IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p-ISSN: 2278-8727, Volume 27, Issue 3, Ser. 5 (May. – June. 2025), PP 37-44
www.iosrjournals.org

The integration of artificial intelligence in smart cities: Opportunities, Challenges and Prospects

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Abstract:
In response to the growing challenges of urbanization, cities are increasingly adopting the Smart City model by integrating artificial intelligence (AI) to optimize urban services. This study explores the role of AI in key areas such as mobility, energy, healthcare, and waste management, while analyzing the governance challenges it entails, particularly in the Moroccan context.
The research adopts a comparative qualitative approach, based on the analysis of ten peer- reviewed scientific articles published between 2020 and 2025, covering both Moroccan (Casablanca, Tangier, Salé...) and international cities (Seoul, London, Chicago...). The analysis is structured around a thematic grid and categorized by strategic sectors.
Findings show that AI enhances the efficiency of public services and promotes more transparent governance. However, its implementation poses ethical, technical, and social concerns, particularly regarding data protection and the digital divide. The study concludes that an inclusive and ethical governance framework is essential to fully leverage AI for sustainable and equitable urban transformation.

Keywords: *artificial intelligence, smart cities, urban governance, digital transformation, Morocco.*

Date of Submission: 25-06-2025 Date of Acceptance: 05-07-2025

I. Introduction

In a context of growing and rapid urbanisation, cities are facing major challenges. These include managing ageing infrastructure, optimising public services and guaranteeing a high quality of life for increasingly large and concentrated populations. To overcome the challenges posed by these c o m p l e x issues, the concept of the 'Smart City' has emerged as a major strategic response, based on the integration of information and communication technologies (ICT) and the optimal use of data (Batty et al., 2012).

Artificial intelligence (AI) is at the heart of this transformation. The analytical, predictive and automation capabilities of AI have the potential to revolutionise urban management. This revolution will pave the way for smoother transport systems, optimised energy consumption and more responsive emergency services (Allam & Dhunny, 2019).

In emerging countries such as Morocco, the ambition to transform cities into "smart cities" has become a strategic priority.

The aim is to make these cities more competitive and improve living conditions for their residents. As part of the modernisation of their infrastructure and services, several cities, including Casablanca, Tangiers and Salé, have embarked on a digitisation process. For those involved in regional development and the digital transition, understanding the dynamics of integrating artificial intelligence (AI) is of vital importance. This approach influences the effectiveness of urban public policies and the ability to create more inclusive, connected and attractive areas. Indeed, it acts on two main axes: communication with citizens and the management of local ecosystems (Benali & Charkaoui, 2021).

Nevertheless, it is worth highlighting the undeniable potential of artificial intelligence (AI) to optimise urban services. This can include traffic management, predictive infrastructure maintenance and more efficient waste management (Zhang et al., 2021). Research in the literature and practical experience reveal that its integration raises complex issues and significant challenges for territorial governance. In the contemporary context, the ethical challenges related to privacy and the use of data, the persistence of a digital divide that can exacerbate inequalities in access to intelligent services, and the need to put in place appropriate regulatory and governance frameworks, represent major obstacles to be overcome (Cugurullo, 2020).

Decisions relating to artificial intelligence (AI) in cities cannot be purely technical; they require in-depth reflection on their social impact, acceptability and compliance with democratic values. These challenges highlight the urgent need to understand the mechanisms by which urban cities can deal with this complexity, in order to ensure the optimal integration of artificial intelligence.

As part of this research, we focused on the fundamental tension between, on the one hand, the opportunities offered by artificial intelligence (AI) and, on the other, the challenges inherent in its governance. This focus is relevant and justified, as the results of our study show. We have been challenged by the imperative to transcend a technological approach to the smart city to embrace the human, ethical and political issues inherent in the integration of artificial intelligence, particularly in contexts where infrastructures and regulations are in a development or transformation phase. The aim of this study is to provide concrete answers to assist stakeholders in using AI in a responsible and sustainable manner, ensuring that innovation effectively serves the general interest.

