Budownictwo i Architektura 24(1) 2025, 113-132

DOI: 10.35784/bud-arch.6579
Received: 25.09.2024; Revised: 14.12.2024;
Accepted: 14.12.2024; Available online: 31.03.2024

Review Article

The intelligent cities conversion process based on AI and technologies integration: a systematic literature review

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Abstract: The vision of an intelligent city remains ambiguous, with multiple concepts indicating a gradual alignment over time between the ideas of a smart city and a sustainable city. Intelligent cities are considered an evolved concept of urban development, as they combine artificial intelligence and machine learning to form systems that can learn, adapt, and make decisions. A systematic literature review methodology is utilised to define the theoretical scope and to answer the research question. The analysis targeted comprehensive literature covering published topics on intelligent cities over the past twenty years, employing a reproducible and straightforward method to reduce bias by providing verifiable data processing details. The methodology includes identifying studies, explaining the selection process, conducting analysis and synthesis, and deriving conclusions. Eighty-six "intelligent city" papers were analysed by theme, methodology, and results. The literature on intelligent cities covers various topics, such as urban mobility, infrastructure development, risk management, AI integration, sustainability, ecosystems, community involvement, challenges, technological innovations, and inclusive governmental changes.

Keywords: intelligent city, intelligent technology, smart cities, ICT, infrastructure innovations, systematic literature review, knowledge-based decision, AI and intelligent city ecosystems

1. Introduction

The idea of linking everyday items through existing networks gained popularity with the advancement of intelligent machines and their current progress (Silva et al., 2018). The evolution of the smart city focuses on the information infrastructure that fosters economic transformation and social control (Li & Cao, 2020). Technological advancements have influenced the development of urban areas, giving rise to two significant visions: smart cities

and intelligent cities. Although both aim to use technology to enhance quality of life, their practices and levels of technological integration differ.

The term "smart city" can be defined as an urban setting that utilises information and communication technology (ICT) and other technologies to improve the efficiency of traditional city functions and the quality of services for urban residents (Gubbi et al., 2013; Neirotti et al., 2014). One common definition describes a smart city as the integration of physical, social, industrial, and ICT infrastructure to enhance the city's intelligence. Another definition describes a smart city as an advanced urban area that employs ICT and various technologies to improve the quality of life for residents while ensuring the availability of resources for future generations across social, economic, and environmental dimensions (Neirotti et al., 2014; Silva et al., 2018; Singh & Manoharan, 2024). Smart cities are shaped by digital technologies and the Internet of Things (IoT) (Gubbi et al., 2013), which are used to collect large amounts of data, optimise resource utilisation, apply cloud computing, and improve the effectiveness of municipal services (Li & Cao, 2020). Smart cities analyse data using sensors, artificial neural systems, and interconnected devices to control various aspects of city infrastructure (Manoharan et al., 2023). The infrastructure managed includes traffic, energy consumption, and public amenities (Das et al., 2019). The main goal of smart cities is to enhance operational efficiency and deliver high-quality services to residents (Ibănescu et al., 2022).

Many studies differentiate between digital, smart, and intelligent cities, although they are all approaches to addressing the challenges caused by urbanisation (Çinar Umdu & Alakavuk, 2020a). They are based on the use of technology. The meanings of these terms are often unclear, and their distinctions are not well defined (Çinar Umdu & Alakavuk, 2020a). The EU defines smart cities as areas where ICT enhances traditional networks (European Commission, 2020). An urban area enhanced by ICT is commonly referred to as a smart city. Smart cities are often distinguished from intelligent cities. An intelligent city is one equipped with information technology. The primary objective of a smart city is sustainability (Manoharan et al., 2023).

Lately, numerous studies have aimed to achieve a more practical understanding of intelligent cities through their defining features. These analyses have increasingly emphasised the multidisciplinary nature of various fields. However, the vision of an intelligent city remains ambiguous, with multiple concepts indicating a gradual alignment over time between the ideas of a smart and a sustainable city (Azevedo Guedes et al., 2018). Intelligent cities are considered an evolved concept of urban development because they combine artificial intelligence and machine learning (Das et al., 2019) to form systems that can learn, adapt, and make decisions. While smart cities depend on real-time data processing (Azevedo Guedes et al., 2018), intelligent cities use AI to analyse comprehensive data (Çinar Umdu & Alakavuk, 2020a), understand patterns, and make decisions (Singh & Manoharan, 2024). As a result, intelligent cities can maintain their infrastructure, such as AI-controlled transportation systems that can predict and adapt to upcoming traffic patterns, and provide customised public services to meet each resident's needs, opening up a world of possibilities (Ali & Panchal, 2020).

The distinctions between smart and intelligent cities depend on the level of technology adopted to support decision-making processes (Çinar Umdu & Alakavuk, 2020a). Smart cities' responses are based on data inputs and programmed algorithms (Das et al., 2019). In contrast, intelligent cities have the flexibility to change continuously and actively, utilising the outcomes of data processing to address residents' evolving needs (Singh & Manoharan, 2024).

