smart cities

Review

Artificial Intelligence in Smart Cities—Applications, Barriers, and Future Directions: A Review

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Abstract: As urbanization continues to pose new challenges for cities around the world, the concept of smart cities is a promising solution, with artificial intelligence (AI) playing a central role in this transformation. This paper presents a literature review of AI solutions applied in smart cities, focusing on its six main areas: smart mobility, smart environment, smart governance, smart living, smart economy, and smart people. The analysis covers publications from 2021 to 2024 available on Scopus. This paper examines the application of AI in each area and identifies barriers, advances, and future directions. The authors set the following goals of the analysis: (1) to identify solutions and applications using artificial intelligence in smart cities; (2) to identify the barriers to implementation of artificial intelligence in smart cities; and (3) to explore directions of the usage of artificial intelligence in smart cities.

Keywords: smart cities; artificial intelligence; AI; technology; barriers

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1. Introduction

As cities around the world continue to struggle with the complexities of urbanization, the emergence of smart cities offers a promising solution to new challenges. At the heart of this transformation, there is artificial intelligence (AI), which can revolutionize various aspects of urban life. From optimizing transportation systems to managing environmental resources, enhancing governance, improving quality of life, fostering economic growth, and empowering citizens, AI plays an important role in unlocking the full potential of smart cities. Smart cities use advanced technologies, data analytics, and digital infrastructure to enhance the efficiency, sustainability, and quality of life for residents [1]. These cities integrate various smart solutions across multiple sectors, including transportation, energy, healthcare, governance, education, and more, to address urban challenges and improve overall well-being. Key characteristics of smart cities include the use of Internet of Things (IoT) devices for collecting data and interconnected digital platforms for seamless communication and collaboration between stakeholders [2]. Smart cities are strongly connected to the term Industry 4.0 and the increasingly popular term Society 5.0 [3], which represents a vision of a highly advanced society where technology serves as a catalyst for positive social and economic transformation. Humanity has always been striving for progress by building more and more technologically advanced cities in which more and more intelligent people, aware of the environment, live. However, it should be emphasized that there is also a concept that contributes to enormous progress, especially in smart cities—this concept is artificial intelligence. AI not only introduces enormous technological changes but also has a huge impact on people's behavior and lifestyle. Artificial intelligence can be implemented into almost every area of human life.

Since AI development provides changes at a very fast pace, the authors decided to examine the latest literature that discusses the topic of AI. Due to the fact that AI issues can be studied in many aspects, the authors decided to focus on the selected area, which is smart cities. Therefore, in this paper, the authors present a literature study on the topic of artificial intelligence in smart cities. The paper then presents the analysis of the literature from 2021 to 2024, which is available on Scopus. All analyzed papers were tagged with both the keywords "smart city" and "artificial intelligence". The articles were analyzed by dividing them into six main categories, which are the six main areas of the smart city.

This manuscript is divided into 10 sections. Section 2 presents materials and methods. Sections 3–8 describe the results of the literature analysis, and every section refers to one of the smart city areas (smart governance, smart economy, smart mobility, smart environment, smart living, smart people). Section 9 presents the discussion of the results. This paper is finished with Section 10—conclusions.

This paper makes a unique contribution by offering a detailed examination of the role of artificial intelligence in shaping smart cities. Unlike many existing studies that focus on specific aspects of AI or smart cities, this paper takes a holistic approach, exploring AI's applications across six key areas: smart governance, smart economy, smart mobility, smart environment, smart living, and smart people. One of the distinctive aspects of this paper is its comparative analysis of AI usage within each area. Through detailed comparisons, it highlights the core objectives, data utilization strategies, citizen engagement approaches, automation of services, sustainability focuses, security measures, integration of emerging technologies, predictive analytics, inclusive solutions, and economic impacts of AI implementations. This comprehensive overview provides readers with a nuanced understanding of how AI contributes to various aspects of urban life.

Also, this paper goes beyond simply enumerating AI applications by delving into the challenges and considerations associated with AI deployment in smart cities. It identifies ethical considerations, the digital divide, security and compliance issues, and language bias as key challenges that must be addressed to ensure responsible and equitable AI implementation. By acknowledging these challenges and offering insights into overcoming them, this paper provides valuable guidance for policymakers, urban planners, and technologists involved in shaping the future of smart cities.

Rather than solely focusing on AI's benefits, this paper also addresses the challenges associated with AI deployment in smart cities. It highlights ethical considerations, the digital divide, security and compliance issues, and language bias as key challenges that must be addressed for responsible and equitable AI implementation. By acknowledging these challenges, this article offers a more balanced perspective on the complexities of integrating AI into urban environments. In addition to identifying challenges, this paper offers practical recommendations for overcoming them. It suggests that it is necessary to build trust through transparent communication, engage stakeholders through education and awareness campaigns, establish ethical guidelines for AI development, implement community-based digital literacy programs, and emphasize human-centered design principles. These recommendations provide actionable insights for policymakers, urban planners, and technologists working in the field of smart cities.

2. Materials and Methods

This study uses literature review as a method of research. The authors conducted an analysis of publications indexed by Scopus. Using a search engine, they concluded that there are more than 30,000 papers indexed with the keyword "smart city" and over 442,000 papers with the keyword "artificial intelligence" in this database (data from the day of 29 January 2024). The authors limited the research to the years 2021–2024, and the search results are presented in Table 1. The authors have selected a period covering the last three years, from 2021 to 2023, including January 2024 (data from 29 January). This period was chosen to ensure this review article focuses on the most recent developments in the intersection of artificial intelligence and smart city initiatives. When it comes to the number of papers that are described at the same time by both "artificial intelligence" and "smart city" keywords, the search showed that there have been 773 papers published since 2021.

Table 1. Search results for papers with the given keywords on Scopus.

Keywords	Number of Papers—Scopus	Number of Papers since 2021—Scopus
smart city	31,785	11,327
artificial intelligence	442,077	116,373
smart city, artificial intelligence	1623	773

Choosing "artificial intelligence" and "smart city" as keywords for searching papers, the authors aimed to cast a wide net that would capture diverse perspectives and developments in the field. By selecting these broad terms, they ensured that the review would include various applications of AI in the context of urban environments, allowing the authors to provide a comprehensive overview of the current state of research and emerging trends. Additionally, focusing on these keywords enabled authors to target literature that directly addresses the intersection of advanced technologies and the challenges and opportunities of modern city living, aligning closely with the objectives of our review.

The authors decided to review selected 773 articles. In the beginning, they divided the papers according to the year of publication. It can be said that the numbers in 2021–2023 are quite similar; while looking only at articles containing the keyword "artificial intelligence", a growing trend is noticed. Figure 1 shows the articles on Scopus in the years 2021–2024 in numbers depending on keywords.

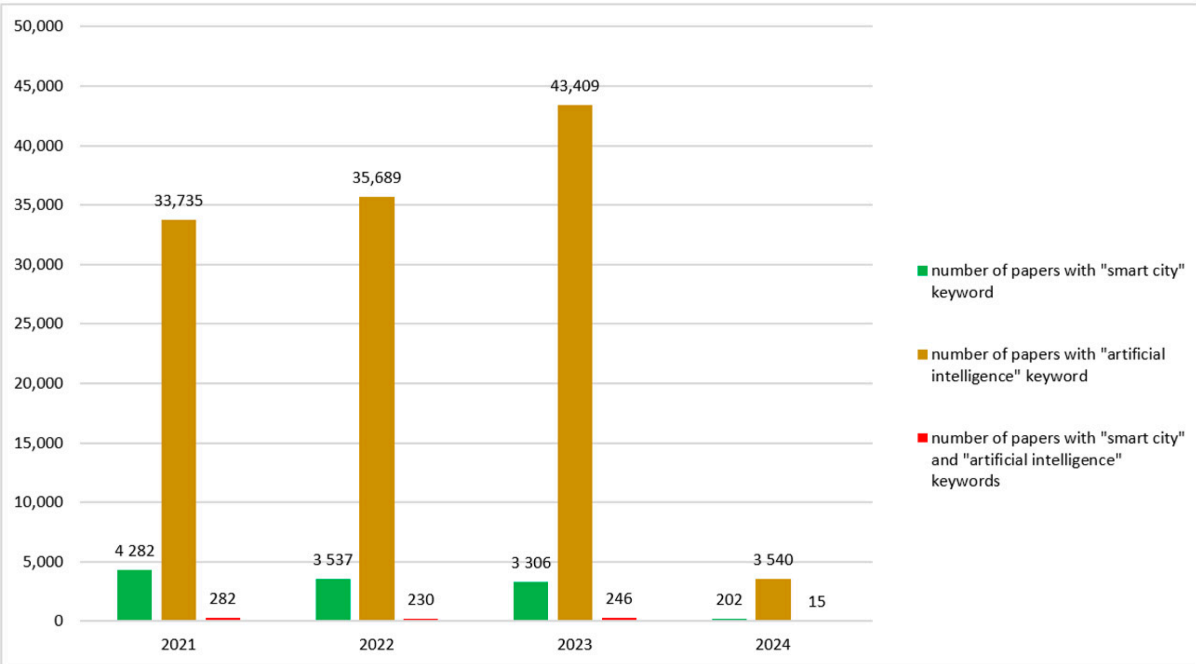

Figure 1. Search results for papers with given keywords published in 2021–2024 on Scopus (data from 29 January 2024).

Due to the fact that 773 is a great number of papers, the authors decided to select at least 20% of articles (at least 155 papers) that would be described in detail in a review paper. To do this, the authors provided some criteria for choosing articles for the next stage of research. These criteria included the following: (1) original papers that closely align with the objectives and scope of the review paper; (2) well-conducted research providing substantial insights into the topic of smart cities and the usage of AI in them; (3) papers that offer fresh insight or findings on the topic; and (4) papers that describe the practical approach to the topic of AI in smart cities. Based on the mentioned criteria, the authors made a selection, reviewing abstracts of 773 papers and, as a result, leaving 157 articles for the next stage. These papers were subject to full-text review and description in this paper. Figure 2 shows the selection process.

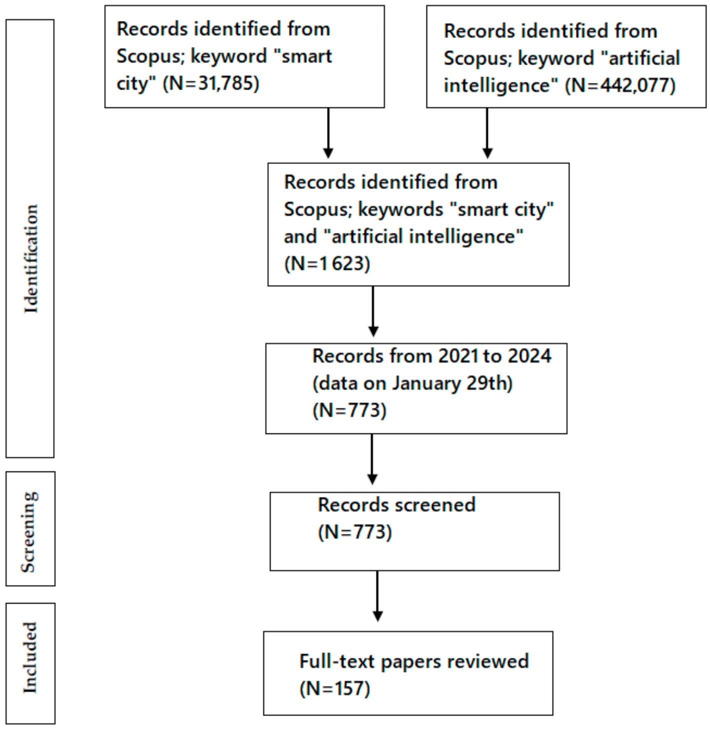

Figure 2. The paper selection process.

In the next step, the papers were divided into categories. The authors adopted 6 main categories, which are general areas of smart cities. First, those pillars were identified in the McKinsey Global Institute report in 2018 [1]. They include the following areas (pillars) [1,4,5]:

- Smart governance;
- Smart economy;
- Smart mobility;
- Smart environment;
- Smart living;
- Smart people.

The authors have used those predefined areas because the concept of six dimensions of smart city is most widespread in the scientific literature. There are some other concepts that can be spotted in some papers, for example, “smart culture”, “smart healthcare”, “social inclusion”, etc., but they are only used in single papers. It would be difficult to use them comprehensively in the analysis while the main body of papers uses six-dimension approach. The authors have decided to use these six main categories as this popular and common division leads to better comparability of the study. Also, the more categories, the bigger the overlap and difficulty to categorize papers. Smart governance focuses on the application of digital technologies to enhance the efficiency and transparency of administrative processes [6]. This involves the use of data analytics, artificial intelligence, and other technologies to improve decision-making, streamline public services, and foster citizen engagement. Through smart governance, cities aim to create a more responsive and inclusive urban administration [7]. In the context of smart cities, a smart economy focuses on leveraging technology and innovation to drive economic growth and sustainability. This includes the promotion of digital businesses, the development of smart infrastructure, and the integration of technologies like blockchain to enhance economic transactions [8]. The goal is to create a dynamic and resilient urban economy that can adapt to the challenges of the modern era [9]. Smart mobility addresses the seamless integration of innovative technologies to enhance transportation systems. This involves the use of intelligent traffic management, efficient public transportation, and the implementation of sustainable modes of travel, such as electric vehicles and bike-sharing programs. The goal is to optimize urban mobility, reduce congestion, and minimize the environmental impact of transportation [1,5]. The concept of a smart environment revolves around leveraging technology to monitor and manage the urban surroundings efficiently. This includes the implementation of smart waste management systems, air and water quality monitoring, and the integration of green spaces. By utilizing sensors and data analytics, cities can work toward creating healthier and more sustainable living environments for their residents [10,11]. The concept of smart living encompasses the integration of technology to enhance the quality of life for city residents [12]. This involves the deployment of smart home systems, IoT-enabled devices, and digital services that cater to the needs of individuals and communities. Smart living aims to create a more comfortable and connected urban experience, fostering a sense of well-being and community [13]. Smart people refer to the integration of technology to empower individuals and communities within a city. This involves initiatives such as digital literacy programs, online education platforms, and the promotion of inclusive and accessible technology. Smart people aim to equip residents with the skills and tools needed to thrive in a digital society, fostering a more knowledgeable and empowered citizenry [14,15]. The areas of smart city analyzed are described in Table 2.

Table 2. The main areas of smart cities.