With this in mind, the article in question seeks to answer the following question: To what extent does the integration of artificial intelligence into the management of smart cities make it possible to improve urban services, while posing new challenges for territorial governance?

In order to achieve this objective, this study aims to:

- Define and analyse the main contributions of AI to optimising urban services (mobility, energy, security, etc.).
- Highlight and identify the main challenges (ethical, societal, technical, regulatory) posed by the integration of AI for territorial governance.

- Analyse potential solutions and best practices for responsible and inclusive governance of AI in the context of smart cities.
- To review existing literature in order to synthesise knowledge and provide a balanced perspective on this complex topic.
- Draw conclusions and propose operational recommendations for decision-makers and territorial development professionals, applicable at the end of this research work.

This article is structured into four main sections: Introduction, Methodology, Results and Discussion, and Conclusion. The following section, entitled "Methodology", presents the research approach. This will be based on a synthesis of scientific articles, as defined in the literature. In the results and discussion section, we will discuss the major contributions of AI to improving urban services and the main challenges in terms of territorial governance. In conclusion, this research work proposes key points and avenues for future investigations.

II. Material And Methods

This study is based on a comparative qualitative approach, aimed at analysing in depth the way in which digital transformation, particularly through artificial intelligence, is impacting information systems and databases in the territories, both in Morocco and internationally. To achieve this, a cross-analysis of ten indexed academic articles published between 2020 and 2025 was carried out.

1. Composition of the corpus

The articles were selected according to the following criteria:

Publication period: between 2020 and 2025
Academic indexing: peer-reviewed journals accessible via recognised scientific platforms (e.g. ScienceDirect, Springer, Web of Science, etc.)
Thematic relevance: each article deals with the impact of digital transformation, artificial intelligence or emerging technologies (IoT, Big Data, Cloud, etc.) on information systems, databases and/or urban governance
Contextual diversity: articles on Moroccan territories (Salé, Casablanca, Marrakech, Taroudant, etc.), but also on international cities (Singapore, Chicago, London, Seoul, etc.).
This corpus includes case studies (Salé, Moroccan cities, international smart cities), systematic reviews (e.g. Ben Rjab et al., 2023), and empirical and prospective research (Allaki and Elmoudden; Delli, 2023; Shrivastava, 2024).

2. Analytical approach

As part of this work, each article was read and summarised according to a common framework, structured around the following headings:

- Introduction
- Methodology used by the author of the article (case study, literature review, econometric approach, interviews, etc.)
- Main findings
- Recommendations for companies and regions
- Areas for improvement or future research

The various summaries were then pooled, compared and analysed in a thematic convergence approach, making it possible to identify the main lessons learned from the articles studied.

3. Qualitative analysis tools

The analysis used the following tools:

Thematic content analysis: extraction of key recurring concepts (e.g. smart city, digital governance, citizen participation, data security, infrastructures, digital inclusion).
Comparative cross-analysis: comparison of approaches, territorial contexts and results between the different articles.

Grouping by strategic axis: the articles were classified according to the priorities addressed: AI in transport, in governance, in waste management, in energy, or in urban services.

Relevance of the method

The approach we have adopted has a number of advantages:

- It allows us to cross-reference local and international experiences in the field of territorial digitalisation.
- It gives us a critical reading of common issues such as cybersecurity, inclusion, transparency and participation, while taking into account the specific features of each context.
- specificities of each context.
- It structures our thinking around lessons that are transferable to businesses and local authorities alike.

In this way, this comparative method is fully in line with the objectives of our study: to produce a well-argued and useful summary for understanding the levers and challenges of the digital transformation of territories in the age of artificial intelligence.