This systematic review explores the existing literature on intelligent cities in urban planning studies and infrastructure engineering to provide an overview of the current topics discussed. It also aims to classify the major themes explored in previous studies on intelligent cities and to analyse and evaluate the methodologies used to reach conclusions, such as qualitative, quantitative, case studies, and empirical data analysis. This study highlights the technological advances employed to realise the concept of intelligent cities, as well as their social and economic impacts on people. It aims to identify gaps in the existing research to guide future studies.

2. Methods

A systematic literature review methodology is employed to establish the theoretical scope and to answer the research question. The analysis targeted comprehensive literature covering published topics on intelligent cities over the past twenty years, utilising a reproducible and straightforward method to reduce bias by providing verifiable data processing details. The methodology consists of the following steps: identifying studies, explaining the selection process, conducting analysis and synthesis, and deriving outcomes. The steps for applying the study methodology are as follows:

1. **Finding studie**s: Appropriate studies were sourced from academic databases such as ScienceDirect, Google Scholar, JSTOR, and the Web of Science. The authors used search strings to explore and identify how the term "intelligent city" was used. One keyword, "intelligent city," was defined as a combined term to filter results. This keyword was converted into search strings by conducting abstract and title searches of books, chapters, journal articles, and conference proceedings.
2. **Studies selection explanation**: The initial search on ScienceDirect produced 80,104 articles in various languages. From 2004 to 2024, 62,051 articles were published over the last twenty years. After excluding various article types unrelated to urban planning – including 4,585 review articles, 46,090 research articles, and 5,042 book chapters – the overall count was reduced to 55,717 articles. The next step involved filtering out unrelated journals and topics, resulting in 1,598 articles. Finally, articles that did not feature "intelligent city" as a combined term were excluded, producing 108 results, of which 86 were relevant to our topic.
3. **Analysis and synthesis**: The software VOSviewer was employed to conduct a keyword co-occurrence analysis, as shown in Fig. 1. The list of references was downloaded and provided to VOSviewer to create the bibliometric map. The resulting network and identified themes offer a general understanding of the topics discussed in relation to the intelligent city.

3. Results

3.1. Descriptive analysis

The keywords from the articles were clustered using VOSviewer descriptive analysis, as shown in Tab. 1. This analysis provides a general overview of the topics discussed in these papers, as illustrated in Fig. 2.

