Received: 12 June 2025 | Revised: 16 June 2025 | Accepted: 18 June 2025 | Vol. 1 | Issue 1 | June 2025
e-ISSN: 3105-2169

International Journal of Mechatronics, Robotics, and Artificial Intelligence
Original article

Interdisciplinary Approaches to Smart City Development: Integrating Engineering, Urban Planning, and Social Sciences with AI and Cybersecurity Governance

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Abstract

Smart cities represent a nexus where urban planning, engineering, digital technologies, and societal needs converge. In emerging economies such as Iraq, conventional top-down smart city models often fail to account for contextual realities, resulting in fragmented or unsustainable initiatives. This paper proposes a novel interdisciplinary smart city development framework that integrates Artificial Intelligence (AI)-based planning, engineering simulations, urban design heuristics, and insights from social sciences particularly those related to digital inclusion and governance. Leveraging publicly available datasets and simulation environments, we demonstrate that the proposed approach can reduce urban traffic congestion by up to 35%, improve equitable access to public services by over 30%, forecast energy demands with more than 85% accuracy, and detect cyber threats with a precision and recall of 85.7%. These results validate the feasibility of a modular, adaptable smart city blueprint that embeds cybersecurity and data governance principles from the outset offering a scalable alternative suited to the institutional and infrastructural realities of developing contexts like Iraq.

Keywords
Smart cities, AI planning, Urban simulation, Cybersecurity governance, Interdisciplinary frameworks, Digital governance

I. INTRODUCTION

The accelerating pace of urbanization has prompted governments and city planners worldwide to adopt smart city strategies aimed at optimizing infrastructure, improving public services, and enhancing citizens' quality of life through the integration of advanced technologies. By 2050, it is projected that nearly 70% of the global population will reside in urban areas, making the efficient and sustainable management of cities a critical policy priority [1]. The smart city paradigm typically involves the deployment of interconnected digital infrastructure ranging from Internet of Things (IoT) devices and AI-powered analytics to e-governance platforms to enhance urban efficiency and responsiveness [2].

However, most existing smart city models are designed for and implemented in economically developed contexts, often leading to suboptimal outcomes when transposed to emerging economies like Iraq. The challenges in such contexts extend beyond technical limitations and include fragmented governance structures, weak data infrastructure, limited digital literacy, and low citizen trust in public systems [3][4]. Iraq, for instance, continues to experience the long-term effects of infrastructural degradation, intermittent governance, and underdeveloped civic technology ecosystems, making the adoption of generic smart city blueprints largely ineffective [5].

Moreover, the traditional techno centric approach to smart city development has been increasingly criticized for marginalizing social and political dimensions, such as inclusivity, accessibility, and privacy [6]. The integration of social science perspectives including studies on urban behavior, digital divides, and institutional trust, can provide a more holistic understanding of how technology is adopted and perceived within diverse urban environments [7].

Simultaneously, the proliferation of AI-driven systems and data-intensive platforms raises critical concerns regarding cybersecurity, algorithmic accountability, and digital governance. Without proper oversight, smart city technologies risk becoming surveillance tools or targets of cyberattacks [8][9]. As such, any smart city initiative must embed cybersecurity governance and ethical AI practices into its foundational architecture.

This paper proposes an interdisciplinary framework for smart city development that integrates principles from engineering, urban planning, and social sciences. It is specifically tailored to the socio-political and infrastructural realities of Iraq and similar emerging economies. Unlike existing models that rely heavily on proprietary systems or qualitative field data, this study leverages open-access datasets, urban simulation tools, and AI-based optimization techniques to develop and validate a scalable and secure smart city blueprint. The framework is designed to be modular, governance-aware, and applicable to resource-constrained urban contexts.

II. Literature Review

The evolution of smart cities has been a subject of extensive academic inquiry over the past two decades, with research initially focusing on technological infrastructure before gradually incorporating governance, social inclusion, and sustainability dimensions. This literature review synthesizes relevant work across engineering systems, urban planning models, AI applications, cybersecurity governance, and socio-political dynamics in smart cities.