III. Results

1. Impact and applications of AI in smart cities

The table below highlights the cross-cutting role of AI as a lever for innovation in smart cities. It illustrates how AI is transforming various aspects of urban management, improving efficiency, sustainability and citizens' quality of life. Concrete examples (Chicago, Seoul, London) highlight these aspects in a measurable way:

Table 1: Domains, Specific Applications and Contributions of AI in Smart Cities

Domain	- **Applications**	- **Benefits of AI**
Security and surveillance	- **Real-time surveillance via smart cameras and drones** - **Crime prevention**	- **Crime reduction (e.g. Chicago: -39%)** - **Predictive surveillance and improved public safety**
Waste Management	- **Optimisation of collection rounds** - **Prediction of waste volumes** - **Intelligent sorting**	- **Reduction in collection costs (e.g. Seoul: -20%)** - **Increased recycling (e.g. Seoul: +15%)**
Transport and	- **Adaptive traffic light systems**	- **Reduce traffic jams (e.g. London: -13%**

Urban Mobility	- **Predictive traffic modelling** - **Real-time route recommendations** - **Autonomous vehicles**	**delays)** - **Improved waiting times at intersections (up to - 40%)** - **Increased road safety**
Energy	- **Monitoring energy consumption** - **Promotion of renewable energies**	- **Optimisation of energy management** - **Reducing energy consumption**
Environment	- **Monitoring pollution** - **Adapting to climate change**	- **Better management of environmental resources** - **Anticipating climate risks**
Public health	- **Anticipating epidemics** - **Improving telemedicine**	- **Proactive prevention of health crises** - **Improved access to healthcare**
Urban planning and management	- **Use of AI-enhanced GIS (Geographic Information Systems)** - **Digital twins** - **Drones for urban management**	- **More informed decision-making** - **Optimising urban development strategies** - **Adaptation to changing conditions**

Source: compiled by us

2. Key factors and pillars for the development of Smart Cities

Digital transformation is a fundamental pillar for the development of smart cities in Morocco, based on key technologies such as the Internet of Things (IoT), artificial intelligence (AI) and cloud computing. Reliable and secure digital infrastructures are essential to support connected urban services, in particular through high connectivity, marked by a high density of mobile equipment and significant Internet accessibility, even in rural areas. Fixed broadband subscriptions, accounting for 46.3% of connections, and the deployment of secure internet servers (26.2%) play a crucial role in this dynamic, while mobile subscriptions (16.1%) also make a significant contribution (Allaki and Elmoudden. 2023).

To optimise urban flows, it is recommended that priority be given to broadband internet access and the deployment of intelligent infrastructures, such as sensors, energy management systems and intelligent transport networks. However, the lack of robust computing infrastructures, requiring high-performance devices for training AI algorithms, represents a major obstacle. Significant efforts have also been made to digitise the Moroccan public administration, in particular tax services, land registry and the justice system, boosting efficiency and transparency (AIT EL HAJ. 2020). The standardisation of data and communication protocols is essential for integrating the various systems, while the financing of heavy infrastructure and quality transport networks remains a determining factor.

In addition to technology, the development of smart cities depends on skilled human capital and intelligent collaboration. The training of a skilled workforce, via universities and the fight against school dropouts, is crucial to meeting the growing technological needs. The lack of knowledge and expertise among skilled workers is a brake on the deployment of AI, underlining the importance of boosting training and promoting digital literacy. Digital and social inclusion is also a priority to ensure that innovations benefit everyone, including vulnerable groups, and to prevent the adoption of AI from exacerbating inequalities or leading to a digital divide. Particular attention must be paid to this issue to ensure equitable urban transformation (Ben Letaifa, 2015).

