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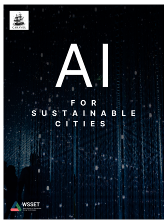

Technical article

Artificial Intelligence-Driven Smart Cities: A Framework for Addressing Contemporary Urban Challenges (Case Study: Baghdad)

Mazin Ismael Raheem [1]* and Maha Ismail Raheem [2]

[1] *University of Nottingham, Department of Architecture and Built Environment, Nottingham, United Kingdom.*
[2] *University of Information Technology and Communications, Baghdad, Iraq.*

ABSTRACT

In order to address current urban difficulties, this study investigates how artificial intelligence (AI) can improve smart city frameworks. This paper contends that integrating AI techniques—such as machine learning, predictive analytics, and data-driven decision-making—can greatly enhance urban performance and sustainability, despite the fact that traditional smart city models mostly rely on information and communication technology. The research employs an applied and inductive methodology. First, by combining AI-driven systems with smart city concepts, a thorough theoretical framework is created. Second, a set of AI-oriented urban indicators are used to assess the framework's efficacy in the city of Baghdad as a case study. In order to replicate AI-assisted decision-making, the analysis combines survey data with analytical interpretation. The results show that AI-enhanced smart city systems can boost resource management, government transparency, environmental sustainability, and service efficiency. However, sociocultural, technological, and economic obstacles continue to be major obstacles to implementation. The study's conclusion suggests strategic investments in digital infrastructure, data systems, and AI capabilities as well as an AI-based urban model that can be modified for growing cities.

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1. INTRODUCTION

Rapid population increase, environmental degradation, ineffective resource management, and infrastructure pressure are just a few of the unprecedented problems urban regions around the world are currently confronting. As a result, the idea of "smart cities" has surfaced as a calculated strategy to enhance urban living by incorporating digital technologies (Anthopoulos & Fitsilis 2010).

However, given the growing complexity of urban processes, conventional smart city models—which mostly rely on information and communication technologies (ICT)—are no longer adequate. Artificial

* Corresponding author. Email address: alymr1@nottingham.ac.uk (Mazin Ismael Raheem)

Intelligence (AI) has recently come to light as a revolutionary force that can improve smart city performance through autonomous, adaptive, and predictive technologies (Cyberspace 2004). The use of data-driven techniques to evaluate patterns, correlations, and performance indicators in a way consistent with artificial intelligence systems is referred to in this study as "AI-based analytical approach (Raheem & Raheem 2026).

Cities may transition from reactive administration to proactive, data-driven decision-making thanks to AI. Urban systems may optimise public services, trash management, energy consumption, and traffic flows using intelligent automation, real-time data processing, and machine learning algorithms (Serpoushan & Yaghoubi 2012 and Graham & Marvin 1996).

Thus, this study contends that the incorporation of AI into smart city frameworks—which turn them into intelligent, adaptable, and resilient urban systems—is the key to the future of sustainable cities.

The increasing significance of incorporating AI into municipal systems to address climate and environmental concerns is highlighted by recent research in sustainable urban development.

1.1. RESEARCH PROBLEM

Even if smart city efforts are becoming more and more popular, there is still a big disparity in how well complicated urban problems are handled. The limited incorporation of AI technology in existing smart city models is a major contributing factor to this disparity.

The majority of current frameworks rely on static digital systems and are unable to support intelligent decision-making, analyse vast amounts of data, or forecast future urban patterns. Because of this, cities still struggle with inefficiencies in energy consumption, transportation, service delivery, and environmental management.

Thus, the inadequate integration of AI-driven methods into smart city frameworks, which restricts their efficacy in resolving current urban problems, can be characterised as the research challenge.

1.2. RESEARCH OBJECTIVES

Developing an AI-driven framework for smart cities that improves their capacity to handle current urban issues is the primary goal of this project.

The particular goals consist of:

- To examine the shortcomings of conventional smart city models.
- To investigate how artificial intelligence may enhance urban systems.
- To provide a theoretical framework that combines AI with elements of smart cities.
- To suggest AI-based metrics for assessing urban performance.
- To use a real-world case study (Baghdad) with the suggested framework.
- To determine the main obstacles preventing AI from being used in smart cities.

1.3. RESEARCH HYPOTHESIS

By enhancing efficiency, sustainability, and decision-making processes, artificial intelligence greatly improves smart city frameworks' capacity to address modern urban concerns.

1.4. RESEARCH METHODOLOGY

This study combines theoretical advancement with practical research using an inductive and applied research technique. The three primary phases of the methodology are data acquisition, analytical modelling, and data processing.

To assess urban performance across important smart city indicators, a systematic questionnaire was created. Each of the items on the questionnaire represented a distinct urban indicator, such as infrastructure, services, governance, and the environment.