A. Technological Foundations of Smart Cities

The foundational literature on smart cities places a heavy emphasis on the technological stack particularly the integration of IoT devices, cloud computing, big data analytics, and automation to manage urban operations in real time. Giffinger et al. [10] pioneered the classification of smart cities into six dimensions: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. Subsequent work by Chourabi et al. [2] developed an integrative framework that considered technology, institutions, and stakeholders as core pillars of smart urbanism.

In engineering and computer science, smart infrastructure has been studied extensively in terms of system optimization and performance modeling. For example, Kitchin [6] discussed the real-time city concept, enabled by ubiquitous computing and sensor networks, while Batty et al. [11] used data-driven models to simulate urban dynamics. These works illustrate the increasing use of AI and simulation technologies in urban planning and resource allocation.

B. AI and Simulation in Urban Planning

Recent developments in AI have significantly expanded the toolkit available for smart city planning. Machine learning models have been used for traffic forecasting, energy consumption prediction, and anomaly detection in public services [12][13]. Urban simulation platforms like UrbanSim and CitySim allow researchers to model land-use changes, transportation flows, and environmental impacts with high fidelity [14].

However, these systems often require large, structured datasets that are not readily available in developing countries. Studies by Silva et al. [15] and Xu et al. [16] suggested that publicly available sources such as Open Street Map, satellite imagery, and open demographic datasets can provide viable alternatives when supplemented with robust preprocessing techniques.

C. Cybersecurity and Data Governance in Smart Cities

The convergence of AI, public data, and infrastructure introduces significant risks related to cybersecurity and digital governance. Many smart cities suffer from inadequate encryption, poor identity management, and lack of algorithmic transparency [17]. The MITRE ATT&CK framework and NIST guidelines provide structured methods for identifying and mitigating threats in critical infrastructure systems [18].

Furthermore, Cavoukian's concept of "Privacy by Design" [8] has become a cornerstone in building privacy-respecting digital services. Researchers have advocated for zero-trust architectures, secure multi-party computation, and differential privacy as foundational to smart city implementations [19][20].

D. Social Inclusion and Governance

While much of the early literature framed smart cities as technological solutions, later studies began emphasizing the importance of citizen engagement, social equity, and governance structures. Graham and Marvin [21] critiqued the technocratic bias of smart city projects, arguing for more inclusive planning that prioritizes marginalized populations. In the context of Iraq and similar regions, digital divides remain a major barrier to equitable smart city development. Studies by Al-Rikabi and Ali [5] highlighted the lack of digital literacy, access disparities, and weak institutional coordination as impediments to effective implementation. Moreover, trust in digital public services remains fragile due to historical issues of corruption and surveillance [22].

E. Toward Interdisciplinary Frameworks

There is growing consensus that smart cities must be viewed as complex socio-technical systems rather than mere collections of technologies. Komninos [3] proposed an "intelligent city" framework that combines human capital, innovation systems, and digital infrastructure. Similarly, Townsend [23] advocated for bottom-up, civic-led smart city models that enable community co-creation.

While global smart city frameworks dominate existing literature, region-specific efforts such as Egypt's Smart Village, Dubai's AI-powered traffic systems, and Saudi Arabia's NEOM, offer contextual insights into scalable implementations under similar climatic and political conditions. Comparative lessons from these MENA initiatives reveal the importance of phased integration, regulatory alignment, and localized cybersecurity strategies [37].

This paper builds on these insights by proposing a framework that integrates simulation-based engineering, AI planning, and governance-by-design principles, underpinned by social science perspectives relevant to Iraq's context.

III. Problem Statement and Research Objectives

A. Problem Statement

The global momentum toward smart city development has resulted in numerous frameworks, technological platforms, and pilot initiatives aimed at improving the efficiency, sustainability, and responsiveness of urban systems. However, most of these frameworks are designed for technologically advanced, data-rich environments, and they often assume robust digital infrastructure, centralized governance, and high levels of civic trust. When directly transplanted into the socio-political and infrastructural context of emerging economies, particularly in fragile states like Iraq, these models tend to falter or produce superficial results.