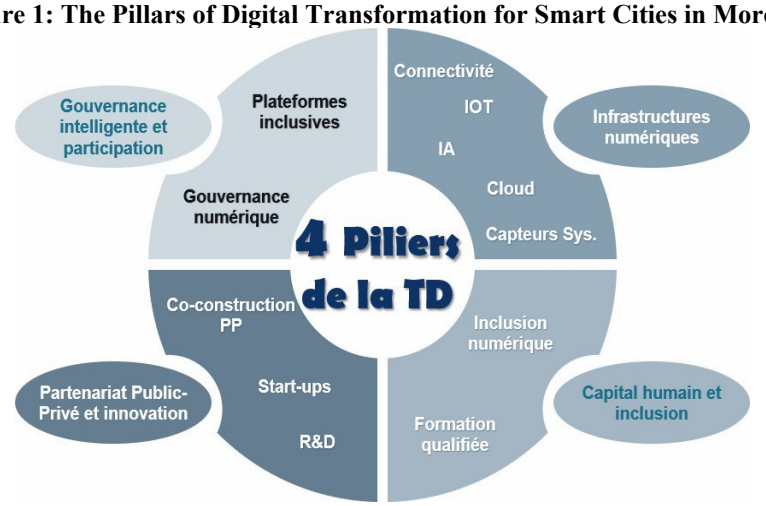
Intelligent governance, based on participation, transparency and the use of information and communication technologies (ICTs), is another essential pillar. Strengthening digital governance through transparent and inclusive platforms enables citizens to be actively involved in the design and implementation of urban AI projects, thereby promoting their social acceptability and relevance. Improved transparency, through clear communication of decisions and easier access to information, is recommended, as is the adoption of new technological mechanisms to encourage citizen participation. Ethical and inclusive data governance, involving communities, users and businesses, is needed to meet the needs of the population. Morocco's ambition is an urban development model based on open, transparent and non-discriminatory digital governance, in which citizens play an active and committed role.

Finally, collaboration between the public and private sectors is essential to maximise the benefits of AI while minimising its risks and costs, by moving towards a logic of co- construction. The Digital Morocco 2020 Plan provides a structuring framework and financial resources to support the transformation of cities. The mobilisation of all stakeholders - private sector, public sector, civil society and citizens - is crucial to the success

of this transition (Khalloufi & Berrado, 2021). The creation of a local digital innovation ecosystem, including universities, start-ups, local authorities and NGOs, is strongly recommended, as is support for research and development (R&D). A clear and forward-looking strategy, integrating local start-ups and the private sector, is essential to guide the future of smart cities in Morocco, in alignment with the needs and realities of the territory (Ben Letaifa, 2015).

The following diagram summarises the key pillars of digital transformation for smart cities in Morocco:

Figure 1: The Pillars of Digital Transformation for Smart Cities in Morocco



Source: compiled by us

3. The Moroccan context and the potential for Smart City transformation

For the past two decades, Morocco has been undergoing rapid urbanisation, with the urban population expected to exceed 64% by 2022 and an estimated 70% by 2035, according to the Rapport du haut-commissariat au plan 2023. This demographic growth is putting increasing pressure on cities, which are faced with complex challenges in terms of mobility, the environment, governance and public services. Faced with these challenges, the Smart City concept is emerging as a promising solution. However, the Western model, characterised by costly technologies, is not directly transposable to Moroccan realities. So an intermediate model, described as a "pseudo Smart City", adapted to the needs of emerging countries, is being favoured to meet local specificities while incorporating relevant technological solutions (Allaki and Elmoudden 2023).

The rise of electronic payment and the widespread use of social networks are evidence of changing attitudes and growing interaction between citizens and their urban environment. These reliable and secure digital infrastructures are an essential basis for supporting the connected services of smart cities, enabling optimised management of urban flows.

Significant progress has been made in the digitisation of public administration, notably through the dematerialisation of tax services (online declarations and payments), land registry, etc.

(online declarations and payments), land registry services (online requests and consultations) and the justice system (tracking of cases and electronic filings). These initiatives aim to enhance efficiency, transparency and confidence, which are crucial to Morocco's attractiveness, particularly to investors (AIT EL HAJ D., 2020).

