use of technologies like Blockchain, Artificial Intelligence and Internet of Things in mitigating the smart city or urban challenges effectively and also to understand the most perceived risks or challenges in different sectors.

The list of questions and responses are given in Chapter IV – Results.

3.7 Research Design

The study employed a mixed-methods strategy in order to address the problem comprehensively.

In terms of the **quantitative dimension**, trends were established through surveys. This made it possible to understand key problems and market gaps.

As for the **qualitative element**, the experience of creating prototypes and designing systems was useful. Understanding how solutions can be created and tested in practice was particularly helpful.

All in all, such approaches complemented theoretically oriented research with applied one, combining data and creativity into one output.

3.8 Population and Sample

The survey in question was carried out among urban communities during a duration of three months. It was an online survey thereby making it easy to reach a wider sample space of respondents.

Responders were teachers, students, workers, and ordinary city residents among other groups. These and other features made it possible to gather diverse opinions and experiences.

In prototype feedback, certain industry stakeholders were considered. The ERP testing was performed by professionals possessing pain points, supply chain management specialists, intercompany accounting experts, and chief financial officer. These groups contributed significantly in order to ensure that the solutions were appropriate in the market and catered for the real problems of the people.

3.9 Participant Selection

The Participants were teachers, students, workers, researchers, sustainability practitioners, and ordinary city residents, urban dwellers among other groups. These and other features made it possible to gather diverse opinions and experiences.

3.10 Instrumentation

The research used a **40-question comprehensive survey** to gather data. The survey was designed to understand critical risks and challenges across various units or sectors of smart cities. It provided insights into pain points and areas where innovative solutions could be applied.

For prototype development, several technical tools and platforms were used:

- **Next.js** was used to build the front-end interface, ensuring a user-friendly experience.
- **C#.Net** powered the back-end microservices for robust operations.
- **Hyperledger Fabric** with CouchDB and Golang APIs formed the blockchain framework, ensuring secure and transparent processes.

- **Azure Cloud** handled server operations, deployment, and scalability.
- **Azure Cosmos** was used as the common database for storing and accessing data efficiently.
- **Python** and **Gemini LLM**, along with NLP and ML libraries, were leveraged for predictive analytics and advanced dashboarding.
- **Python's statistical models** played a key role in developing optimization solutions and building digital twin measures.

This combination of tools enabled the creation of scalable, secure, and innovative prototypes tailored to address the identified risks.

3.11 Data Collection Procedures

Data was collected using an online survey conducted over three months. The survey included 40 questions, focusing on identifying critical risks and challenges across various smart city sectors. Participants were from diverse backgrounds, including educators, researchers, sustainability practitioners professionals, students, and urban residents.

For the prototypes, feedback was gathered through direct interactions with industry experts. These included ERP consultants, supply chain professionals, intercompany accountants, and CFOs. Their insights helped refine the prototypes, ensuring they addressed real-world challenges and were market-ready.

This combination of survey responses and expert feedback provided a comprehensive understanding of the problem areas and guided the development process effectively.

3.12 Data Analysis

3.12.1 Survey Analysis

*Ai*For analyzing the survey responses, statistical tools like Python and Jupyter Notebook were used. Key metrics were extracted to identify trends, challenges, and critical risk areas. Techniques like trend analysis and TRA (Theory of Reasoned Action) modeling helped pinpoint patterns in responses. Some key findings are as follows:

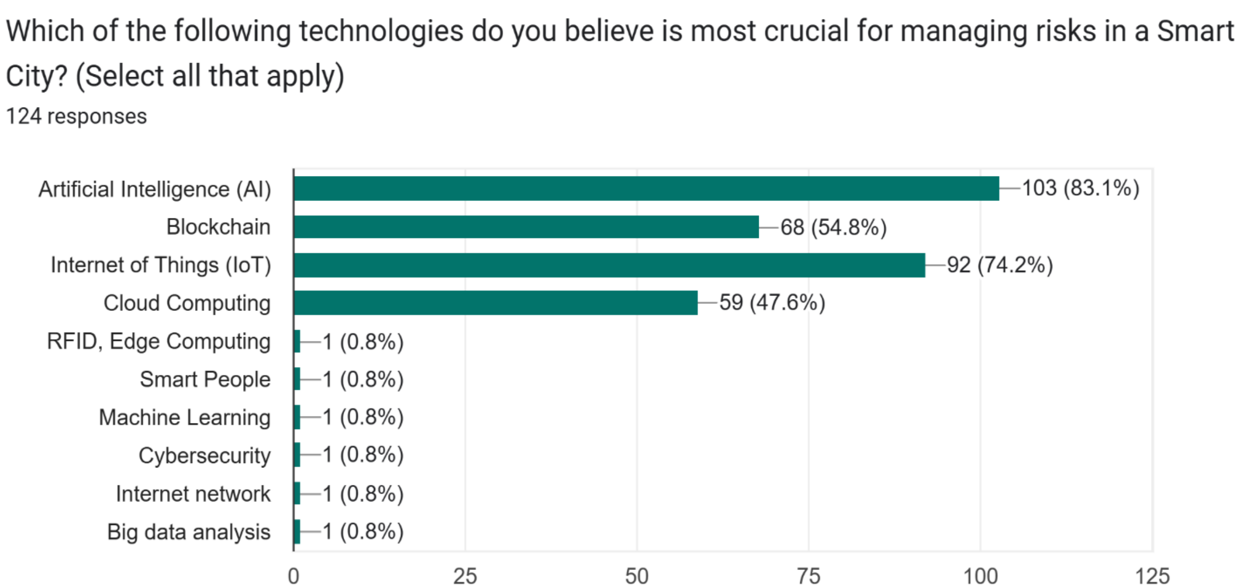


Figure 73: Tech Choice for Smart City Innovations

The response above implies the choice of AI, Blockchain and IoT as the emerging top 3 technologies which will be crucial in managing Smart city challenges.

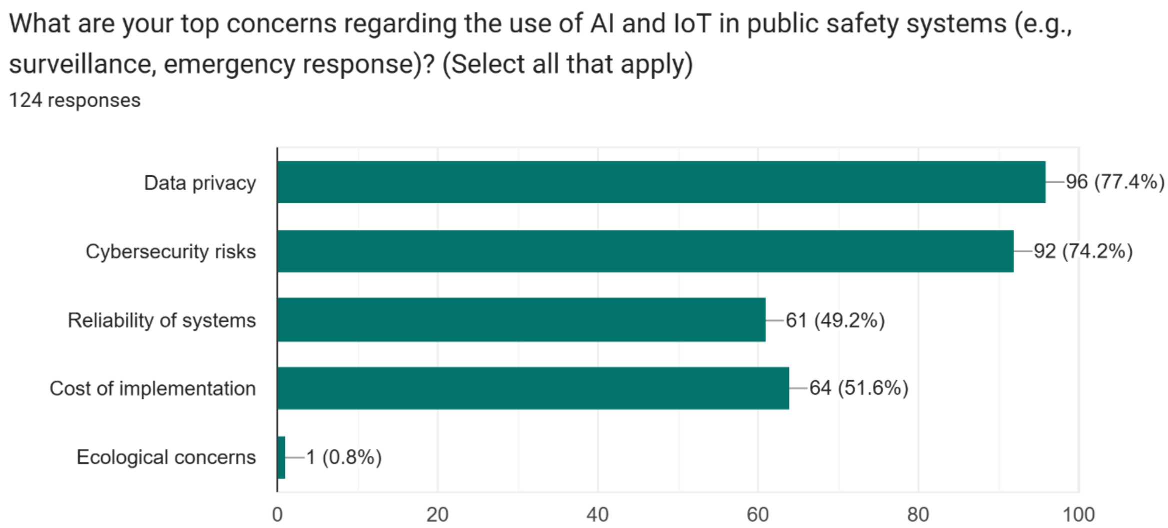


Figure 74: Top Concern in Public Safety regarding use of AI And IoT

Two Factors being studied here,

1. Risks to be mitigated with the use of Technology
2. Risks from the technology

The above response talks about Risks from Technology, i.e. people here voted mostly for Data Security and Cybersecurity Risks, which raises concern on ethical use of AI or encrypted IoT devices.

The primary concern seems that the people want to know the following:

- Who controls their data?
- How is their privacy being safeguarded?

- What happens if these systems fail or are misused?

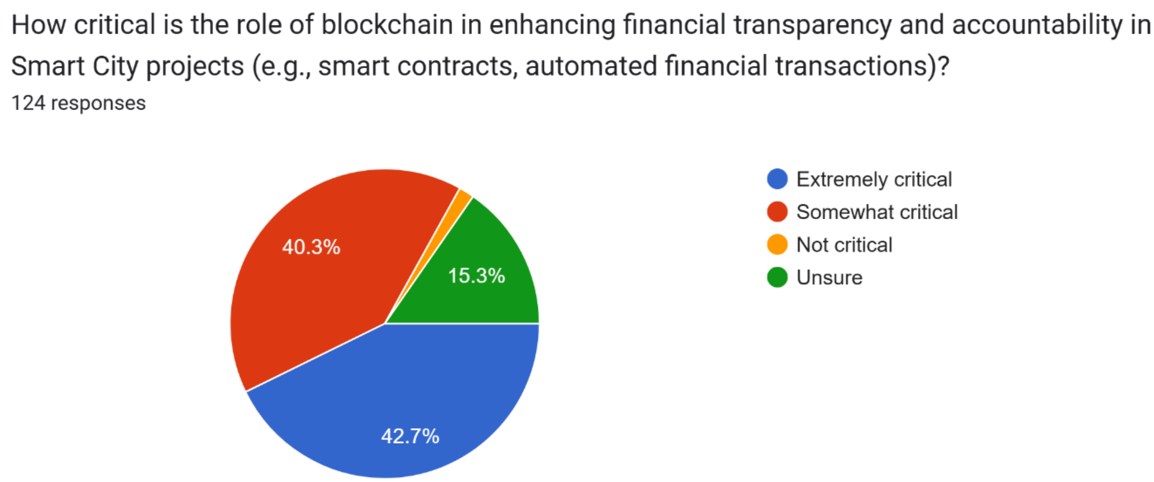


Figure 75: Blockchain for financial operations

The above response clearly indicates that Blockchain's immutable ledger is the chosen platform for trust in financial transparency and accountability.

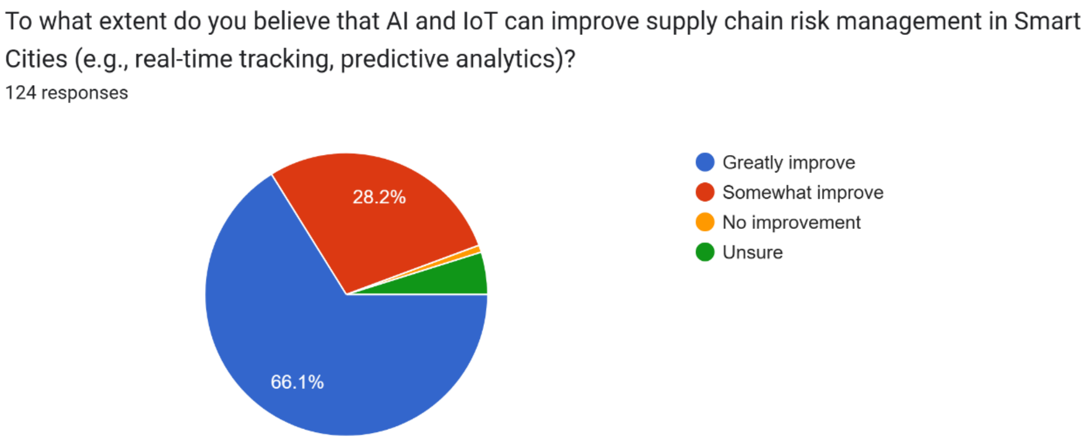


Figure 76: Role of AI and IoT in Supply Chain real time tracking

The above response implies that people are aware of the power of predictive analytics and real-time tracking to mitigate supply chain risks.

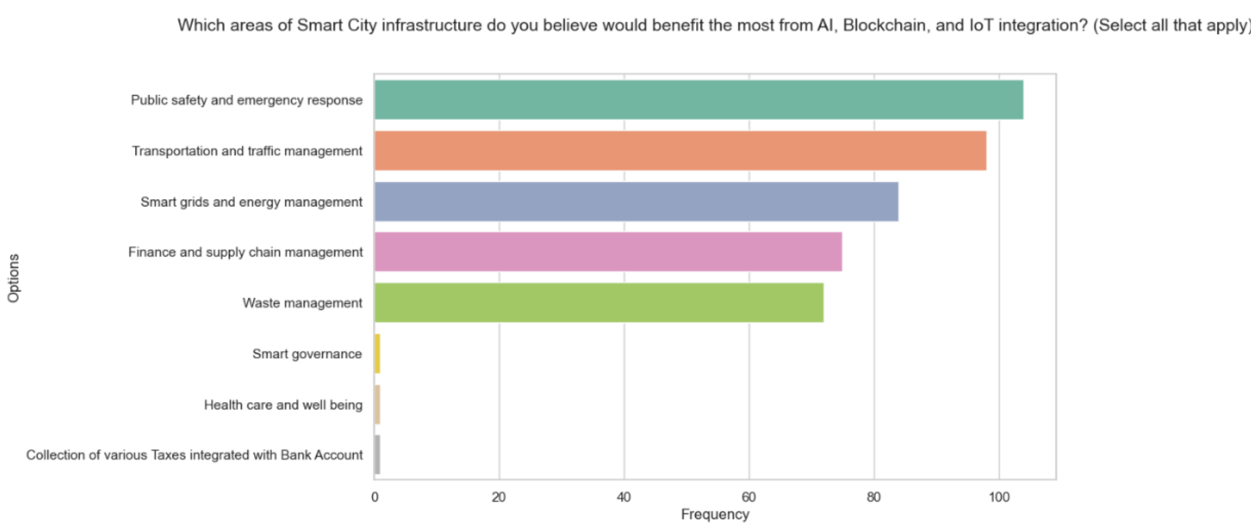


Figure 77: Sectors to be benefitted most by Deep Techs

The above response clearly indicates that public safety, mobility, energy and finance and Supply chain are sought to be the most critical sectors to be disrupted by blockchain, AI, and IoT.