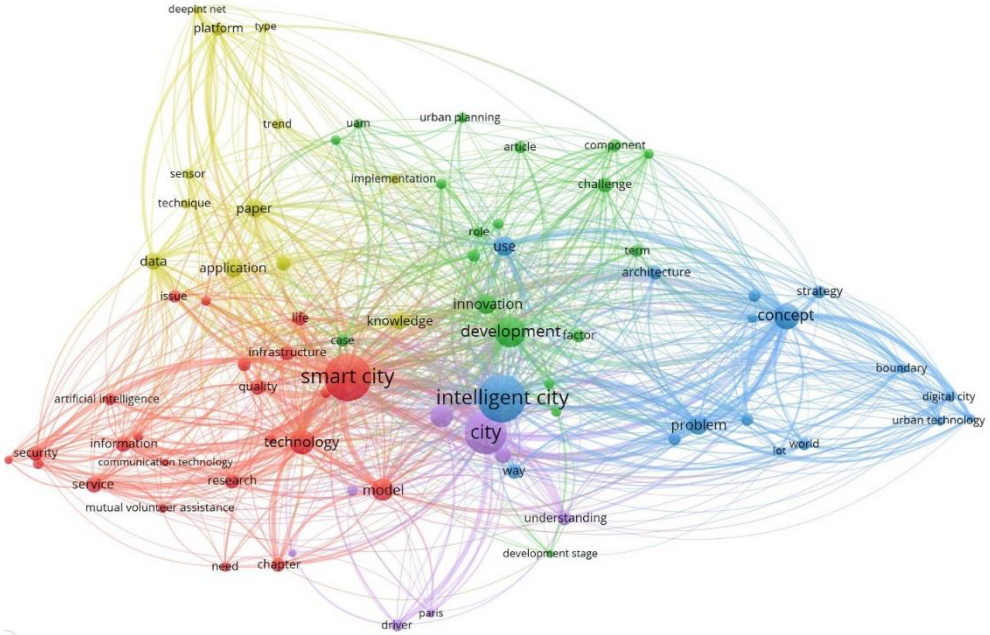

Fig. 1. Analysis of 1598 articles using VOSviewer

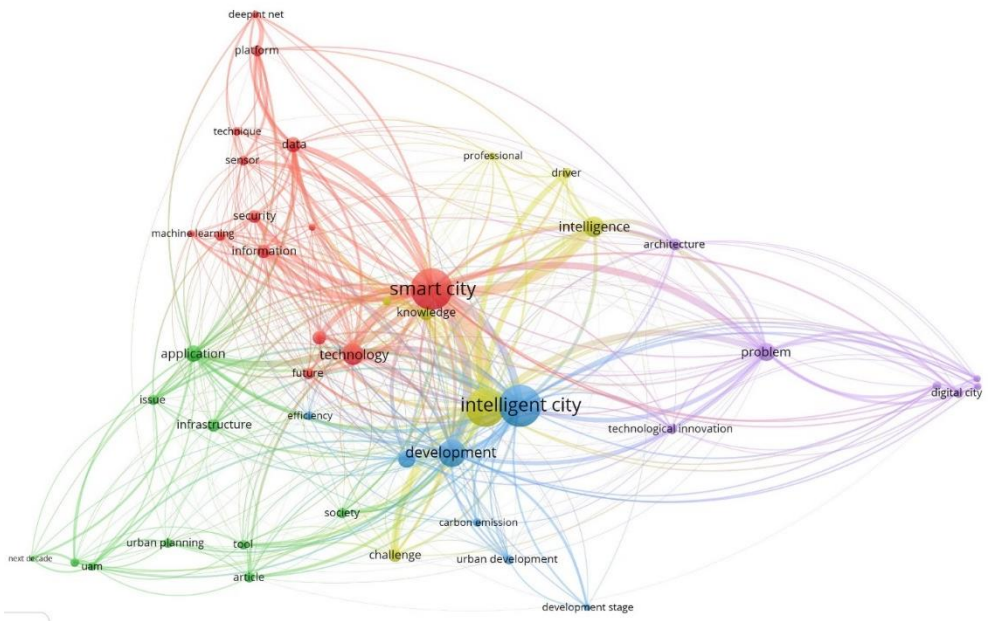

Fig. 2. Analysis of 106 articles using VOSviewer

Table 1. The general keyword clusters resulting from the analysis comprise five clusters.

Clusters	Items in each cluster
Cluster 1 Intelligent city	Intelligent city, carbon emission, development, development stage, efficiency, innovation, urban development
Cluster 2 Smart city	Smart city, artificial intelligence, communication technology, data, deep internet, future, information, machine learning, platform, quality, security, sensor, technique, technology application
Cluster 3 Digital city	Digital city, architecture, modern world, problem, similarity, technological innovation, urban technology
Cluster 4 Infrastructure	Infrastructure, issue, next decade, society, tool, UAM, urban air mobility, urban planning
Cluster 5 Challenges	Challenge, city, driver, intelligence, knowledge, need, professional

Table 1 presents the keywords in each cluster, providing a brief overview of the focus areas in previous studies by categorising the main topics in the articles and offering a general understanding of the intelligent cities theme.

3.2. Themes analysis

The literature on intelligent cities covers various topics, such as urban mobility, infrastructure development, risk management, artificial intelligence (AI) integration, sustainability, ecosystems, community involvement, challenges, technological innovations, and inclusive governmental changes. The following section discusses and analyses these studies based on their themes and methodologies. Figure 3 illustrates the thematic analysis of previous studies.

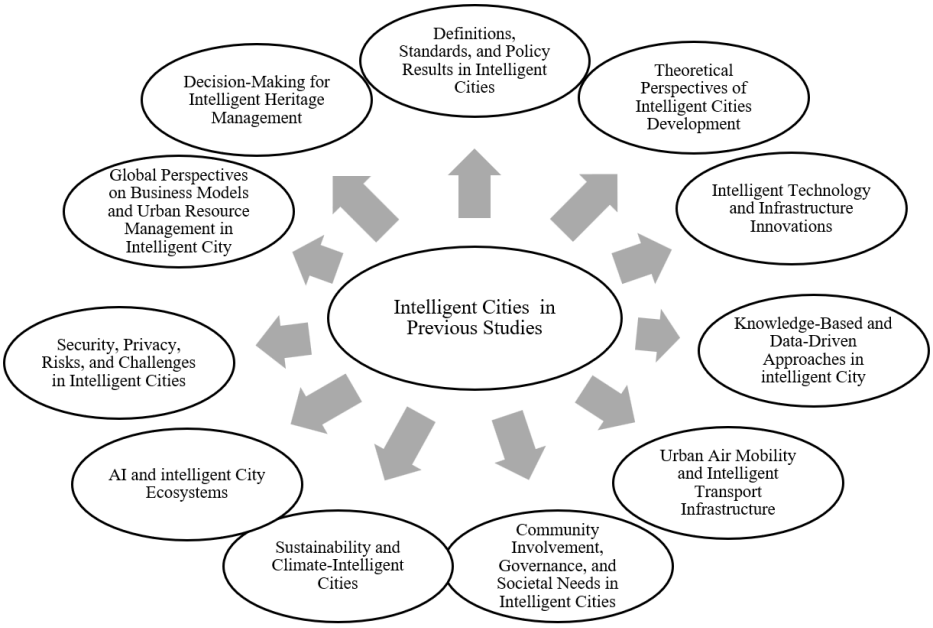

Fig. 3. The analysis of the themes in previous studies

1. Definitions, standards, and policy results in intelligent cities

Many studies have discussed the definitions and standards of intelligent cities, as well as the differences between intelligent and smart cities (Angelidou, 2015). Several works highlight the importance of having a clear definition of intelligent cities due to the overlap of terms such as digital and smart cities (Komninos, 2015). Many studies focus on the critical factors of smart cities that influence the development of intelligent cities and examine metrics for urban intelligence to understand their features and performance (Ghaffarianhoseini et al., 2018). Moreover, the evolving research domain of smart cities has been mapped (Albino et al., 2015; Ojo et al., 2016). Another study explores the legal and regulatory challenges involved in transitioning from smart to intelligent cities, in order to manage the risks associated with technological innovations (Boban & Weber, 2018; Orzeł, 2017) (Embarak, 2022). The classification of cities – such as intelligent, sustainable, green, digital, and smart cities – was also a significant topic in previous research (Oakley & Townsend, 2014).