Responses were measured using a five-point Likert scale, where 1 represents extremely low and 5 represents extremely high. The questionnaire was examined to make sure it was clear and pertinent to the goals of the study.

The study used a random sampling strategy to focus on users and urban dwellers in Baghdad. A total of 100–150 replies were gathered.

A wide range of age groups, professions, and degrees of digital awareness were represented among the participants. A wider representation of urban perceptions was made possible by this diversity.

To make it easier to compare indicators, the collected data was transformed into percentage ratings. The replies were averaged and normalised to a percentage scale in order to determine each indicator score.

While the suggested AI-based approach permits future weighted changes, all indicators were given equal weight in the base study to guarantee consistency.

The study incorporates a data-driven analytical strategy backed by the AI-Driven Urban Performance Index (AUPI) to improve analytical rigour.

The analysis is centred on:

- Finding trends and connections among indicators.
- Differentiating between low, medium, and high performance levels.
- Analysing outcomes in a way that is predictive and compatible with AI-based systems.

The study uses an AI-inspired analytical framework that mimics how intelligent systems evaluate urban data, even if sophisticated machine learning techniques are not directly applied.

By shifting from descriptive analysis to structured and comprehensible evaluation, this strategy fortifies the methodological basis.

Cronbach's Alpha was used to evaluate the questionnaire's reliability.

1.5. AI-BASED ANALYTICAL FRAMEWORK

This paper presents a simple AI-based analytical framework for evaluating urban indicators in order to overcome the drawbacks of simply descriptive analysis.

The foundation of the concept is the idea that artificial intelligence systems depend on finding correlations, patterns, and predicted trends in data. The information gathered from the questionnaire is used in this study as an input dataset that represents urban performance metrics.

To mimic how machine learning algorithms might handle such data, a conceptual model is created. The model emphasises:

Finding relationships between indicators (e.g., infrastructure and service efficiency).

dividing performance levels into three groups: low, medium, and high.

analysing patterns to forecast future advancements under AI integration.

The framework bridges the gap between theoretical discussion and practical application by offering an organised approximation of AI-inspired analytical framework, even though a complete computational AI model is outside the purview of this study.

This strategy is in line with current research that highlights the importance of data-driven analytical thinking as a prerequisite for implementing AI fully in urban systems.

The following equation illustrates AI-Driven Urban Performance Index (AUPI):

$$AI\ Score = \frac{\sum Indicators}{N} \tag{1}$$

An AI-Driven Urban Performance Index (AUPI) is suggested as a reduced quantitative model to improve the study's analytical rigour (Mahmood & Al-saatee, et al. 2025).

Each urban indicator in this model denotes a quantifiable facet of city performance (e.g., governance, mobility, environment, and services), and each indicator's relative importance (weight) is represented by (wi). The index aggregates and normalises weighted indicators to determine an overall performance score.

This method is similar to how machine learning models combine several features to provide a single prediction. Despite being simplified, the model facilitates comparative study between various urban sectors and offers an organised approximation of AI-based evaluation.

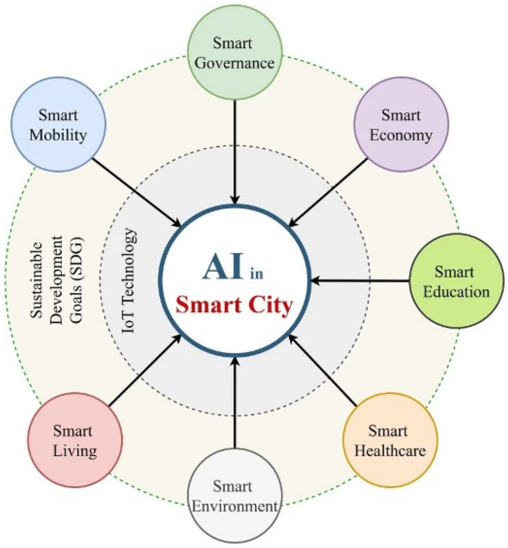

Figure 1. AI-Based Smart City Framework (Kasun & Mamta 2022).

The framework shows how data input (questionnaire indicators), analytical processing (AUPI model), and output (urban performance evaluation and predictive insights) are related.

It demonstrates how unstructured data is transformed into structured decision-support outputs through AI-inspired analysis.

1.6. RESEARCH CONTRIBUTION

By offering a streamlined AI-based analytical framework specifically designed for emerging cities, where access to extensive urban datasets is scarce, this study adds to the body of existing knowledge.

This study presents the AI-Driven Urban Performance Index (AUPI) as a useful and flexible tool for assessing urban systems utilising perception-based data, in contrast to earlier research that relies on intricate computer models.