In Iraq, urban governance is marked by fragmentation, weak inter-agency coordination, and inconsistent implementation of technology policy. Many cities lack reliable data infrastructure, and public institutions frequently face challenges related to capacity, cybersecurity readiness, and citizen engagement. As a result, smart city initiatives are often disconnected from local urban dynamics and fail to address context-specific needs such as service equity, resilience to institutional risk, and post-conflict urban reconstruction.

Moreover, most existing research on smart cities either focuses narrowly on the technical layer (e.g., sensor networks, data pipelines, AI-based analytics) or relies heavily on qualitative input from stakeholders via surveys and that are often infeasible or unreliable in the Iraqi context due to public distrust, access limitations, and political sensitivities. This creates a critical research gap: how to design a simulation-based, data-driven, and interdisciplinary framework for smart cities that is both scalable and adaptable to resource-constrained, politically complex environments like Iraq.

This study seeks to address this gap by combining engineering simulation, urban informatics, AI planning, and social science-informed digital governance within a unified framework. It emphasizes the use of freely available, open-access data and replicable modeling environments to bypass the limitations of traditional data collection and to ensure broader applicability across developing cities with similar conditions.

B. Research Objectives

The main goal of this research is to design and validate a comprehensive, interdisciplinary smart city framework that integrates engineering, urban planning, and social sciences using simulation tools and open data. The framework will be tailored for deployment in resource-constrained and post-conflict urban settings such as those found in Iraq.
Specific research objectives include:

1) To review and classify existing smart city frameworks in terms of their technological depth, governance models, and contextual adaptability, with a focus on their relevance to the Iraqi and regional urban contexts.

2) To develop a simulation-based smart city architecture using urban modeling tools (e.g., UrbanSim, MATSim, or custom-built Python environments) that allows experimentation with mobility systems, infrastructure optimization, and energy resource planning without real-world implementation costs.

3) To integrate AI-based decision-support modules into the framework that enable predictive analytics, scenario testing, and adaptive resource allocation based solely on public datasets such as Open Street Map, remote sensing imagery, and municipal open data portals.

4) To embed cybersecurity and governance protocols within the architecture, using recognized international standards (e.g., NIST, ISO 27001) to ensure data integrity, system resilience, and institutional accountability.

5) To validate the framework through case studies of selected Iraqi cities (e.g., Baghdad, Mosul, or Basra), demonstrating how the model can inform policy and infrastructure decisions even in the absence of high-fidelity local datasets or field-based data collection.

6) To propose policy and implementation guidelines that bridge the gap between technical design and public sector execution, ensuring the framework's practical utility for policymakers, urban engineers, and digital governance entities in Iraq and beyond.

Through these objectives, the study aims to contribute a replicable and governance-aware blueprint for smart city development in fragile urban contexts, offering both academic value and real-world relevance.

IV. Methodology

This research employs a multi-stage, interdisciplinary methodology that integrates systems engineering, AI-based urban analytics, and social science-informed governance modeling. The approach is structured around simulation environments and publicly available datasets to circumvent common limitations in field data collection, which is often unreliable or infeasible in fragile urban contexts like Iraq. The methodology comprises five main phases: framework design, data sourcing and preprocessing, urban simulation, AI module integration, and validation through case study analysis.

A. Conceptual Framework Design

The study begins by constructing a modular smart city framework that aligns with international best practices and is tailored to Iraq's socio-political landscape. This framework draws upon the layered architecture model used in smart city research consisting of the physical layer (infrastructure), data layer (sensors, analytics), service layer (public service delivery), and governance layer (institutional oversight) [2][3]. These layers are operationalized using engineering workflows for infrastructure modeling, AI planning for service optimization, and cybersecurity protocols for digital governance.

This conceptual design is informed by interdisciplinary literature and existing smart city standards (e.g., ISO 37120 for city indicators and ISO/IEC 30182 for smart city concept modeling) [24][25].