Area	Description	Examples
Smart Governance	Involves the use of technology to enhance public services, improve government efficiency, and foster citizen engagement in decision-making processes.	• E-Government platforms; • Digital civic participation tools; • Data-driven policy-making.
Smart Economy	Focuses on leveraging technology to drive economic growth, innovation, and sustainability, fostering a dynamic and resilient urban economy.	• Innovation hubs and technology parks; • Digital payment systems and smart transactions; • Data-driven economic development strategies.
Smart Mobility	Focuses on intelligent and efficient transportation solutions, integrating technology to enhance mobility, reduce congestion, and improve accessibility.	• Intelligent traffic management systems; • Electric and autonomous vehicles; • Integrated public transportation systems.
Smart Environment	Aims to create sustainable and eco-friendly urban spaces, leveraging technology to monitor and manage natural resources, reduce pollution, and enhance overall environmental quality.	• Smart waste management systems; • Air and water quality monitoring; • Energy-efficient street lighting.
Smart Living	Encompasses the application of technology to enhance the quality of life for residents, covering areas such as healthcare, education, and safety.	• Smart homes with IoT devices; • Telehealth and remote healthcare services; • Smart education initiatives.
Smart People	Emphasizes the importance of empowering and engaging citizens through technology, promoting education, awareness, and inclusivity.	• Digital literacy programs; • Citizen engagement platforms; • Inclusive community development initiatives.

Sources: [1,6–17].

This paper employs a narrative review approach to explore the applications, barriers, and future directions of artificial intelligence in smart cities. Narrative review approaches offer a more flexible framework for synthesizing information from diverse sources [18–20]. In this paper, the authors conducted an extensive search of the literature related to AI in smart cities, drawing from academic journals and conference proceedings. Throughout the review process, the authors likely identified common themes, trends, and challenges emerging from the literature. They have organized findings into thematic sections, such as smart mobility, smart environment, smart governance, smart living, smart economy, and smart people, to provide structure to the narrative. In addition to summarizing existing research, the authors provided critical insights and interpretations based on a synthesis of the literature. By adopting a narrative review approach, the authors were able to offer a comprehensive analysis of AI in smart cities, synthesizing insights from a wide range of sources to provide a nuanced understanding of the topic. This approach allowed for flexibility in exploring complex issues and generating new perspectives, contributing to the ongoing discourse on the role of AI in shaping urban futures.

The analysis method used in this paper involved a collaborative effort between the authors to classify the papers and identify key themes within each main category. Initially, the authors likely conducted independent reviews of the literature to familiarize themselves with the existing research on the implementation of AI in smart cities. Following this initial review, they likely came together to discuss their findings, compare notes, and identify common themes and problems across the literature.

During this collaborative process, the authors likely categorized the papers into different main areas, such as smart mobility, smart environment, smart governance, smart living, smart economy, and smart people. Within each main category, the authors likely identified sub-themes or specific topics that were commonly discussed in the literature.

Table 3 shows articles that are assigned to a given smart city area. Some articles overlap because they concern more than one area. The total number of papers in every category is as follows: smart governance—34; smart economy—24; smart mobility—44; smart environment—27; smart living—41; and smart people—11. The total number of papers is 157, but adding up the number of papers in the above-mentioned categories, there are 181 papers—this is due to the fact that some papers overlap. Sixteen papers are in exactly two categories, and four papers are in exactly three categories.

Table 3. The reviewed papers in analyzed categories.

Category (Area of Smart City)	Papers
Smart governance	[21–54]
Smart economy	[16,17,23,24,27,35,55–72]
Smart mobility	[23,24,35,43–46,50–52,64,72–104]
Smart environment	[105–131]
Smart living	[55,57,128–166]
Smart people	[67,131,167–175]
Total number of papers	157

The analysis method may have involved thematic analysis, where the authors systematically identified and analyzed patterns or themes within the literature. This could have included identifying recurring topics, trends, challenges, and opportunities related to AI implementation in smart cities.

To form the barriers and future directions, the authors likely followed a similar process of reviewing the literature, identifying common challenges and trends, and collaboratively discussing and categorizing them into distinct categories. This could have involved synthesizing the findings from the literature review and drawing connections between different studies to form a comprehensive understanding of the barriers and future directions of AI implementation in smart cities.

The following Sections 3–8, review publications in a given smart city area. In other words, each section shows what artificial intelligence solutions appear in smart cities in publications from 2021 to 2024.

The objectives of this paper include the following:

- O1: To identify applications of using artificial intelligence in smart cities;
- O2: To identify the barriers to implementation of artificial intelligence in smart cities;
- O3: To explore directions of the usage of artificial intelligence in smart cities.

3. Smart Governance

3.1. Main Important Solutions Used in AI Implementation in Smart Governance

The integration of artificial intelligence in smart governance is transforming the landscape of public administration, offering innovative solutions to enhance efficiency, transparency, and citizen engagement. Urban administrators, particularly in major cities worldwide, are exploring the deployment of advanced information technologies, including AI, to deliver e-governance services [21]. The key objective is to leverage AI capabilities to provide citizens with easy access to relevant information without requiring extensive technological expertise. AI, with its text, speech, and image processing capabilities resembling human functions, is poised to play a pivotal role in reshaping the delivery of government services in smart cities [22–24].

To empirically study the factors influencing the adoption of AI-enabled service delivery in the context of smart governance, researchers often employ frameworks such as the unified theory of acceptance and use of technology [25]. Survey-based data collection techniques are utilized to gather insights from citizens, and advanced statistical tools like structural equation modeling are applied to analyze the data [21].

Findings from such studies underscore both the positive and negative social impacts of AI in governance. A critical aspect is the development of conceptual frameworks identifying enablers and barriers to successful AI adoption from the citizens' perspective [26,27]. These frameworks aim to guide smart city management in navigating the complexities of implementing AI-driven solutions. In practical terms, the research often identifies key enablers and barriers that significantly influence the adoption intention of AI in smart governance [28]. The emphasis is on creating a balanced and equitable AI service delivery system that caters to the diverse socioeconomic levels within smart cities. This is particularly relevant in nations like India, characterized by large populations and developing economies [28,29].

The insights gained from these studies contribute to the formulation of policies and recommendations for governments and technology service providers. The goal is to ensure that AI-based services in smart governance are not only technologically robust but also socially responsible and accessible to all segments of the population [30].

For example, Oleksy et al. [31] investigate the impact of artificial intelligence algorithms on the perception of cities in the context of urban management and governance. This study, conducted in Poland, aimed to explore the impact of algorithmic governance on the perceived friendliness and controllability of the city, as well as the acceptance of algorithms by residents. The results of the experimental study showed that the acceptance of algorithms increased when they were portrayed as working in collaboration with humans, as opposed to making decisions independently. Also, the study concluded that a city implementing unsupervised algorithms in urban governance may be perceived as unfriendly and uncontrollable compared to a city where algorithms collaborate with human city officials. The perceived friendliness of the city was identified as a crucial factor influencing individuals' willingness to accept algorithms in decision-making processes related to social benefits or transport management.

Bokhari and Myeong [32] conducted a Korean study about the implications of artificial intelligence on smart decision-making, yet there has been a notable scarcity of attention given to contextual elements like the Internet of Things (IoT) and smart governance. The outcomes of the study illuminate a substantial and positive multi-mediating impact emanating from the IoT and smart governance on the correlation between AI applications and smart decision-making, aligning with the initial predictions [33].

The usage of AI chatbots in the smart governance area of smart cities was described by Jain et al. [34]. The paper delineates a three-layered methodology for preparing a rule-based chatbot and employs natural language processing to present clear instructions in a chat-like interface. This innovation not only facilitates the efficient utilization of new systems but also contributes to improved customer support through its innovative interface and responsiveness.

The usage of multi-agent systems in critical application areas of smart cities was described by Arora et al. [35]. Smart governance focuses on leveraging multiple agents to streamline administrative processes, ensuring efficient and responsive governance. The paper written by Al-Besher and Kumar [36] emphasizes the importance of governments leveraging artificial intelligence and the Internet of Things (IoT) to enhance the efficiency and effectiveness of e-government services. The authors underscore the need for a careful integration of e-government services, as improper implementation may lead to threats, particularly in terms of data privacy and security breaches. AI techniques are identified as valuable tools for addressing these threats, offering sophisticated solutions by detecting anomalies and securing data to prevent potential cyber-attacks.

Zhou [37] points out that artificial intelligence plays a pivotal role in addressing urban challenges, fostering citizen connectivity, and delivering high-quality public services. The important thing in smart government is an organic fusion of AI technology and urban public services, which emerges as the key to determining whether AI can indeed catalyze the enhancement of urban public services. The author advocates for exploring the dynamic synergy between AI technology and urban public services as a strategic imperative.

Table 4 presents the main important solutions for AI implementation in smart cities in the area of smart governance. The main importance of AI implementation in particular smart city areas was selected based on the frequency of occurrence in the scientific literature to ensure that they represent commonly discussed and well-documented applications of artificial intelligence in various areas of smart cities. By describing them, the paper provides a comprehensive overview of the current landscape of AI implementation in smart cities, reflecting the most prevalent and impactful use cases. This approach helps to highlight trends, emerging technologies, and successful strategies that have gained recognition and traction within the research community, contributing to a more robust understanding of the potential benefits and challenges associated with AI in urban environments.

Table 4. Main important AI implementation in smart governance area of smart cities.

Solution	Description
Chatbot for Citizen Services	Implementing AI-powered chatbots to provide instant responses to citizens' queries, streamline information dissemination, and enhance accessibility to government services.
Predictive Policing	Using AI algorithms to analyze crime data and predict potential crime hotspots, enabling law enforcement agencies to allocate resources more effectively and prevent criminal activities.
AI-based Decision Support Systems	Deploying decision support systems that leverage AI to assist government officials in making informed and data-driven decisions, improving overall governance processes.
Fraud Detection in Public Services	Utilizing AI for fraud detection and prevention in public services, such as welfare programs, to enhance accountability and ensure resources are allocated efficiently.
AI-enhanced Civic Engagement Platforms	Developing platforms that leverage AI to analyze citizen feedback, preferences, and concerns, facilitating better policymaking and fostering active civic participation.
Automated Document Processing	Implementing AI for automated processing of documents, reducing administrative burdens, minimizing errors, and enhancing the efficiency of government workflows.
Facial Recognition for Security	Using AI-powered facial recognition systems for enhanced security and identity verification in public spaces or government facilities to ensure public safety.
AI in Urban Planning	Integrating AI in urban planning processes to analyze data, predict future trends, and optimize city development, leading to more efficient and sustainable urban environments.
Smart Traffic Management Systems	Implementing AI-driven traffic management systems to optimize traffic flow, reduce congestion, and enhance overall transportation efficiency within smart cities.
AI-enabled Disaster Response	Utilizing AI for efficient disaster response by analyzing real-time data, predicting disaster impacts, and coordinating timely and effective emergency services.

Sources: [21–32,34–41].

3.2. Barriers to AI Implementation in Smart Governance

Implementing AI solutions for smart governance faces several barriers that warrant careful consideration. One significant challenge revolves around the complexity of integrating AI into existing governance systems. Governments often operate on legacy infrastructure, making the incorporation of AI technologies a complex process that requires substantial adaptation and compatibility [42,43].

A critical barrier lies in the lack of comprehensive understanding and expertise among government officials and decision-makers regarding AI technologies. Limited awareness of the capabilities and potential applications of AI can hinder effective decision-making and lead to reluctance to embrace these transformative solutions.

Another hurdle is the issue of data privacy and security. As AI relies heavily on vast datasets for training and decision-making, ensuring the protection of sensitive citizen information becomes a vital concern. Establishing robust data protection measures, complying with regulations, and building trust among the public are challenges that must be addressed to facilitate successful AI implementation in smart governance [44].

Financial constraints pose a substantial barrier, particularly for governments with limited budgets. The initial investment required for AI infrastructure, software development, and ongoing maintenance can be substantial. Overcoming financial barriers involves strategic planning, budget allocation, and identifying cost-effective solutions to make AI implementation feasible for smart governance initiatives [45]. Interoperability challenges further impede the seamless integration of AI solutions into existing governance frameworks. Ensuring that AI systems can interact effectively with diverse technologies and platforms is essential for cohesive smart governance. The lack of standardized protocols and interfaces complicates this interoperability, requiring concerted efforts to establish compatibility [23,46].

Ethical considerations and societal acceptance constitute significant barriers as well. Issues related to algorithmic bias, fairness, and accountability demand careful scrutiny. Ensuring that AI systems operate transparently, equitably, and align with societal values is crucial to overcoming ethical challenges and garnering public trust [47]. Legal and regulatory complexities present obstacles in navigating the governance landscape. Governments must grapple with developing and adapting regulations that govern the use of AI in various sectors. Striking a balance between innovation and regulation is essential to create a conducive environment for AI implementation in smart governance [48].

Table 5 presents a description of barriers to implementing AI-based solutions in the smart governance area. The table also provides a description of how to overcome them.

The integration of artificial intelligence into smart governance initiatives brings forth ethical and privacy concerns. One primary ethical consideration revolves around the potential for algorithmic bias. AI systems, when trained on biased datasets, may perpetuate or exacerbate existing biases, leading to unfair or discriminatory outcomes. Addressing this concern requires meticulous scrutiny of training data, transparency in algorithmic decision-making processes, and the implementation of measures to mitigate bias [49]. In Table 6, there is a description of ethical and privacy concerns connected with AI implementation in smart governance solutions. These concerns highlight the need for transparent, accountable, and ethically guided practices in the deployment of AI technologies in government processes. The methods to address the concerns may include establishing clear ethical guidelines, ensuring transparency in AI algorithms, implementing security measures, and actively involving citizens in decision-making [50].

Table 5. Barriers to AI solution implementation in smart governance area.

Barrier	Description	Methods of Overcoming
Lack of Public Awareness	Citizens may not fully understand the benefits and implications of AI in smart governance, leading to skepticism and resistance.	Conduct awareness campaigns, educate the public about AI's potential benefits, and address concerns through open communication.
Data Privacy and Security	Concerns about the misuse of personal data and the potential for breaches can hinder the adoption of AI in governance.	Implement robust data protection measures, adhere to stringent privacy regulations, and establish transparent data governance policies.
Ethical Concerns and Bias	AI systems may inadvertently perpetuate biases or exhibit unethical behavior, raising concerns about fairness and accountability.	Incorporate ethical guidelines in AI development, conduct regular audits for bias, and involve diverse stakeholders in the decision-making process.
Limited Financial Resources	Budget constraints may limit the investment in AI infrastructure and talent needed for effective implementation.	Explore public–private partnerships, seek funding opportunities, and prioritize phased implementation with scalable solutions.
Technological Infrastructure	Inadequate technological infrastructure can impede the deployment and integration of AI systems within existing governance frameworks.	Invest in upgrading infrastructure, collaborate with tech companies, and adopt modular approaches for seamless integration.
Resistance from Government	Bureaucratic resistance and lack of support from government officials can hinder the adoption of AI-driven initiatives.	Foster a culture of innovation, provide training to government employees, and showcase successful pilot projects to gain internal support.