By applying the paradigm to the Baghdad scenario, the study also closes the gap between theoretical AI principles and practical urban difficulties.

2. LITERATURE REVIEW

The integration of information and communication technology (ICT) to enhance urban services and infrastructure was the main focus of early research on smart cities. These strategies highlighted e-governance, data sharing, and digital connectivity as important forces behind urban change.

However, because these models rely on static systems rather than intelligent and adaptable solutions, they have been criticised for their inadequate capacity to handle complex and dynamic urban concerns.

2.1. DEFINITION OF SMART CITY

An urban system that incorporates digital technologies, data infrastructures, and artificial intelligence to improve people' quality of life, sustainability, and efficiency is known as a "smart city" (Walters 2011 and Raheem et al. 2024).

Modern smart cities are increasingly powered by AI-based systems that can learn, forecast, and adjust to urban dynamics, in contrast to conventional definitions that mostly concentrate on information and communication technology (ICT). Therefore, a smart city functions as an intelligent ecosystem made up of interconnected layers, such as human capital, environmental systems, governance mechanisms, and technology infrastructure (Raheem et al. 2026b).

In this situation, artificial intelligence plays a key role in enabling cities to move from reactive management to proactive and predictive urban government by converting data into actionable insights.

2.2. SMART CITIES USING ARTIFICIAL INTELLIGENCE

By enabling data-driven, adaptable, and autonomous urban systems, artificial intelligence is essential to the development of smart cities. Large volumes of data produced by sensors, gadgets, and human interactions can be processed by cities using AI technologies to create intelligent behaviours (Benninger 2001 and Raheem et al. 2026a).

Machine learning, deep learning, computer vision, natural language processing, and predictive analytics are important AI technologies utilised in smart cities. Numerous urban applications are supported by these technologies (Castells 1997).

AI is utilised in transportation systems to anticipate traffic jams and optimise traffic signals in real time. Artificial intelligence (AI) algorithms in energy systems estimate energy demand and optimise distribution, reducing consumption and carbon emissions. AI makes it possible to monitor air quality in real time and identify pollution issues early on in environmental management (Komninos 2008 and Bakici et al. 2013).

Additionally, by improving decision-making procedures through data analysis and scenario modelling, AI promotes wise governance. This enables decision-makers to assess various urban approaches and choose the most effective and long-lasting ones.

As a result, the incorporation of AI makes smart cities intelligent, adaptable, and sustainable urban systems that can handle intricate and ever-changing problems (Yovanof & Hazapis 2009 and Park & Kim 2018).

2.3. SUSTAINABILITY & ENERGY

Recent studies on smart cities have made sustainability a major focus, especially when it comes to energy systems, environmental management, and carbon reduction.

AI's ability to optimise energy usage, lower emissions, and increase system efficiency has been demonstrated by recent research that have investigated its integration with sustainable energy systems.

Additional research emphasises how energy systems and sophisticated process engineering may promote sustainable urban transitions, especially through data-driven optimisation and intelligent resource management (Elwardany 2025; Riffat et al. 2026; Shen & Yang 2026; and Raheem & Raheem 2026).

Together, these studies highlight how crucial it is to integrate AI with sustainability frameworks in order to achieve long-term urban resilience.

2.4. TECHNIQUES FOR SMART CITIES POWERED BY AI

A wide range of tactics that incorporate institutional, social, and technological aspects are needed to make the shift to AI-driven smart cities.

The deployment of digital infrastructure, such as Internet of Things (IoT) devices, data platforms, and artificial intelligence (AI) systems with real-time data processing and predictive analysis capabilities, is the first step in technological transformation.

Second, improving digital literacy and guaranteeing universal access to smart services are the main goals of social transformation. Urban data ecosystems require active participation from citizens as both creators and users (Karakounos et al. 2017).

Third, investing in innovation, startups, and AI-driven sectors that promote sustainability and urban growth is a key component of economic transformation.

Fourth, the creation of legal frameworks that encourage data exchange, openness, and the moral use of AI is a component of governance reform (Recnagel 2022).

Together, these changes allow cities to develop from static digital landscapes into intelligent, dynamic systems that are always learning and adapting.

2.5. THE INTEGRATED TIERS CAN BE USED TO ORGANISE AI-DRIVEN SMART CITIES:

The data layer is the first level, where digital platforms, IoT devices, and sensors are used to gather urban data. This data is processed by AI systems to produce forecasts and insights.

The urban environment is represented by digital twins and simulation models in the second level, known as the physical-virtual integration layer. AI improves these models by making scenario testing and real-time analysis possible (Reim et al. 2002).