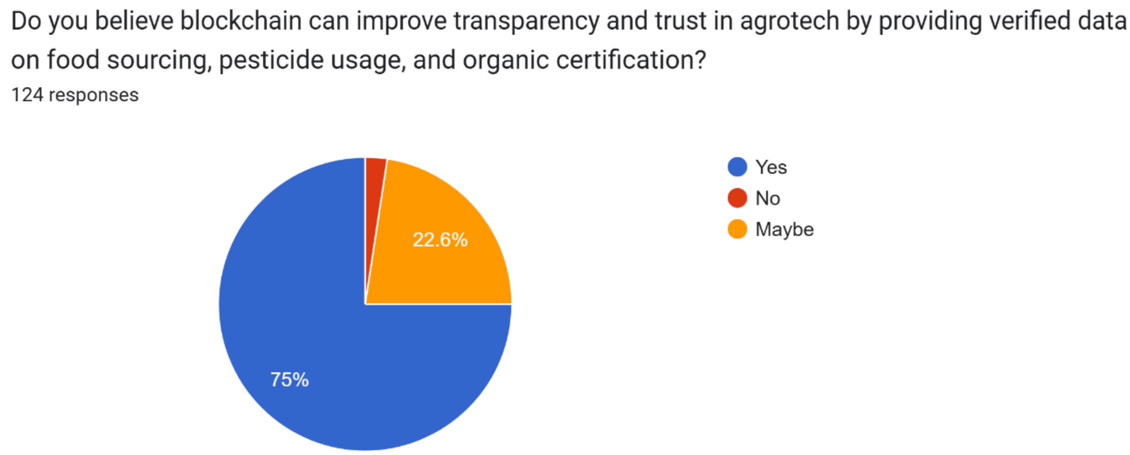
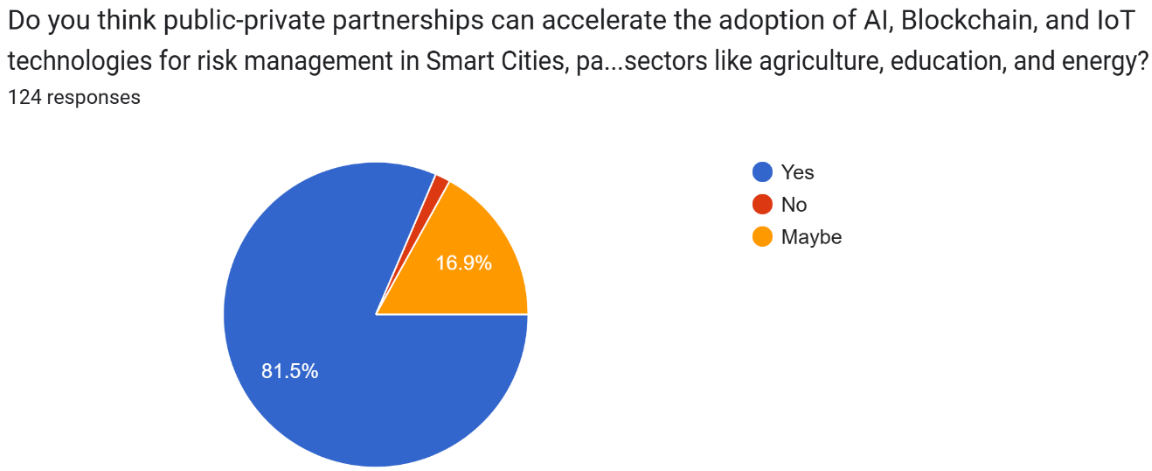


Figure 78: Blockchain in food quality

The above response implies clearly that Blockchain will a trusted technology in authenticating food quality measures in organic food industry, which also talks about blockchain based product life cycle management.



This implies there will high probability of B2G kind of collaborations in the coming future to accelerate the adoption of technologies in Smart City innovations and Risk Management.

How effectively does your organization handle the risk (i.e., the risk that remains after all mitigation strategies) when implementing AI in real-time operations? "1" being least effectively and "5" being most effectively.

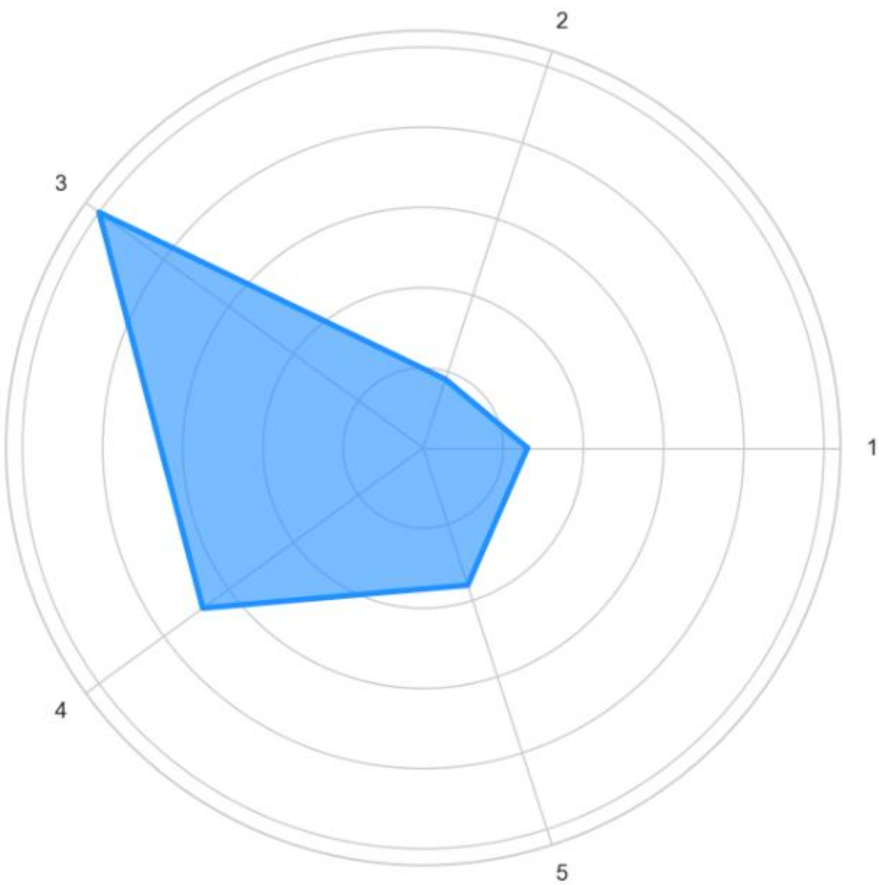


Figure 79: How effectively does your organization handle the risk (i.e., the risk that remains after all mitigation strategies) when implementing AI in real-time operations

In the above response we can see Maximum response falls in Neutral Zone (3) which indicates that there is huge scope that industries will be taking efforts in coming days to handle risks more efectively with AI implementation. Lots of scope of AI adoption is visible here in mitigating risks effectively.

The survey response quite aligns to the hypothesis of the research with which the study is initiated and there are still lots of scope of improvements in technology adoptions in effective Smart City risk prediction and mitigation.

3.12.2 Prototype Evaluation

Both products, Swikriti and Viniyog, are at the MVP stage and have already been launched. They are being showcased at various industry forums and events. The feedback so far has been overwhelmingly positive. The solutions are gaining appreciation and attention for their innovative approaches. This process of showcasing and gathering feedback is helping refine the products further and validate their market fit.

3.13 Research Design Limitations

This research focused on two critical sectors: supply chain and corporate finance, specifically cross-border intercompany reconciliation risks. While the survey questionnaire was comprehensive and covered most micro-units of a smart city, there is room for further studies.

Other sectors within the smart city framework could be explored in greater detail, especially in terms of innovation and risk management.

Additionally, more targeted research could be conducted to analyze demographic preferences and the adoption of smart technologies for risk management across developing and developed countries.

3.14 Conclusion

The research began with a broader vision to address risk management in smart cities using advanced technologies like AI, IoT, and blockchain. It then narrowed its focus to two critical areas, supply chain and corporate finance, where these risks are most evident. Through this work, significant progress was made, from identifying industry pain points to designing and building innovative solutions like Swikriti and Viniyog. These products are now at the MVP stage and have been showcased with positive feedback, highlighting their potential impact. This research achieved its purpose of bridging theoretical insights with practical innovations, paving the way for smarter, safer city ecosystems.

CHAPTER IV:

RESULTS

4.1 Survey Results

1. How familiar are you with the concept of Smart Cities and the technologies (AI, Blockchain, IoT) that enable them?

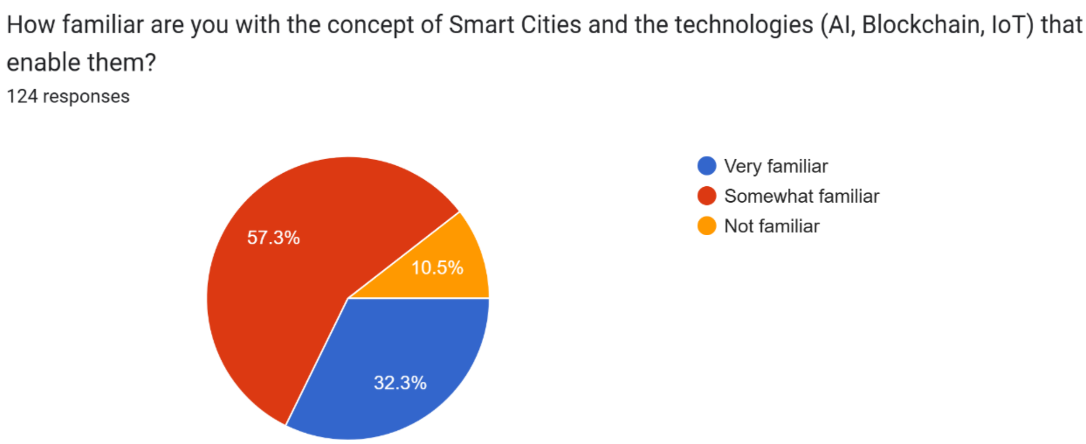


Figure 80:How familiar are you with the concept of Smart Cities and the technologies (AI, Blockchain, IoT) that enable them?

2. Which of the following technologies do you believe is most crucial for managing risks in a Smart City? (Select all that apply)

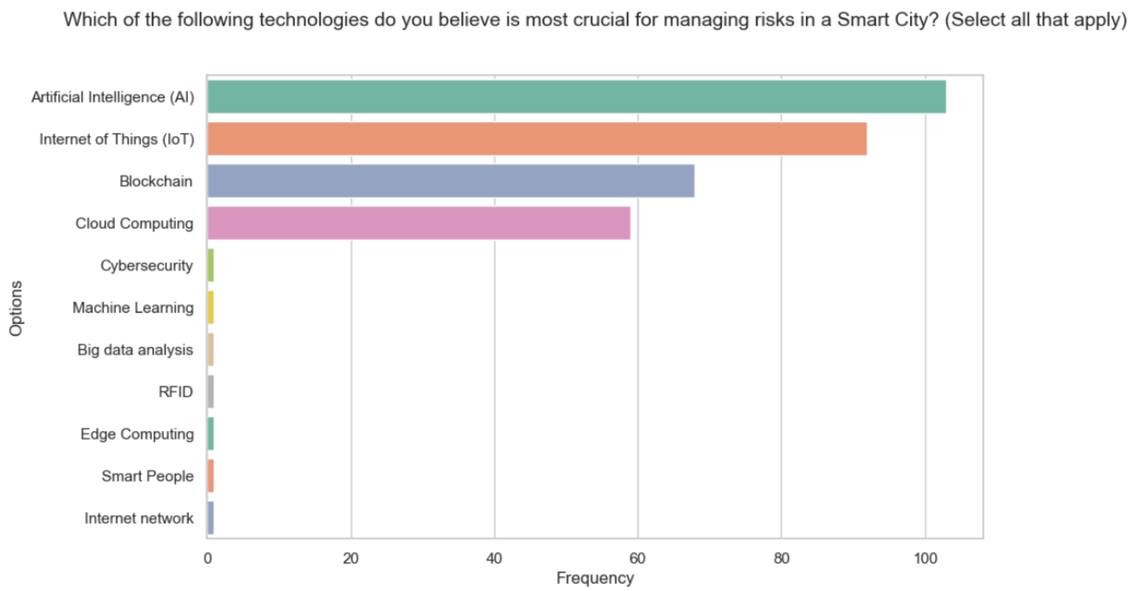


Figure 81:Which of the following technologies do you believe is most crucial for managing risks in a Smart City?

3. How effective do you think AI-enabled video surveillance and data analytics are in mitigating public safety risks in Smart Cities?

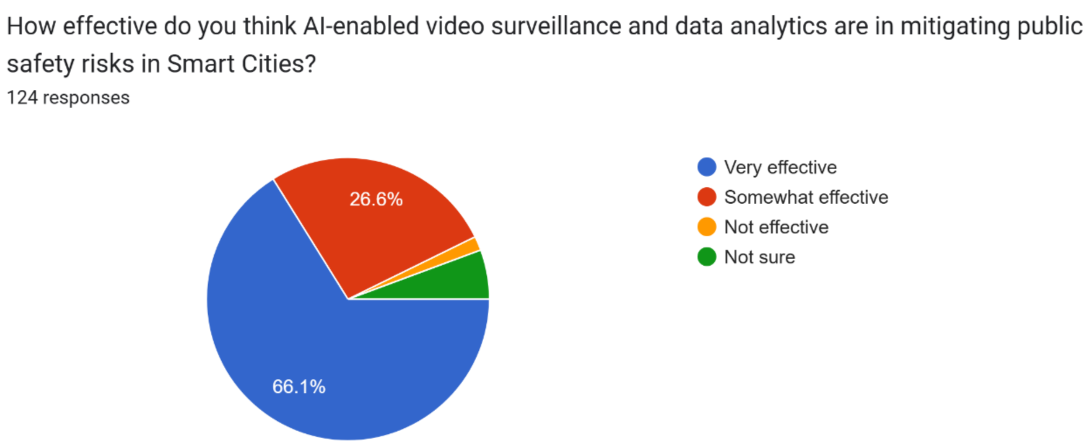


Figure 82: How effective do you think AI-enabled video surveillance and data analytics are in mitigating public safety risks in Smart Cities?