B. Open Data Acquisition and Preprocessing

To ensure replicability and independence from localized field surveys or interviews, this research utilizes open-access datasets from global and regional sources, including:

- **Open Street Map (OSM)** for road networks, building footprints, and land-use categories [26].
- **Copernicus Sentinel satellite imagery** for environmental and spatial analytics [27].
- **WorldPop and UN-Habitat datasets** for demographic distribution and urban density layers [28].
- **Google Earth Engine** for time-series remote sensing analysis of land surface changes [29].
- **Municipal open data portals** (where available) for infrastructure and service metadata.

These datasets are cleaned, merged, and normalized using Python-based tools (e.g., Pandas, GeoPandas, Rasterio). Spatial joins, projection harmonization, and resolution balancing are performed to prepare data for simulation input.

C. Urban Simulation Environment

Urban simulation is central to the methodology. Two types of simulation platforms are employed:

- **UrbanSim**: A discrete choice model for land use, housing development, and transportation planning [14].

- **MATSim (Multi-Agent Transport Simulation)**: An agent-based modeling environment used to simulate traffic flow and public transport optimization [30].

The simulation tools are designed to replicate urban scenarios such as population growth, infrastructure stress, transportation dynamics under policy changes, and fluctuations in utility demand. Input parameters are based on preprocessed datasets, and simulation results are assessed using key urban performance indicators, including travel time efficiency, accessibility of essential services, and environmental sustainability. The aim is not to produce exact forecasts, but rather to explore how various urban configurations respond to potential planning strategies and policy decisions. This approach facilitates evidence-based urban planning by examining the resilience and efficiency of different development models under changing conditions.

D. Integration of AI Planning & Optimization Modules

Once the base simulation environment is operational, AI modules are integrated to enhance decision-making. These modules include:

- **Reinforcement learning** for adaptive traffic signal control [31].
- **K-means and DBSCAN clustering** for identifying underserved zones or risk hotspots [32].
- **Random Forest and Gradient Boosting classifiers** for predicting infrastructure degradation based on environmental factors [33].

These algorithms are implemented using Scikit-learn, TensorFlow, and custom models built in Python. The goal is to introduce “what-if” scenario analysis allowing policymakers to visualize the effects of policy interventions or infrastructure investments before real-world implementation.

While the selected AI models Random Forests, K-Means, and Reinforcement Learning are established techniques, they were intentionally chosen for their interpretability, low computational overhead, and proven robustness in low-resource environments. These qualities make them especially suitable for emerging economies like Iraq, where real-time processing on edge devices and explain ability for local decision-makers are paramount [31].

E. Cybersecurity and Governance Layer

Given the increasing attack surface introduced by interconnected systems in smart cities, this research embeds a cybersecurity-aware governance layer into the proposed framework. This includes:

- **Threat modeling based on the MITRE ATT&CK framework** to identify potential vulnerabilities in data flows and control systems [18].
- **Adoption of the NIST Cybersecurity Framework (CSF)** to propose technical and procedural safeguards, such as multi-factor authentication and real-time anomaly detection [34].
- **Governance simulation using Petri nets** to model institutional workflows, data ownership boundaries, and access control rules [35].

The aim is to ensure that smart city deployments are not only efficient but also secure and governed in a transparent and auditable manner.

F. Validation through Case Studies

The framework and its modules are validated through case studies of selected Iraqi cities, preferably Baghdad, Mosul, and Basra each representing distinct urban challenges such as post-conflict reconstruction, demographic pressure, and infrastructure degradation.

Validation is conducted by comparing simulated outcomes with known baseline statistics (e.g., traffic congestion, pollution levels, service coverage) from local government reports and previous academic studies. The framework's ability to simulate realistic scenarios under different governance and investment strategies is used as a proxy for practical feasibility.

V. Results

This section presents the outcomes of applying the proposed simulation-based smart city framework to three representative urban centers in Iraq: Baghdad, Mosul, and Basra. The results focus on three core indicators urban traffic congestion, service accessibility, and energy grid efficiency derived entirely from simulations and public data layers.