2. Theoretical perspectives of intelligent cities development

The development stages and concepts highlight the importance of interdisciplinary collaboration in building sustainable and intelligent cities (Yigitcanlar et al., 2019). The transition from digital cities to intelligent cities involves the use of Information and Communication Technologies (ICTs) (Çinar Umdu & Alakavuk, 2020b), the introduction of Intelligent Plans (IP), and the continuous evaluation of urban systems to promote learning, innovation, and competitiveness in managing urban challenges (Batista Silva et al., 2012; Embarak, 2022; Neves, 2009). Furthermore, case studies have explored the evolution of digital cities into intelligent urban developments, such as in Portugal (Neves, 2009). Many studies have also developed theoretical frameworks to address the complex nature of intelligence in intelligent cities (Kropp et al., 2021; Liugailaitė-Radzvickienė & Jucevičius, 2014).

Several studies emphasise the shift towards next-generation intelligent cities, focusing on people and the integration of advanced technologies (Watson et al., 2014). They analyse case studies of cities such as London, Amsterdam, Vienna, and Stockholm, underlining the importance of collaboration between citizens and stakeholders in shaping the intelligent city of the future (Pramanik et al., 2023; Varadharajan and Rian Leevinson, 2021).

3. Intelligent technology and infrastructure innovations

Several studies have examined the role of intelligent technology in urban development, proposing the integration of intelligent systems and digital networks, such as the City Car prototype, to enhance urban life (Deakin and Al Waer, 2011; Mitchell, 2007). The exploration of spatial intelligence in cities like Bletchley Park, Cyberport Hong Kong, and Amsterdam demonstrates how intelligence can improve urban efficiency and governance (Komninos, 2011). A book on intelligent cities discusses spatial intelligence, top-down and bottom-up planning approaches, and intelligent city strategies, using examples from urban areas such as Amsterdam, Manchester, and Helsinki (Komninos, 2015). The importance of collaboration between technological experts and stakeholders is emphasised to bridge gaps in the implementation, design, security, resilience, and sustainable development of intelligent cities (Bhagat et al., 2014; Metwally & Ibrahim, 2022, Kar et al., 2021). Technological innovations aimed at improving pedestrian experiences in urban environments were also discussed, such as the use of live data to adjust paths and pedestrian crossings (Oakley & Townsend, 2014). Another study proposed the use of sensors to stabilise shorelines in intelligent coastal cities, using the case of Sidi Abdel Rahman Bay in Egypt as an example (Zaki et al., 2023).

4. Knowledge-based and data-driven approaches in intelligent city

Emerging technologies enhance urban infrastructure and civil management through knowledge-based decision-making (Santinha & Anselmo de Castro, 2010). Big data management is also applied in decision-making processes within intelligent cities; for example, Geographic Information Systems (GIS) and geostatistical techniques are used to process geotechnical data for urban planning and civil protection in Thessaloniki (Kokkala & Marinos, 2022). Intelligent and Knowledge City Programmes (ICPs and KCPs) promote sustainable urban development and are regarded as cost-effective strategies that contribute to optimising urban metabolism and enhancing innovation (Salvati et al., 2013). Some studies propose comprehensive "knowledge systems" to define, extract, apply, and share knowledge among urban professionals, aiming to prevent isolated knowledge silos and support more intelligent and sustainable urban environments (Zheng, 2023).

5. Urban air mobility and intelligent transport infrastructure

Studies have highlighted the importance of intelligent transport systems (ITS) in intelligent cities to address mobility challenges and congestion by integrating technologies such as communication models and wireless sensor networks (WSNs) to enhance automation and safety (Dinc & Sahingoz, 2019; Jawad & Nitulescu, 2023; Pawłowska, 2018).

One study emphasises the need to align Urban Air Mobility (UAM) infrastructure with urban planning principles and property legislation in intelligent cities (Perperidou & Kirgiafinis, 2023). It also discusses the significance of vertiports, maintenance facilities, energy supply systems, and regulatory frameworks to support UAM (Mavraj et al., 2022). The Horizon UAM project explores the potential of UAM by assessing its technical feasibility and social acceptance (Di Vito et al., n.d.; Wołek & Hebel, 2019). Another study conducted in Lisbon investigates UAM within a living lab setting to enhance quality of life (Gouveia et al., 2023).