Sources: [21,23–26,29,30,33,38,39,43–48].

Table 6. Ethical and privacy concerns connected with AI implementation in smart governance.

Concern	Description
Lack of Transparency	The opacity of AI algorithms and decision-making processes in governance can lead to a lack of trust among citizens.
Potential for Unintended Bias	AI systems may inadvertently perpetuate biases, resulting in unfair or discriminatory outcomes in government decisions.
Privacy Violations	The collection and use of citizens' personal data by AI systems can raise concerns about privacy and individual rights.
Lack of Accountability	The decentralized nature of AI decision-making can make it challenging to assign responsibility in case of errors or harm.
Inadequate Security Measures	Weak security protocols may expose sensitive government data to unauthorized access, leading to security breaches.
Lack of Ethical Guidelines	Absence of clear ethical guidelines for AI development and deployment in governance may result in ethically questionable practices.
Impact on Civil Liberties	The use of AI in surveillance and monitoring activities may infringe on citizens' civil liberties, raising ethical concerns.
Limited Citizen Involvement and Consent	Citizens may not be adequately informed or involved in decisions regarding AI implementation in governance, affecting consent.

Sources: [23,24,38,39,44–46,49–54].

Privacy concerns emerge prominently as AI systems in smart governance often rely on vast datasets that may contain sensitive personal information. The collection, storage, and processing of such data raise questions about the protection of citizens' privacy rights. Striking a balance between harnessing the power of AI for governance efficiency and safeguarding individual privacy is a complex ethical challenge [27,51]. Governments must establish robust data protection frameworks, adhere to stringent privacy regulations, and implement measures such as anonymization and encryption to mitigate privacy risks. The transparency of AI decision-making processes is another ethical concern [52]. The opacity of complex AI algorithms can make it challenging for citizens to understand how decisions that impact them are reached. Promoting transparency in AI systems is crucial for accountability, fostering public trust, and ensuring that governance decisions are explainable and justifiable [53].

There is also the ethical consideration of accountability and responsibility for AI-driven decisions. Determining who is responsible when an AI system makes an erroneous decision or causes harm is a complex issue. Governments need to establish clear lines of accountability, define responsibilities for AI system outcomes, and develop mechanisms for addressing unintended consequences [54].

The use of AI in surveillance and predictive analytics for law enforcement and security purposes raises ethical dilemmas related to individual freedoms and civil liberties. Striking a balance between ensuring public safety and respecting individual rights poses a persistent challenge. Implementing strict guidelines, oversight mechanisms, and public engagement is crucial to navigating these ethical considerations [43,50]. Also, the deployment of AI in smart governance may intensify concerns about job displacement. Automation driven by AI has the potential to render certain job roles obsolete, leading to economic and social challenges. Governments must proactively address these concerns through workforce reskilling initiatives, economic policies, and social programs to mitigate the impact of AI-driven automation on employment [24,53].

3.3. Future Directions of AI Implementation in Smart Governance

In Table 7, there is a description of the potential future direction of AI implementation in smart governance. In the foreseeable future, the incorporation of artificial intelligence into smart governance is expected to progress along several significant trajectories. One key aspect is the evolution of data-driven decision-making, where AI technologies will play a pivotal role in analyzing the large volumes of data generated within smart cities. Through the utilization of AI algorithms, municipal authorities can make well-informed decisions founded on predictive trends, optimize the allocation of resources, and augment overall operational efficiency in governance processes. Another notable trajectory is predictive policing, whereby AI algorithms will be deployed to scrutinize historical data and discern potential crime hotspots. By proactively allocating resources to these identified areas, law enforcement agencies can bolster public safety efforts and preventively combat criminal activities.

Table 7. Future directions of artificial intelligence implementation in smart governance area.

Direction	Description
Data-driven Decision-making	AI will play a crucial role in analyzing vast amounts of data generated in smart cities to support data-driven decision-making by city officials. This includes predicting trends, optimizing resource allocation, and enhancing overall efficiency.
Predictive Policing	AI algorithms will be employed for predictive policing, using historical data to identify potential crime hotspots and allocate resources proactively, thereby enhancing public safety.
Smart Infrastructure	AI will be integrated into city infrastructure to enable real-time monitoring and maintenance. This includes smart traffic management, waste management, and efficient energy usage for a sustainable urban environment.
Citizen Engagement	AI-driven chatbots and virtual assistants will enhance citizen engagement by providing personalized services, answering queries, and gathering feedback, leading to improved communication between citizens and government.
Automated Public Services	Government services will be automated using AI, making processes such as permit approvals, license renewals, and public service requests more efficient and accessible to citizens.
Urban Planning and Design	AI tools will assist urban planners in designing more efficient and sustainable city layouts. This includes optimizing transportation networks, green spaces, and infrastructure to meet the evolving needs of the population.
Cybersecurity	AI will be used to strengthen cybersecurity measures in smart cities, detecting and preventing cyber threats in real time to safeguard critical infrastructure and protect sensitive citizen data.

The integration of AI into the infrastructure of smart cities is poised for substantial expansion. This includes the deployment of AI-driven systems for the real-time monitoring and maintenance of critical infrastructure components like traffic management, waste management, and energy utilization. Through the utilization of AI technologies, cities can forge more sustainable and efficient urban environments. Also, there is a promising outlook for enhanced citizen engagement through the adoption of AI-driven chatbots and virtual assistants. These tools will enrich communication between citizens and governmental entities by offering personalized services, addressing inquiries, and eliciting feedback, thereby nurturing a more interactive and responsive governance.

The automation of public services through AI is expected to streamline governmental operations, making tasks such as permit approvals, license renewals, and public service requests more efficient and accessible to citizens. In terms of urban planning and design, AI tools will provide valuable assistance to urban planners in formulating more efficient and sustainable city layouts. This entails the optimization of transportation networks, green spaces, and infrastructure to meet the evolving needs of the populace while curbing environmental impact. Cybersecurity stands out as a critical domain where AI will play a key role in fortifying measures to protect smart cities against cyber threats. By promptly detecting and forestalling potential security breaches, AI-powered systems can fortify critical infrastructure and shield sensitive citizen data, thereby ensuring the overarching security and resilience of smart city environments.

4. Smart Economy

4.1. Main Important Solutions Used in AI Implementation in Smart Economy

In the case of the smart economy area, AI is creating a fertile ground for entrepreneurship and innovation in the smart city. AI-powered platforms can connect startups with potential investors and partners, facilitating collaboration and knowledge sharing. AI can also be used to analyze market trends and identify new business opportunities, providing invaluable insights for entrepreneurs. Moreover, AI-driven technologies are enabling the development of new products and services, further boosting the city's economic vibrancy [55,56].

AI is also streamlining operations and enhancing productivity across various industries in the smart city. AI-powered chatbots can provide customer support, freeing up human agents to focus on more complex tasks. AI-driven predictive analytics can help businesses anticipate demand and optimize supply chains, reducing waste and improving efficiency [57]. Additionally, AI is transforming manufacturing processes, automating repetitive tasks, and optimizing resource allocation, leading to increased productivity and cost savings [58]. Healthcare in a smart city benefits from AI-powered solutions, ranging from predictive analytics for disease outbreak monitoring to personalized treatment plans based on individual health data [17]. Remote patient monitoring and AI-driven diagnostics contribute to the proactive management of public health, ensuring timely interventions and reducing the burden on healthcare infrastructure [16,17,58,59].

For example, Bjukya et al. [60] explore the domain of cybersecurity within the context of the "Internet-of-Medical-Vehicles (IOMV)," a specialized application emerging from the convergence of connected healthcare and connected vehicles. This system communicates across diverse networks during its travel and faces significant security risks posed by sophisticated cyber-attacks, posing potential threats to the lives of patients on board. Wang et al. [59] explore the role of a distinguishing Bert model in the context of a medical dialogue system, emphasizing its significance in the development of a sustainable smart city. The authors identify smart medicine as a crucial element in the construction of a sustainable smart city, with an intelligent dialogue system serving as a key component to deliver personalized and efficient healthcare services, enhancing life quality.

The application of machine learning (ML) and natural language processing (NLP) by BlueDot, a Canadian company, to track, recognize, and report the spread of COVID-19 exemplifies how AI can be harnessed for effective public health surveillance and response in a smart economy context. The solution was described by Herath and Mittal [16]. BlueDot's AI-powered platform, which analyzes vast amounts of data from various sources, including news articles, social media posts, and travel records, was able to identify and predict the emergence of COVID-19 with remarkable accuracy. Notably, BlueDot detected the novel coronavirus nine days before the World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDCP) released their official statements acknowledging its existence. The successful application of AI to track and predict the spread of COVID-19 underscores the potential of AI to enhance public health surveillance and response in smart economies. By leveraging AI's ability to analyze vast amounts of data and identify patterns, cities, and governments can make informed decisions to protect public health and safeguard their economies.

Sikos and Szendi [61] have examined the smart economy aspects of smart cities using Hungary as an example. The text contributes to the understanding of economic and environmental sustainability in Hungarian cities with county rights, employing a comprehensive analysis that integrates sustainable development goals, specific indicators, and clustering techniques. It emphasizes the importance of innovative and smart solutions in addressing contemporary challenges for cities, ultimately contributing to the discourse on building a smart economy within the context of sustainable development.

The problems connected with automation usage in smart cities were described by Ray et al. [62]. The application of artificial intelligence, coupled with automation, is envisioned to create a new smart environment encompassing many aspects of a smart city. In this case, a very important step is the progression from IoT to IoE, facilitated by advancements in communication technologies, ultimately contributing to the realization of a more interconnected and intelligent urban environment.

Zhou points out [63] the importance of the importance of cutting-edge artificial intelligence technology usage such as blockchain, virtual reality (VR), sharing economy, and other emerging modes in the smart economy of smart cities. The author describes the multifaceted impact of technology across diverse segments of the economy, showcasing the intersection of technology with key areas of societal interest.

Duan et al. [64] explore the regulation of artificial intelligence and its impact on the orderly development of China's intelligent economy, with a particular focus on the broader context of smart cities. It highlights the gradual increase in the proportion of artificial intelligence within the national and global economy, leading to the emergence of novel concepts and forms such as enterprise digital transformation and the meta-universe. To achieve the appropriate level of a smart economy, the focus should be on strengthening infrastructure construction, improving public services, enhancing the social governance system, and reinforcing talent training that is aligned with the objectives of building smart cities. The macro-control measures outlined in the text contribute to the innovative development of the intelligent economy within the context of a broader urban environment. These measures are designed to position China at the forefront of technological advancements and economic innovation, particularly in the context of smart cities that leverage AI for enhanced efficiency, sustainability, and quality of life. Table 8 presents the main important solutions for AI implementation in the area of smart economy.

Table 8. Main important AI implementation in smart economy area of smart cities.

Solution	Description
AI-powered Financial Analytics	Utilizing AI algorithms to analyze financial data, predict market trends, and provide insights for better investment decisions and economic planning.
Supply Chain Optimization	Implementing AI in supply chain management to enhance efficiency, reduce costs, and improve the overall resilience of the economic ecosystem.
AI-driven Customer Relationship Management	Leveraging AI for personalized customer interactions, predictive analytics, and efficient management of customer relationships in various industries.
Fraud Detection and Prevention	Using AI to detect and prevent fraudulent activities in financial transactions, online commerce, and various economic sectors, ensuring security and trust.

Table 8. *Cont.*

Solution	Description
Automated Business Process Automation	Implementing AI-powered automation to streamline and optimize business processes, reducing operational costs and increasing productivity in the smart economy.
Dynamic Pricing and Revenue Optimization	Applying AI algorithms for dynamic pricing strategies, optimizing revenue models, and adapting pricing structures based on market demand and other factors.
AI-based Predictive Analytics	Implementing predictive analytics using AI to forecast economic trends, identify emerging opportunities, and guide strategic decision-making for businesses and policymakers.
Smart Advertising and Marketing	Utilizing AI in advertising and marketing to personalize campaigns, analyze consumer behavior, and optimize strategies for enhanced targeting and engagement.
Autonomous Financial Advisory	Introducing AI-driven financial advisory services that provide personalized investment advice, wealth management, and financial planning for individuals and businesses.

Sources: [16,23,24,27,55–71].

4.2. Barriers to AI Implementation in Smart Economy

The implementation of AI in the smart economy of a smart city is not without challenges, including concerns related to data privacy, security, and ethical considerations. Striking a balance between technological advancement and responsible governance becomes imperative to ensure that the benefits of AI are harnessed while safeguarding the rights and privacy of the citizens. Data privacy and security concerns also emerge as formidable barriers to the widespread adoption of AI in the smart economy. The sensitive nature of data utilized by AI systems raises apprehensions regarding unauthorized access, breaches, and potential misuse. Striking a delicate balance between leveraging the power of AI for economic advancement and safeguarding individuals' privacy rights becomes a critical consideration [64].

Another notable barrier lies in the lack of standardized regulations and ethical frameworks governing AI implementation. The absence of clear guidelines poses challenges in ensuring responsible and fair use of AI technologies. Developing comprehensive regulations that address ethical considerations, bias mitigation, and accountability is essential for fostering trust in AI systems within the smart economy. Also, the shortage of skilled professionals proficient in AI technologies presents a significant hurdle [16,58,72]. The demand for AI expertise surpasses the current supply, creating a skills gap that impedes the effective implementation and management of AI solutions. Bridging this gap requires substantial investments in educational programs and workforce development initiatives [35].

Financial constraints also hinder the widespread adoption of AI in the smart economy. The upfront costs associated with implementing AI solutions, coupled with uncertainties regarding return on investment, may deter businesses and governments from embracing these technologies [55,56,64]. Addressing financial concerns necessitates strategic planning, incentivizing investments, and showcasing the long-term benefits of AI implementation [57]. Table 9 presents the described barriers and methods for overcoming them.

The important concern connected with the smart economy is the ethical implications of AI decision-making processes. As AI systems become increasingly autonomous and make decisions that impact various aspects of the smart economy, questions arise regarding accountability, transparency, and fairness [63,65,66,72]. The opacity of certain AI algorithms raises concerns about potential biases, discriminatory outcomes, and the lack of interpretability in decision-making, challenging the ethical foundations of these technologies [16].

The challenge of balancing the benefits of AI-driven innovations with the protection of individual privacy rights becomes increasingly complex. Striking this delicate balance requires the development and adherence to stringent ethical standards and legal frameworks [64]. Ethical AI principles, encompassing transparency, accountability, fairness, and privacy preservation, are essential in guiding the responsible development and deployment of AI technologies in the smart economy [35].

