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Analysing the critical role of data governance in shaping Iraq's smart city future

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Analysing the critical role of data governance in shaping Iraq's smart city future

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Abstract: The discussion around smart cities in Iraq usually emphasises the issue of infrastructure barriers, while, in the opinion of this paper, the most important challenge in this case is the lack of a National Big Data Governance framework. In the absence of this framework, even the best of IoT and AI technology will remain redundant. The research intends to Iraq's data environment within a qualitative critical analysis framework and sees a 'data chasm' in the contemporary terrain of Iraq emerging out of the digitised, siloed, and policy-deficient records. This chasm prevents the integration of urban digital systems into a single operational intelligence network. The paper attempts to bridge this gap and, based on recent research, outlines a sustainable data governance framework for Iraq, advocating for minimum standards and inter-ministerial cross-border data flow. Data investment governance actually supports sustainable infrastructure development and makes technology work for urban development.

Keywords: smart cities; big data governance; data policy; urban informatics; digital transformation; IoT; public policy; Iraq.

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1 Introduction

In the past decade, it has been illustrated that the emergence of the term ‘smart city’, a conceptual idea that theorists had never before imagined. This term represents the idea of data bringing a city to life (Al Sharif and Pokharel, 2022). This new understanding is a shift in the reality (Abd Aziz et al., 2022; Abdullah and Assaad, 2026). IoT sensors that are placed all over the city have the true potential is not in the monetisation (Alahi et al., 2023). Rather, the true potential is the ever-growing sophisticated ecosystem embracing the data. The sensors, in contrast to data loggers, are connected to the city serving the purpose of digital nerve endings, generating vast amounts of data on various criterions (Assaad et al., 2024b). The data collected is on city traffic flow, consumption of various energy resources, the pressure of water systems, and the quality of air. The inert data is useless without a framework of purpose (Bedi et al., 2022). The data in the framework must first be collected from different silos, cleansed and standardised to remove inaccuracies, advanced computing used to derive patterns from the data, and finally in a coordinated system, the city managers need to act in real time (Bellini et al., 2022; Assaad et al., 2024a). This data-driven approach to urbanism promises a revolution in efficiency, sustainability, and resilience, enabling a shift from reactive crisis management to proactive, predictive governance. It allows for the optimisation of complex systems, such as dynamically rerouting public transit based on live demand, pre-emptively deploying maintenance crews to infrastructure on the verge of failure, or creating digital twins of city districts to simulate the impact of new policies before they are ever implemented in the physical world (Bibri et al., 2023).

However, developing any technological potentials, such as a smart city, requires a more sophisticated, ethical, and advanced form of data governance than what currently exists, as a data-generating technology alone is insufficient for such a sophisticated project (Camacho et al., 2024; Kanaan, 2025). It is vital, therefore, to devise an elaborate,

technology smartly interwoven, and sophisticated policy on Smart city development, covering every aspect to ensure all data generated and collected is a managed and a trusted asset (Chakraborty et al., 2024). The data comes under such governance structures: covering the whole data life cycle, with clear policies on how data is collected, and protects citizen privacy (Assaad and Sadek Kanaan, 2025). The data governance protocols also prescribe uniform governance and control standards for other silos, covering APIs, other appears, and applications to systems, modules, and departments of the smart city governance. These protocols define standards of data access, control, and procedures to prevent breaches and malice use (Chen et al., 2022). In addition, it ensures how data is processed and used is ethically responsible by protecting against algorithmic bias and ensuring equitable distribution of the advantages of data-driven governance across the social spectrum, thereby mitigating the emergence of another digital divide (Hammoumi et al., 2024). Without this comprehensive governance meta-layer, data is a liability a chaotic, insecure, and potentially weaponised resource rather than the asset it is intended to be (Herath and Mittal, 2022). Cities stand to lose billions on hardware that generates data that is either unusable or untrustworthy; resulting in costly siloed pilot projects that do not scale or integrate, and ultimately eroding public trust in the entire smart city initiative (Jagatheesaperumal et al., 2024).