The human-centred layer, which is the third level, is where people engage with intelligent systems. Based on user behaviour and demands, AI facilitates social engagement, tailored services, and adaptive urban experiences (Taylor et al. 2012).

Together, these three tiers create a coherent intelligent urban system that is always innovating and optimising.

2.6. FEATURES OF SMART CITIES

Several essential characteristics define an AI-driven smart city:

- AI-supported data-driven decision-making.
- Predictive skills that foresee urban problems before they arise.
- Adaptability to social and environmental changes in real time.
- The use of digital twins to integrate the real and virtual worlds.
- AI optimisation models for sustainable resource management.
- Digital services that are accessible and inclusive for all citizens (Wong et al. 2008; Saffari & Hosseinnia 2009 and Kumar et al. 2008).

By highlighting intelligence, adaptability, and sustainability, these characteristics set AI-enabled smart cities apart from conventional digital cities.

2.7. SMART CITIES POWERED BY AI ARE ESSENTIAL FOR SOLVING TODAY'S URBAN PROBLEMS

Through predictive modelling, AI improves spatial planning in terms of population density, enabling cities to better control expansion.

AI-based simulation techniques can optimise land allocation and maintain urban identity while guaranteeing functional efficiency when it comes to land-use conflicts.

By evaluating demand trends and dynamically distributing resources, AI guarantees fair access to services (Mahmoudi 2005).

By maximising land usage and eliminating needless physical infrastructure through digital alternatives, artificial intelligence (AI) promotes the growth of green spaces in environmental sustainability.

AI-powered transportation systems that optimise routes, shorten travel times, and minimise emissions greatly reduce traffic congestion and pollution.

In general, AI converts reactive tactics to predictive and optimised solutions for urban problems (Grant & Clarke 2010).

A number of recent studies highlight how AI may optimise energy use and lower emissions in urban settings.

2.8. AI-BASED INDICATORS AND THEIR THEORETICAL FOUNDATION

The suggested indicators are derived from the junction of artificial intelligence capabilities and smart city frameworks in order to guarantee scientific rigour.

As a result, every signal in this study is connected to a particular AI feature:

- Intelligent governance is backed by decision-support systems and data analytics.
- Predictive models for traffic optimisation enable smart mobility.
- Sustainable Environment: Powered by AI-based environmental analysis and real-time monitoring.
- AI-driven innovation and data-driven economic insights will improve the digital economy.
- AI applications in healthcare, education, and safety systems support social well-being.

This functional connection guarantees that the indicators represent the operational role of AI in urban systems rather than only being descriptive (Nam & Pardo 2011 and Tommy 2003).

The suggested indicator approach is consistent with current research in AI-driven urban systems, where systems' capacity to analyse data, recognise patterns, and facilitate intelligent decision-making is used to assess urban performance.

In line with AI-based system design concepts, this method goes beyond conventional descriptive metrics in favour of a functional and computational approach to urban evaluation (Raheem & Raheem 2026; Nam & Pardo 2011 and Tommy 2003).

Every statistic shows how well the city can use AI technologies to boost sustainability and performance.

Table 1. Urban Indicators Powered by AI for Smart Cities.

Dimension	Indicator Example	AI Role
Intelligent Governance	Open data platforms	Data analysis & transparency
Smart Mobility	Traffic prediction systems	Machine learning models
Sustainable Environment	Air quality monitoring	Real-time AI analytics
Digital Economy	Innovation & startups	AI-driven economic insights
Social Well-being	Smart healthcare & education	AI-driven economic insights

2.9. RESEARCH GAP

There are still a number of gaps in the growing corpus of research on AI applications and smart cities.

First, a lot of research concentrates on either sustainability or technology without completely incorporating both factors into a cohesive framework.

Second, little research has been done on the use of AI-driven models in developing cities, where infrastructure and data availability continue to be major obstacles.

Lastly, only a small number of research offer streamlined analytical frameworks that connect theoretical AI ideas with real-world urban applications.

Using Baghdad as a case study, this research attempts to close these gaps by creating an AI-based framework specific to the setting of emerging cities.

3. PRACTICAL STUDY

3.1. SELECTION OF CASE STUDIES

Baghdad was chosen as a case study because of its potential for implementing smart city technologies and its complicated urban difficulties. Baghdad includes essential components including population density, infrastructure frameworks, and new digital initiatives, even if it has not yet fully integrated smart city systems. This makes it an ideal setting for evaluating the suitability of an AI-powered smart city framework, especially in developing nations.

3.2. URBAN CONTEXT OF BAGHDAD

One of the biggest cities in the Middle East, Baghdad deals with a number of intricate urban issues, such as traffic jams, ageing infrastructure, fast population increase, and environmental deterioration.