4. What are your top concerns regarding the use of AI and IoT in public safety systems (e.g., surveillance, emergency response)? (Select all that apply)

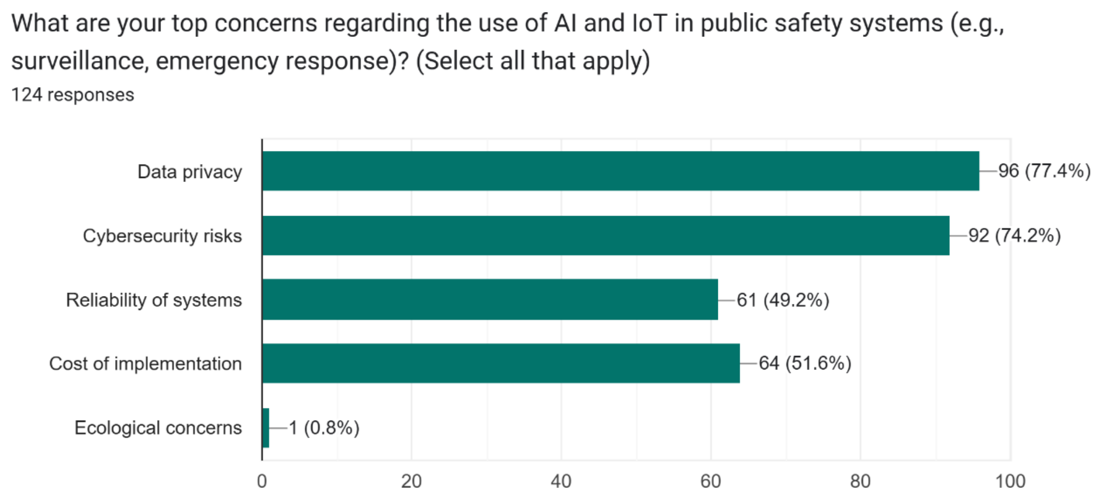


Figure 83:What are your top concerns regarding the use of AI and IoT in public safety systems (e.g., surveillance, emergency response)?

5. Would you trust a blockchain-based system to securely manage public safety data (e.g., crime reports, emergency response times)?

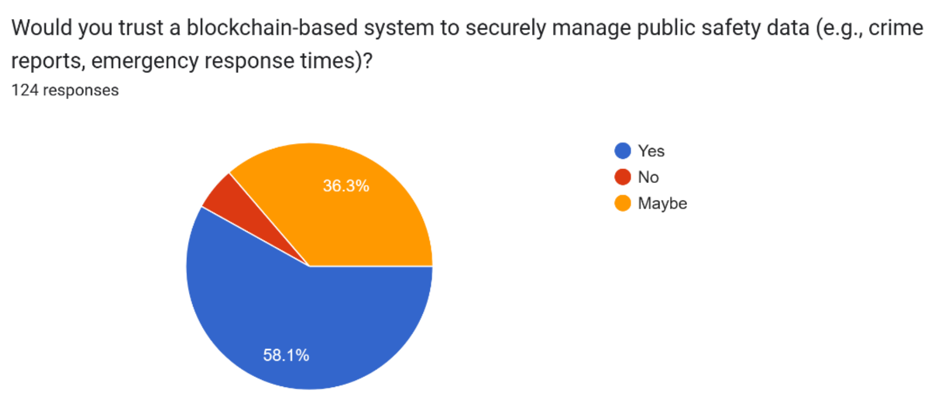


Figure 84: Would you trust a blockchain-based system to securely manage public safety data (e.g., crime reports, emergency response times)?

6. How critical is the role of blockchain in enhancing financial transparency and accountability in Smart City projects (e.g., smart contracts, automated financial transactions)?

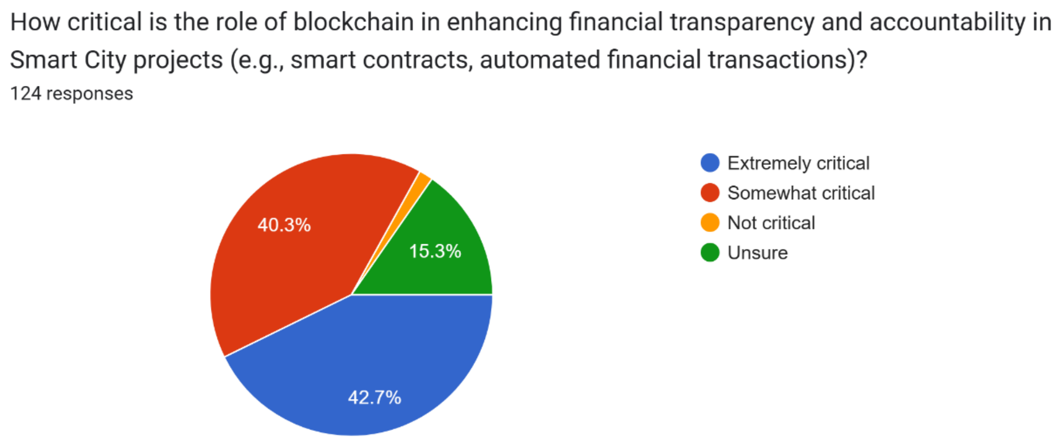


Figure 85: How critical is the role of blockchain in enhancing financial transparency and accountability in Smart City projects (e.g., smart contracts, automated financial transactions)?

7. To what extent do you believe that AI and IoT can improve supply chain risk management in Smart Cities (e.g., real-time tracking, predictive analytics)?

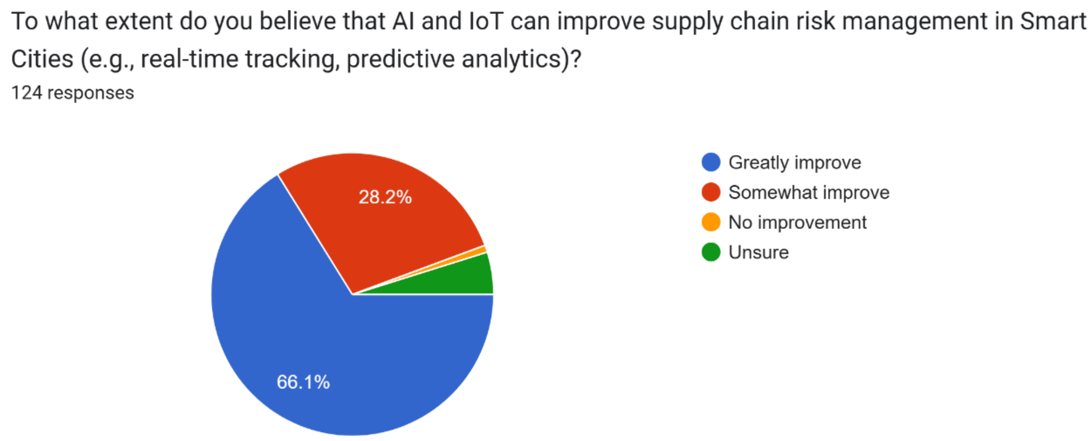


Figure 86: To what extent do you believe that AI and IoT can improve supply chain risk management in Smart Cities (e.g., real-time tracking, predictive analytics)?

8. What are the key challenges in adopting blockchain for supply chain risk management in Smart Cities? (Select all that apply)

Figure 87: What are the key challenges in adopting blockchain for supply chain risk management in Smart Cities?

9. How important do you consider IoT and AI in managing risks related to smart grids (e.g., power outages, energy theft, peak load management)?

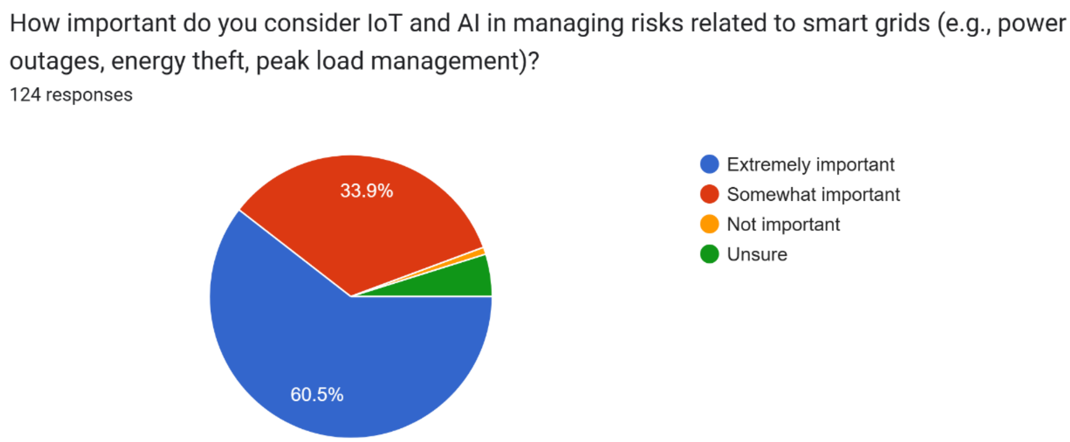


Figure 88: Importance of IoT and AI in managing risks of smart grids

10. Do you believe blockchain can enhance the security and efficiency of smart grid transactions (e.g., decentralized energy trading, billing)?

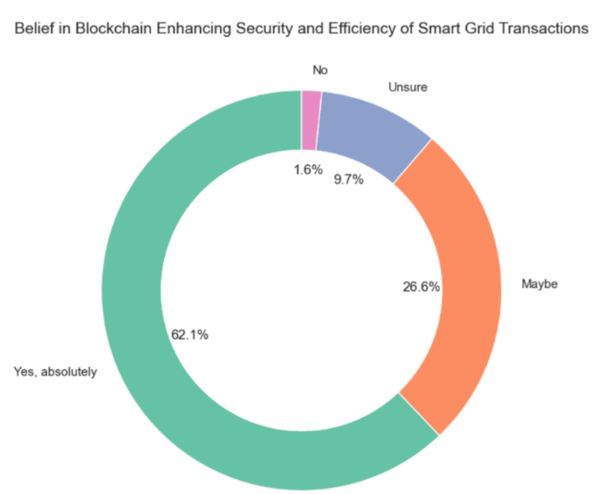


Figure 89: Do you believe blockchain can enhance the security and efficiency of smart grid transactions (e.g., decentralized energy trading, billing)?

11. What are the primary risks that you see in the adoption of IoT for smart grid management? (Select all that apply)

Figure 90: What are the primary risks that you see in the adoption of IoT for smart grid management?

12. How concerned are you about data privacy and security when it comes to using AI and IoT technologies in Smart Cities?

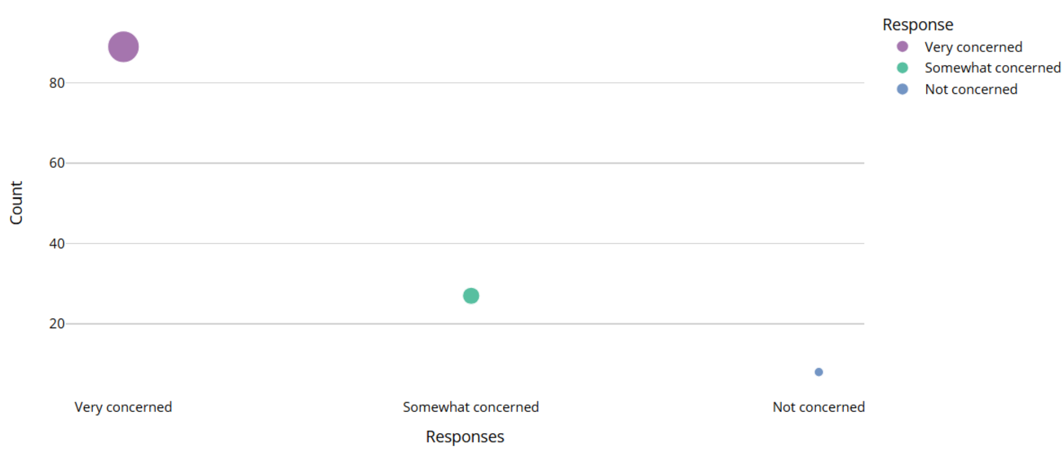


Figure 91:How concerned are you about data privacy and security when it comes to using AI and IoT technologies in Smart Cities?

13. Which areas of Smart City infrastructure do you believe would benefit the most from AI, Blockchain, and IoT integration? (Select all that apply)

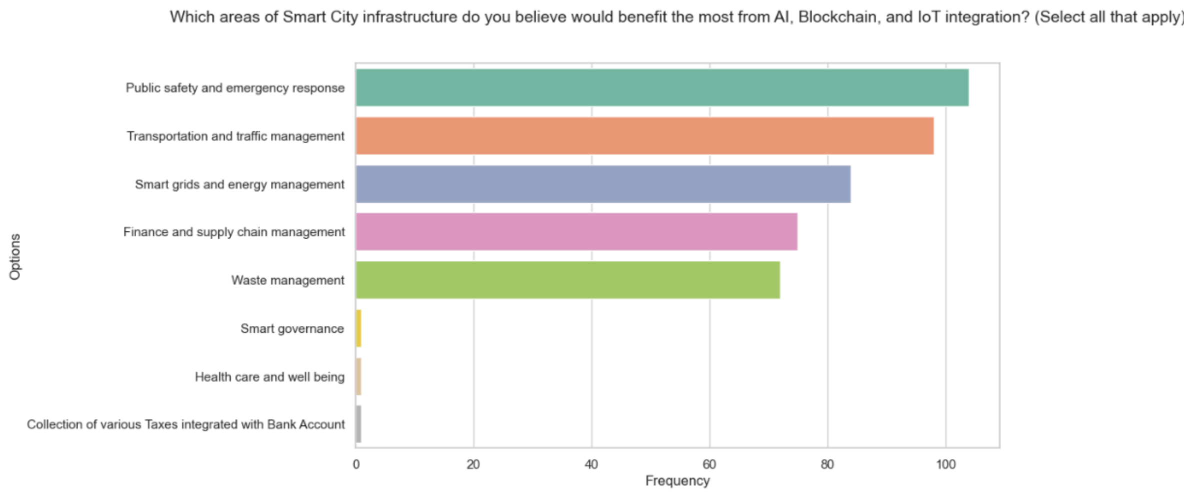


Figure 92:Which areas of Smart City infrastructure do you believe would benefit the most from AI, Blockchain, and IoT integration?