Also, the potential for widespread surveillance in smart cities, driven by AI-powered systems, raises ethical concerns related to civil liberties. The constant monitoring of individuals' activities, even for the purpose of optimizing urban services, may infringe upon privacy rights and contribute to a surveillance state. Addressing these concerns necessitates careful consideration of the societal implications of AI implementations, fostering public awareness, and involving communities in decision-making processes [35,56,57,62,72]. In Table 10, there is a description of ethical and privacy concerns connected with AI implementation in smart economy solutions (note that this time, concerns are not described, as in the previous areas of smart cities).

Table 9. Barriers to AI solution implementation in smart economy area.

Barrier	Description	Methods of Overcoming
Lack of Skilled Workforce	Insufficient expertise in AI technologies and data analytics in the workforce can hinder the adoption of AI in the economy.	Invest in training and education programs, collaborate with academic institutions, and incentivize upskilling for employees.
Uncertain Regulatory Landscape	Ambiguous or evolving regulations related to AI can create uncertainty and legal challenges for businesses and economic activities.	Advocate for clear and adaptive regulations, engage with policymakers, and actively participate in shaping responsible AI policies.
Integration with Legacy Systems	Compatibility issues with existing legacy systems may impede the seamless integration of AI technologies into economic processes.	Develop migration strategies, invest in interoperability solutions, and gradually phase in AI applications with legacy system updates.
High Implementation Costs	The initial costs associated with implementing AI solutions can be a barrier, especially for small and medium-sized enterprises (SMEs).	Explore cost-sharing models, incentivize pilot projects, and offer financial support or subsidies for AI adoption, particularly for SMEs.
Data Security and Privacy Concerns	Concerns about the security and privacy of sensitive data used in AI applications can hinder trust and adoption in the smart economy.	Implement robust data encryption, comply with data protection laws, and establish transparent data handling practices to build trust.
Resistance to Change	Resistance from stakeholders, including employees and management, due to fear of job displacement or reluctance to adopt new technologies.	Develop change management strategies, communicate the benefits of AI adoption, and involve employees in the transition process.
Limited Awareness and Understanding	Lack of awareness and understanding of AI benefits and applications may hinder businesses from exploring AI solutions.	Conduct awareness campaigns, provide educational resources, and showcase successful AI implementations in similar industries.
Ethical and Bias Concerns	Concerns about ethical considerations and potential biases in AI algorithms can lead to hesitancy in adopting AI solutions for economic activities.	Implement ethical guidelines in AI development, conduct regular audits for bias, and prioritize fairness and transparency in AI algorithms.

Sources: [16,17,35,55–57,61,64–66,72].

Table 10. Ethical and privacy concerns connected with AI implementation in smart economy.

Concern	Description
Impact on Employment and Job Displacement	The automation of certain economic tasks through AI may raise concerns about job displacement and its impact on the workforce.
Limited Stakeholder Involvement and Consent	Limited involvement of stakeholders, including employees and consumers, in AI-related decisions may affect consent and trust.
Algorithmic Fairness and Equity	Concerns about algorithms perpetuating or exacerbating existing social inequalities, resulting in biased outcomes across diverse groups.
Manipulation of Economic Systems	The potential for AI to be used to manipulate markets, trade, or economic policies, leading to unfair advantages or destabilization.
Intellectual Property Issues	Challenges related to the ownership and protection of intellectual property in AI-generated content, products, or innovations.
Unintended Economic Consequences	The possibility of unintended economic effects due to AI-driven decisions, such as market bubbles, financial crises, or unforeseen economic shifts.
Cross-border Data Governance	Issues related to the cross-border flow of economic data, compliance with diverse data protection laws, and international data governance standards.
Dependency on AI-Driven Systems	Concerns about overreliance on AI systems in economic decision-making, leading to potential vulnerabilities and systemic risks.
Ethical Considerations in Automation	The ethical implications of automating tasks that traditionally involve human judgment, such as financial advice, legal decisions, or ethical dilemmas.

Sources: [16,27,35,58–60,62,64,72].

4.3. Future Directions of AI Implementation in Smart Economy

In Table 11, there is a description of the potential future direction of AI implementation in the smart economy. A prominent trajectory involves the evolution of smart financial systems, where AI assumes a key role in automating mundane tasks, fortifying fraud detection capabilities, and refining financial transactions. Through the application of AI algorithms, financial systems can foster a more secure and efficient economic environment. Another focal area is predictive financial analytics, in which AI algorithms are employed to predict market trends, mitigate risks, and facilitate well-informed investment decisions for both businesses and government entities.

Table 11. Future directions of artificial intelligence implementation in smart economy area.

Direction	Description
Smart Financial Systems	AI will enhance financial systems by automating routine tasks, improving fraud detection, and optimizing financial transactions, fostering a more secure and efficient economic environment.
Predictive Financial Analytics	AI algorithms will be employed for predictive financial analytics, helping businesses and governments anticipate market trends, manage risks, and make informed investment decisions.
Automated Business Processes	AI will automate various business processes, including supply chain management, inventory control, and customer service, leading to increased productivity and streamlined operations for businesses in the smart city.
Digital Currency and Blockchain	AI will likely play a role in the development and management of digital currencies, and its integration with blockchain technology can enhance the security and transparency of financial transactions within the smart economy.
Personalized Marketing	AI-driven analytics will enable businesses to deliver more personalized and targeted marketing strategies, enhancing customer experiences and increasing the effectiveness of advertising campaigns in the smart city.
Talent Matching and Workforce Management	AI will facilitate efficient talent matching by analyzing skill sets and job requirements, improving workforce management, and contributing to the growth of a dynamic and adaptive job market within the smart city.
Smart Contracts and Legal Tech	AI-powered smart contracts will automate and streamline legal processes, reducing bureaucracy and enhancing the efficiency of contract enforcement and resolution of legal issues within the smart economy.
Financial Inclusion	AI-driven solutions will contribute to financial inclusion by providing innovative and accessible financial services to all segments of the population, ensuring that the benefits of the smart economy are widespread.
Data Monetization	AI will enable businesses and governments to extract valuable insights from data, leading to the monetization of data assets. This includes selling data-driven insights to third parties and fostering economic growth.
Sustainable Business Practices	AI will support the adoption of sustainable business practices by optimizing resource usage, reducing waste, and promoting eco-friendly initiatives, contributing to a more environmentally conscious smart economy.

AI is poised to transform business operations through automation across various domains, such as supply chain management, inventory control, and customer service functions. This automation holds the promise of enhancing productivity and streamlining operations for businesses operating within smart urban landscapes. Also, the amalgamation of AI with digital currency and blockchain technology is anticipated to bolster the security and transparency of financial transactions within the smart economy, thereby instilling trust and reliability in economic dealings.

The proliferation of personalized marketing strategies is expected to thrive with the aid of AI-driven analytics, empowering businesses to deliver bespoke marketing campaigns that enhance customer experiences and optimize advertising efficacy. It can be stated that AI will assume a pivotal role in talent matching and workforce management by scrutinizing skill sets and job prerequisites, thereby fostering the evolution of a dynamic and adaptable job market within smart cities. The advent of AI-powered smart contracts holds the potential to automate and streamline legal procedures, curtailing bureaucracy and amplifying the efficiency of contract enforcement within the smart economy. Financial inclusion represents another pivotal area where AI-driven solutions are projected to make substantial headway by furnishing innovative and accessible financial services to all strata of society, thereby ensuring widespread access to the benefits of the smart economy.

5. Smart Mobility

5.1. Main Important Solutions Used in AI Implementation in Smart Mobility

The convergence of AI and smart mobility technologies is an important factor in efficient, sustainable, and interconnected transportation systems, and because of that factor, they are now starting to be used in smart cities. For example, AI can be used to optimize traffic flow and reduce congestion by analyzing vast datasets in real time [73–75]. Through advanced algorithms, AI-powered traffic management systems can predict traffic patterns, identify bottlenecks, and dynamically adjust signal timings to alleviate congestion [76]. This not only enhances the overall efficiency of transportation networks but also reduces fuel consumption and greenhouse gas emissions [77].

Kubik [78] describes AI-based solutions, specifically focusing on machine learning applications to enhance the management of shared mobility systems. The author has prepared a model showcasing the potential for precise identification of journeys involving vehicles from shared mobility systems. The practical implementation of the model not only streamlines management processes but also remains open to future updates.

AI serves as the backbone of navigation and decision-making processes in autonomous vehicles. Self-driving cars leverage machine learning algorithms to interpret and respond to the surrounding environment, ensuring safe and reliable navigation [79]. This has the potential to revolutionize urban mobility by enhancing safety, reducing accidents, and increasing overall transportation accessibility. The paper describes the big potential of AI in the case of shared mobility systems [80,81].

The usage of AI-based solutions facilitates the development of predictive maintenance systems for public transportation infrastructure [82]. By analyzing sensor data from buses, trains, and other transit vehicles, AI algorithms can predict and preemptively address maintenance needs, minimizing downtime and improving the reliability of public transportation services [83].

Musa et al. [84] describe an aspect of sustainable traffic management in smart cities, acknowledging the complexity and heterogeneity of urban transportation systems. In the study, there is a description of the integration of the Internet of Things (IoT) and intelligent transportation system (ITS) applications to address traffic-related challenges in smart cities. In the context of a hybridized stream of human-driven vehicles (HDVs) and connected automated vehicles (CAVs), real-time traffic data and information from AI sensors and ITS-based devices are utilized. The collected data undergo processing and transmission using machine learning algorithms and cloud computing. This approach is aimed at enabling effective traffic management, the formulation of decision-making policies, and documentation for future reference.

The very interesting case of using AI in smart mobility is connected with the safe mobility of senior citizens. The case was described by Bokolo [85]. According to him, public transportation systems must be both inclusive and safe, leveraging emerging technologies such as AI-based services. These AI services aim to provide personalized recommendations to enhance mobility inclusion and safety, particularly for vulnerable road users such as senior citizens aged 65 and above. The research has identified the potential use of emerging technologies, such as AI-based machine learning, to further enhance inclusive and safe mobility for senior citizens.

Smart mobility platforms powered by AI enable seamless integration of various transportation modes, including public transit, ride-sharing, and bike-sharing. These platforms provide users with real-time information, optimizing route planning and promoting multi-modal transportation solutions [86–88]. AI algorithms analyze user preferences, historical data, and real-time conditions to suggest personalized and efficient transportation options, contributing to a more user-centric and responsive urban mobility experience [89].

Also, AI-driven smart parking solutions alleviate the challenges associated with finding parking spaces in crowded urban areas. Sensor-equipped parking spaces, coupled with AI algorithms, enable drivers to locate available parking spots effortlessly, reducing traffic congestion and minimizing the environmental impact of unnecessary circling [90,91].

AI can also be used in the case of micromobility. Fong et al. [92] explored the integration of artificial intelligence in the context of sustainable micromobility management within smart cities. Various smart applications, safety-related services, and information services are reliant on a comprehensive vehicle-to-infrastructure (V2I) network and an integrated vehicular cloud solution. In this case, AI is utilized for adaptive modulation and self-cognizant prognostics, with the specific goal of addressing challenges related to parking and road congestion issues within a sustainable smart city environment.

Table 12 presents the main important solutions for AI implementation in smart cities in the area of smart mobility. The presented table provides examples of solutions involving the implementation of AI in smart mobility, each addressing specific challenges or aspects of transportation. These solutions leverage AI technologies to enhance efficiency, safety, and user experience in the realm of smart mobility.

Table 12. Main important AI implementation in smart mobility area of smart cities.

Solution	Description
Intelligent Traffic Management	Implementation of AI-powered traffic management systems that analyze real-time data to optimize traffic flow, reduce congestion, and enhance overall transportation efficiency.
Predictive Maintenance for Vehicles	Using AI algorithms to predict when vehicles and infrastructure components require maintenance, minimizing downtime and improving the reliability of smart mobility systems.
Autonomous Vehicles	Deployment of autonomous vehicles that leverage AI technologies, including machine learning and computer vision, to navigate and operate safely in urban environments.
Ride-sharing Optimization	AI-driven algorithms for optimizing ride-sharing services, improving route planning, reducing travel times, and enhancing the overall efficiency of shared transportation options.
Smart Parking Solutions	Utilizing AI to develop smart parking systems that provide real-time information on parking availability, reducing traffic congestion and enhancing the parking experience.
Personalized Travel Assistance	AI-driven virtual assistants or mobile apps that offer personalized travel recommendations, route planning, and real-time updates to enhance the user experience in smart mobility.
Dynamic Pricing for Transportation	Implementing AI algorithms to dynamically adjust pricing for transportation services based on demand, traffic conditions, and other factors to optimize resource allocation.
Traffic Incident Prediction	AI models analyze historical and real-time data to predict and prevent traffic incidents, enabling proactive measures and improving overall safety in smart mobility.
Multi-modal Integration	Developing platforms that integrate various transportation modes seamlessly, allowing users to plan and pay for multi-modal journeys efficiently using AI-based coordination.

Sources: [46,73–86,89–99].

5.2. Barriers to AI Implementation in Smart Mobility

Besides the many advantages of smart mobility, there are also some problems that need to be resolved. One notable impediment is the interoperability issue, wherein existing transportation infrastructure often lacks standardized data formats and communication protocols. The heterogeneity of data sources and systems poses a significant challenge in developing cohesive AI solutions, hindering their capacity to seamlessly interact with diverse components of the smart mobility ecosystem [100].

Also, the high capital costs associated with deploying AI-driven technologies in smart mobility present a formidable barrier to entry. The acquisition, installation, and maintenance of the requisite hardware, sensors, and computational infrastructure demand substantial financial investments [23,93]. Municipalities and transportation authorities, already grappling with budget constraints, may find it challenging to allocate resources for the implementation of comprehensive AI solutions [80].

The inherent resistance to change within traditional bureaucratic structures constitutes another barrier to the widespread adoption of AI in smart mobility. The integration of novel technologies necessitates a paradigm shift in decision-making processes, organizational structures, and regulatory frameworks [46,50,51]. Such transitions are often met with skepticism and resistance, impeding the swift deployment of AI-driven solutions in the smart mobility sector [101].

Ethical and privacy concerns also loom large as impediments to the integration of AI in smart mobility [72]. The collection and utilization of vast amounts of personal data for AI applications, such as route optimization and personalized transportation recommendations, raise legitimate concerns regarding individual privacy and data security. Striking a balance between the benefits of AI-enhanced mobility and the protection of user privacy represents a crucial challenge in the adoption of these technologies [46,102].

It is also worth mentioning that the lack of standardized regulations governing the deployment of AI in transportation systems poses a regulatory challenge. As AI-driven technologies evolve, there is a pressing need for clear and uniform guidelines to address safety, liability, and ethical considerations [50]. The absence of a cohesive regulatory framework creates uncertainty, deterring stakeholders from embracing AI solutions in smart mobility [52,101].