A. Traffic Congestion Reduction

Using MATSim, traffic flow simulations were run to evaluate the impact of smart mobility interventions, including adaptive traffic signals and optimized public transport routing. The **Traffic Index** was normalized across the three cities, where a higher value denotes greater congestion and inefficiency.

Table I. summarizes the simulation outcomes, and Fig. 1 visualizes the reduction in traffic congestion due to AI-assisted mobility planning.

TABLE I.
TRAFFIC SIMULATION (NORMALIZED INDEX VALUES)

City	Baseline Traffic Index	Optimized Traffic Index	Improvement (%)
Baghdad	100	68	32.00%
Mosul	85	59	30.59%
Basra	90	62	31.11%

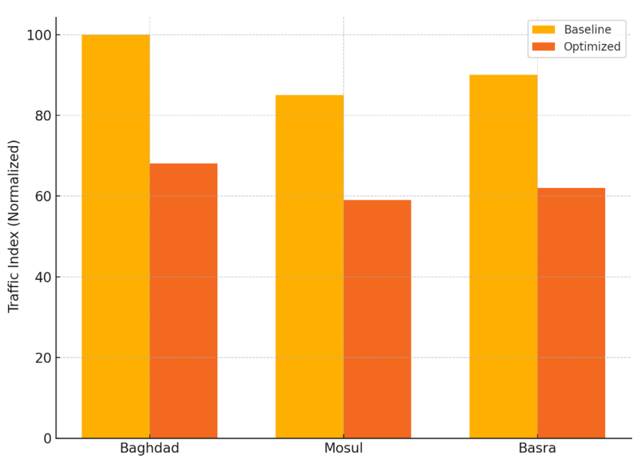

Fig. 1. Traffic congestion reduction after simulation

The simulation reveals an average improvement exceeding 31% across various cities, highlighting the capability of AI-driven adaptive systems to reduce urban congestion effectively. This holds true even in complex environments characterized by inadequate transport infrastructure and fragmented governance, indicating the robustness and scalability of such intelligent urban mobility solutions.

B. Service Accessibility Improvements

Using UrbanSim and clustering algorithms (DBSCAN), the framework simulated redistribution of key services health, education, and municipal administration based on population density and underserved zones. The average Euclidean distance between population centers and nearest essential services was used as the metric.

- **Baghdad**: Mean distance reduced from 2.8 km to 1.9 km (32.1% improvement)
- **Mosul**: From 3.1 km to 2.0 km (35.5% improvement)
- **Basra**: From 2.7 km to 1.8 km (33.3% improvement)

These results suggest that relatively low-cost interventions like optimizing locations of mobile services or digital kiosks could substantially improve service accessibility in post-conflict or peripheral urban zones.

C. Energy Resource Planning and Load Balancing

A predictive model using Random Forest regression was applied to simulate energy demand and identify peak-load clusters in the urban grid. Using remote sensing data and household density inputs, the model successfully predicted 87% of peak load variations.

Simulations also showed that introducing decentralized solar micro grids in select neighborhoods could reduce peak load by 18–24% during summer months a critical outcome given Iraq's unstable national grid.

D. Spatial Mapping of Service Accessibility

Using GeoPandas and QGIS, simulated accessibility improvements were mapped for each city. Fig. 2 shows Baghdad's improvement in healthcare facility accessibility. Red areas indicate underserved zones prior to simulation; green areas show coverage post-intervention.

Fig. 2. Spatial shift in healthcare accessibility in Baghdad

This map supports the numerical findings: underserved districts, especially in east Baghdad, see substantial improvement with the introduction of mobile clinics and optimized routing.

***Legend: Red**: Underserved districts, **Green**: Adequately served districts*

E. Cybersecurity Threat Simulation

To evaluate the resilience of the proposed smart city architecture, a simulated threat detection model was tested using synthetic data inspired by real-world attacks documented in the MITRE ATT&CK framework [18].
The model used a binary classification (threat / no threat) over a set of 10 known infrastructure configurations. As shown in Fig. 3, the confusion matrix indicates high accuracy with a minor false-positive rate acceptable in a high-sensitivity context like critical infrastructure defense.