14. What do you see as the most significant barrier to adopting AI, Blockchain, and IoT technologies for risk management in Smart Cities? (Select all that apply)

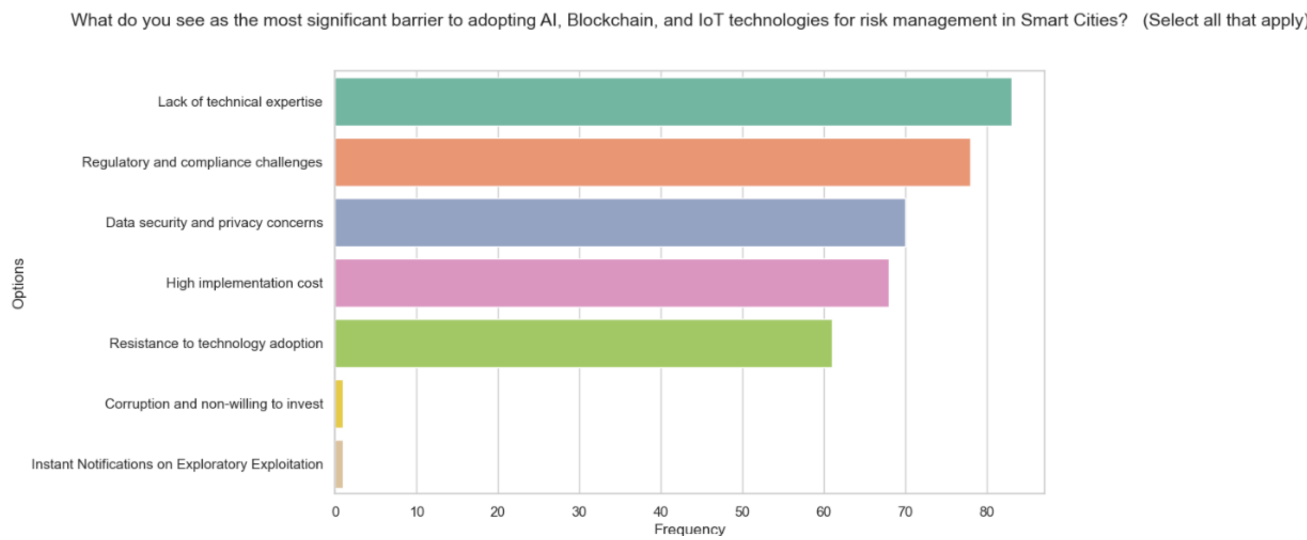


Figure 93: What do you see as the most significant barrier to adopting AI, Blockchain, and IoT technologies for risk management in Smart Cities?

15. How significant is the role of IoT in improving risk management for Smart City agricultural supply chains (e.g., crop monitoring, real-time weather data, soil conditions)?

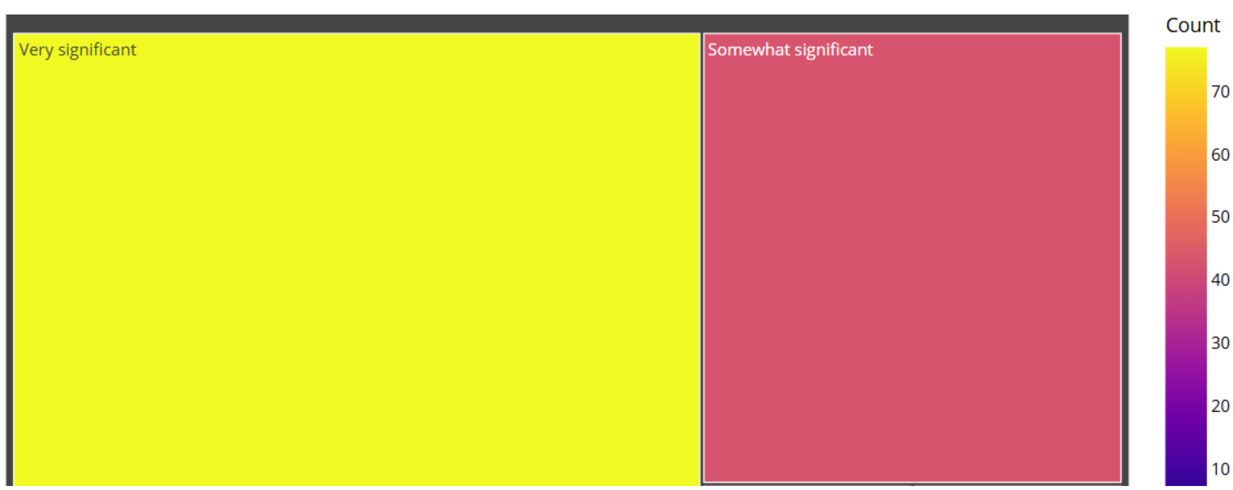


Figure 94: How significant is the role of IoT in improving risk management for Smart City agricultural supply chains (e.g., crop monitoring, real-time weather data, soil conditions)?

16. What are the key risks in managing agricultural operations in Smart Cities, and how can AI and Blockchain mitigate them? (Select all that apply)

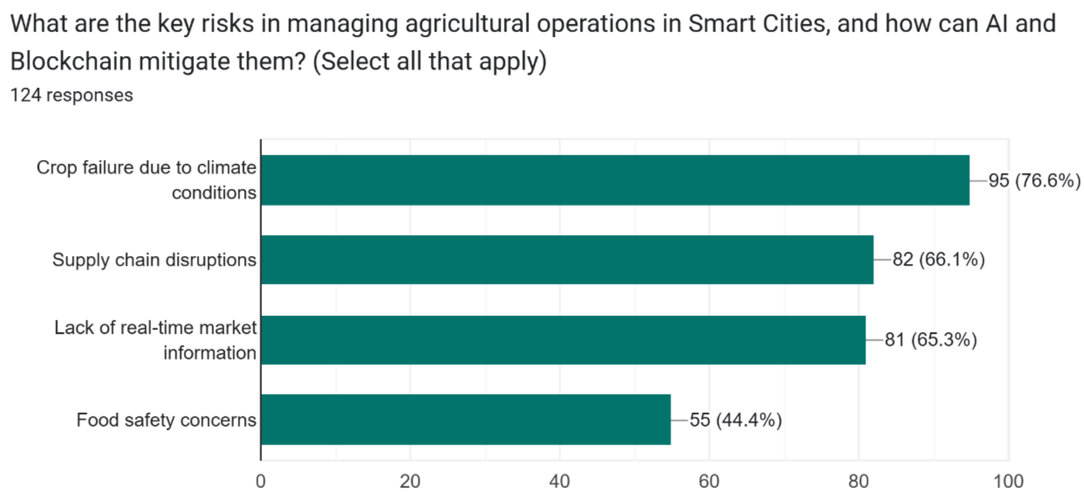


Figure 95: What are the key risks in managing agricultural operations in Smart Cities, and how can AI and Blockchain mitigate them?

17. Do you believe blockchain can improve transparency and trust in agrotech by providing verified data on food sourcing, pesticide usage, and organic certification?

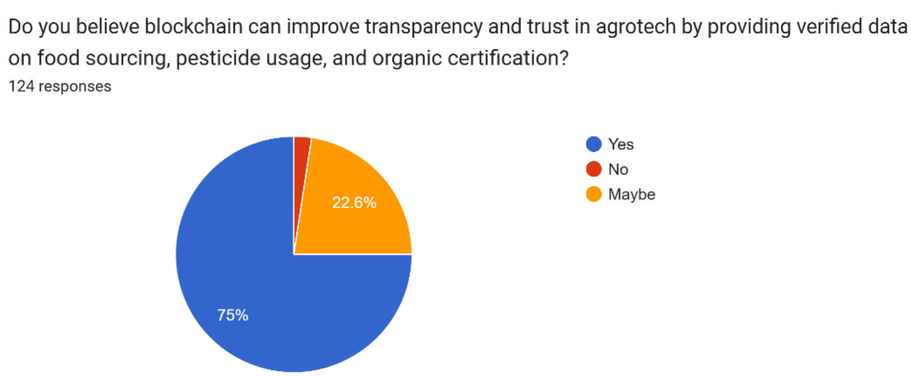


Figure 96: Do you believe blockchain can improve transparency and trust in agro-tech by providing verified data on food sourcing, pesticide usage, and organic certification?

18. How important do you think AI and IoT are in creating smart, secure, and personalized learning environments in Smart Cities?

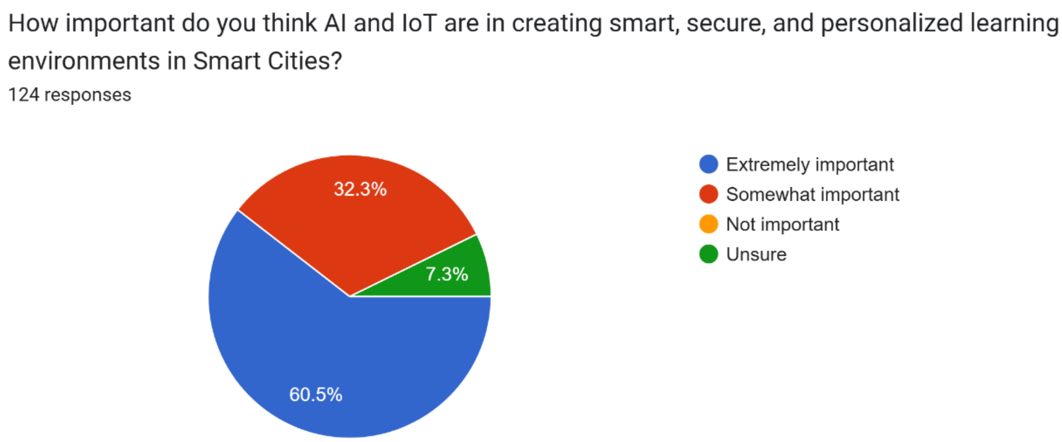


Figure 97: How important do you think AI and IoT are in creating smart, secure, and personalized learning environments in Smart Cities?

19. Which of the following AI-enabled tools can most effectively manage risks in the education sector of Smart Cities? (Select all that apply)

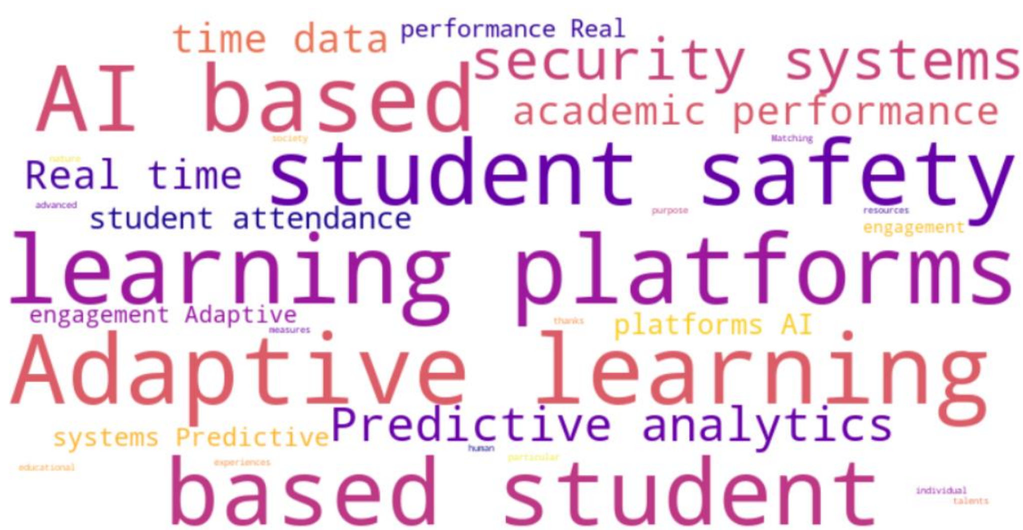


Figure 98: Which of the following AI-enabled tools can most effectively manage risks in the education sector of Smart Cities?

20. What concerns do you have regarding the use of AI and Blockchain for managing student data in Smart City educational institutions (e.g., privacy, data accuracy, security)? (Select all that apply)

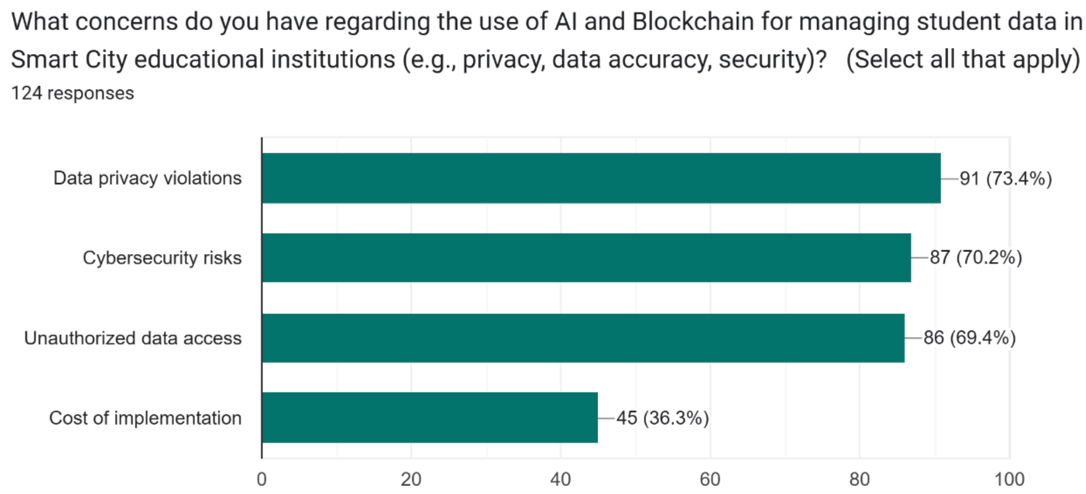


Figure 99: What concerns do you have regarding the use of AI and Blockchain for managing student data in Smart City educational institutions (e.g., privacy, data accuracy, security)?

21. How effective do you think Blockchain can be in verifying educational credentials and reducing fraud in Smart City schools and universities?

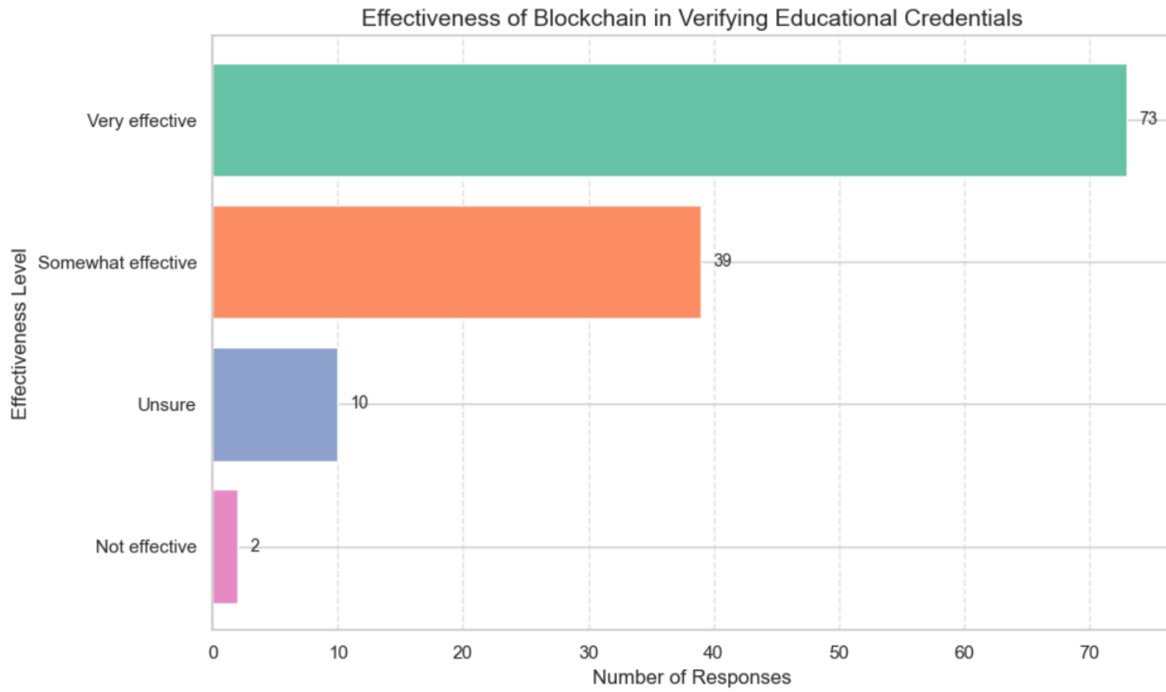


Figure 100: How effective do you think Blockchain can be in verifying educational credentials and reducing fraud in Smart City schools and universities?