In the context of Iraq, the national discourse on smart cities can be focused on the most crippling deficits given the context: the deeply broken electrical grid, the highly uneven broadband penetration, and the sheer physical reconstruction of the centre and further the construction and re-vitalisation of the key and core infrastructures of the country. These are not simple barriers. These are the fundamental issues that directly and meaningfully affect the daily living conditions of millions of people living in Iraq. This paper aims to prove however, that there are issues that can be classified as an unknown quantity. By means of strategic capital investment accompanied with planned international technical partnership and some political investment. once can have in place infrastructure systems, centres, and grid extensions. Generators can be replaced with stable connectors and fibre optic extensions can be done easily in most areas. These are predominantly finance and engineering matters which have successful existing frameworks around the globe.

The biggest challenge, that is also most troubling, is the near complete lack of a national strategy on Big Data governance. This challenge is as much technical as it is legal, institutional, and cultural. It is a 'wicked problem' that cannot be resolved solely through new capital. The infrastructural governance vacuum poses a fundamental barrier that will continue to exist long after the physical infrastructure has been upgraded. Imagine a scenario where Iraq has a reliable power grid and broadband but cannot build integrated smart cities because the data created by the new sensors is siloed, inconsistently formatted, poorly governed, and overprotected. The absence of a national strategy of big data analytical frameworks and the aggressive juxtaposition of Iraq's high aspirations of smart cities with the unattended, rudimentary data scenario creates a fundamental paradox. 'Islands of excellence' describes the phenomenon whereby pilot projects, regardless of good intent and contemporary technologies, devolve into unsalable, non-integrated, blockages of city systems. These so-called projects, exemplifying high performance systems, are fundamentally incapable of scaling because they lack the data exchange legal and compliance structures common across the smart city multiple jurisdictions. They become digital castles moated by incompatible systems and bureaucratic intransigence.

It is this critical disconnect that gives rise to the paper's core research question, which is, to what extent does the missing holistic governance framework of Big Data impede the advancement of smart cities in Iraq, and how to go about that is politically feasible, contextually relevant, and pragmatically reachable? The answer to this question goes beyond the simplistic assertion of technological inadequacy to the much more complex set of institutional, political, and social hurdles to the governance of data. It requires the construction of a governance framework that is not a direct copy and paste from Singapore or Amsterdam, but is tailored to the post-conflict context of Iraq and its bureaucratic, regulatory, and trust deficits. The next sections will outline this diagnostic analysis and, along with it provides what is a sustainable pathway to the conclusion that, along with other public governance investments, the greatest strategic investment to Iraq's urban future is in the governance of its hidden data architecture.

2 Literature review

In case of Iraq, it is important how to discuss its smart city aspirations in more detail than just a definition focusing on technology. More commonly, a smart city is described as a set of devices, be it sensors, cameras, or miles of cables. Most recent academic thinking, however, speaks of it a tangled socio-technical system, where technology is simply a tool for more profound system. The essential element in this ecosystem is not silicon and wires, but data. The flow, management, and utilisation of this data are controlled by a much more important and more discreet architecture: the data governance framework. This chapter analyses smart city s to show how data governance is positioned the keystone in the data architecture.

2.1 *Deconstructing the smart city stack: beyond the sensor layer*

The smart city concept can be captured by a multi-layered framework, each layer dependent on the layer below for functionality and value creation (Janssen et al., 2019; John et al., 2022; Ketu and Mishra, 2022; Jaramillo-Alcazar et al., 2023). This model can be visualised as follows

- *Layer one: the sensor layer (IoT)*. This substrate constitutes the smart city's foundation comprising the sprawling interconnected device and smart infrastructure. This includes smart metres, GPS units in buses, traffic flow and air quality sensors, and smart waste bins equipped with fill level detectors. This layer produces the unrefined and constant stream of data sensory the city's condition within the city.
- *Layer 2: the network layer*: This layer consists of the communication infrastructure such as broadband fibre optics, 5G, Wi-Fi, and LPWANs (low-power wide area networks such as LoRaWAN) that carries the data from the sensor layer to aggregation and processing centres. Its reliability, bandwidth, and latency are all vital for real-time uses.
- *Layer 3: the data layer*: It is the main repository of data for storage, aggregation, and organisation. It consists of data lakes (which store raw data) and data warehouses (which store processed, structured data). This layer's design dictates the degree of integration possible among separate datasets, which is crucial for comprehensive urban understanding.