6. Community involvement, governance, and societal needs in intelligent cities

Communities of Practice (CoPs) and technological determinism are not merely buzzwords – they serve as catalysts for change (Carta, 2014). They contribute to enhancing online service delivery and urban regeneration through knowledge-sharing and capacity-building (Deakin, 2012, Shao et al., 2020). Technological determinism in intelligent cities highlights a broader understanding of urban development drivers, including the role of institutional leadership (Santinha & Anselmo de Castro, 2010). The Intelligent Cities project integrates e-governance and e-urban planning to improve urban management through a city-wide intelligent information system (Curwell et al., 2004). One study analyses intelligent city initiatives with a focus on addressing human needs—such as opportunity and justice—warning against the risks of rigid operating systems and emphasising the need for proactive strategies to mitigate potential harms (Catlett et al., 2023). Perhaps the most promising aspect is the potential to enhance quality of life through the use of information and communication technology (ICT) (Romanelli & Romanelli, 2023). Sensor-based systems and automation can support this goal, provided overhyped claims are avoided. A balanced approach should prioritise transparency and accountability to ensure tangible benefits for residents and communities (Routray et al., 2019). Integrating knowledge networks and advanced communication infrastructure can also enhance cognitive capabilities (Komninos, 2006). For example, the development of intelligent cities in Portugal – such as in Almada, Oeiras, Aveiro, and the Peninsula de Setúbal – illustrates how telecommunications and digital technologies have been integrated into municipal subsystems to improve urban management and support e-governance (Da Graça et al., 2005).

7. Sustainability and climate-intelligent cities

Intelligent cities can leverage digital solutions to achieve sustainability goals (Weinstock & Gharleghi, 2013). One study introduces the concept of Climate-Intelligent Cities as a means to reach zero-emission targets (Pee & Pan, 2022). Another suggests enhancing urban sustainability and quality of life by combining principles of intelligent and slow cities, with case studies from Spain and South Korea (Tocci, 2017). A further study presents a conceptual framework for intelligent city development that integrates ecological, technological, and social dimensions to create sustainable communities (Abdoullaev, 2011). One study identifies models, frameworks, and tools that examine the connection between intelligent city concepts and environmental sustainability (Trindade et al., 2017). In China, another study investigates carbon emission reduction through mechanisms such as intelligent industry and government policy interventions (Liu & Zhang, 2023). The definition of low-energy buildings is also discussed, focusing on aligning Nearly Zero Energy Buildings (NZEB) with societal needs and innovative grid development to advance intelligent urban sustainability (Avgeris & Groumpos, 2018).

8. AI and intelligent city ecosystems

Integrating artificial intelligence (AI) into urban systems is essential in intelligent cities, particularly for mitigating risks such as natural disasters (Yigitcanlar et al., 2020). The intelligence architectures within intelligent city ecosystems include agglomeration, orchestration, empowerment, and contrivance (Komninos, 2018, Mitchell et al., 2021). AI has been applied in managing neural networks and LED traffic light systems, such as in Bogotá (Gonzalez et al., 2020). Deepint.net, an AI-driven platform, supports intelligent city management by enabling comprehensive data analysis and real-time decision-making (Corchado et al., 2022). AI also enhances information and communication technologies (ICTs) in intelligent cities, thereby supporting urban development (Voda & Radu, 2018) (Komninos, 2016). Furthermore, intelligent cities are viewed as dynamic ecosystems that utilise IoT and AI technologies to promote growth, efficiency, and competitiveness (Yovanof & Hazapis, 2009, de Jong et al., 2015). In the Greek context, the strategic use of ICTs in intelligent cities plays a crucial role in fostering knowledge diffusion, decision-making, cooperation, and intelligence gathering, all of which contribute to community development (Stratigea, 2012).

9. Security, privacy, risks, and challenges in intelligent cities

Security and privacy considerations play a significant role in shaping intelligent cities (Komakech, 2005, Watson et al., 2014). Political, technological, and socioeconomic challenges are also critical factors in the design and management of intelligent urban environments (Mohammed, 2020). Machine learning and artificial intelligence (AI) can be utilised to optimise resource usage and deliver intelligent services, while simultaneously addressing security and privacy risks (Ahmed et al., 2021). The challenges of establishing smart and intelligent cities in African countries highlight the need for decentralisation, particularly through the development of secondary cities (Mandaza-Tsoriyo et al., 2022).

10. Global perspectives on business models and urban resource management in intelligent city

Adapting business models to guide the evolution of intelligent cities is essential for supporting policymakers, as demonstrated in the case of Paris' smart city initiative (Khelladi et al., 2020, Komninos, 2009). Modern technologies can be employed to manage urban resources and encourage sustainable design patterns (Armyanova, 2021). The development of intelligent cities in China, the United States, and Europe has introduced a new approach

to categorising global intelligent cities based on their stages of growth and development (Wu, 2018b, 2018a). Efforts to create intelligent living environments and realise smart city ambitions play an influential role in making urban areas more dynamic and responsive (Bhagat et al., 2014; Jopek, 2019).