22. How crucial is the role of IoT in monitoring and managing energy consumption within Smart Cities?

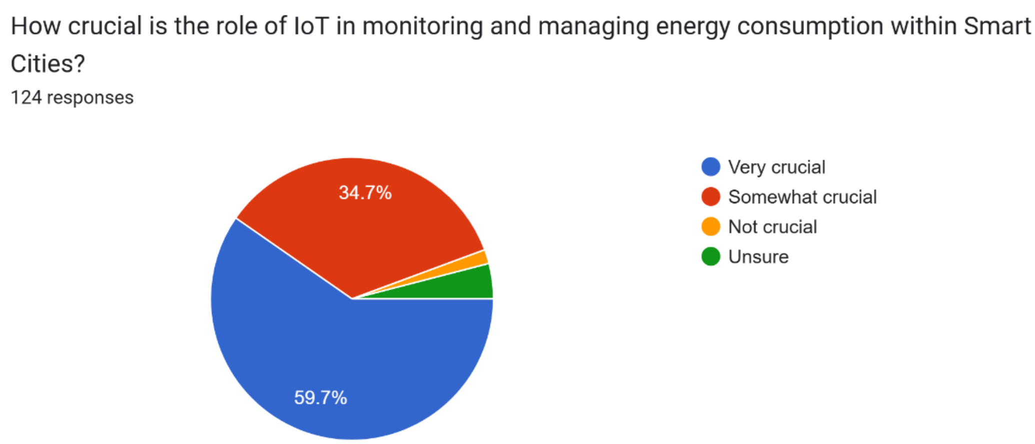


Figure 101: How crucial is the role of IoT in monitoring and managing energy consumption within Smart Cities?

23. What are the primary risks related to energy management in Smart Cities that AI and Blockchain could address? (Select all that apply)

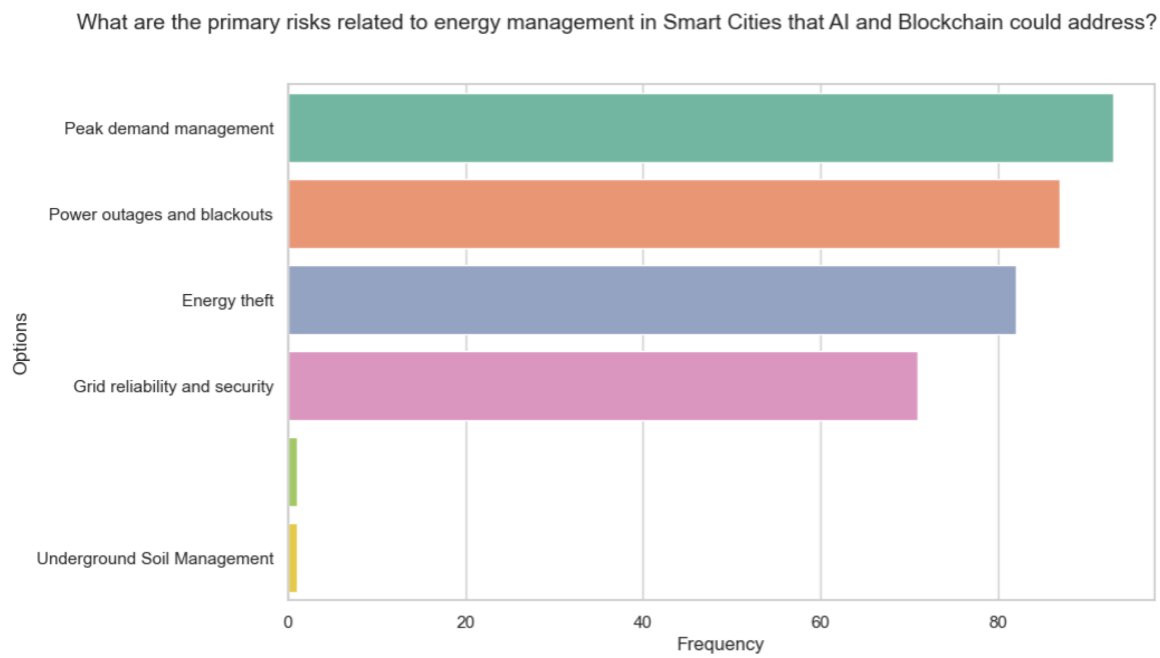


Figure 102: 23. What are the primary risks related to energy management in Smart Cities that AI and Blockchain could address?

24. What are the most significant challenges in adopting AI and IoT technologies in managing Smart City energy grids? (Select all that apply)

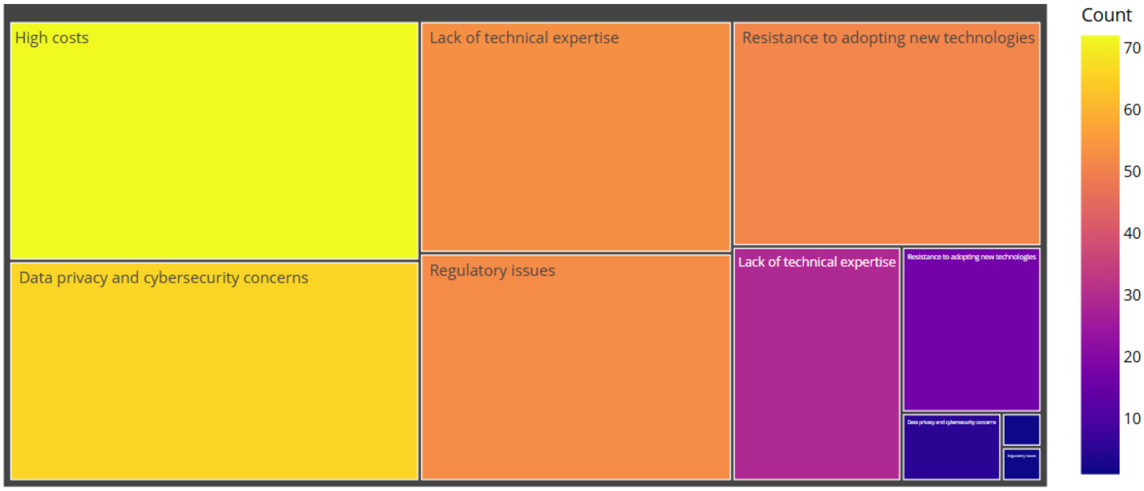


Figure 103: What are the primary risks related to energy management in Smart Cities that AI and Blockchain could address?

25. Do you think public-private partnerships can accelerate the adoption of AI, Blockchain, and IoT technologies for risk management in Smart Cities, particularly in sectors like agriculture, education, and energy?

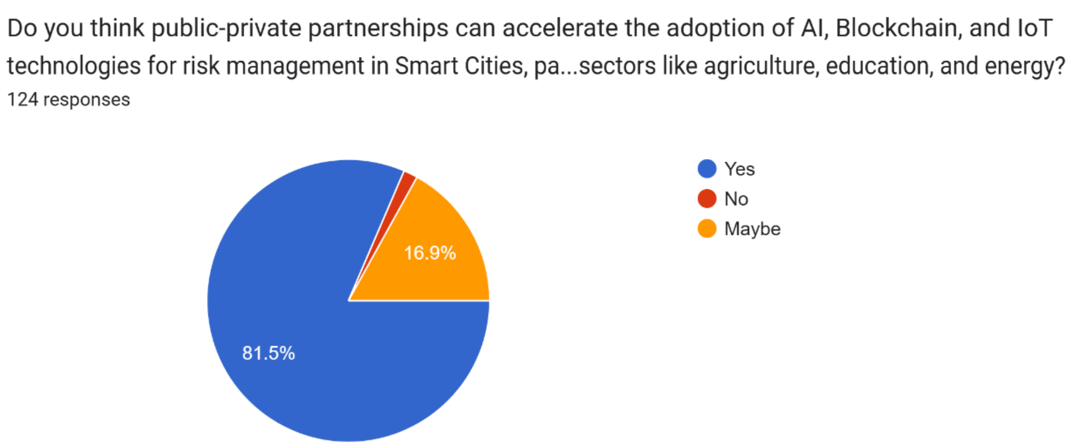


Figure 104: Do you think public-private partnerships can accelerate the adoption of AI, Blockchain, and IoT technologies for risk management in Smart Cities, particularly in sectors like agriculture, education, and energy?

26. How do you rate the importance of AI, Blockchain, and IoT in enhancing risk management for healthcare systems in Smart Cities (e.g., real-time monitoring, predictive analytics, electronic health records)?

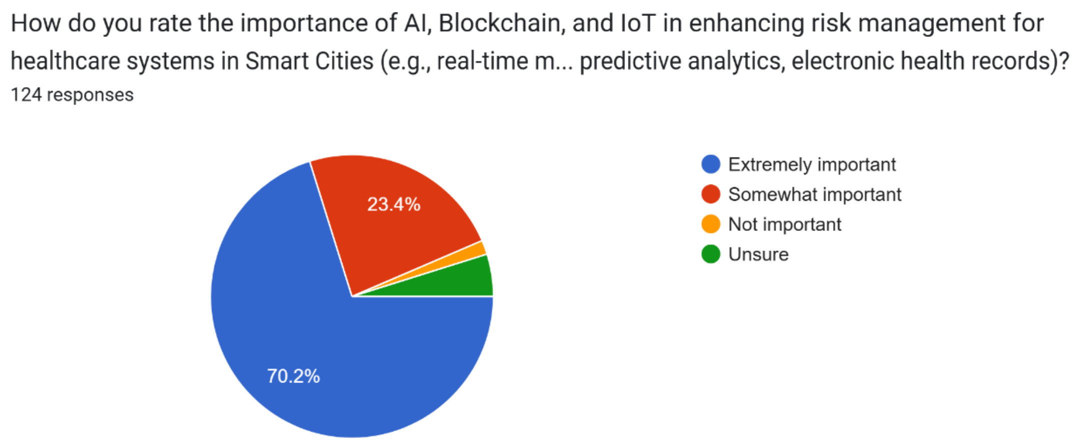


Figure 105: How do you rate the importance of AI, Blockchain, and IoT in enhancing risk management for healthcare systems in Smart Cities (e.g., real-time monitoring, predictive analytics, electronic health records)?

27. Which healthcare risks can be most effectively mitigated by AI and Blockchain in Smart Cities? (Select all that apply)

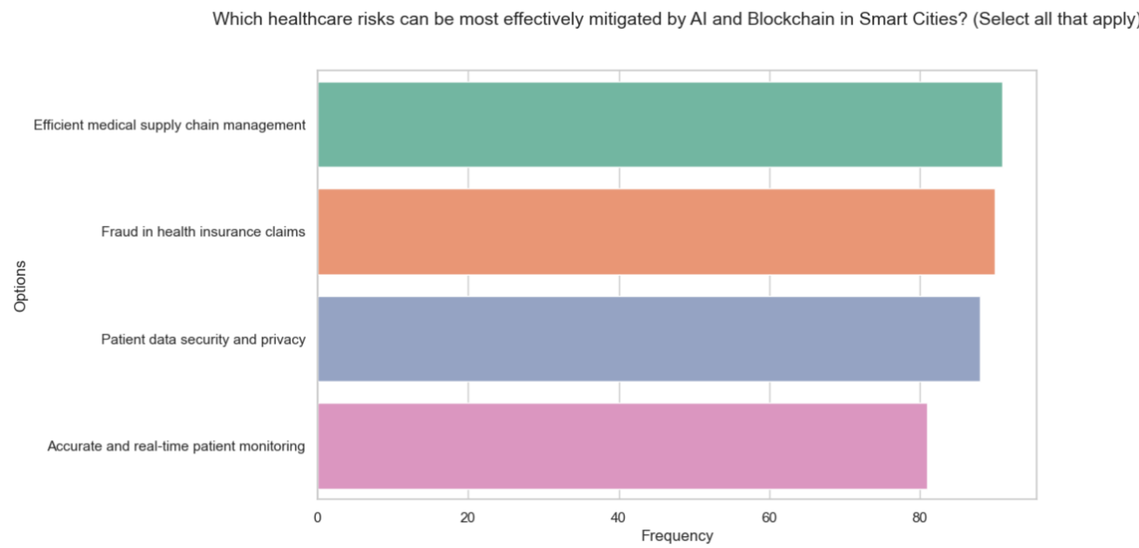


Figure 106: Which healthcare risks can be most effectively mitigated by AI and Blockchain in Smart Cities?

28. "What risks do you foresee from integrating AI with IoT and Blockchain technologies in your industry (e.g., privacy violations, security breaches, operational failures)? Select all that apply)"

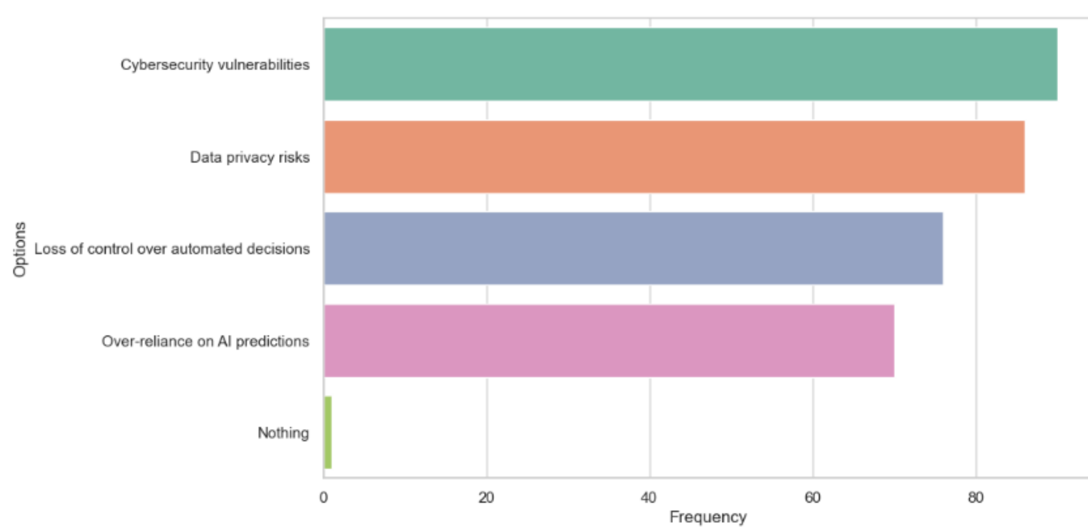


Figure 107: What risks do you foresee from integrating AI with IoT and Blockchain technologies in your industry (e.g., privacy violations, security breaches, operational failures)?