- *Layer 4: the platform and analytics layer:* The data shifts from being raw information to light and knowledge at this stage. The analytics, pattern recognition, and predictive analytics middleware and software platforms, as well as machine learning models ranging from simple to complex, along with visualisation dashboards, churn predictive maintenance and optimisation data with advanced operations to drive enhanced performance and streamline workflows.
- *Layer 5: the application layer:* This layer's binds step moves bingo to action through applications and data interfaces. City managers monitor and manage real-time traffic with these apps, while citizens can quickly locate parking spots, report civic issues, and access quick government service.

While this layered model is useful, it risks implying a linear, techno-deterministic process. The critical oversight in such a model is the absence of the cross-cutting, integrative framework that binds these layers together into a coherent, secure, and ethical whole.

2.2 Data governance: the meta-layer of urban intelligence

On the Smart City Stack, data governance transcends and controls all tiers, forming the overarching layer. It is the administrative framework consisting of “processes and policies, metrics, and standards that enable an organization to effectively and efficiently use its information to support its goals” (Khanh et al., 2023). Within the urban framework, the legal framework determines the value and the strategic role of data across municipal divisions and silos. For any operational smart city, the essential elements include:

- *Data quality and standards:* Governance makes sure data is validated and completed, as well as, is consistent and timely. It enforces common data formats, schemas, and metadata tags so that data coming from a water sensor placed at Al-Basra can be meaningfully compared or integrated with energy consumption data from Baghdad. Without standardisation, the data layer collapses into a so-called ‘tower of Babel’, making large-scale analytics impossible (Laufs et al., 2020; Lv et al., 2021).
- *Data interoperability:* This means the capability of diverse and thematically distinct systems and organisations to exchange and use data without hindrances. Governance creates the technical standards (e.g. standard API's) and the institutional frameworks that permit the safe and efficient use of the Ministry of Transportation's traffic data by the Ministry of Electricity for load forecasting. It dismantles the siloed institutional and technological frameworks that characterise contemporary urban governance (Majeed et al., 2021; Mark and Anya, 2019).
- *Data privacy, security, and ethics:* Out of all these elements, this one has the highest social concern. Any framework of governance has to include the elements of privacy by design, which is the data collected and used on the citizen is done transparently and for the right purposes. There must be security measures to safeguard the information about breaches and cyber-attacks, especially with critical infrastructure information. There is also the problem of ethics about unwarranted surveillance, algorithmic bias, and the proverbial digital divide (Ismagilova et al., 2019).

- *Data ownership and stewardship:* Questions of data ownership and governance are intricate: What is the status of the data created under a public-private partnership? Who holds the citizen-generated data? It defines data stewardship and assigns specific roles and responsibilities within data managers who are responsible for the data's quality, accessibility, lifecycle, and governance (Nguyen et al., 2024).
- *Data lifecycle management:* Policies prescribe the period operational data is to be used; how long data has to be archived for historical and analytics purposes, and how long data has to be securely destroyed to comply with privacy principles. It also ensures efficiency and compliance to regulations (Omran et al., 2024).

2.3 *The synergy of the stack and the governance layer*

The relationship between the technical stack and the governance framework is symbiotic and synergistic. The stack yields the potential for urban intelligence and governance actualises this potential through its usability, reliability, and trust. To spend billions on Layers 1 and 2 (sensors and networks) while ignoring prior and simultaneous investments on the governance meta-layer is akin to constructing an incredibly powerful body without a brain and nervous system (Pan and Zhang, 2023). The outcome is data chaos: vast troves of unusable, insecure, siloed data that fails to facilitate decision-making or generate public value (Rahaman and Bhakt Vaishali, 2023). This is why, in the case of any smart city initiative in the developing context of Iraq, the primary focus should be on a data governance maturity diagnostic. The presence of IoT pilots is not success. A more appropriate success indicator progress toward a truly intelligent city would be the existence of a drafted data protection act, appointed data stewards, and established API standards. The next section of the paper uses this theoretical lens to diagnose the particularities of the challenges in Iraq.