The city's transport systems are under a lot of strain, which causes traffic jams and higher emissions. Environmental sustainability issues are also exacerbated by insufficient green space and ineffective waste management systems.

Despite these problems, Baghdad's current urban form and growing digital consciousness make it possible for the city to embrace smart city technologies. However, its capacity to move toward an intelligent urban model is constrained by the lack of linked data systems and sophisticated analytical tools.

3.3. DATA GATHERING AND AI-FOCUSED METHODOLOGY

It's crucial to remember that this study's dataset is perception-based and comes from user answers rather than actual urban sensor data. Nonetheless, this information offers insightful information about perceived urban performance, service accessibility, and user experience.

Perception-based data is a useful stand-in for assessing system performance in developing countries, since real-time urban datasets are frequently few or unavailable.

Recent urban studies that use survey-based indicators as a first step toward data-driven smart city planning complement this strategy.

The gathered data can be viewed as a condensed dataset that represents the performance of urban systems from an AI-based analytical standpoint.

Infrastructure and environmental indicators are consistently lower than governance and economic indicators, according to patterns found in the dataset. This suggests areas that AI-driven optimisation might prioritise.

This kind of pattern recognition illustrates how machine learning systems categorise performance levels and find correlations between variables to inform decisions.

3.4. COMPARATIVE PERSPECTIVE

A comparative viewpoint is presented to put the results in context. The Baghdad case study's conclusions align with observations from other developing cities, where issues with digital transformation, infrastructure, and environmental sustainability are prevalent.

Similar research shows that cities in the early phases of smart transformation frequently have mediocre performance levels, especially when it comes to data accessibility and service effectiveness.

This comparison shows that Baghdad's current situation is not exceptional, but rather reflects a larger trend in emerging urban situations that are moving toward intelligent and AI-driven systems (Mahmood & Al-saatee, et al. 2025 and Raheem & Raheem 2026).

3.5. LIMITATIONS

The use of perception-based data instead of real-time urban information, such as traffic patterns, energy usage, or environmental monitoring, is a limitation of this work.

Although this method offers insightful information, large-scale urban data and sophisticated AI models should be used in future studies to improve precision and prediction power.

4. RESULTS

Method of Data Processing and Scoring. A five-point Likert scale, with 1 being extremely low and 5 being extremely high, was used to gauge the questionnaire replies.

Responses were transformed into percentage ratings through a normalisation procedure to make analysis easier.

The following formula was used to determine each indication score:

- Each indicator's mean response value was calculated.
- To get a percentage score, the mean was divided by the maximum value (5) and then multiplied by 100.

This method is in line with standard procedures in survey-based urban studies and enables consistent comparison across all parameters.

With an overall average of 55.47%, the data analysis showed reasonable performance across the majority of parameters. However, a number of important insights become apparent when seen from an AI-focused viewpoint.

First, metrics pertaining to openness and governance exhibit comparatively better performance, indicating a fundamental preparedness for digital transformation. However, their efficacy is constrained by the absence of sophisticated data analytics tools.

Second, metrics pertaining to infrastructure and the environment show poorer performance, suggesting the lack of prediction and optimisation systems that are normally made possible by AI.

Third, the biggest obstacle to implementing AI-driven solutions is socioeconomic considerations, especially financial constraints. The deployment of intelligent systems is hampered by the lack of access to digital infrastructure and technologies.

Predictively speaking, the data indicates that integrating AI might greatly enhance underperforming industries, including waste management, traffic control, and service delivery.

Overall, the findings show a disconnect between the potential of AI-driven urban systems and current digital capabilities.

Table 2. Assessment of AI-Based Indicators (Case Study of Baghdad).

Indicator	**Score (%)**
Open Data & Transparency	67%
Public Awareness of Digital Transition	55%
Legal Frameworks	44%
Green Building Availability	35%
Energy Efficiency	50%
Smart Infrastructure	45%
Economic Opportunities	69%
Public Services	53%
Health Improvement	52%
Security	51%
Learning Accessibility	66%
Average	**55.47%**

4.1. INTERPRETATION OF RESULTS

Each urban indicator's relative performance is represented by the computed percentage scores. These numbers can be understood as input features for assessing overall system performance from an AI-based analytical standpoint.

Higher ratings show preparedness for AI integration, while lower scores highlight crucial areas in need of optimisation.

This interpretation aligns with the way machine learning models rank variables according to how much they contribute to the overall performance of the system.

The dataset shows possible predictive associations from the standpoint of AI analysis. Lower scores in environmental and infrastructural indicators, for instance, imply that these industries would gain the most from AI-based optimisation models.