29. In your opinion, what are the most critical risk mitigation strategies when deploying AI in sensitive sectors like healthcare, finance, and public safety? (Select all that apply)

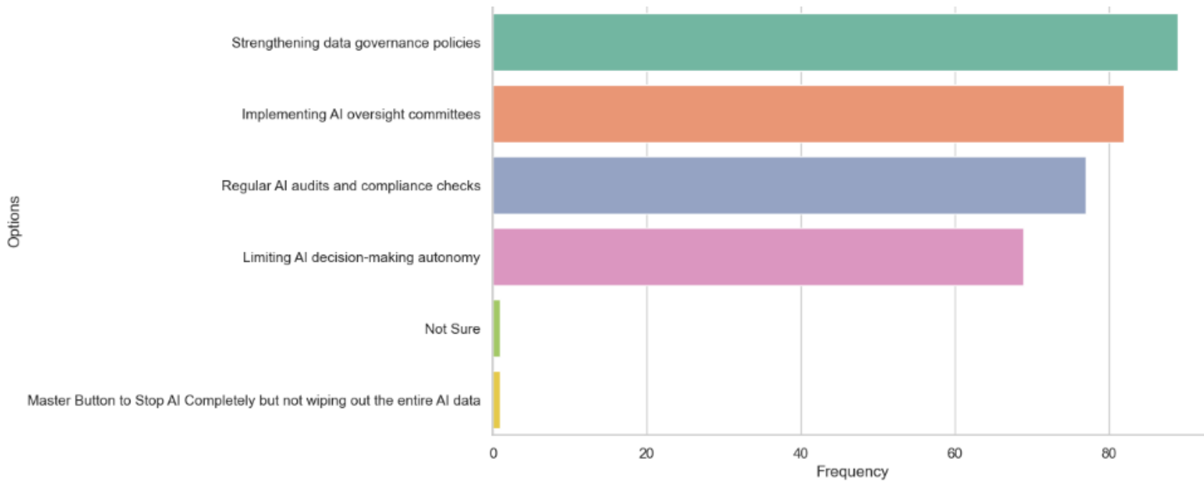


Figure 108: In your opinion, what are the most critical risk mitigation strategies when deploying AI in sensitive sectors like healthcare, finance, and public safety?

30. How effectively does your organization handle the risk (i.e., the risk that remains after all mitigation strategies) when implementing AI in real-time operations? "1" being least effectively and "5" being most effectively.

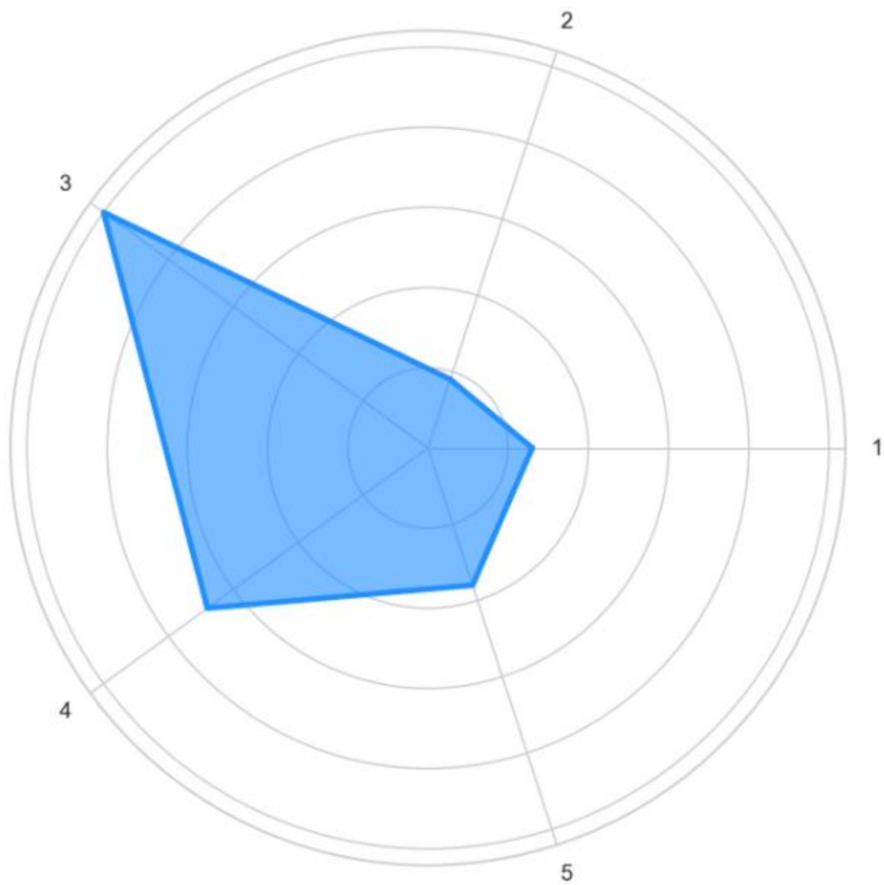


Figure 109: How effectively does your organization handle the risk (i.e., the risk that remains after all mitigation strategies) when implementing AI in real-time operations

31. What action points would you consider critical for reducing residual risks when using AI for public safety (e.g., real-time surveillance, risk assessment in emergency management)? Select all that apply)

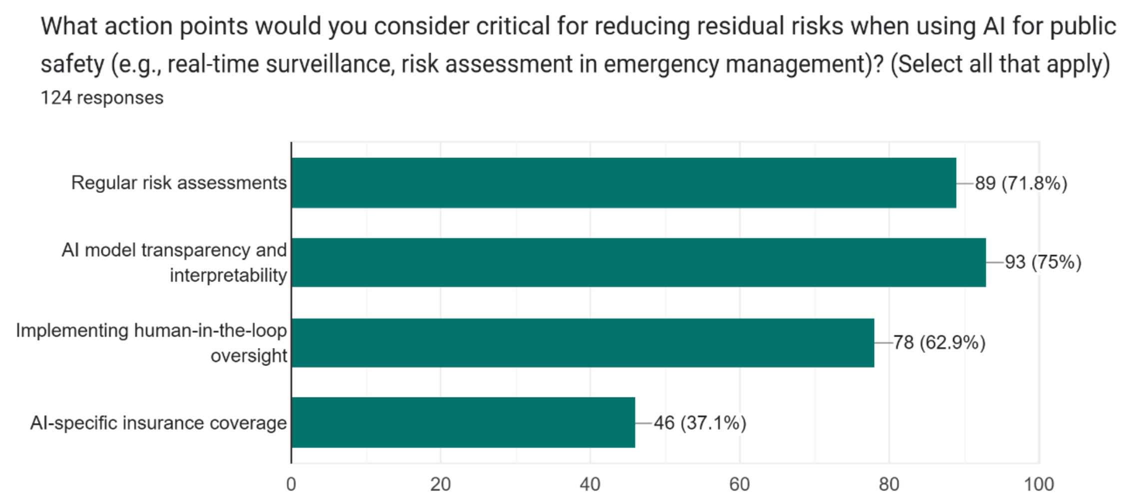


Figure 110: What action points would you consider critical for reducing residual risks when using AI for public safety (e.g., real-time surveillance, risk assessment in emergency management)?

32. What potential financial risks do you associate with integrating AI, Blockchain, and IoT in supply chain management, and how do you plan to mitigate them?

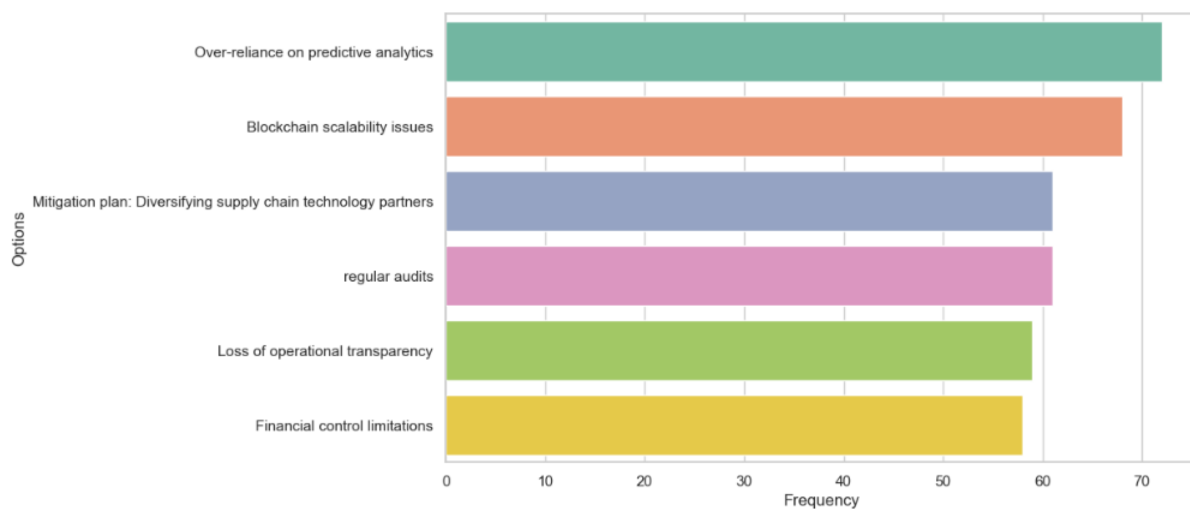


Figure 111: What potential financial risks do you associate with integrating AI, Blockchain, and IoT in supply chain management, and how do you plan to mitigate them?

33. What are the primary risks when combining AI, Blockchain, and IoT in the healthcare sector (e.g., patient data privacy, system interoperability)?

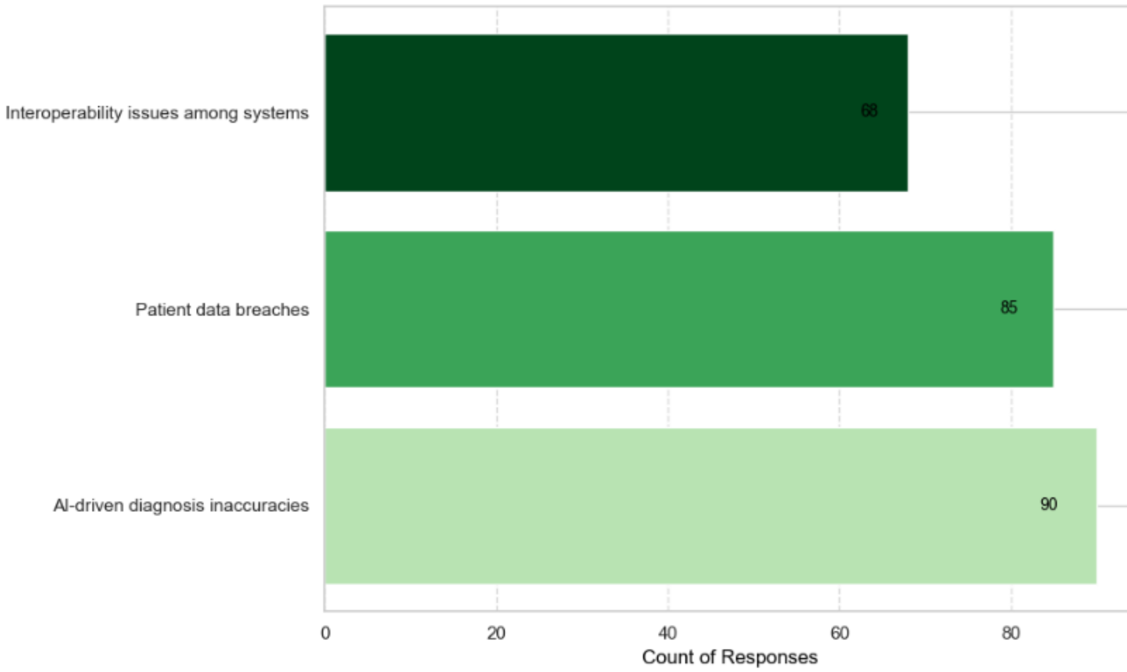


Figure 112: What are the primary risks when combining AI, Blockchain, and IoT in the healthcare sector (e.g., patient data privacy, system interoperability)?

34. How do you plan to address risks arising from the collaboration of AI, Blockchain, and IoT in tracking supply chain assets and ensuring data security?

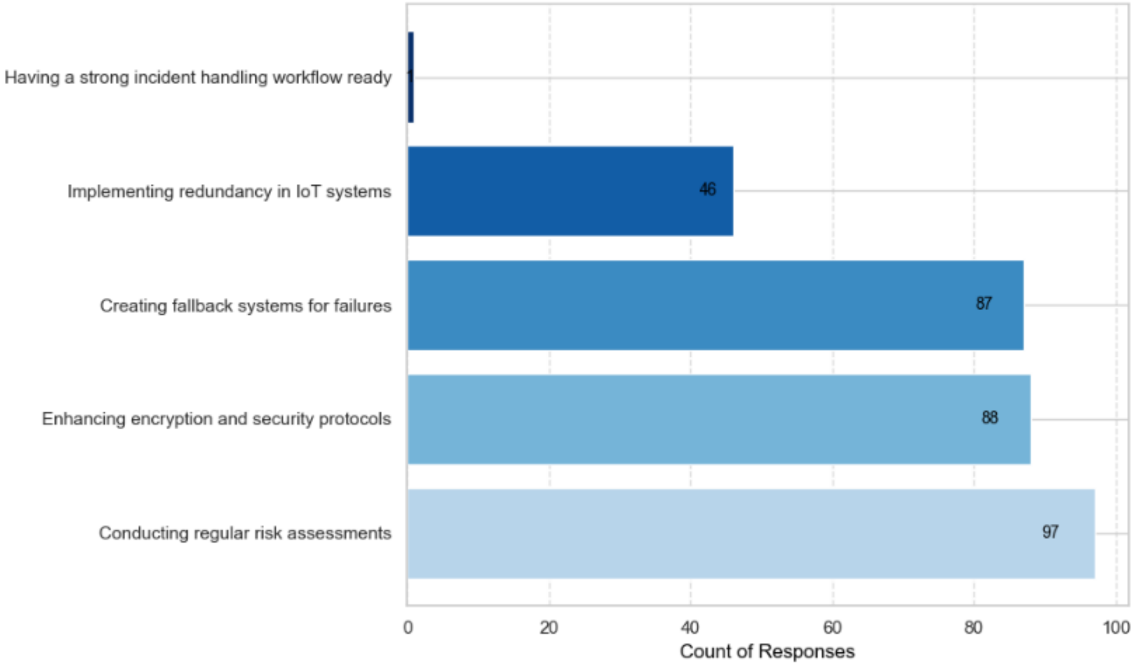


Figure 113: How do you plan to address risks arising from the collaboration of AI, Blockchain, and IoT in tracking supply chain assets and ensuring data security?