11. Decision-making for intelligent heritage management

An approach that integrates sustainable development principles has been introduced to manage the complex decision-making tasks related to heritage buildings in intelligent cities. This approach facilitates effective decision-making and provides recommendations for heritage preservation (Tripathy et al., 2022).

3.3. Methodologies analysis

Previous studies that analysed and explored various aspects of intelligent cities employed diverse methodologies. Table 2 presents an overview of these methodological approaches:

Table 2. Methodologies used in previous studies

Methods	The description	Studies
Data collection and analysis methods	Used to study various aspects of intelligent cities, such as quality of life, urban air mobility (UAM) solutions, and infrastructure. This approach relies on real-world data collection and its analysis to generate insights that support understanding of urban transformation.	Deakin, 2012; Gouveia et al., 2023; Kokkala & Marinos, 2022; Komninos, 2011; Mavraj et al., 2022; Pee & Pan, 2022; Wołek & Hebel, 2019
Analytical approaches	Applied in many studies to develop theoretical frameworks through analytical methods and literature reviews. These approaches explore diverse aspects of intelligent cities, such as intelligent city ecosystems and historical contexts, offering insights into complex urban phenomena.	Di Vito et al., n.d.; Komninos, 2009; Perperidou & Kirgiafinis, 2023; Yigitcanlar et al., 2020; Albino et al., 2015; Batista Silva et al., 2012; Jopek, 2019; Komninos, 2018; Liugailaitė-Radzvickienė & Jucevičius, 2014; Mohammed, 2020; Ojo et al., 2016; Salvati et al., 2013; Voda & Radu, 2018
Qualitative approach via systematic literature reviews (SLR)	Aims to synthesise previous research on a wide range of themes, including intelligent city strategies, knowledge-based approaches in urban development, sustainability, knowledge management, legal and regulatory frameworks, environmental concerns, intelligent city concepts, social needs, and urban challenges. This method helps to identify research gaps in the field of intelligent cities.	Batista Silva et al., 2012; Carta, 2014; Catlett et al., 2023; Çinar Umdu & Alakavuk, 2020b; Corchado et al., 2022; Deakin & Al Waer, 2011; Komakech, 2005; Komninos, 2015, 2016; Liugailaitė-Radzvickienė & Jucevičius, 2014; Mandaza-Tsoriyo et al., 2022; Mavraj et al., 2022; Ojo et al., 2016; Salvati et al., 2013; Santinha & Anselmo de Castro, 2010; Trindade et al., 2017; Weinstock & Gharleghi, 2013; Yovanof & Hazapis, 2009

Methods	The description	Studies
Case study analyses	Case studies include diverse examples such as Lisbon's living lab for UAM, the City Car prototype, and projects like Deepint.net. These studies provide practical insights and lessons learned from real-world applications.	Abdoullaev, 2011; Bhagat et al., 2014; Boban & Weber, 2018; Curwell et al., 2004; Dinc & Sahingoz, 2019; Ghaffarianhoseini et al., 2018; Gonzalez et al., 2020; Jawad & Nitulescu, 2023; Komninos, 2011, 2016; Metwally & Ibrahim, 2022; Mitchell, 2007; Neves, 2009; Orzeł, 2017; Pawłowska, 2018; Pramanik et al., 2023; Routray et al., 2019; Stratigea, 2012; Tocci, 2017; Tripathy et al., 2022; Varadharajan & Rian Leevinson, 2021; Watson et al., 2014; Yovanof & Hazapis, 2009
Quantitative and mixed-methods approach	Combines qualitative and quantitative techniques. These studies employ remote sensing, numerical simulations, quasi-natural experiments, and statistical analyses to evaluate aspects such as pedestrian infrastructure, shoreline stabilisation, and the impact of policies on carbon emissions. This approach offers a comprehensive understanding of intelligent city dynamics.	de Jong et al., 2015; Liu & Zhang, 2023; Oakley & Townsend, 2014; Zaki et al., 2023

3.4. Conclusions analysis

By analysing the findings of previous studies, we can identify the main areas of interest in the field of intelligent cities, highlighting the essential elements required for their effective development and implementation. Eight key areas of interest emerge from the literature:

1. **Intelligent cities infrastructure and urban air mobility**:

Several studies propose frameworks for integrating Urban Air Mobility (UAM) into urban environments by involving citizens and stakeholders, aiming to improve quality of life and address climate change (Perperidou & Kirgiafinis, 2023; Wołek & Hebel, 2019), such as in the Horizon UAM project (Di Vito et al., n.d.). These studies also explore automated maintenance and urban planning strategies (Mavraj et al., 2022). AI-based methods, including neural networks and LED traffic systems, are employed to manage traffic flow and reduce congestion (Gonzalez et al., 2020).