Similarly, readiness for AI integration, especially in data-driven decision-making systems, is indicated by reasonable performance in governance indicators.

These interpretations show how patterns are usually found and intervention areas are prioritised by machine learning models.

With an average score of roughly 55.47%, Baghdad's overall performance might be considered moderate according to the proposed AI-Driven Urban Performance Index (AUPI).

This score shows that the city is at a medium level of preparedness for AI integration from an AI-based analytical standpoint. The entire index value is greatly decreased by lower-scoring indicators, especially in infrastructure and environmental sustainability, indicating priority areas for AI-driven intervention.

On the other hand, sectors that are better suited to AI-based systems are indicated by higher-scoring variables like economic potential and transparency, which have a positive impact on the index.

4.2. UNCERTAINTY AND VARIABILITY

It is crucial to remember that the findings are based on perception-driven data, which could add some subjectivity and uncertainty. Differences in user experience, awareness, and expectations may be reflected in variations in replies.

Nonetheless, a respectable degree of reliability is suggested by the results' consistency across several indications. A generalised picture of urban performance is produced by using aggregated averages, which also lessen individual bias.

To further lower uncertainty and increase accuracy, future research should use real-time urban datasets and sophisticated statistical techniques.

4.3. PREDICTIVE POTENTIAL

Potential future improvements under AI integration scenarios can be estimated using the current dataset based on the AI-Driven Urban Performance Index (AUPI).

It is anticipated that the total urban performance index will greatly increase if important low-performing indicators—like infrastructure and environmental sustainability—are improved by AI-based optimisation systems.

This illustrates the predictive power of AI systems, which exploit trends in current data to forecast future events and inform strategic urban planning choices.

4.4. STATISTICAL CONSIDERATIONS

The use of mean values and normalised scores offers a fundamental quantitative framework for analysis even though sophisticated statistical tests were not used in this investigation.

The validity of the overall conclusions is supported by the comparatively balanced distribution of scores, which shows moderate variability among indicators. In the context of developing smart cities, this level of analysis is suitable for exploratory research.

5. DISCUSSION

The results of this study highlight that the shift from conventional smart cities to AI-driven smart cities represents a fundamental change in urban management paradigms rather than just a technology advancement.

ICT-based systems lay the groundwork for digital transformation, but they lack the intelligence needed to manage intricate and ever-changing urban problems. AI gives cities the ability to react proactively rather than reactively by introducing predictive, adaptive, and autonomous capabilities.

Baghdad serves as an example of how deliberate investments in data infrastructure and digital capacity building may make AI integration beneficial even for communities with limited resources.

But the report also identifies important issues, such as limited data, a lack of technical know-how, and financial limitations. To fully utilise AI in urban development, these issues must be resolved.

Table 3. Urban Performance Interpretation by AI.

Sector	**Current Status**	**AI Potential Impact**
Traffic	Moderate	High improvement via prediction
Environment	Weak	Significant via monitoring
Economy	Strong	Enhanced through AI innovation
Services	Moderate	Optimization by AI

These results are consistent with recent studies that emphasise the significance of data-driven urban systems in journals devoted to sustainability and climate change.

6. CONCLUSIONS

This study shows that the development of smart cities into sustainable, effective, and adaptable urban systems is greatly aided by artificial intelligence.

The study demonstrates that conventional smart city models, which mostly rely on ICT, are inadequate to handle challenging urban issues. By facilitating predictive analysis, wise decision-making, and efficient resource management, the incorporation of AI improves urban performance.

The findings of the case study show that although cities like Baghdad have the fundamental components for smart transformation, there are still large gaps in terms of infrastructure and AI preparedness.

Therefore, the successful integration of AI technology into frameworks for urban planning and management is essential to the development of sustainable cities.

7. RECOMMENDATIONS

The following suggestions are put forth in light of the research's findings:

- Create national plans for incorporating AI into urban planning.
- Make investments in digital infrastructure, such as IoT systems and data platforms.
- Encourage open data projects to aid in the development of AI and transparency.
- Increase local AI capabilities through training and education initiatives.
- Promote cooperation between the public, business, and academic sectors.

- Put pilot AI ideas into action in important industries like waste management, energy, and transportation.
- Provide inexpensive access to digital technology to overcome financial obstacles.

These suggestions are meant to facilitate the shift to sustainable cities powered by AI, especially in developing nations.

AUTHOR CONTRIBUTIONS

Mazin Ismael Raheem: responsible for the conceptualisation, methodology development, data analysis, and manuscript writing. **Maha Ismail Raheem**: provided expert guidance and consultation in the fields of computer science and artificial intelligence, contributing to the development and refinement of the study.

COMPETING INTERESTS

The authors have no competing interests to declare.