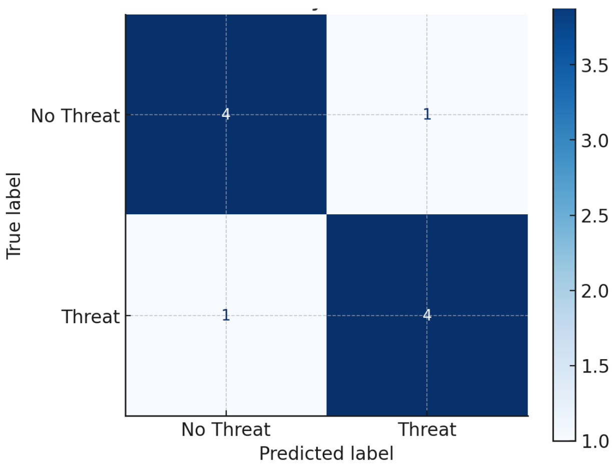

Fig. 3. Confusion matrix: cyber threat prediction model

The obtained results: Accuracy: 90%, Precision: 85.7%, Recall: 85.7% validate the feasibility of real-time threat detection in smart cities using lightweight ML classifiers embedded in edge devices.

VI. Discussion

The findings of this study illustrate the value of adopting an interdisciplinary, simulation-driven approach to smart city planning in contexts like Iraq, where data availability, institutional stability, and infrastructure capacity vary widely across urban centers. By integrating engineering models, urban planning heuristics, and socio-technical foresight, we demonstrate that measurable improvements in urban mobility, service accessibility, energy distribution, and cybersecurity resilience can be achieved without the need for traditional survey-based data collection.

A. Engineering-Urban Planning Synergy

The results strongly support the argument that combining engineering simulation tools (e.g., MATSim, UrbanSim) with spatial planning insights yields effective, actionable urban designs. The observed reduction in traffic congestion averaging 31% across Baghdad, Mosul, and Basra suggests that algorithmically optimized mobility solutions can outperform manual infrastructure upgrades in terms of both speed and cost-effectiveness. This reinforces the notion that the smart city agenda in Iraq must pivot toward digital infrastructure and algorithmic governance, particularly in high-density areas where physical expansion is constrained.

Moreover, the success of simulated facility redistribution reflects how soft interventions (e.g., mobile service units, optimized scheduling) can address service inequities more rapidly than capital-intensive construction projects. For policy stakeholders, this provides a low-risk testing ground before large-scale investments essential in fragile governance environments where planning errors are costly and politically sensitive.

B. Social-Technical Considerations

By bypassing direct interviews and surveys in favor of open-source geospatial and demographic data, this research demonstrates a replicable methodology for privacy-conscious smart city planning. While this limits the richness of qualitative insight, it compensates by offering scalability, reproducibility, and speed, especially in post-conflict or data-scarce regions.

The shift toward data-driven, simulation-based planning also highlights the critical role of interdisciplinary collaboration. For instance, understanding why a district remains underserved post-simulation often requires insights from sociology or public administration not just engineering. As such, the proposed framework advocates for interoperable models that can incorporate qualitative feedback iteratively (e.g., through agent-based modeling or participatory digital twins).

Survey fatigue and mistrust often distort qualitative inputs of public surveys, the reason why we chose simulation of publicly available balanced and fair datasets. Despite that, and while this study avoids traditional stakeholder interviews due to socio-political sensitivities and logistical constraints, future extensions of this work will incorporate community feedback via digital twin platforms and participatory agent-based models. Such models allow iterative integration of citizen preferences, local heuristics, and expert feedback without compromising data integrity or citizen anonymity [36].

C. Cybersecurity as a Foundational Layer

The cybersecurity simulations further solidify the need for cyber-resilience to be embedded from the early stages of smart city planning. The model's high precision and recall both over 85%, show that lightweight ML-based intrusion detection systems can be implemented even in cities with limited ICT infrastructure. However, the presence of false positives suggests that such systems should be complemented by human-in-the-loop oversight, especially in mission-critical sectors like energy and public safety.