In Table 13, there is a description of barriers to implementing artificial intelligence-based solutions in the smart mobility area of a smart city. In the table, there is also a description of how those barriers can be overcome.

Table 13. Barriers to AI solution implementation in smart mobility area.

Barrier	Description	Methods of Overcoming
Lack of Infrastructure Integration	Inadequate integration of AI technologies with existing transportation infrastructure can hinder the seamless implementation of smart mobility solutions.	Invest in upgrading infrastructure, promote collaboration between public and private sectors, and adopt standardized data protocols.
Regulatory Challenges	Ambiguous or restrictive regulations may pose barriers to the widespread adoption of AI-driven smart mobility solutions.	Advocate for clear and adaptive regulations, engage with policymakers, and participate in shaping responsible AI policies for mobility.
Data Privacy and Security Concerns	Concerns about the collection and utilization of personal data in smart mobility applications may impede user trust and acceptance.	Implement robust data protection measures, comply with privacy regulations, and educate users about data handling practices.
High Implementation Costs	The initial costs associated with deploying AI technologies in smart mobility systems may be a barrier for cities and transportation providers.	Explore public–private partnerships, seek funding opportunities, and prioritize phased implementation with scalable solutions.
Lack of Public Acceptance	Resistance or skepticism from the public due to concerns about safety, job displacement, or privacy may impede the acceptance of AI in smart mobility.	Conduct public awareness campaigns, engage in open communication, and address concerns through pilot projects and demonstrations.
Technological Unreliability	Technical issues, system malfunctions, or vulnerabilities in AI-driven mobility solutions can hinder their reliability and safety.	Conduct rigorous testing, implement fail-safe mechanisms, and prioritize continuous monitoring and updates to ensure system reliability.
Limited Interoperability	Lack of standardized protocols for interoperability among different smart mobility systems may hinder seamless connectivity and collaboration.	Advocate for industry-wide standards, encourage collaboration between stakeholders, and invest in technologies that promote interoperability.

Sources: [43–46,80,93,100–104].

In Table 14, there is a description of ethical and privacy concerns connected with AI implementation in smart mobility solutions (note that this time, concerns are not described, as in the previous areas of smart cities).

The important ethical concern revolves around the collection and utilization of personal data inherent in AI-driven smart mobility applications. The vast troves of data generated by individuals during their interactions with smart transportation systems, including location information, travel patterns, and user preferences, pose a substantial risk to privacy [50,51]. The potential for unauthorized access, misuse, or data breaches raises significant ethical questions regarding the safeguarding of sensitive information. Addressing these concerns necessitates the development and implementation of robust privacy-preserving mechanisms and encryption protocols to protect individuals' personal data from inadvertent exposure or malicious exploitation [103].

Also, the ethical implications extend to the transparency and explainability of AI algorithms employed in smart mobility applications. As these algorithms increasingly influence critical decisions in transportation systems, stakeholders demand a clear understanding of the decision-making processes. Ensuring transparency not only instills trust but also facilitates accountability, allowing users and regulatory bodies to comprehend and scrutinize the mechanisms by which AI-driven systems operate [46,104].

Table 14. Ethical and privacy concerns connected with AI implementation in smart mobility.

Concern	Description
Impact on Traffic and Infrastructure	Poorly managed AI applications in smart mobility may exacerbate traffic issues or cause strain on existing transportation infrastructure.
Public Safety Concerns	Malfunctions or unethical use of AI in smart mobility systems may compromise public safety, leading to accidents or security risks.
Surveillance and Privacy Intrusion	Concerns about excessive surveillance and intrusion into individuals' privacy through the use of AI-powered monitoring systems in smart mobility.
Data Ownership and Control	Issues related to the ownership and control of the vast amounts of data generated by AI in smart mobility, raising questions about user rights.
Algorithmic Decision-Making	Ethical considerations surrounding the use of algorithms to make critical decisions in smart mobility, impacting individuals' lives and choices.
Accessibility and Inclusivity	Ensuring that AI-powered smart mobility solutions are designed to be accessible and inclusive for all individuals, including those with diverse needs.
Job Displacement in Transportation	Concerns about the potential displacement of jobs in the transportation sector due to the automation of certain tasks through AI in smart mobility.

Sources: [24,35,46,64,72,80,93,100–104].

Concerns about algorithmic bias and discrimination also pervade the ethical discourse surrounding AI in smart mobility. If not meticulously designed and trained, AI models may inadvertently perpetuate or exacerbate existing societal biases, leading to discriminatory outcomes in areas such as route optimization, resource allocation, or service accessibility. Ethical considerations necessitate rigorous scrutiny of AI models to identify and rectify biased patterns, ensuring fair and equitable outcomes for all users [80,101].

Another factor worth mentioning is connected with the ethical use of AI in smart mobility, which requires a delicate balance between innovation and the protection of individual freedoms. Striking this balance mandates the establishment of clear guidelines and regulatory frameworks that uphold privacy rights while fostering technological advancements. Policymakers must grapple with the challenge of crafting legislation that encourages responsible AI deployment without stifling innovation or hindering the societal benefits of smart mobility technologies [72,103,104].

5.3. Future Direction of AI Implementation in Smart Mobility

In Table 15, there is a description of the potential future direction of AI implementation in smart mobility. The development and deployment of autonomous vehicles, where AI technologies will assume a central role in enhancing safety, mitigating traffic congestion, and fortifying overall transportation efficiency within smart cities, will be important in the future development of smart mobility. AI-powered systems are expected to revolutionize traffic management by optimizing traffic flow through real-time monitoring, predictive analytics, and adaptive traffic signal control mechanisms. This endeavor seeks to minimize congestion and improve the efficiency of transportation networks.

Intelligent enhancements to public transportation systems represent another pivotal facet, with AI facilitating real-time updates, route optimization, and an enriched user experience for commuters utilizing buses, trains, and other public transport modalities. The proliferation of ride-sharing services and Mobility-as-a-Service (MaaS) platforms is expected to be expedited by AI, providing users with seamless integration of diverse transportation modes and customized mobility options to meet individual requirements.

Smart parking solutions harnessing AI technologies are anticipated to alleviate parking challenges through real-time availability updates, automated payment systems, and predictive parking analytics, thereby diminishing traffic congestion and enhancing parking efficiency. AI algorithms will play a crucial role in predicting traffic patterns and furnishing dynamic route optimization, aiding drivers and autonomous vehicles in navigating cities more efficiently while mitigating travel time and congestion.

Table 15. Future directions of artificial intelligence implementation in smart mobility area.

Direction	Description
Autonomous Vehicles	AI will play a key role in the development and deployment of autonomous vehicles, enhancing safety, reducing traffic congestion, and improving overall efficiency in smart city transportation.
Traffic Management	AI-powered systems will optimize traffic flow through real-time monitoring, predictive analytics, and adaptive traffic signal control, minimizing congestion and improving the efficiency of transportation networks.
Intelligent Public Transportation	AI will enhance public transportation systems by providing real-time updates, optimizing routes, and improving the overall user experience for commuters using buses, trains, and other public transport modes.
Ride-sharing and Mobility as a Service (MaaS)	AI will facilitate the growth of ride-sharing services and Mobility-as-a-Service platforms, offering seamless integration of different transportation modes, providing users with convenient and personalized mobility options.
Smart Parking Solutions	AI will be utilized to develop smart parking solutions, including real-time availability updates, automated payment systems, and predictive parking analytics, reducing traffic congestion and enhancing parking efficiency.
Traffic Predictions and Routing	AI algorithms will predict traffic patterns and provide dynamic route optimization, helping drivers and autonomous vehicles navigate the city more efficiently while minimizing travel time and congestion.
Infrastructure Maintenance	AI will contribute to the maintenance of smart city infrastructure, monitoring roads, bridges, and other transportation assets for signs of wear and tear, and scheduling maintenance activities to ensure safety and reliability.
Pedestrian and Cyclist Safety	AI-powered systems will enhance pedestrian and cyclist safety by detecting and responding to potential hazards, providing warnings to both drivers and vulnerable road users to reduce the risk of accidents.
Air Mobility Integration	AI will play a role in integrating air mobility solutions, such as drones and flying taxis, into the urban transportation network, providing alternative modes of transport for faster and more efficient city mobility.
Sustainable Transportation	AI will contribute to the promotion of sustainable transportation modes, optimizing electric vehicle charging infrastructure, managing energy consumption, and encouraging the adoption of eco-friendly transport options.

The contribution of AI to the maintenance of smart city infrastructure is anticipated to be substantial, with AI-powered systems vigilantly monitoring transportation assets for signs of wear and tear and orchestrating maintenance activities to ensure safety and reliability. Augmented pedestrian and cyclist safety is on the horizon, with AI-powered systems capable of detecting and responding to potential hazards and issuing warnings to both drivers and vulnerable road users to mitigate accident risks. The integration of air mobility solutions, such as drones and flying taxis, into the urban transportation network is foreseen, offering alternative modes of transport for faster and more efficient city mobility, with AI playing a central role.

6. Smart Environment

6.1. Main Important Solutions Used in AI Implementation in Smart Environment

When it comes to this area, one of the important aspects related to a smart environment is energy saving and the effective use of energy in cities. There are many studies in the literature on the efficiency of energy consumption based on the use of artificial intelligence. The paper written by Li et al. [105] discusses energy efficiency challenges in smart cities and proposes a solution using IoT-based smart metering and AI technologies. The proposed system aims to predict energy consumption in smart cities using data from energy efficiency datasets and recurrent neural networks for load forecasting. The goal is to optimize energy management and scheduling in the smart grid to improve overall efficiency. On the other hand, energy theft is a real problem that needs to be solved. This problem is identified by the authors of [106]. They propose a multi-objective diagnosing structure named an Energy Theft Prevention System to detect energy theft. The system utilizes a combination of machine learning techniques, such as gated recurrent unit, grey wolf optimization, deep recurrent convolutional neural network, and long short-term memory. The results from the simulation have been compared with the existing technique in terms of delivery ratio, throughput, delay, overhead, energy conversation, and network lifetime. They show that the proposed system is more effective than existing systems. There are many studies on monitoring and improving energy efficiency based on AI in smart cities—for example, [105,107,108]. There are more solutions based on artificial intelligence in the area of energy in cities in the area of controlling and improving energy consumption, and they can be divided into those that concern individual residents and entire communities [109].

Another important aspect of a smart environment is the air quality in cities. In this area, there are also various solutions based on artificial intelligence. The paper [110] discusses the application of nature-inspired AI techniques in air quality modeling in the example of seven smart cities in India. The study utilizes a data-driven approach combining artificial neural networks with particle swarm optimization, a nature-inspired optimization technique, to predict air quality levels. The chapter highlights the importance of accurate air quality modeling for assessing the impact of pollution on both living and non-living entities and emphasizes the role of AI models in providing early warnings for high pollutant concentrations. In another paper, the authors [111] present the AirQo system, which is designed to fill air quality data gaps in low-resource urban settings. The system includes autonomous sensors customized for deployment in resource-constrained environments, a distributed sensor network, a network manager tool for installation and maintenance tracking, and a platform for data access and analytics. Overall, the paper offers a template for designing and deploying technology-driven solutions to address environmental health challenges in cities with limited resources. There are also solutions for air quality prediction using regression [112] and neural networks [113] for forecasting air pollutants [114] and for air pollution monitoring [115,116].

Smart cities take action toward reducing noise. The paper [117] discusses the development of a real-time noise and exhaust emissions monitoring system for sustainable and intelligent transportation systems as part of the European Union project 'NEMO: Noise and Emissions Monitoring and Radical Mitigation.' The system utilizes IoT applications and AI algorithms to gather vehicle noise and exhaust emissions data in European cities, categorize them into different classes of emitters, and enable infrastructure managers to take appropriate actions in nearly real time. The results showcase the creation of a comprehensive solution to monitor and mitigate noise and emissions for sustainable transportation systems. Other authors [118] study the monitoring of sound data occurring in cities using AI. Their study proposes a dual-branch residual network for environmental sound classification (ESC), integrating feature fusion to enhance recognition accuracy. Additionally, novel data pre-processing techniques, including loop-padding and time-frequency data enhancement, are employed to improve model performance on the dataset.

Environmental artificial intelligence in smart cities can also be used to predict the quality of drinking water. AI can improve water management and combat water pollution [119]. Moreover, Lu et al. [120] discuss the problem of securing drinking water supply in smart cities. They describe an early warning system based on an online sensor network and machine learning. There are also more studies on the quality of water. Jiang et al. [121] build an integrated system to safeguard the quality of urban river water using ICT, while Anjum et al. [122] examine groundwater quality in a smart city using GIS and machine learning algorithms. Another paper [123] addresses the growing need for accurate rainfall estimation, particularly in urban areas facing more frequent and intense floods due to human-induced land use changes and climate change. It highlights the potential of citizen science as a supplementary source of rainfall data to improve spatial and temporal coverage. The research proposes a novel method of estimating rainfall intensity using recorded audio data, which can be integrated into smart city systems for real-time weather forecasting.

Specifically, a convolutional neural network inversion model is introduced for acoustic rainfall intensity estimation, demonstrating superior performance compared to traditional methods, especially for higher rainfall intensities. These findings suggest the feasibility of using acoustic rainfall sensing tools for citizen science applications in smart cities.

A smart environment also means rational and responsible resource management. One of the most important resources in the reference to cities is energy and its sources. Artificial intelligence is also used in this area. It aims at enhancing the efficiency, reliability, and sustainability of smart grids. A smart grid can be defined as a modernized electrical grid that applies digital technology to control and manage electricity generation, distribution, and consumption [124]. In their paper, Alsolami et al. [125] explore the application of deep reinforcement learning techniques in optimizing energy trading in smart grid and demand response within a peer-to-peer energy market, aiming to maximize cost reductions for households. The study employs decentralized training and performance-based learning to maximize policy and value functions, formalizing the complexity of domestic energy trading as a partially observable Markov decision process. Ali et al. [126] use machine learning to tackle the peculiar consumption of electricity in power grids in the context of building green smart cities. On the other hand, Sulaiman et al. [127] focus on utilizing long short-term memory (LSTM) and recurrent neural networks (RNNs) to enhance the dynamic properties of contemporary smart grids.

Table 16 shows the main important AI implementation in the smart environment area.

Table 16. Main important AI implementation in smart environment area of smart cities.