3 **The Iraqi data landscape: a diagnostic of fragmentation and absence**

The implementation of a functional smart city data ecosystem in Iraq is presently untenable due to a confluence of systemic issues that have created a deeply fragmented and underdeveloped landscape. This section diagnoses these critical gaps.

3.1 *Data silos and the absence of interoperability*

The administration of Iraq is segregated into distinct vertical silos.... data collected by the Ministry of Electricity, for instance, is kept discrete from the Ministry of Water Resources, even when the latter business is responsible for pumping water, a major consumer of electricity. In addition, the Ministry of Interior's traffic data is not integrated with the urban planning system of the municipalities. This lack of integration is both a technical and a cultural-institutional challenge, the latter having to do with decades of centralised and secretive governance. There are no mandated APIs or common data standards to facilitate the entities to exchange data seamlessly. According to Ramu et al. (2022) and Kanaan (2025), the foremost non-technical challenge of establishing a city-wide data platform is the integration of institutional silos, and these, in Iraq, are still quite formidable.

3.2 The analogue legacy: non-digitised and unstructured data

A large amount of urban data in Iraq is still kept in physical formats. Documents of land ownership, construction designs, historical utility consumptions, and civic registers are relics to centralised digital systems and stored in paper systems. The misguided and uncalibrated digital spreadsheets contribute to the staggering, 'data debt'. A costly, tedious, and intricate process of data analysing is needed to carry out the digitisation of stored data. The potential inconsistency and errors minimises the reliability of analogue data, which goes against the notion of smart cities, as proposed by Kumar et al. (2025), wherein data needs to be available in instant and machine readable manner.

3.3 Acute shortage of data literacy and human capital

Iraqi governmental institutions are not equipped with the ability to manage, analyse, or govern data. A critical shortage exists for data scientists, data engineers, and policy wonks on data governance. University programs have been lethargic in responding to the international demand for such capability, and the region has suffered from extreme brain drain. This extreme shortage of human capital implies that, even in the hypothetical situation where data is present and the requisite infrastructure is in place, there exist very few professionals who could transform that data into intelligence for urban management. As van den Broek and van Veenstra (2018) put it, "the most critical element in data collaborations is the human factor", which is far too often ignored in technology-centric initiatives.

3.4 The legal and regulatory vacuum

There is no comprehensive legislation regulating data privacy, security and ownership in Iraq. There is no analogue to the European Union's General Data Protection Regulation (GDPR) or even elementary data protection legislation. This absence results in great confusion for a number of reasons:

- *Public confidence:* Citizens tend to be very skeptical of government data collection programs, especially in the aftermath of conflict, without any legal assurances that their information will be misused or breached.
- *Private sector reluctance:* There is reluctance among technology companies to fund the internet of things (IoT) and data analytics projects in the absence of a legal mechanism that is specific to their obligations and rights in relation to the data that they assist in creating, managing and controlling.
- *International data flows:* The legal framework surrounding the use of international clouds for data storage and processing in cross border s lacking in clarity. This absence of regulation serves to stifle innovation and entrench data fragmentation.

3.5 Infrastructure-induced data scarcity

The gap in development that this paper identifies as most responsible is governance, but it does recognise the interdependent relation with infrastructure. The power grid's unreliability prevents IoT sensors from functioning with any degree of reliability. The

thinly populated regions that ring the major metro centres have very little, if any, broadband coverage, which stifles the data that can be collected and transmitted. This leads to data scarcity there isn't enough high quality, consistent data generated to drive the advanced analytics frameworks which characterise a smart city. Thus, investment in infrastructure is still a necessary, though not sufficient, prerequisite condition for advancement.