2. **Intelligent city technologies:**

The transformation of urban environments into intelligent cities relies heavily on the adoption of advanced technologies, such as predictive systems for vehicles and buildings (Mitchell, 2007), and the integration of AI in city planning (Yigitcanlar et al., 2020). Key aspects of intelligent cities include structure, function, planning, strategy development, and community engagement (Komninos, 2009, 2015). Advanced ICT is seen as a driver that transforms urban planning into a more dynamic and responsive process (Batista Silva et al., 2012). In Portugal, intelligent cities have promoted both urban and regional intelligence

(Neves, 2009). Intelligent cyber platforms, such as Deepint.net, support enhanced urban management and decision-making (Corchado et al., 2022).

3. Community and stakeholder collaboration:

Numerous studies highlight the importance of incorporating social, environmental, and cultural dimensions in intelligent city development (Deakin & Al Waer, 2011; Komninos, 2011; Santinha & Anselmo de Castro, 2010). A dynamic urban environment should integrate principles from both intelligent and slow cities (Tocci, 2017). Communities of Practice (CoPs) accelerate the transformation towards intelligent urban development (Deakin, 2012). People-centred approaches are essential, involving the adoption of technology to address urban challenges while placing human needs at the forefront (Pramanik et al., 2023; Shao et al., 2020; Varadharajan & Rian Leevinson, 2021).

4. Sustainable development in intelligent cities:

Developing intelligent cities requires holistic approaches that incorporate digital, ecological, and social dimensions (Abdoullaev, 2011). In African contexts, this includes prioritising decentralisation, public–private partnerships, and citizen engagement (Mandaza-Tsoriyo et al., 2022). Knowledge-based strategies are also identified as means to improve city efficiency (Komakech, 2005). Integrating human needs into intelligent city solutions underlines the importance of democratic governance (Catlett et al., 2023). Linking environmental sustainability with intelligent city concepts supports the goal of sustainable urban development (Trindade et al., 2017), along with the application of Integrated Community Plans (ICPs) and Knowledge City Plans (KCPs) (Jopek, 2019; Salvati et al., 2013).

5. Intelligent cities urban planning and policy:

Effective intelligent city development must address legal challenges, particularly those associated with technological innovation and its risks (Albino et al., 2015; Boban & Weber, 2018; Çinar Umdu & Alakavuk, 2020b; Ghaffarianhoseini et al., 2018; Orzeł, 2017). Developmental stages in intelligent cities influence urban planning and policy decision-making (Wu, 2018b, 2018a), including considerations around Fourth Industrial Revolution technologies (Embarak, 2022). The literature also highlights the importance of adaptable business models (Khelladi et al., 2020), stakeholder collaboration (de Jong et al., 2015; Yovanof & Hazapis, 2009), holistic strategic planning (Angelidou, 2015), and effective policy mechanisms (Liu & Zhang, 2023).

6. Knowledge sharing in intelligent cities:

Evaluating traditional concepts is essential for fostering innovation within intelligent cities (Komninos, 2016). Interdisciplinary collaboration supports the development of resilient and intelligent cities (Kar et al., 2021) and encourages the adoption of innovations such as knowledge networks, communication infrastructure, and enhanced innovation capacity (Komninos, 2006, Zheng, 2023). Digital solutions in urban planning also contribute to the creation of Climate-Intelligent Cities (Pee & Pan, 2022), while AI plays a crucial role in improving urban living standards (Voda & Radu, 2018).

7. Urban resource management in intelligent city:

Intelligent cities offer significant potential for improving urban resource management (Armyanova, 2021). The establishment of multisource datasets supports data-driven decision-making processes (Kokkala & Marinos, 2022; Komninos, 2018). Effective management of safety, security, and resilience in complex urban infrastructure systems is critical (Ahmed et al., 2021; Avgeris & Groumpos, 2018; Watson et al., 2014; Zaki et al.,

2023). An ecosystem-based approach to intelligent city development emphasises the importance of systemic resilience (Mitchell et al., 2021).

8. Quality of life and urban experience in intelligent cities:

Urban mobility is a key indicator of quality of life in intelligent cities (Wołek & Hebel, 2019). Collaboration between technology experts and stakeholders enhances both the quality of life and the pursuit of sustainable development in intelligent urban areas (Metwally & Ibrahim, 2022). The shift toward intelligent cities contributes to greater growth, efficiency, and competitiveness (Yovanof & Hazapis, 2009), as well as improvements in pedestrian experiences and innovative infrastructure solutions (Mitchell, 2007; Oakley & Townsend, 2014).

4. Discussion

After analysing previous studies based on themes and results, several research gaps can be identified:

1. Combining urban planning strategies with intelligent technologies in previous studies by focusing on practical guidelines – rather than relying solely on theoretical frameworks and concepts – would provide actionable insights for urban planners to effectively utilise intelligent technologies within existing urban infrastructure. Additionally, while case study approaches have been valuable, they are often limited to specific contexts. There is a need to implement more comprehensive approaches that can address a wider range of urban settings and conditions.
2. While many studies address community involvement, they often fail to explore the specific roles of communities in the planning and decision-making processes. To ensure transparency and accountability, governance standards must also be thoroughly examined and clearly defined.
3. Numerous studies treat environmental sustainability separately from economic and social sustainability, despite these being the three core dimensions of intelligent city planning. Additionally, while much attention has been given to mitigation strategies in developing cities, there is a need for further research on how intelligent cities can adapt to the impacts of climate change.
4. Urban planners are increasingly seeking data security frameworks to apply in their work, yet existing studies often emphasise data-driven approaches while overlooking data privacy and protection. There is a need to develop methodologies that integrate secure data analysis directly into the urban planning process.
5. Research on Urban Air Mobility (UAM) has largely focused on its technological components, with limited attention to how UAM infrastructure can be practically integrated into urban planning. Urban planners would benefit from studies that examine how UAM can be embedded into the design and function of city landscapes.
6. Previous research typically concentrates on individual disciplines – such as urban planning, technology, or social studies. However, interdisciplinary studies are crucial to developing a comprehensive framework that supports urban planners in the holistic implementation of intelligent city strategies.
7. Existing studies often overlook the need for both short- and long-term economic planning in the deployment of intelligent city technologies. There is a clear need to develop business models that address the financial requirements for the expansion, implementation, and ongoing maintenance of intelligent cities.

Reviewing the methodologies used in previous studies reveals several gaps. Many studies rely exclusively on either qualitative or quantitative approaches, with limited use of mixed-methods research, which could offer more comprehensive insights and add greater value to the literature on intelligent cities. There is also a notable lack of longitudinal studies examining the development and long-term impact of intelligent cities; instead, most research is cross-sectional, which limits understanding of changes over time. Case study methodologies often focus on individual cities, making them less applicable to broader contexts. Urban planners would benefit from more generalised studies that analyse multiple cities to extract transferable insights. Additionally, there is a methodological gap in studies that conduct detailed stakeholder analysis to better understand the roles and interests of different actors and their influence on the planning process. Finally, current methodologies often overlook the practical challenges of implementing technology in intelligent cities – particularly issues such as citizen acceptance and engagement – which are crucial for successful integration.

5. Conclusions

Numerous studies have aimed to gain a better understanding of intelligent cities by examining their defining features. These analyses increasingly emphasise the multidisciplinary nature of the field. Many studies distinguish between digital, smart, and intelligent cities, viewing them as distinct concepts and approaches for addressing the challenges posed by urbanisation. The primary distinction between smart and intelligent cities lies in the level of technology adopted to support decision-making processes. Intelligent cities are characterised by their adaptability and flexibility, continuously evolving through data-driven insights to meet the changing needs of urban residents. Previous research confirms that technological advancements have significantly influenced urban development, contributing to the emergence of intelligent cities. The methodologies employed in these studies are varied and include data collection and analysis methods, analytical approaches, qualitative approaches through systematic literature reviews (SLRs), case study analyses, and quantitative and mixed-methods approaches. The key themes explored in the literature on intelligent cities include: Definitions, Standards, and Policy Results in Intelligent Cities; Theoretical Perspectives of Intelligent Cities Development; Intelligent Technology and Infrastructure Innovations; Knowledge-Based and Data-Driven Approaches in Intelligent Cities; Urban Air Mobility and Intelligent Transport Infrastructure; Community Involvement, Governance, and Societal Needs in Intelligent Cities; Sustainability and Climate-Intelligent Cities; AI and Intelligent City Ecosystems; Security, Privacy, Risks, and Challenges in Intelligent Cities; Global Perspectives on Business Models and Urban Resource Management in Intelligent Cities; and Decision-Making for Intelligent Heritage Management.

By analysing the findings of previous studies, we can identify the critical areas of interest in the study of intelligent cities, highlighting the essential components for their successful growth and implementation. Eight core areas of interest have been defined: Intelligent Cities' Infrastructure and Urban Air Mobility; Intelligent City Technologies; Community and Stakeholder Collaboration; Sustainable Development in Intelligent Cities; Intelligent Cities' Urban Planning and Policy; Knowledge Sharing in Intelligent Cities; Urban Resource Management in Intelligent Cities; and Quality of Life and Urban Experience in Intelligent Cities.

6. Recommendation

Future studies on intelligent cities should focus on the following areas: developing a comprehensive framework for researchers and practitioners that encompasses the various dimensions of intelligent cities, including infrastructure, technology, community engagement, sustainability, urban planning, knowledge sharing, resource management, and quality of life. There is also a need to implement multidisciplinary approaches to address the complex challenges faced by intelligent cities and to work towards standardising mechanisms for knowledge sharing and capacity building among stakeholders involved in intelligent city development.

Abbreviations

IoT	Internet of Things
IP	Intelligent Plans
UAM	Urban Air Mobility
KCPs	Knowledge City Plans
ICPs	Integrating Community Plans
SLR	Systematic Literature Reviews
EU	European Union
AI	Artificial intelligence
ICPs	Intelligent City Programs
WSNs	Wireless Sensor Networks
ITS	Intelligent Transport Systems
CoPs	Communities Of Practice
NZEB	Zero Energy Buildings
ICTs	Information and Communication Technologies

Funding

No funding source available.

Data availability

The Data can be shared upon request.

Declaration of competing interest

The authors have declared no conflict of interests.

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