DATA ACCESSIBILITY

Anonymised questionnaire responses served as the basis for the dataset used in this investigation. The article contains a condensed version of the data.

Subject to privacy concerns, the authors may provide more information upon reasonable request.

ETHICAL APPROVAL

Through a questionnaire survey, human volunteers are involved in this investigation. Every participant was made aware of the study's objectives, and their involvement was entirely voluntary.

No personally identifiable information was recorded, and responses were gathered anonymously. The only usage of the data was for study.

Since this study used non-sensitive survey data, formal ethical approval was not necessary; however, all methods were carried out in compliance with accepted research ethics guidelines.

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REFERENCES

Anthopoulos L. & Fitsilis P., 2010. From Online to Ubiquitous Cities: the Technical Transformation of Virtual Communities. In A. B. Sideridis & C. Z. Patrikakis (Eds.), Next Generation Society: Technological and Legal Issues (Proceedings of the Third International Conference, e-Democracy. Athens, Greece. Sep 23-25.2009). Vol. 26. Berlin, Germany: Springer. DOI: https://doi.org/10.1007/978-3-642-11631-5_33.

Bakici T., Almirall E. & Wareham J., 2013. A Smart City Initiative. The Case of Barcelona Journal of the Knowledge Economy. Vol. 4, No. 2. DOI: doi.org/10.1007/s13132-012-0084-9.

Benninger C., 2001. Principles of Intelligent Urbanism in Ekistics. Athens. Vol. 69, No. 412.

Castells M., 1997. The Rise of the Network Society. The Information Age: Economy, Society, and Culture, UK, Oxford, Blackwell: [online] available from <https://onlinelibrary.wiley.com/doi/book/10.1002/9781444319514> [22 June 2025].

Cyberspace, 2004. The World of Digital Architecture, Images Publishing. Australia: [online] available from <https://books.google.co.uk/books/about/Cyberspace.html?id=8MPR2AEnM7sC&redir_esc=y> [13 Aug. 2025]

Elwardany, M., 2025. Bibliometric Analysis of Research Trends in Steam Boiler Efficiency Improvement. International Journal of Thermodynamics, 28(2), 115-128. DOI: https://doi.org/10.5541/ijot.1608741.

Graham S. & Marvin S., 1996. Telecommunication and the City. London and New York: Routledge: [online] available from <https://www.routledge.com/Telecommunications-and-the-City-Electronic-Spaces-Urban-Places/Graham-Marvin/p/book/9780415119030> [21 Jan. 2025].

Grant N. & Clarke A., 2010. Biomass - a Burning Issue. Retrieved April 22, 2012, from AECB building Knowledge: [Online] available from <http://www.aecb.net/publications/biomass-a-burning-issue/> [17 Sep. 2025].

Karakounos A., Dimoudi S. & Zoras A., 2017. The Influence of Bioclimatic Urban Redevelopment on Outdoor Thermalcomfort, Energy and Buildings. DOI: https://doi.org/10.1016/j.enbuild.2017.11.035.

Kasun H. & Mamta M., 2022. Adoption of Artificial Intelligence in Smart Cities: A Comprehensive Review. International Journal of Information Management Data Insights. 2. 1-21. DOI: https://doi.org/10.1016/j.jjimei.2022.100076.

Komninos N., 2008. Intelligent Cities-Building 3rd Generation Systems of Innovation. URENIO. Aristotle University.

Kumar R., Sinha A., Singh B. & Modhukalya U., 2008. A Design Optimization Tool of Earth-to-Air Heat Exchanger Using a Genetic Algorithm. [CrossRef] Renew. Energy, Vol. 33, No. 88. DOI: https://doi.org/10.1016/j.renene.2008.01.006.

Mahmood M. & Al-saatee, Hayam & Al-Bakry, Jaber H. & Sabur, Ali & Al-Helli, Marwah & Al-Graiti, Ali & Mohammed, Ali & Ismaeel, Zeyad & Mohson, Zainab & Ali J., 2025. The Importance of Empowering the Smart City in Iraq: A Case Study of Baghdad Municipalities. International Journal of Sustainable Development and Planning. 20. 1133-1141. DOI: doi.org/10.18280/ijsdp.200319.

Mahmoudi M., 2005. Wind Tower as a Natural Cooling System in Iranian Architecture, Proceeding of Passive and Low Energy Cooling in Buildings. Conference, Greece.

Nam T. & Pardo A., 2011. Smart City as Urban Innovation Focusing on Management, Policy and Context. DOI: doi.org/10.1145/2072069.2072100.

Park K. & Kim S., 2018. Utilising Unused Energy Resources for Sustainable Heating and Cooling System in Buildings: A Case Study of Geothermal Energy and Water Sources in a University. [CrossRef] Energies, Vol. 11, No. 36.