Solution	**Description**
Energy efficiency system	It utilizes AI technologies to predict energy consumption, optimize energy management, and schedule in the smart grid to improve overall efficiency.
Air quality prediction system	It predicts air quality levels, providing early warnings for high pollutant concentrations and highlighting the importance of accurate air quality modeling for assessing the impact of pollution on living and non-living entities.
Energy Theft Prevention System	It utilizes a combination of machine learning techniques to detect energy theft
Early warning system for drinking water	It utilizes an online sensor network and machine learning for early detection of threats to drinking water supply in smart cities.
Integrated system for urban river water quality	It incorporates ICT to safeguard the quality of urban river water while examining groundwater quality in a smart city using GIS and machine learning algorithms.
Optimization of energy trading in smart grid	It applies deep reinforcement learning techniques to optimize energy trading and demand response within a peer-to-peer energy market, aiming to maximize cost reductions for households.

Sources: [105,107,108,110,119,121,122,124].

6.2. Barriers to AI Implementation in Smart Environment

In Table 17, some implementation barriers are presented. First of all, there are concerns about the security of data that are generated and monitored by AI. On the one hand, a large amount of data creates a risk of cyber threats, but on the other hand, AI can also be used to improve the security of data in smart cities [128]. Furthermore, according to Wang et al. [129], the biggest barriers identified based on the authors' study by the authors include lack of infrastructure, insufficient funds, cybersecurity risks, and lack of trust in AI. Lack of infrastructure is a general problem, but it is connected with a lack of standardization among different AI systems and devices within smart environments in smart cities. It also refers to the lack of specialists who are fully able to build special systems and operate AI-based solutions. Another problem is the high cost of implementing the mentioned AI solution on a large scale. Naturally, these investments can be beneficial in the future; however, such a big undertaking is difficult to implement in terms of money, time, and planning [130]. Another barrier is a social barrier. Artificial intelligence often encounters significant fear and skepticism among the public [131]. Concerns regarding potential job displacement, privacy infringement, and reliance on decision-making algorithms are only a few of the problems. These apprehensions pose barriers to the adoption and effective deployment of AI technologies in smart cities and urban areas. Addressing these apprehensions necessitates engagement with stakeholders through comprehensive outreach and education campaigns.

Table 17. Barriers to AI solution implementation in smart environment area.

Barrier	Description	Methods of Overcoming
Data Privacy and Security Concerns	Concerns about the privacy and security of data collected by AI systems in smart environments, particularly in regard to personal information and sensitive data.	Implementation of robust encryption and data protection protocols; conducting regular security audits and assessments; providing transparency about data collection and usage policies to users.
Lack of Interoperability	Incompatibility and lack of standardization among different AI systems and devices used in smart environments, leading to challenges in data sharing and communication between systems.	Developing and adopting industry-wide standards and protocols for interoperability; investing in middleware solutions to facilitate communication between different AI solutions.
High Implementation Costs	The high costs associated with implementing AI systems in smart environments, including hardware, software, training, and maintenance expenses.	Applying for funding opportunities and public–private partnerships; conducting cost–benefit analyses to examine the long-term value and return on investment of AI implementations.
Lack of Technical Expertise	Shortage of skilled professionals with expertise in AI, data science, and related fields needed to develop, deploy, and maintain AI systems in smart environments.	Investing in education and training programs to develop a skilled workforce in AI and data science; fostering collaboration between academia, industry, and government to share knowledge and expertise.
Infrastructure Limitations	Inadequate infrastructure, including outdated or insufficient network connectivity, power supply, and sensor networks, can hinder the deployment and operation of AI systems in smart environments.	Investing in upgrading and modernizing existing infrastructure to support the deployment of AI systems; expanding broadband and network coverage to ensure reliable connectivity.
Public Perception and Acceptance	Concerns and skepticism among the public regarding the use of AI in smart environments.	Engaging with stakeholders through outreach and education campaigns to raise awareness and address misconceptions about AI.

Sources: [128–131].

6.3. Future Directions of AI Implementation in Smart Environment

Table 18 presents future directions of AI solutions in smart environments. First, the future of the implementation of artificial intelligence in smart environments holds promising advancements in many areas. In smart cities, AI algorithms can revolutionize energy management by optimizing consumption, integrating renewable sources, and enhancing grid stability. Additionally, AI-based systems for real-time monitoring of air and water quality will play a crucial role in providing environmental sustainability through pollution detection. Furthermore, AI-powered solutions can bolster safety in urban areas by enabling crime prediction, optimizing emergency responses, and enhancing surveillance capabilities. What is more, in agriculture, the digitalization of AI can enable precision farming techniques, optimize crop management, and contribute to food security while promoting sustainable practices. The integration into water resource management will facilitate the efficient use and conservation of water resources through quality assessment and distribution optimization. In construction, AI can make changes in building design and construction processes, minimizing environmental impact and improving energy efficiency in infrastructure projects. These advances show the potential of AI to face critical challenges and for sustainable development in smart environments.

Table 18. Future directions of artificial intelligence implementation in smart environment area.

Direction	Description
Energy management	The implementation of AI algorithms for optimizing energy consumption in smart environments in smart cities, more rational energy management, enhanced grid stability, and integration of renewable energy sources
Environmental monitoring	Development of AI-based systems for real-time monitoring of air and water quality, pollution detection, and climate modeling to provide environmental sustainability

Table 18. *Cont.*

Direction	Description
Public safety	The development of AI-powered systems for crime prediction, emergency response optimization, and surveillance enhancement, providing safety for residents in urban environments
Urban agriculture	Digitalization of AI for precision agriculture, urban farming optimization, and crop management to enhance food security and promote sustainable agriculture practices
Water resource management	The implementation of AI solutions for water quality assessment and water distribution optimization to ensure efficient use and conservation of water resources
Sustainable construction	The integration of AI into building design, material selection, and construction process to minimize environmental footprint and enhance energy efficiency of interface structure projects

7. Smart Living

7.1. Main Important Solutions Used in AI Implementation in Smart Living

Smart living is one of the areas of a smart city that may manifest itself in various ways. One of its elements may be smart buildings/homes that are supposed to make people's lives more comfortable; save energy, resources, and money; improve safety; and enable greater control of a given apartment or other building by residents. A smart home refers to a residence equipped with various devices and appliances that are connected to a central network and can be controlled remotely by a smartphone, tablet, or computer [132]. Smart homes often use heating and cooling devices called Heating, Ventilation, and Air Conditioning (HVAC) systems. These systems use artificial intelligence to optimize heating and cooling processes. At the same time, the home remains comfortable for users. There is some research in the literature on HVAC systems showing their benefits, measurable positive results, and possibilities [133–136]. In smart homes, there are also smart thermostats that minimize energy usage and help to adjust the temperature to the needs of residents [137,138]. Another solution used in intelligent houses is intelligent lighting. It is not only a system for turning on and off the lighting in rooms or outside the house, but it also has more functions, for example, changing the lighting intensity depending on demand and time of day, as well as remote lighting control and its control using mobile devices [139]. Smart buildings often have smart windows and blinds as an element of their infrastructure. Such windows use various types of modern materials and achievements in material science, regulating light transmission and using solar energy to regulate the temperature in the house [140–142]. We should also mention other devices based on the Internet of Things that operate at home, such as smart refrigerators. Refrigerators not only save energy but can also control product expiration dates, minimize food waste, check user purchases, and order products when they run out. Such devices learn the user's preferences and needs and try to meet their need for completeness and shopping [143–145].

As it has been mentioned, one of the solutions for smart living is smart lighting in smart buildings. However, intelligent lights do not only have to be present in buildings but also on the streets. Such lighting based on artificial intelligence systems can be used to increase safety and energy savings on streets—in places where pedestrians walk. Deepaisarn et al. [146] present research on automated street light adjustment systems based on AI-assisted data analytics, while Kurt and Kiyak [147] study AI-based light control in the areas of schools, living spaces, social areas, and roads. On the other hand, intelligent traffic lighting at intersections is used in cities. Thanks to such solutions, residents can move more efficiently on the roads, and unnecessary waiting is avoided, which also affects the quality of life of residents, both pedestrians and drivers. In their paper, Natalia et al. [148] present empirical research on the practical impacts of integrating AI into a smart city, mainly related to traffic lights. The study examines various AI applications, including smart traffic management. The results demonstrate significant improvements in urban mobility due to the AI-based traffic lights. The use of AI-powered smart traffic management yields a 32.94% rise in traffic volume, signifying a noteworthy progression toward improved urban mobility. The paper of [149] explores the impacts of Artificial Intelligence of Things (AIoT) in smart cities, particularly focusing on optimizing vehicular traffic. Through a case study, the research demonstrates that integrating AI algorithms, computer vision, and blockchain technology into a vehicle traffic optimization system can lead to a significant 20% reduction in traffic congestion during peak hours. Additionally, the use of blockchain ensures data security and immutability, enhancing trust in the system and promoting sustainability in urban environments.

Smart cities also offer smart healthcare, which aims to improve healthcare delivery and outcomes. Using IoT devices, wearable sensors, and remote monitoring systems, smart healthcare solutions enable continuous health monitoring, early disease detection, and personalized treatment plans. Additionally, AI algorithms can analyze large amounts of healthcare data to identify patterns, predict disease outbreaks, and optimize resource allocation within healthcare systems. Telemedicine platforms facilitate remote consultations and medical diagnostics, reducing the need for physical appointments and improving access to healthcare services, especially in underserved urban areas. In the literature, there are some papers that concern this area of smart living. Ali et al. [150] propose a method for enhancing the performance of healthcare services in smart cities using hybrid optimization techniques. Zhong and Deng [151] study a cloud and IoT-enabled workload-aware healthcare framework using an ant colony optimization algorithm. Hassan et al. [152] develop principles for AI-driven smart city healthcare monitoring. Abirami and Karthikeyan [153] propose a digital twin-based healthcare system with smart virtual care facilities to enhance the earlier stages of disease prediction and a patient-centric diagnosis mechanism from remote locations. There are more papers on smart healthcare, including [154–157].

Smart living is more and more connected with wearable technologies, such as virtual reality (VR), augmented reality (AR), and mixed reality (MR). These technologies give a lot of opportunities for smart living experiences—from virtual home tours and interactive furniture placement to immersive interior design and smart home training simulations. Using these technologies, users can visualize and interact with their living spaces in entirely new ways, leading to more informed decisions, streamlined maintenance processes, and, ultimately, a more connected and personalized living experience. Also, research shows that more and more people are into VR gaming [158]. What is more, smart cities have developed the idea of the metaverse. Bibri and Jagatheesaperumal [159] present a detailed overview of the literature on the potential applications, opportunities, and challenges pertaining to the deployment of XR technologies in IoT applications within smart cities. There is a great future in the area of the metaverse as an element of intelligent cities. The primary focus of the study is on navigating the challenges pertaining to the IoT applications powered by VR and AR as key components of MR in the metaverse. More authors discuss the topic of metaverse and smart cities, and the examples are [160,161].

Virtual solutions are also connected to cybersecurity problems. There is also much research on cybersecurity technology based on AI. Jia et al. [162], Bekkali et al. [163], and Bokhari and Myeong [164] study cyber security defense for smart cities; Prabakar et al. [165] examine cyberattack detection by IoT with AI in a sustainable smart city; and Al-Marghilani [166] describes artificial intelligence-enabled cyberbullying-free online social networks in smart cities.

Table 19 shows the main important AI implementation in smart living areas.

Table 19. Main important AI implementation in smart living areas of smart cities.

Solution	Description
Smart Homes	Integration of various devices and appliances connected to a central network, controlled remotely for improved comfort, energy savings, resource management, and safety
Heating, Ventilation, and Air Conditioning	AI-optimized systems for heating and cooling processes in homes, ensuring user comfort while maximizing energy efficiency
Intelligent Lighting Systems	Lighting systems with advanced functions such as automatic turn on/off, adjustment of intensity based on demand and time of day, remote control, and integration with mobile devices
AI-based Street Lighting Systems	Street lighting systems using AI analytics for safety and energy savings, automatically adjusting brightness based on real-time data and optimizing illumination in pedestrian areas

Table 19. *Cont.*

Solution	Description
Smart Healthcare Solutions	Utilization of IoT devices, wearable sensors, and AI algorithms for continuous health monitoring, disease detection, personalized treatment plans, telemedicine platforms, and improved access to healthcare services, particularly in urban areas
Metaverse Integration	Incorporation of XR technologies within IoT applications in smart cities, navigating challenges, and exploring opportunities for metaverse development as an element of intelligent urban environments

Sources: [132–135,146–150,152,154,159].

7.2. Barriers to AI Implementation in Smart Living

The successful implementation of AI solutions in smart living environments faces various barriers. As previously noted, privacy concerns, particularly regarding the collection and use of personal data, are the social barrier [131]. Residents may worry about the collection and use of their personal data by AI systems, leading to fears of breaches of privacy and unauthorized access to sensitive information [128]. Reliability and safety are also major concerns, especially in critical areas like healthcare and emergency response, where errors or malfunctions could have serious consequences. Some AI algorithms may not be programmed to solve problems that were not planned in the programming. New solutions using AI can also be a challenge for some groups of people, particularly for elderly individuals, people with disabilities, or those with limited access to technology. Some groups of people may not understand AI solutions and may not know what to do or how to behave. This can present digital divides and inequalities. Other barriers are connected with the physical side. Infrastructure limitations, inadequate Internet connectivity, or outdated hardware can hinder the deployment of AI-powered systems [129]. Finally, the big barrier is the cost of implementation and development [130]. Addressing these barriers effectively is crucial to ensuring the successful adoption and implementation of AI solutions in smart living environments. Table 20 presents these barriers and the methods to overcome them.

Table 20. Barriers to AI solution implementation in smart living areas.

Barrier	Description	Methods of Overcoming
Privacy concerns	Residents may have concerns about the collection and use of personal data by AI-powered systems in smart homes and cities, fearing potential breaches of privacy and unauthorized access to sensitive information.	Implementation of robust data encryption and anonymization techniques to protect personal data; development of AI algorithms that prioritize data privacy by processing information locally on edge devices rather than transmitting sensitive data to centralized servers.
Problems with reliability and safety	The potential problems with reliability and safety of AI-based systems in smart homes and cities, particularly in critical areas such as healthcare, transportation, and emergency response, where errors or malfunctions could have serious consequences.	Implementation of rigorous testing and validation procedures to ensure the accuracy and reliability of AI algorithms before deployment in critical applications; providing ongoing monitoring and maintenance of AI systems to detect and address any issues or vulnerabilities promptly, ensuring optimal performance and safety over time.
Limited access	Concerns may arise about the accessibility and inclusivity of AI-powered solutions in smart living environments, particularly for elderly individuals, people with disabilities, or those with limited access to technology, potentially exacerbating digital divides and inequalities.	Designing AI systems with accessibility features such as voice control, gesture recognition, and adjustable interfaces to accommodate diverse user needs and preferences; ensuring compatibility with assistive technologies and devices commonly used by individuals with disabilities, facilitating seamless integration into daily routines and activities.