The Digital Morocco 2020 Plan, as a key government programme, structures these efforts by positioning the country as a regional digital hub. This plan provides a strategic framework and financial resources to support the transformation of cities towards intelligent models.

Several Moroccan cities, including Tangier, Casablanca and Marrakech, show significant potential to become Smart Cities, with an ambitious project to transform six cities by 2026, also including Rabat, Ifrane and Fez. Tangier stands out for its high-quality infrastructure, including industrial and logistics zones, an efficient road and rail network (notably the TGV), an international airport and the Tangier-Med port. The Cité

Mohammed VI Tanger Tech project embodies this ambition. Casablanca, the main economic metropolis, has a diversified infrastructure with an airport, a tramway and regional development programmes that reinforce its potential. Marrakech, with its rich historical heritage, boasts major institutions such as a university and a university hospital, as well as tourist and transport infrastructures such as an international airport and a rail link. The royal "City of Permanent Renewal" programme has enhanced its capabilities, positioning it as a serious candidate to join the network of smart cities.

The transformation towards smart cities in Morocco requires a collective effort involving the public sector, the private sector, civil society and citizens. This transition requires substantial funding to develop heavy infrastructure, high-quality transport networks and innovation and research and development (R&D) centres. A clear, forward-looking strategy is essential to guide this evolution, based on accessible technology, open digital governance based on transparency and non-discrimination, and the active participation of citizens as committed stakeholders. The introduction of a code of good practice or specific Moroccan standards for smart cities is also recommended in order to structure this transformation and stimulate healthy competition between cities.

IV. Discussion

1. AI: an essential ally for improving urban services:

According to the results analysed in the articles, they clearly reveal the positive impacts of integrating artificial intelligence into the management of smart cities. By drawing on advanced technologies such as the IoT, AI optimises the management of urban resources, reduces costs and significantly improves citizens' quality of life. Take the example of the city of London, where intelligent mobility systems are reducing traffic jams and CO emissions,
while in Seoul, AI is optimising waste management and increasing recycling rates. These two

concrete examples demonstrate profoundly that AI is not just a technological innovation or a technological lever but also a genuine strategic tool for responding to the issues and challenges of contemporary city life(Shrivastava, 2024).

In terms of governance, AI has made it possible to improve the transparency and efficiency of services while encouraging informed decision-making thanks to the exploitation of massive data (Big Data). However, this progress is accompanied by crucial questions about the equity and accessibility of these innovations, particularly in contexts where the digital divide remains a reality.

2. Morocco: potential and opportunities to be fully exploited

Morocco is well positioned to reap the benefits of AI in the development of its smart cities. National efforts and initiatives, such as Maroc Numérique and Maroc Digital 2020, demonstrate a clear institutional commitment to modernisation. Strong digital connectivity and increased Internet accessibility provide fertile ground for the implementation of AI solutions. Tangiers, Casablanca and Marrakech, for example, illustrate this potential, thanks to ambitious projects combining modern infrastructures and innovative solutions (Allaki and Elmoudden, 2023).

However, to maximise these opportunities, it is imperative to strengthen local AI skills, improve technological infrastructures and ensure an intelligent and participative governance framework. Particular attention must be paid to social inclusion and equity of access to prevent AI from exacerbating existing inequalities.

3. Persistent challenges and emerging risks

Despite the obvious benefits, the integration of AI into smart cities is being held back by technological, organisational and environmental obstacles. Concerns about the protection of personal data, cyber-attacks and the explicability of algorithms give rise to legitimate misgivings. In addition, the high cost of the technologies and resistance to change are holding back their adoption, particularly in cities with limited budgets (Ben Rjab et al., 2023).

These challenges are even more acute in a context where legislation is struggling to keep pace with technological advances. Concerns about mass unemployment and economic inequality add a socio-political and

ethical dimension that cannot be ignored. These concerns are particularly relevant in a country like Morocco, where urban governance must be aligned with sustainable development objectives and the reduction of social inequalities.