Raheem, M. I., Zheng, X., & Wood, C., 2026a. Harnessing Thermal Stress for Sustainable Zero-Energy Building Design in Iraq. Green Technology & Innovation, 2(1), pp. 176–188. DOI: https://doi.org/10.65582/gti.2026.010.

Raheem, M., & Raheem, M. I., 2026. Artificial Intelligence-Powered Smart City Transformation: A Framework and Comparative Case Study Analysis. Artificial Intelligence for Sustainable Cities, 1(1), pp.105–118. DOI: https://doi.org/10.65582/aifsc.2026.007.

Raheem, M., Zheng, X., & Wood, C., 2026b. Geothermal–Passive Hybrid Cooling via Courtyard-Integrated EAHE: A CFD-Based Framework for Low-Energy Residential Construction in Hot, Arid Areas. Research and Reviews in Sustainability, 2(1), pp.125–136. DOI: https://doi.org/10.65582/rrs.2026.009.

Raheem, M., Zheng, X., & Wood, C., 2024. Using Thermal Propulsion to Build Zero-Energy Structures in Iraq. "SET2024: 21st International Conference on Sustainable Energy Technologies 12 to 14th A ugust 2024, Shanghai, China: Sustainable Energy Technologies 2024 Conference Proceedings. Volume 1", pp. 375- 383: [Online] available from <https://nottingham-repository.worktribe.com/output/42837471> [15 April 2026].

Recnagel, 2022. Sprenger, Schramek Taschenbuch fur Heizung + Klima Technik, 80. Ausgabe 2021/2022: [Online] available from <https://www.bookcity.pl/recknagel-taschenbuch-fur-heizung-und-klimatechnik-80-ausgabe-2021-2022-premiumversion/pid/A40378540> [15 Dec. 2025].

Reim A., Beck B., Korner W., Petricevic R., Glora M., Weth M., Schliermann T., Fricke J., Schmidt C. & Potter F., 2002. Highly Insulating Aerogel Glazing for Solar Energy Usage. Solar Energy, Vol. 72, No. 1. DOI: doi.org/10.1016/S0038-092X(01)00086-X.

Riffat, S., Oliveira, A., Jarimi, H., Razak, T. R., Riffat, J., & Chen, Z., 2026. Editorial: Advancing Energy Access, Innovation, and Sustainability. Energy Catalyst, 2. DOI: https://doi.org/10.65582/ec.2026.001.

Saffari H. & Hosseinnia A., 2009. SM. Two-Phase Euler–Lagrange CFD Simulation of Evaporative Cooling in a Wind Tower. Energy Build. DOI: doi.org/10.1016/j.enbuild.2009.05.006.

Serpoushan S. & Yaghoubi M., 2012. Solar Energy Calculation on 3D Surfaces. Iran. Energy Journal. Vol. 1, No. 13.

Shen, Y., & Yang, H., 2026. Performance Analysis of Indoor CO_2 Capture Methods across Operational Contexts for Building Emissions Reduction. Global Decarbonisation, 2(1), 1–19. DOI: https://doi.org/10.65582/gd.2026.002.

Taylor T., Counsell J., Geens A., Gill S. & Oakley G., 2012. Checking "Fabric First" Really Works: In Construction Tests Using Thermography. 33rd AIVC Conference "Optimising Ventilative Cooling and Air Tightness for (Nearly) Zero-Energy Buildings, IAQ and comfort". Copenhagen, Denmark.

Tommy K., 2003. Natural Ventilation in Buildings Architectural. Concepts. Consequences and Possibilities, Thesis of Doctorate Ingenior. URN: NBN: No.-7242.

Toudert F., 2005. Dependence of Outdoor Thermal Comfort on Street Design in Hot and Dry Climate. PhD Thesis, TU Dortmund University, Germany.

Walters D., 2011. Smart Cities: Smart Places, Smart Democracy: from Based Codes. Electronic Governance and the Role of Place in Making Smart Cities. DOI: https://doi.org/10.1080/17508975.2011.586670.

Wong P., Shimod Y., Nonaka M., Inoue M. & Mizuno M., 2008. Semi-Transparent PV: Thermal Performance, Power Generation, Daylight Modelling and Energy Saving Potential in a Residential Application. Renewable Energy 33. DOI: doi.org/10.1016/j.renene.2007.06.016.

Yovanof S. & Hazapis N., 2009. An Architectural Framework and Enabling Wireless Technologies for Digital Cities & Intelligent Urban Environments. Wireless Personal Communication. DOI: doi.org/10.1007/s11277-009-9693-4.