Table 20. *Cont.*

Barrier	Description	Methods of Overcoming
Infrastructure limitations	The deployment of AI-powered systems in smart living environments may be hindered by existing infrastructure limitations, such as inadequate Internet connectivity, outdated hardware, or insufficient data storage and processing capabilities.	The deployment of AI-powered systems in smart living environments may be hindered by existing infrastructure limitations, such as inadequate Internet connectivity, outdated hardware, or insufficient data storage and processing capabilities; collaboration with telecommunications providers, technology companies, and government agencies to develop strategic plans and funding initiatives for improving infrastructure resilience and capacity, ensuring reliable and efficient delivery of AI services to residents.
Cost and affordability	Residents may face financial barriers to accessing AI-powered solutions in smart living environments, as the upfront costs of acquiring and implementing these technologies may be prohibitive for some individuals or communities.	Exploring innovative financing models such as public–private partnerships, subscription-based services, or community investment funds to distribute costs more equitably and facilitate broader adoption of AI solutions in smart cities; offering subsidies, grants, or tax incentives to incentivize investment in AI technologies for smart living.

Sources: [55,57,128–131].

7.3. Future Directions of AI Implementation in Smart Living

Smart cities are constantly developing, and the area of smart living is important for the inhabitants. Artificial intelligence creates great potential for use in these cities. Some solutions are already being implemented, but there are many directions and areas for the use of AI. Table 21 presents some future directions for the implementation of artificial intelligence. Among them, personalized health care can be found. It will be increasingly better in intelligent spaces in the future. Healthcare is one of the most important aspects of human life because, sooner or later, it affects everyone. The direction of development of personalized medicine and healthcare is crucial for the inhabitants of smart cities; hence, there are many solutions related to artificial intelligence that will monitor people's health, support their treatment, and also improve the safety of sick people and people undergoing treatment [156]. Another area is the improvement of smart homes in order to improve the comfort of residents and save costs and energy. In smart cities, renewable energy sources should also be used on an increasing scale. Smart living in smart cities may also be related to the increasingly advanced virtual reality technology. There is more and more research and practice regarding the metaverse. An important direction is also to raise awareness and encourage people to use artificial intelligence.

Table 21. Future directions of artificial intelligence implementation in smart environment living.

Direction	Description
Personalized Healthcare Monitoring	Implementing AI-driven wearable devices and sensors for continuous health monitoring, early disease detection, and personalized treatment plans
Enhanced Home Automation	Advancing AI-powered smart home systems to optimize energy usage, improve safety, and enable greater control and convenience for residents
Sustainable Resource Management	Leveraging AI to optimize resource usage and conservation in areas such as energy, water, and waste management, promoting environmental sustainability, increasing the use of renewables for energy production
Inclusive and Accessible Technologies	Developing AI solutions with accessibility features to accommodate diverse user needs, including elderly individuals and people with disabilities, fostering inclusivity in smart living environments
Community Engagement and Empowerment	Utilizing AI-powered platforms for community engagement, empowerment, and decision-making processes to enhance civic participation and promote social cohesion
Advanced Virtual Reality Experiences/Toward Metaverse	Expanding the use of virtual and augmented reality technologies for immersive smart living experiences, including virtual home tours, interactive design simulations, and virtual training programs. This direction also opens a way to function or even live in metaverse
Integration of Blockchain Technology	Integration of blockchain technology with AI systems in smart living environments to improve data security, privacy, and transparency in transactions and interactions

8. Smart People

8.1. Main Important Solutions Used in AI Implementation in Smart People

The area of 'smart people' in smart cities encompasses initiatives and technologies that empower residents with the skills, knowledge, and resources to actively engage and benefit from urban advancements, including education, digital literacy, community participation, and lifelong learning opportunities. Stretz et al. [67] highlight some characteristics of smart cities in the context of people, namely humane, self-aware, and cooperative. The authors pay attention to the word 'self-awareness' that should characterize people in smart cities. Self-awareness provides a new definition of smartness. It refers to initiatives and technologies that promote the understanding of individuals' own behavior, habits, and impact on the urban environment, fostering greater mindfulness, responsibility, and proactiveness in shaping sustainable and inclusive communities.

The previously described smart city areas are more popular when it comes to practical and theoretical research in the literature. However, it can be concluded, based on the literature analysis, that this area of intelligent people is not yet heavily exploited in the context of recent research on Scopus. When it comes to the latest research on AI in this area of smart cities, there are not many of them. The first paper is the one already mentioned [67], which highlights the self-awareness of people and discusses AI and innovations in smart cities that must also be understood by inhabitants. Feher [167] investigates the expectations surrounding smart mentality and citizen participation in technology-driven cities. Through the analysis of 150 mainstream trend reports, white papers, and research summaries from various sectors, including business, government, and academia, the study examines changing trends in the related academic literature. The analysis highlights factors such as open data, communities, collective participation, socio-technical engagement, and empowerment as prominent themes while also noting underrepresented areas such as anonymity, neighborhood-based implementations, and temporary human roles, along with privacy concerns and ethical issues. Another paper [168] focuses on shaping climate awareness, enhancing smart governance, and supporting social participation and inclusion. The authors prove that AI-based educational tools can be supportive when implementing adaptation policies toward climate neutrality based on our proposed AI-based model shaping climate awareness.

A good example of a study on the problem of smart people in smart cities is a paper by Pilling et al. [169]. The authors describe the AI for Lancaster Programme, a collaborative effort between Lancaster City Council, the International Organization for Artificial Intelligence Legibility, PETRAS, and Imagination Lancaster. It outlines the design concepts implemented in the city to effectively communicate the use of artificial intelligence to its citizens, drawing upon interviews and research findings to evaluate these designs. The paper emphasizes the importance of responsible AI implementation in urban settings. Furthermore, it discusses how the insights gleaned from the AI for Lancaster Programme can contribute to informing smart city initiatives and fostering the development of hybrid sociologies that refer to the interactions between urban, social, and technological dynamics. Overall, the paper discusses the significance of AI in urban contexts while prioritizing ethical considerations and citizen engagement. Mlynar et al. [170] notice that there are different approaches to AI development. The first one is focused on AI benefits for society, and the other is on technological advances while, at the same time, not paying attention to society and the issues connected with the impact of AI on people. The authors represent the first approach and study a more profound role for social sciences by shaping discourses on the desired characteristics of AI. Focusing on urbanism, they conducted interviews with 16 urban experts to explore their visions of how AI can and should shape future cities. A similar approach is seen in the paper of Streitz [171]. The author criticizes technology-driven approaches in the development of smart environments. He argues that priorities should be reset by putting humans first and computer technologies with non-transparent AI-based mechanisms second. He bases it on the concept of 'human-technology symbiosis'. The author discusses the concept of humane, sociable, and cooperative hybrid cities, reconciling people and technology by providing a balance between human control and automation as well as privacy and smartness. A city must be 'self-aware' and 'cooperative' toward its citizens.

Another feature of a smart city in the context of a smart people area is inclusivity. In this topic, there is a publication [172] that discusses the problem of taking care of older people using AI. The article proposes leveraging the power of the Internet to integrate various aspects of elderly care, including home care, community services, smart technology, and medical resources. The author introduces the implementation of a "cloud service platform" in the elderly care service industry, aimed at creating a new community development model suitable for aging populations. Additionally, a comprehensive smart community elderly care service system is proposed to facilitate seamless connectivity between medical institutions, service providers, elderly individuals, and their families, offering a range of services encompassing living assistance, medical care, entertainment, and emotional support. Furthermore, the establishment of a feedback mechanism using cloud computing ensures dynamic data updates, enhancing the effectiveness and responsiveness of the system. Overall, the proposed approach not only aims to enhance the quality of life for elderly individuals but also provides a robust information management platform for community elderly care, serving as a valuable reference for future urban aging care initiatives.

Smart people areas also encapsulate the usage of special platforms that make inhabitants aware of certain problems. So far, there are not many papers on this topic, but the authors of [173] present the topic of social media platforms and their role in community neighborhood resilience. The paper focuses on the roles of social media and smart city technologies in enhancing community resilience during the COVID-19 pandemic. The findings underscore the significance of social media and smart city technologies in facilitating community adaptation and recovery from the pandemic's impacts. Such platforms supported by AI may bring benefits during the next pandemic or other crisis. Besides platforms, people in smart cities use innovative applications. An example of one of them is described in [174]. The paper discusses a mobile application that utilizes AI to address the issue of food wastage in supermarkets by sorting and packaging edible food that would otherwise be discarded. This innovative solution aims to distribute weekly food packages to individuals or families in need, ensuring that surplus food is utilized efficiently and no one goes hungry. By reducing food wastage, supermarkets benefit from decreased costs, while underserved communities gain access to essential food items, contributing to a more sustainable future for all stakeholders involved.

Another application is connected with the metaverse [175]. The paper explores the ternary subject structure of spatial culture information dissemination in digital communities from the perspective of metaverse technology. It investigates the information dissemination form and content production within digital communities, emphasizing the integration of human, virtual digital avatars, and AI entities. Ultimately, the paper proposes the construction of an evaluation model for metaverse communities, aiming to achieve reliability, availability, and efficiency in information dissemination mechanisms.

Table 22 presents the main above-mentioned important solutions.

Table 22. Main important AI implementation in smart people area of smart cities.

Solution	Description
Social media platforms for community resilience	Using the roles of social media and smart city technologies in enhancing community resilience during crises such as pandemics. Such platforms help in communication, collaboration, and information dissemination, and they are supported by AI to address various challenges and promote community well-being.
Metaverse technology for spatial culture information dissemination	Metaverse technology explores the integration of humans, virtual digital avatars, and AI entities in digital communities. Its goal is to achieve reliability, availability, and efficiency in information dissemination mechanisms, aiming to enhance communication and interaction within digital communities.

Table 22. *Cont.*

Solution	Description
Platform for elderly care	Implementing a cloud service platform in the elderly care service industry, integrating home care, community services, smart technology, and medical resources to create a new community development model suitable for aging populations. This solution provides a comprehensive smart community elderly care service system to facilitate seamless connectivity between stakeholders, offering various services encompassing living assistance, medical care, entertainment, and emotional support.
Mobile application to prevent food wastage	This application addresses food wastage in supermarkets by utilizing AI to sort and package edible food that would otherwise be discarded. Distributes surplus food to individuals or families in need, reducing costs for supermarkets and providing essential food items to underserved communities, contributing to a more sustainable future.

Sources: [169,172,174,175].

8.2. Barriers to AI Implementation in Smart People

When it comes to the area of smart people, there are also some barriers that are similar to the barriers described earlier. Table 23 outlines four key barriers to the implementation of AI solutions in smart cities in the area of smart people: lack of trust, resistance to change, ethical considerations, and the digital divide. Lack of trust encompasses skepticism and reluctance toward AI technologies due to concerns about reliability, bias, and social impacts. Artificial intelligence can provide great help and comfort for people on the one hand, but on the other, it significantly changes society. Naturally, it is assumed that artificial intelligence will help people develop as a society, creating many opportunities and improving the quality of life. On the other hand, the use of artificial intelligence may make people lazy or blindly rely on technology without verifying, for example, the sources of data information. Resistance to change involves stakeholders' reluctance to adopt AI solutions due to job displacement fears and unfamiliarity with new technologies. AI may pose many threats in many areas. Another problem is ethics. Ethical considerations in AI are crucial and encompass various dilemmas related to fairness, accountability, and transparency in decision-making processes. These dilemmas arise from concerns about biases in AI algorithms, the potential for discrimination in automated decision-making, and the lack of transparency in how AI systems arrive at their conclusions. The lack of human factors can also be scary. Artificial intelligence works on the basis of algorithms, and in exceptional situations, the human factor is necessary, while artificial intelligence will always be devoid of feelings and thinking outside the box. Another barrier is the digital divide, which results from the fact that some generations, especially younger ones, will be able to adopt solutions based on artificial intelligence more quickly, while other generations, e.g., older people, will have problems understanding solutions based on AI. The implementation of solutions of this type may cause differences. It may deepen the negative atmosphere and differences between certain groups, and it may even lead to discrimination. On the other hand, it should also be emphasized that some groups will use artificial intelligence uncritically, while others will think and behave cautiously toward AI.

Table 23. Barriers to AI solution implementation in smart people area.

Barrier	Description	Methods of Overcoming
Lack of Trust	Lack of trust in AI technologies and their developers. It includes concerns about reliability, bias, and potential negative impacts on society. There is also skepticism and reluctance to embrace smart city initiatives.	Building trust through transparent communication, accountability, and responsible AI practices, including rigorous testing, validation, and ongoing monitoring of AI systems to ensure their reliability and fairness.
Resistance to Change	Resistance from stakeholders, including residents, policymakers, and organizations, toward adopting AI solutions due to concerns about job displacement, loss of control, and unfamiliarity with new technologies.	Engaging with stakeholders through education and awareness campaigns to demonstrate the benefits of AI solutions, address misconceptions, and involve them in the co-design and implementation process.

Table 23. *Cont.*

Barrier	Description	Methods of Overcoming
Ethical Considerations	Ethical dilemmas arising from the use of AI in decision-making processes, including issues related to fairness, accountability, transparency, and bias in algorithmic outcomes.	Establishing ethical guidelines and standards for the development and deployment of AI systems, promoting fairness, accountability, transparency, and inclusivity in algorithmic decision-making processes.
Digital Divide	Disparities in access to technology and digital literacy among different demographic groups, hindering the equitable participation and benefits of smart city initiatives.	Implementing community-based digital literacy programs to bridge the gap and ensure all residents have access to technology and the skills needed to effectively engage with AI solutions.

Sources: [131,167,168,171].

8.3. Future Directions of AI Implementation in Smart People

When it comes to smart communities and smart people in smart cities, a lot may change in the coming years. People's lifestyles are changing under the influence of solutions based on artificial intelligence. The future poses many challenges for people living in smart cities and using artificial intelligence. Certainly, an important element is to support individual residents and entire communities in the proper use of AI. Smart cities are supposed to create communities in which people can communicate in a better way, share knowledge, and solve problems together. On the other hand, it is also a big challenge to eliminate the differences caused by technological progress, especially the digital one. As mentioned earlier, a big problem is placing humans above technical solutions. In other words, solutions based on artificial intelligence should be created for humans and not just for imposing artificial intelligence on humans. However, some solutions may make people feel lost, confused, controlled, unaware, and insecure. Referring to the previous thought, the self-awareness of residents is very important in smart cities. An active and self-aware attitude should be developed from an early age. Table 24 sums up these future directions.

Table 24. Future directions of artificial intelligence implementation in smart people area.