35. What specific mitigation strategies would you apply to handle risks of over-automation in supply chain or healthcare operations when using AI, Blockchain, and IoT?

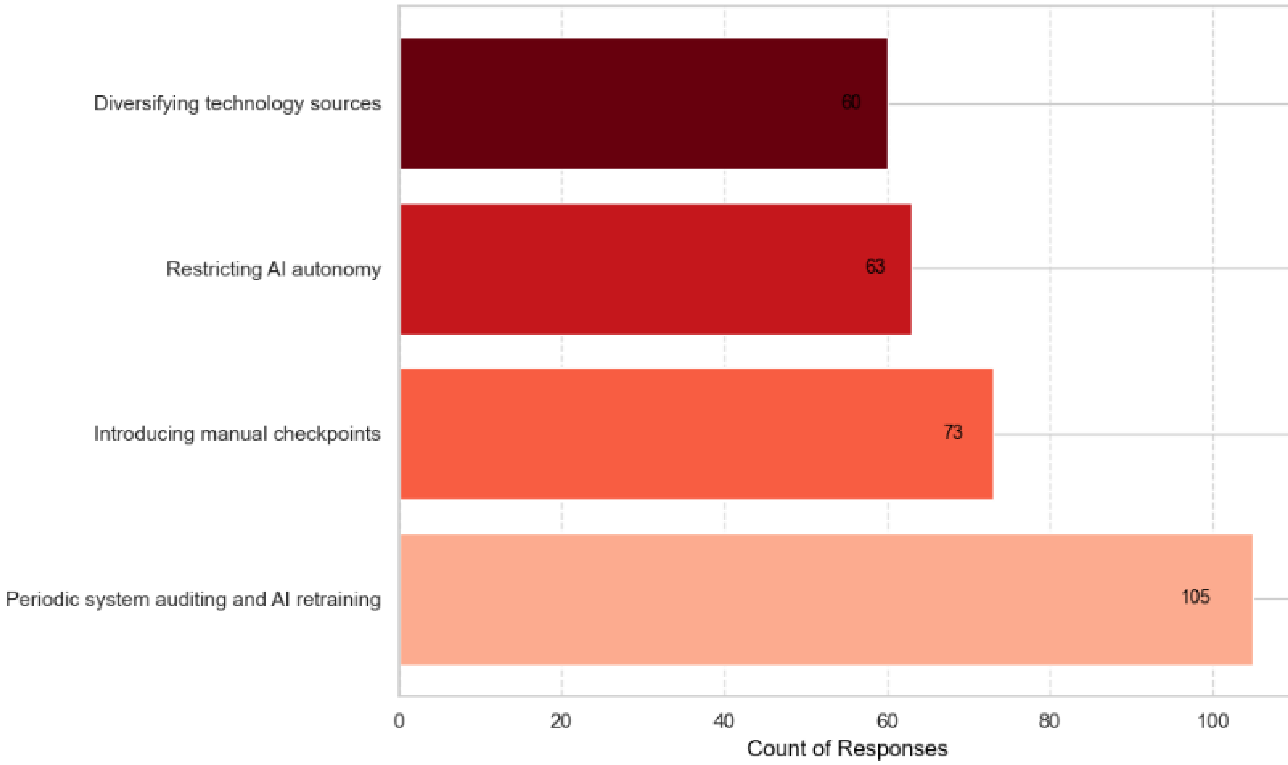


Figure 115: What specific mitigation strategies would you apply to handle risks of over-automation in supply chain or healthcare operations when using AI, Blockchain, and IoT?

36. What would be your approach to mitigate risks from AI in predictive analytics for real estate investments in Smart Cities (e.g., EVA miscalculation, wrong predictive outputs)?

Figure 114: AI Approach to mitigate risks in Real Estate Investments

37. What action points would you recommend for mitigating the risks of deploying AI in the education sector for personalized learning systems?

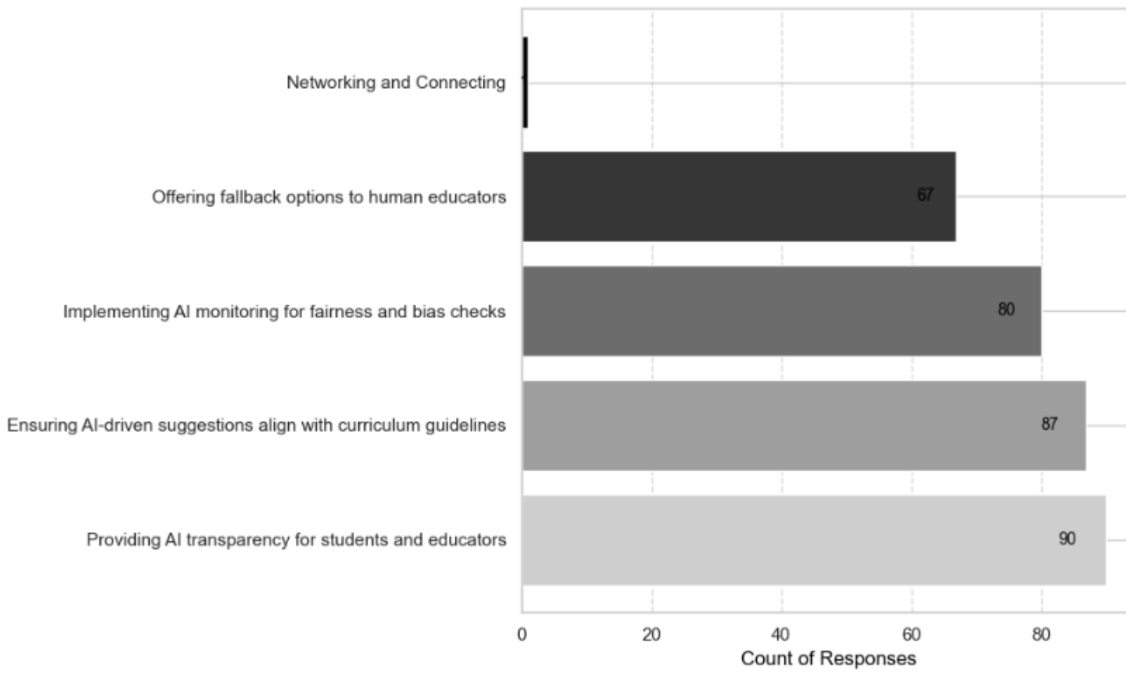


Figure 116: Recommended action points to mitigate risks in AI deployment in Education sector

38. In your opinion, what financial risks might arise from the collaboration of AI and IoT in the energy sector (e.g., smart grids), and how can they be mitigated? How do you quantify residual risks after implementing AI, IoT, and Blockchain in the finance or energy sectors?

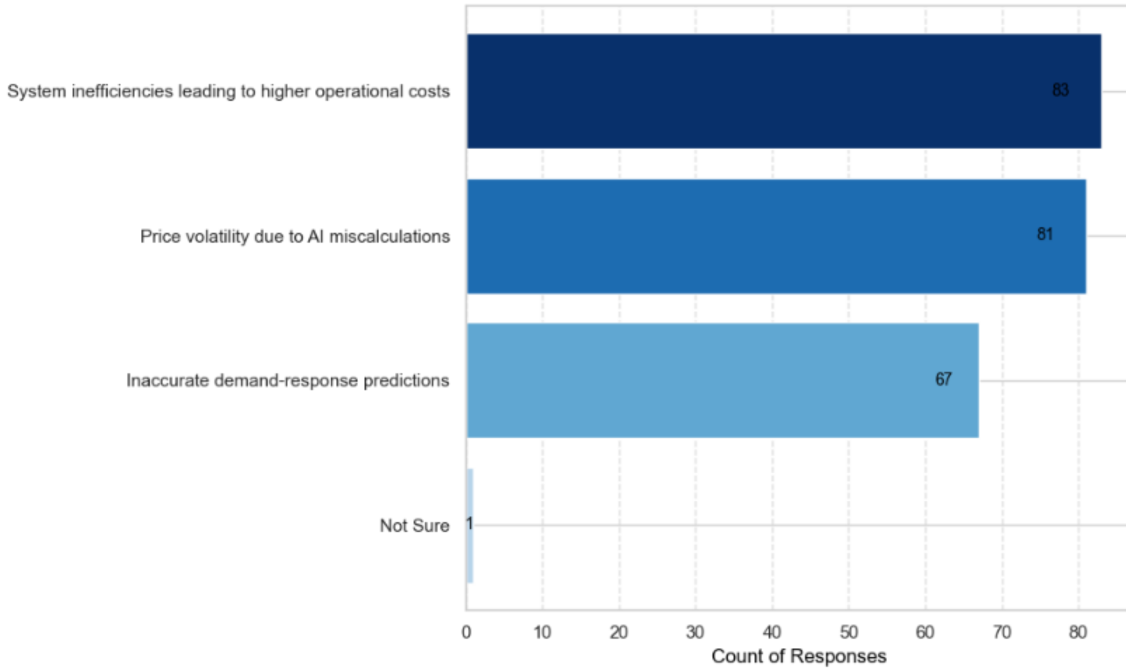


Figure 117: Financial risks might arise from the collaboration of AI and IoT in the energy sector

39. How do you quantify residual risks after implementing AI, IoT, and Blockchain in the finance or energy sectors?

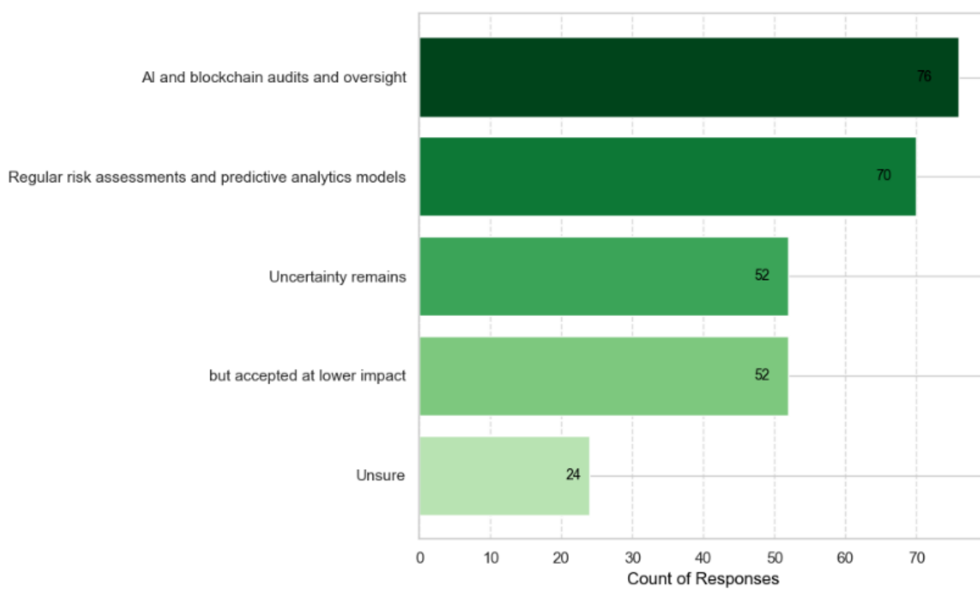


Figure 118: How do you quantify residual risks after implementing AI, IoT, and Blockchain in the finance or energy sectors?

40. What do you think is the best method to calculate Economic Value Added (EVA) after mitigating risks from AI, Blockchain, and IoT integrations in public safety?

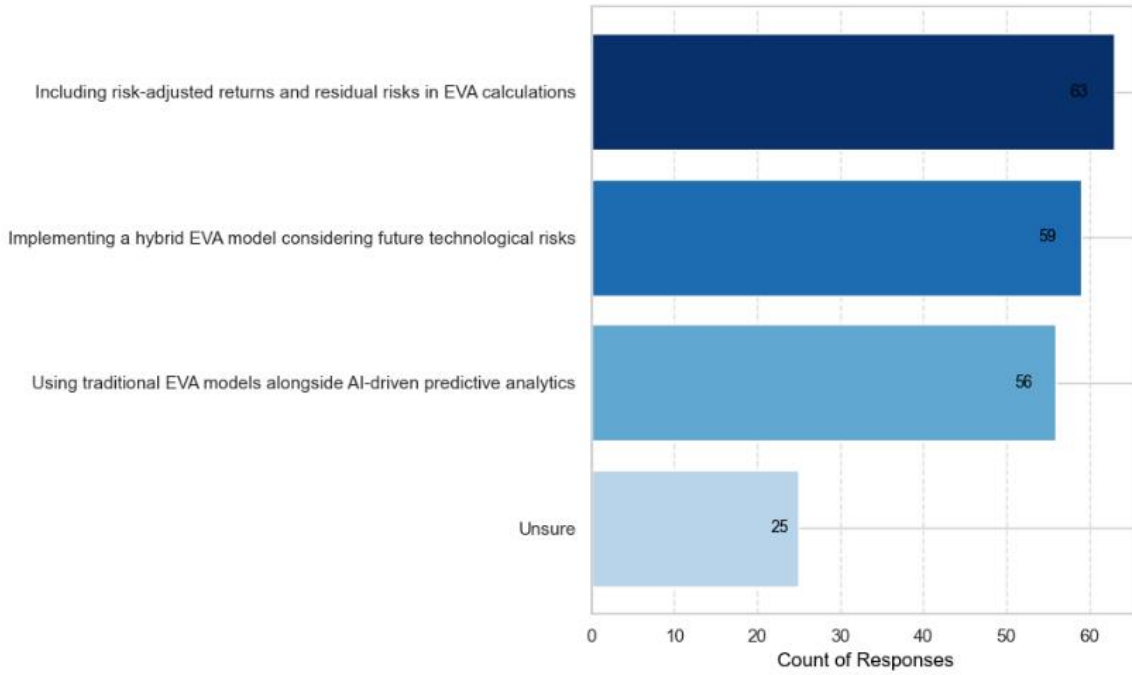


Figure 119: What do you think is the best method to calculate Economic Value Added (EVA) after mitigating risks from AI, Blockchain, and IoT integrations in public safety?