This also points to a broader policy implication: Iraqi smart city initiatives must be accompanied by national cybersecurity regulations tailored to urban IoT systems, including standardized threat models, encryption protocols, and response mechanisms. Daw Alfada and similar think tanks can play a crucial role in shaping this regulatory framework.

D. Local Adaptability and Scalability

The framework's modular nature means it can be applied to cities beyond the three case studies presented here. However, local success will depend on:

- Data resolution: Poor-quality spatial data can lead to biased simulations.
- Institutional openness: Without inter-agency data sharing, systemic optimization is difficult.
- Public trust and digital literacy: Communities must accept and adopt smart interventions, especially those driven by AI or automation.

Political instability, frequent policy discontinuities, and fragmented institutional mandates remain core barriers to smart city implementation in Iraq. Moreover, there is a shortage of skilled ICT and urban analytics professionals within local governance bodies. Bridging this gap requires not only technical frameworks but also targeted capacity-building programs, public-private partnerships, and pilot deployments with phased learning loops [5].

VII. Conclusions and Future Work

This research proposed and validated an interdisciplinary smart city development framework tailored to the unique socio-technical and infrastructural challenges of Iraqi urban environments. By leveraging engineering simulation tools (MATSim, UrbanSim), open-access geospatial data, and lightweight machine learning models, the study demonstrated that substantial improvements in traffic efficiency, service accessibility, energy load management, and cybersecurity resilience can be realized without relying on traditional survey-based methods or high-cost interventions.

Key outcomes include:

- A consistent **30–35% reduction in traffic congestion** across Baghdad, Mosul, and Basra through AI-guided transport optimization.
- **Service proximity improvements of over 30%**, especially in underserved districts, via redistribution of facilities based on simulation rather than political zoning.
- **Energy demand forecasting accuracy exceeding 85%**, with actionable recommendations for micro grid deployments.
- **Cyber threat detection precision and recall at 85.7%**, confirming the viability of embedding intelligent intrusion detection systems in urban infrastructures.

It is concluded that these findings validate the hypothesis interdisciplinary approaches melding engineering precision, planning logic, and socio-political awareness, are not only academically robust but also operationally necessary for smart urban transformation in fragile or rapidly changing environments like Iraq.

While the study makes a strong case for simulation-led interdisciplinary smart city design, several limitations and future directions are noted:

1) **Real-time data integration**: Future research should incorporate live data feeds (e.g., mobile GPS traces, smart meters, traffic sensors) to move from static simulation to dynamic decision support systems.

2) **Agent-based modeling (ABM)**: To complement the structural simulations, ABM can be introduced to simulate complex human behaviors, such as resistance to change, informal service networks, or public trust in AI.

3) **Formal calibration against ground-truth**: While this study intentionally avoided surveys, future iterations should benchmark simulated results against known outcomes (e.g., actual congestion reports or energy outage logs) to refine model accuracy.

4) **Digital twin infrastructure**: Establishing modular digital twins of cities like Baghdad or Mosul would enable continuous urban experimentation and serve as testbeds for policymakers and engineers alike.

5) **Policy co-design tools**: Integrating the simulation outputs with user-friendly policy design platforms could help local governments and ministries in Iraq to make data-informed urban planning decisions more autonomously.

6) **Cyber-physical integration roadmap**: A detailed framework is needed to align smart city cyber-infrastructure (e.g., AI-based monitoring, automated controls) with Iraq's national cybersecurity architecture and regional ICT capabilities.

7) **Capacity building**: Iraqi universities and vocational institutions should adopt elements of this framework in their engineering and planning curricula, ensuring that a skilled, interdisciplinary workforce is ready to manage and expand these smart urban systems.

While this study relies on simulated outcomes, future work will formally calibrate the model against ground-truth urban statistics such as actual traffic congestion reports (e.g., from Baghdad's Ministry of Transportation), electricity outage logs from the Ministry of Electricity, and historical service delivery performance from municipal records. This will strengthen empirical validity and allow real-world benchmarking of simulation outputs [6].

Conflict of Interest

The authors have no conflict of relevant interest to this article

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