Direction	Description
Social support	Enhancing digital literacy and education initiatives to empower residents with the skills needed to effectively engage with AI technologies and navigate the digital landscape.
Community participation	Fostering community participation and collaboration through innovative platforms and technologies that facilitate communication, knowledge sharing, and collective problem-solving.
Ethical AI practices	Promoting ethical AI practices and responsible data governance to address concerns about bias, transparency, and accountability in decision-making processes.
Digital divide	Decreasing the digital divide by ensuring equitable access to technology and resources, particularly among underserved populations and older adults.
Human-centered design principles	Emphasizing the importance of human-centered design principles in the development and implementation of AI solutions, prioritizing user needs, preferences, and values.
Lifelong learning	Encouraging lifelong learning opportunities and continuous skills development to adapt to technological advancements and societal changes.
Proactive and self-aware approach	Empowering individuals to be proactive and self-aware in shaping their urban environments based on AI, fostering a sense of responsibility and agency in creating sustainable and resilient communities.

9. Discussion

Table 25 summarizes the analysis of three areas that were the main goals of the research: the identification of applications of AI usage in smart cities, barriers to the implementation of AI in smart cities, and an analysis of the direction of the usage of AI in smart cities.

Table 25. Applications, barriers, and future directions of AI usage in smart governance, smart economy and smart mobility, smart environment, smart living, and smart people areas of smart cities.

	Application	Barriers	Future
Smart Governance	Enhancing efficiency in governance processes by automating public services, permit approvals, and license renewals. Enhancing communication between citizens and government through AI-driven chatbots and virtual assistants.	Lack of trust due to concerns about reliability, bias, and social impacts of AI technologies. Resistance to adopting AI solutions due to concerns about job displacement and loss of control.	Building trust through transparent communication, accountability, and responsible AI practices. Promoting community participation and collaboration through innovative platforms and technologies.
Smart Economy	Improving economic activities by automating business processes, supply chain management, and workforce management for increased productivity. Enabling financial inclusion by accessible services and promoting sustainable business practices through AI-driven financial analytics.	Resistance to change, job displacement fears, and unfamiliarity with new technologies. Ethical dilemmas related to fairness, accountability, and transparency in decision-making processes.	Establishing ethical guidelines and standards for the development and deployment of AI systems. Encouraging lifelong learning opportunities and continuous skills development to adapt to technological advancements.
Smart Mobility	Optimizing transportation systems through the implementation of smart parking solutions, autonomous vehicles, and dynamic traffic management. Providing real-time updates and improving the overall user experience in public transportation.	Safety concerns related to AI-driven pedestrian and cyclist protection, infrastructure monitoring, and compliance with air mobility regulations. Infrastructure limitations and ensuring compliance with regulations to maintain trust and confidence in smart mobility solutions.	Engaging with stakeholders through education and awareness campaigns to demonstrate the benefits of AI solutions. Enhancing economic activities through optimized business processes, talent management, and sustainable practices.
Smart Environment	Monitoring environmental factors and promoting sustainability through the collection and analysis of data to optimize resource allocation and monitor environmental conditions. Implementing green infrastructure and renewable energy sources, as well as minimizing environmental impact in urban areas.	Ethical dilemmas arising from the use of AI in decision-making processes, including issues related to fairness, transparency, and bias in algorithmic outcomes. Implementing cybersecurity measures to protect personal data and ensure compliance with ethical guidelines.	Implementing community-based digital literacy programs to bridge the digital divide and ensure all residents have access to technology. Forecasting environmental trends and potential hazards by analyzing data from various sources such as weather sensors and pollution monitors.
Smart Living	Improving quality of life for residents by integrating smart home/building devices and IoT technologies to enhance safety, convenience, and overall comfort. Personalizing services and streamlining administrative processes to safeguard personal data and ensure privacy protection.	Privacy concerns and usability issues associated with smart living technologies and services. Ensuring equal access to technology and resources, fostering equal opportunities for urban living.	Emphasizing the importance of human-centered design principles in the development and implementation of AI solutions. Encouraging proactive and self-aware approach, empowering individuals to shape their urban environments.
Smart People	Empowering residents with skills and knowledge through AI-driven educational tools, digital platforms, and data analytics to promote digital literacy and lifelong learning. Promoting community-driven initiatives and empowering individuals with the knowledge and resources.	Digital divide resulting from disparities in access to technology and digital literacy among different demographic groups.	Decreasing the digital divide by ensuring equitable access to technology and resources. Empowering residents with the skills and knowledge to actively engage with and benefit from urban advancements.

When analyzing the application of artificial intelligence across different areas of smart cities, several key differences emerge. In smart mobility, AI is primarily focused on optimizing transportation systems, reducing congestion, and enhancing overall mobility through intelligent traffic management systems and autonomous vehicles. In contrast, in smart environment initiatives, AI is utilized to monitor air and water quality, manage waste, and promote sustainability by optimizing resource usage and minimizing environmental impact. Smart governance utilizes AI to enhance efficiency in governance processes, decision-making, and citizen services, often employing AI-driven chatbots and virtual assistants to improve communication between citizens and government. On the other hand, smart economy initiatives leverage AI for predictive financial analytics, personalized marketing, and talent matching to drive economic growth and innovation in businesses.

In the case of smart living, AI-powered smart home systems, telehealth services, and digital initiatives contribute to improving the quality of life for residents by promoting safety, health, and convenience in various aspects of daily life. In contrast, smart people initiatives focus on empowering residents with the skills, knowledge, and resources needed to actively engage and benefit from urban advancements, often through digital literacy programs and community-driven initiatives.

When analyzing the barriers and methods to overcome them regarding the implementation of artificial intelligence in different smart city areas, several distinctions emerge. In smart governance, one of the primary barriers is the lack of trust in AI technologies and concerns about reliability, bias, and social impacts. To overcome this, transparent communication, accountability, and responsible AI practices are essential, including rigorous testing and ongoing monitoring of AI systems. In contrast, smart economy initiatives may face resistance to change due to job displacement fears and unfamiliarity with new technologies. Engaging stakeholders through education and awareness campaigns to demonstrate the benefits of AI solutions and involve them in the co-design process can help address this barrier.

Smart mobility initiatives may encounter ethical considerations related to safety and privacy in AI-driven transportation systems. Establishing ethical guidelines and standards for the development and deployment of AI systems can address these concerns, promoting fairness, transparency, and inclusivity in decision-making processes. On the other hand, smart environment initiatives may face challenges related to the digital divide, hindering the equitable participation and benefits of AI solutions. Implementing community-based digital literacy programs can help bridge this gap and ensure all residents have access to technology and the skills needed to engage with AI solutions effectively. In smart living, security and compliance issues, such as safeguarding personal data and ensuring privacy protection in smart home devices, are significant barriers. Adhering to relevant regulations and promoting ethical guidelines can help maintain trust and confidence in smart living technologies and services. Finally, smart people initiatives may encounter barriers associated with the lack of trust and resistance to change, as well as concerns about the digital divide and ethical considerations. Empowering individuals with digital literacy skills and promoting lifelong learning opportunities can help address these barriers and ensure equitable access to AI benefits for all residents. The differences in barriers and methods to overcome them in smart city areas reflect unique challenges within each domain, emphasizing the importance of customized approaches to ensure the responsible and equitable deployment of AI solutions.

In the case of the future directions of artificial intelligence implementation in various smart city areas in the table, there is also a description of the main features in particular areas. In smart governance, future directions focus on enhancing digital literacy and education initiatives to empower residents with the skills needed to engage effectively with AI technologies and navigate the digital landscape. This emphasis aims to promote transparency, accountability, and citizen participation in governance processes. In contrast, smart economy initiatives prioritize promoting ethical AI practices and responsible data governance to address concerns about bias, transparency, and accountability in decision-making processes. By establishing ethical guidelines and standards, these initiatives aim to foster trust and confidence in AI-driven economic activities.

Smart mobility initiatives focus on using emerging technologies, such as autonomous vehicles and drones, to advance mobility solutions and improve the efficiency and accessibility of urban transportation systems. Additionally, there is a growing emphasis on decreasing the digital divide by ensuring equitable access to technology and resources, particularly among underserved populations and older adults. This approach aims to promote inclusive mobility solutions that address diverse community needs and promote accessibility for all residents.

In smart environment initiatives, future directions center on utilizing AI and IoT technologies to optimize resource allocation, monitor environmental conditions, and promote sustainability and resilience in urban ecosystems. By collecting and analyzing data from various sources, such as weather sensors and pollution monitors, these initiatives aim to enhance environmental monitoring and management efforts. Furthermore, there is a focus on fostering environmental awareness and encouraging eco-friendly behaviors among residents to promote sustainable urban living.

Smart living initiatives prioritize human-centered design principles and lifelong learning opportunities to adapt to technological advancements and societal changes. By emphasizing user needs and values in the development and implementation of AI solutions, these initiatives enhance the quality of life. There is a focus on promoting proactive and self-aware attitudes to empower them to shape their urban environments actively. The initiatives decrease the digital divide and promote digital literacy through community-based programs and initiatives. By providing equal access to technology, these initiatives aim to ensure that everyone can benefit from technological advancements and actively participate in shaping smart city development. Also, there is a focus on fostering community participation and collaboration through innovative platforms and technologies that facilitate communication, knowledge sharing, and collective problem-solving.

- On the basis of the analysis in this paper, the following guidance for policymakers and urban planners can be given:
- The analysis emphasizes the significance of data utilization in informing decision-making processes across all smart city domains. Policymakers and urban planners should invest in robust data infrastructure to support AI-driven decision-making, as highlighted by the role of data analytics in optimizing resource allocation, enhancing efficiency, and driving innovation.
- The analysis prioritizes citizen engagement and participation in smart city initiatives facilitated by AI-driven communication tools and participatory decision-making platforms. Policymakers and city planners should prioritize transparent and inclusive governance processes, using AI technologies to enhance citizen engagement, as indicated by an emphasis on fostering community participation and collaboration.
- The analysis underscores the potential of AI-driven automation to streamline service delivery and improve efficiency within smart city operations. Policymakers and urban planners should identify opportunities for AI-based automation in key areas, e.g., permit approvals, transportation management, and public services, aligning with the observation of harnessing automation capabilities for operational efficiency.
- The analysis highlights the integration of AI into sustainability-focused initiatives to promote eco-friendly practices and minimize environmental impact within urban ecosystems. Policymakers and urban planners should leverage AI-driven technologies to monitor and manage environmental conditions, support green infrastructure projects, and advance sustainable development goals consistent with the observation of promoting sustainability through AI implementation.
- The analysis emphasizes prioritizing cybersecurity measures, data privacy protection, and regulatory compliance in AI deployment. Policymakers and urban planners should implement robust security protocols and adhere to ethical guidelines to ensure the secure and responsible deployment of AI technologies, aligning with the observation of prioritizing security and compliance in AI implementation.
- The analysis explores synergies between AI and other emerging technologies, such as IoT and blockchain, to enhance the capabilities of smart city initiatives. Policymakers and urban planners should foster collaboration across different technologies to develop holistic solutions that address complex urban challenges effectively, consistent with the observation of integrating AI with other emerging technologies.
- The analysis underscores the importance of designing AI solutions to be inclusive, catering to the needs of diverse communities within smart cities. Policymakers and urban planners should promote accessibility, digital literacy, and community engage-

ment to ensure that all residents can benefit from AI technologies, consistent with the observation of prioritizing inclusive solutions in AI implementation.

10. Conclusions

The rapid advancement of artificial intelligence presents huge opportunities for smart cities to address urban challenges and improve the quality of life of residents. Through an analysis of the literature from 2021 to January 2024, this study has identified the main important applications, barriers to implementation, and future directions of AI solutions in six main areas of smart cities: smart mobility, smart environment, smart governance, smart living, smart economy, and smart people.

This paper provides a comprehensive analysis of AI implementation in various areas of smart cities, including smart governance, economy, mobility, environment, living, and people. Through an analysis of AI usage, barriers, and future directions in each domain, several key insights emerge. AI offers diverse applications and promising potential in advancing smart cities by enhancing efficiency, promoting innovation, optimizing resource usage, and improving the quality of life for residents. However, challenges such as ethical considerations, the digital divide, security, and compliance issues must be addressed to ensure the responsible and equitable deployment of AI solutions.

This paper highlights the importance of considering the unique characteristics and priorities within each smart city area when implementing AI solutions. Differences in core objectives, data utilization, citizen engagement, automation of services, sustainability focus, security and compliance measures, integration of emerging technologies, predictive analytics, inclusive solutions, and economic growth impact underscore the need for tailored approaches to address specific challenges and opportunities.

Also, this paper identifies future directions for AI implementation in smart cities, emphasizing the importance of enhancing digital literacy, promoting ethical AI practices, leveraging emerging technologies, fostering environmental awareness, prioritizing human-centered design principles, and decreasing the digital divide. These future directions aim to empower residents, promote community participation, address societal challenges, and create sustainable and resilient urban environments.

The findings of this paper highlight the transformative potential of AI in advancing smart cities while emphasizing the importance of responsible deployment, citizen engagement, and inclusive development. By addressing key challenges and leveraging emerging opportunities, smart cities can harness the power of AI to address urban challenges and improve the quality of life for all residents.

Overall, the findings of this study highlight the diverse applications and promising potential of AI in the advancement of smart cities. However, challenges such as ethical considerations, the digital divide, and security and compliance issues must be addressed to ensure the responsible and equitable deployment of AI solutions.

The main scientific value of this paper lies in its comprehensive analysis of artificial intelligence implementation across various domains within smart cities. By examining the usage, barriers, and future directions of AI in smart governance, smart economy, smart mobility, smart environment, smart living, and smart people areas, this paper offers valuable insights into the opportunities and challenges associated with AI deployment in urban settings. This paper contributes to the scientific literature by identifying key points in AI application strategies, barriers, and future directions across different smart city areas. This conducted analysis enhances our understanding of the nuanced requirements and priorities within each domain, enabling more tailored and effective approaches to AI implementation. Also, by highlighting the importance of addressing ethical considerations, promoting digital literacy, fostering community engagement, and ensuring inclusive development, this paper provides valuable guidance for policymakers and urban planners involved in smart city initiatives. These insights can inform the design and implementation of AI-driven solutions that are not only technologically advanced but also socially responsible and equitable.

Research limitations of this study include a potential language bias toward English publications and reliance on peer-reviewed sources. Additionally, this study's methodology, which focuses on a literature review approach, may limit the depth of analysis and generalizability of findings to all smart cities globally. A limitation of the research is also connected with the selection of keywords. We have chosen only the basic keywords "artificial intelligence" and "smart city". It is possible to use more specific keywords, for example, "urban AI", "smart governance AI", "public safety AI", etc., in future, more detailed research.

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