4. An integrated vision for moving forward

For AI to become a sustainable lever for urban transformation and a real driver of urban transformation, it must be integrated into a global vision that combines technological innovation, social inclusion and transparent governance, as well as better coordination between all stakeholders. Morocco, with its dynamic digital transformation, has a unique opportunity to build truly intelligent and sustainable cities, provided that the challenges identified are overcome.

This will require closer collaboration between the public and private sectors, appropriate regulation and, above all, the active participation of citizens. The aim is clear: to put AI to work for everyone, to make cities more inclusive, more efficient and more resilient in the face of tomorrow's challenges. This framework will need to take account of local specificities while drawing on international best practice to overcome the challenges identified and maximise the benefits of smart cities.

V. Conclusion

The research carried out as part of this study has shown that artificial intelligence (AI) is a key tool for optimising urban services. AI enables more efficient management of transport, energy, security and waste treatment, while helping to improve the quality of life of city dwellers.

Nevertheless, its integration into the framework of territorial governance raises significant challenges, especially with regard to the protection of personal data, ethical issues, the persistence of the digital divide and the need for appropriate regulatory frameworks. The obstacles to implementing these practices are multiple and include factors such as high costs and resistance to change (Ben Rjab et al., 2023).

For countries such as Morocco that are embarking on the implementation of so-called smart cities, it is crucial to strengthen local skills and establish inclusive governance in order to maximise the opportunities offered by artificial intelligence (AI), but also to prevent the exacerbation of pre-existing inequalities.

In conclusion, it appears that the successful integration of artificial intelligence into urban development depends on a holistic approach, synergistically combining three fundamental pillars: technological innovation, social inclusion and governance that is both transparent and coordinated. The aim is to apply artificial intelligence in the public interest, making cities more efficient, resilient and inclusive.

1. Methodological limitations

This comparative qualitative approach has certain limitations:

- The methodological diversity of the articles analysed (case studies, statistical analyses, literature reviews) makes the comparison sometimes uneven.
- The data remains secondary and depends on the rigour of the articles selected.
- Some contexts are over-represented (Morocco), while others (sub-Saharan Africa, South America) are absent.
- The lack of fieldwork or direct observations limits the empirical scope of the analysis.

2. Research avenues

The challenges identified and the limitations of this study pave the way for several avenues of future research, aimed at deepening understanding and facilitating the responsible integration of AI in smart cities:

- **In-depth study of the social and ethical impact of AI in specific contexts:** Conduct qualitative and quantitative research on the social acceptability of AI, citizens' perceptions of data privacy and use, and the impact of AI on employment and social inequalities, particularly in countries like Morocco where the digital divide is a reality(Lartey & Law, 2025).
- **Research into mechanisms for digital inclusion and equitable access to intelligent services**: Exploring concrete strategies to overcome the digital divide and ensure that the benefits of AI are accessible to all segments of the population, including vulnerable populations.
- **Analysis of financing models and economic viability of AI solutions in urban areas**: Investigate ways to reduce the high costs of AI technologies and encourage their adoption, especially in cities with limited budgets, by exploring innovative public-private partnerships.

- **Empirical case studies and direct observations in disadvantaged cities**: Complementing literature reviews with field research and direct observations in less studied geographical contexts (e.g. sub-Saharan Africa, South America) to enrich the empirical scope of knowledge on the integration of AI in territories.
- **Research into the explicability and transparency of AI algorithms in urban management**: Examine methods for making the decisions of AI systems more comprehensible to decision-makers and citizens in order to increase trust and acceptance (Englund et al., 2021).
- **Evaluating the effectiveness of citizen participation mechanisms in the design and deployment of AI solutions**: Investigating how citizens can be actively involved in the process of digitally transforming their city, ensuring that innovation addresses their needs and concerns.

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