CHAPTER V:

DISCUSSION

5.1 Discussion of Results

The results of this research shed light on the critical challenges in managing risks within key sectors of a smart city. These risks primarily stem from the complexities of supply chain operations and corporate finance, particularly in intercompany reconciliations. The study identified how technology, especially blockchain, AI, and IoT, can be leveraged to mitigate these risks.

The developed solutions, *Swikriti* and *Viniyog*, were tested and found to be practical tools for addressing the pain points identified in the survey. Their MVPs were well-received, confirming that these technologies could offer real-world solutions to these problems.

Further the market of such solutions is studied with “top-down” and “bottom-up” approach and the critical valuation of Targetable Addressable Market (TAM) globally, Serviceable Addressable Market (SAM), Serviceable Addressable Market in Deep Tech, and Serviceable Obtainable Market (SOM) are analyzed. The following analysis shows the Market Trends for such solutions:

TAM, SAM, and SOM are terms used to describe the market size and potential for a product or service. They are key concepts in market analysis, especially when estimating the value of a business. These terms can be understood through two approaches: top-down and bottom-up.

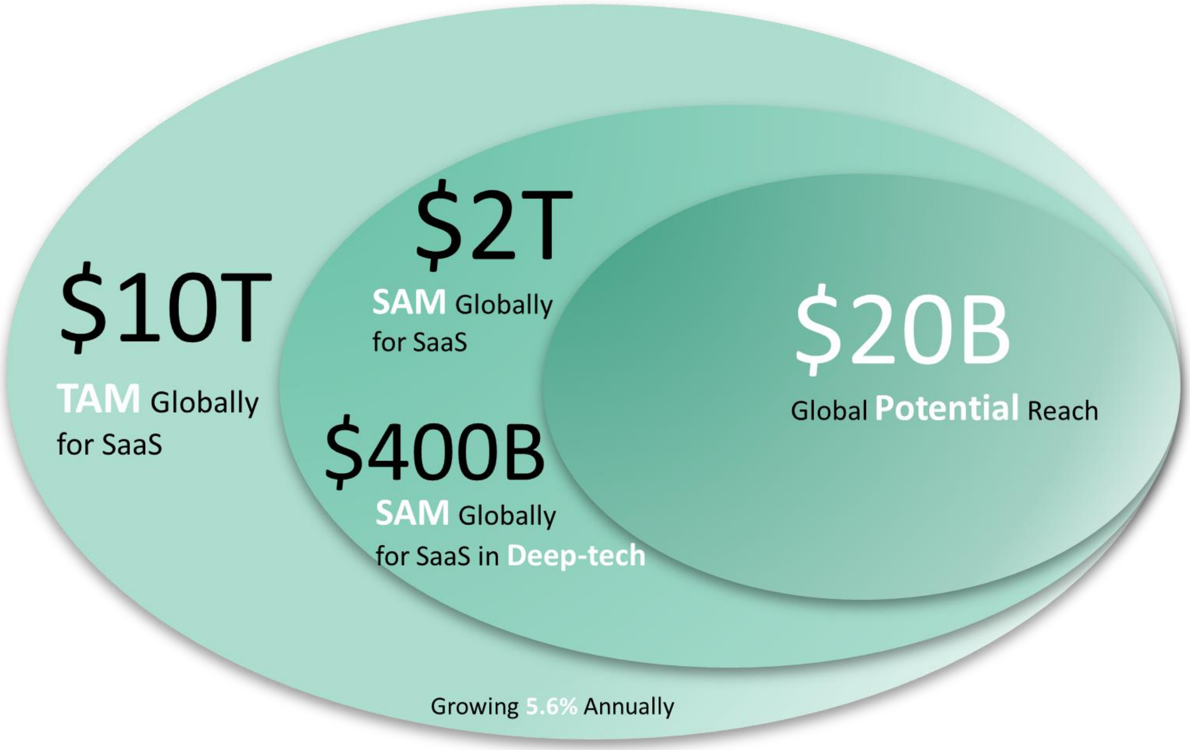


Figure 120: Top-Down and Bottom-Up Approach of Market Valuation of Deep Tech Solutions in Smart City Risk Management & Innovations

TAM (Total Addressable Market) refers to the total demand for a product or service if it were to capture 100% of the market. It’s the biggest possible market size, without considering any constraints or competition.

SAM (Serviceable Available Market) is a subset of TAM. It represents the part of the market that a company can target based on its products, services, and geographical reach. It narrows down the TAM by excluding markets the company can’t access or doesn’t serve.

SOM (Serviceable Obtainable Market) is even more specific. It represents the realistic portion of the SAM that a company can capture within a certain timeframe. SOM takes into account competition, market penetration strategies, and available resources.

In a top-down approach, it is to be started with TAM and use broad industry data to estimate the market size. Then the analysis is narrowed down to SAM and SOM based on factors like the company's ability to serve the market and its market share.

In a bottom-up approach, the market-size is built from the ground up, based on real-world data like customer surveys, sales figures, and competitor analysis. This approach is more grounded and uses the actual market conditions to project the SOM.

TAM, SAM, and SOM give a clear view of where the business stands in terms of overall market opportunity of leveraging Deep Techs like Blockchain, AI and IoT in the Smart City innovation and effective proactive Risk Management Solutions.

CHAPTER VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

This research aimed to explore the risks in two critical sectors within smart cities: supply chain and corporate finance, with a particular focus on intercompany reconciliation. Through comprehensive surveys and prototyping, the research identified the major challenges these sectors face and developed innovative technological solutions to address them. *Swikriti* and *Viniyog* emerged as promising tools for managing risks, and their MVPs are now being showcased to gain industry attention.

6.2 Implications

The implications of this research are significant for industries involved in supply chain management and corporate finance. Integration of AI, IoT, and blockchain, facilitate businesses to manage risks more effectively, improve operational efficiency, and reduce fraud. Governments and policymakers can use the findings to understand the importance of technological solutions in smart city development, especially for risk management in critical sectors.

6.2.1 Sustainable Development Goals – Catered by Viniyog and Swikriti

Goal 8: Decent Work and Economic Growth:

Viniyog promotes financial transparency in global operations. It reducing inefficiencies and enables smoother business workflows.

Swikriti ensures fair trade practices by certifying product quality, benefiting suppliers and producers.

Goal 9: Industry, Innovation, and Infrastructure:

Both platforms use cutting-edge technologies like Blockchain, AI, and IoT to improve operations in supply chain and finance.

Viniyog’s automation simplifies intercompany reconciliations, while Swikriti improves supply chain traceability and certification.

Goal 10: Reduced Inequalities

Viniyog ensures fair practices in intercompany financial settlements, especially for smaller subsidiaries and vendors in global operations.

Swikriti helps smaller suppliers gain access to premium markets by ensuring transparency in product quality.

Goal 12: Responsible Consumption and Production

Swikriti reduces waste by verifying product quality and improving supply chain efficiency. It effectively manages the under-stock and over-stock risks which helps in minimizing wastes.

Viniyog minimizes resource misuse by automating financial reconciliation and avoiding disputes.

Goal 13: Climate Action

Swikriti supports sustainable practices by encouraging traceable and ethical sourcing of products. Viniyog also reduces lots of Emailing and paper work thus further reducing carbon emission.

6.3 Recommendations for Future Research

Future research should explore how these technologies can be integrated into other sectors of smart cities, such as healthcare, education, and urban mobility, and public safety. Additionally, more studies are needed to understand the demographic preferences for adopting such technologies in both developing and developed countries. Further development and testing of the solutions like *Swikriti* and *Viniyog* will also provide valuable insights into their scalability and impact across different industries.

The Go-To-Market strategies are being planned and conducted to test whether the solution is market-fit.

The Go-To-Market strategy around two solutions, Viniyog & Swikriti, is getting conducted based on the followings:

- Free Trials

- Creating Solution & Technology Awareness through blogs, social media live events, Webinars Panel Discussions, Pod-Casts, building Tech Community, inviting developers to work on open-source platforms.
- Dedicated Marketing Team and SEO Optimization
- Content Creation & Management
- Inviting ERP Consultants to test the product on free trials.

These GTM will further recommend on the feature enhancement, functional modification and further scope of work their which provide a platform for research and development of the similar solutions and innovations.

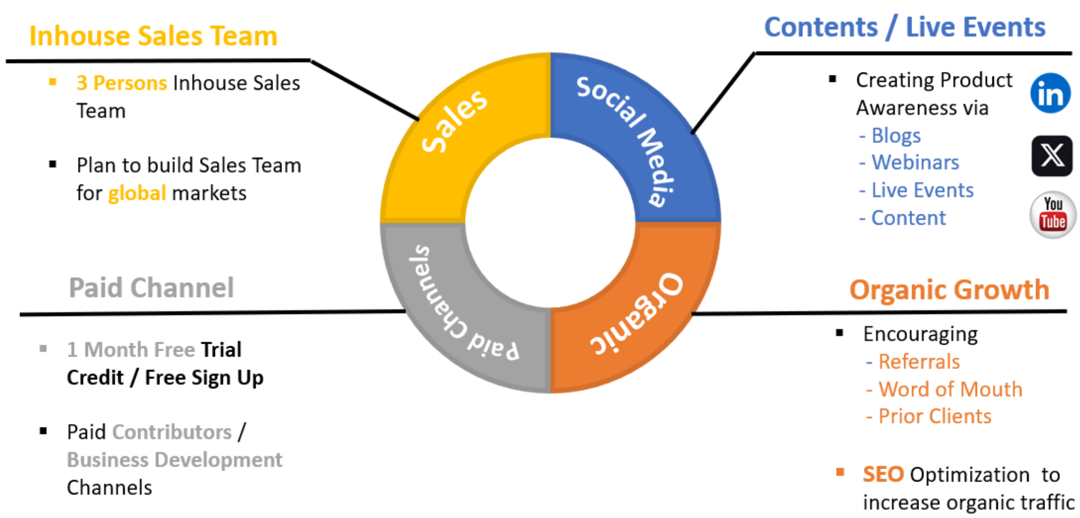


Figure 121: Go-To-Market Strategy - Research & Future Scope

6.4 Conclusion

This research successfully bridged the gap between theoretical risk management in smart cities and practical, technology-driven solutions. The development of **Swikriti** and **Viniyog** represents a significant step forward in addressing the critical risks in supply chain and corporate finance operations. As the world moves towards more digitally connected and intelligent cities, the findings of this study will contribute to making these cities safer, more efficient, and resilient.

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APPENDIX A

SURVEY COVER LETTER

The Survey Cover letter was framed as follows:

"This survey aims to understand the current practices, challenges, and opportunities in risk management for Smart Cities using advanced technologies such as AI, Blockchain, and IoT. It covers domains including finance, supply chain, public safety, and smart grid management. Your insights will guide the development of more robust, secure, and scalable solutions for future Smart Cities."

APPENDIX B

INFORMED CONSENT

Thank you for agreeing to participate in this research study. Before you begin, please take a moment to review the following information:

Purpose of the Study:

The purpose of this study is to understand the current practices, challenges, and opportunities in risk management for Smart Cities, powered by advanced technologies like AI, Blockchain, and IoT. This study will focus on sectors including finance, supply chain, public safety, and smart grid management.

Voluntary Participation:

Your participation in this study is completely voluntary. You are free to withdraw at any time without any consequences.

Confidentiality:

Your responses will be kept confidential and will only be used for the purpose of this research. The data collected will not include any personally identifiable information unless explicitly provided by you. All information will be aggregated and reported in a way that ensures your anonymity.

Risks and Benefits:

There are minimal risks associated with participation in this study. However, your insights will significantly contribute to the development of more effective, secure, and scalable solutions for Smart Cities. There are no direct financial benefits for participating, but your contribution will have an impact on the advancement of technology and risk management strategies.

Contact Information:

If you have any questions or concerns about the study or your participation, please contact Munmun Das at moons2star@gmail.com.

Consent to Participate:

By continuing with this survey, you acknowledge that you have read and understood the information above and consent to participate in this study. You are aware that your participation is voluntary and that you can withdraw at any time.

If you agree to participate, please click "Yes" to continue.

Thank you for your valuable time and contribution to this research.

APPENDIX C

ABBREVIATIONS

1. **AI** - Artificial Intelligence
2. **IoT** - Internet of Things
3. **DLT** - Distributed Ledger Technology
4. **ERP** - Enterprise Resource Planning
5. **MVP** - Minimum Viable Product
6. **CFO** - Chief Financial Officer
7. **R&D** - Research and Development
8. **CRM** - Customer Relationship Management
9. **ML** - Machine Learning
10. **NLP -** Natural Language Processing
11. **SaaS** - Software as a Service
12. **B2B** - Business to Business
13. **B2C** - Business to Consumer
14. **B2G**- Business to Government
15. **SDG** – Sustainable Development Goals
16. **M2M -** Machine to Machine
17. **KPI** - Key Performance Indicator
18. **API** - Application Programming Interface
19. **TAM** - Total Addressable Market
20. **SAM -** Serviceable Available Market
21. **SOM** - Serviceable Obtainable Market
22. **ROI** - Return on Investment
23. **UML** - Unified Modeling Language

24. **DBMS** - Database Management System
25. **SQL** - Structured Query Language
26. **BPM** - Business Process Management
27. **C2C** - Consumer to Consumer
28. **SCM**- Supply Chain Management
29. **QC** – Quality Control
30. **CB** – Certification Body
31. **ICR**- Inter-company reconciliation
32. **AR**- Account Receivable
33. **AP** – Account Payable
34. **SC** – Smart Contract
35. **RP** – Related Parties
36. **RPT** – Trelated Parties Transaction
37. **ERM**- Enterprise Risk Management
38. **IRPT**- Inter related parties transaction
39. **MQ**- Message Queue
40. **DaO**- Decentralized Automomous Organization
41. **GENAI** – Generative AI
42. **PLM** - Product Life cycle management
43. **NoN** – Network of Networks
44. **DT** – Digital Twin
45. **KMP** – Key Managerial Personnel
46. **SAP** – System Application Product
47. **MoM –** Month on Month
48. **LLM –** Large Language Models

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