4 Governance models for developing contexts

Recent literature (2022–2025) on smart city development in challenging environments provides valuable lessons for Iraq. A key insight is that models cannot be imported wholesale from advanced economies like Singapore or Amsterdam; they must be adapted to local contexts.

4.1 *The phased, incremental approach*

Looking more into the studies, more reliable and long-lasting results are reported there is need for a more practical step-wise functional approach rather than continued implementation of mammoth, top-down approach projects. Anthony Jnr (2025) point out that with the cities, the focus should be on a 'minimal viable data platform' focusing on a single, critical use, such as smart solid waste management (SWM). This enables the construction of governance frameworks, which is a quick value addition for the citizens and policymakers, thereby institutional capacity, and pave the way for more sophisticated use cases. This value addition is critical before expanding on more sophisticated use cases and also limits risk and cost management.

4.2 *The role of data stewardship and lightweight governance*

Rather than trying to build a large centralised data agency that is likely to become bureaucratic and ineffective immediately, emerging models suggest designating 'data stewards' at existing ministries as a first step. These people have 'data stewardship' responsibilities for data quality and sharing within their domain and interface with stewards in other ministries (Sarker, 2022; Sharma et al., 2025). This as a result, allows a networked, thin governance framework that is likely to more energetic and effective than a cumbersome central control, particularly in the early phases.

4.3 *Prioritising open data and civic engagement*

As Tasgaonkar et al. (2024) discuss, "Open data has the potential to develop trust and invite innovation, and also to solve local issues, which extends further to the university, NGO, and private sectors". What suggests the importance of this analogy is that for Iraq, equality in relation to data and information is crucial, and the symbolic measure of public trust in the data would significantly improve the national sense of the data in the post-conflict Iraq. It would also set a strong foundation for the other data, for example, maps, census, and budget allocation information, to be further cultivated and used in a more interdisciplinary data initiatives.

4.4 Sandboxes and pilot zones

One of the most revived suggestions in the literature is the use of 'regulatory sandboxes'. This includes the setting up of a specially designated area (like a certain district of Baghdad or Erbil) where innovative frameworks and models of regulation are developed around a limited set of criteria, which would enable the experimentation of data sharing models and technologies in a 'sandbox' setting without breaching the national legal frameworks – which may be missing in the first place (Wang et al, 2024). This enables the regulatory framework to be tested in a more realistic scenario in order to optimise the national focus policymaking.

5 A proposed phased framework for data governance in Iraq

In light of the diagnostic analysis and the profound gaps in the data landscape in Iraq, it is apparent that a 'big bang' approach to implementing a regime of comprehensive data governance is neither practicable nor sensible. The institutional, technical, as well as cultural barriers are far too daunting. In contrast, this paper suggests a practical multi-phased approach that focuses on foundational building blocks with achievable quick wins to create momentum, capacity, as well as political support. In the latest literature on the public sector digital transformation in complex environments, this incremental approach is particularly emphasised (Yang et al., 2023; Whaiduzzaman et al., 2022; Wolniak and Stecula, 2024; Wu et al., 2024). The framework is delineated across four phases of hierarchical succession with focused goals, actions, and indicators of success for each.

5.1 Phase 1: foundation and legislation (months 0–18)

Purpose: Create an action plan that sets legal and institutional boundaries for trust-building activities and clarifies future actions for subsequent data initiatives.

1 *Action 1.1: Appoint a high-level steering committee.*

- *Description:* Create and enter the Ministry National Data Governance Steering Committee Support to the Prime Minister's Office or the Council of Ministers. The committee must have permanent representatives (at least at the level of Director General) from the following core Ministries: Interior, Transportation, Electricity, Oil, Water, Communications, Planning, and Finance. It is important to have on the committee a representative from the national data protection authority being established under Action 1.2.
- *Rationale:* The committee is not intended to manage data at a micro level, but rather to dictate the framework which is then touched upon to resolve Interministerial conflicts and secure funding. In the Top Down approach for committee construction, the primary line of control is important as pointed out by Yang et al. (2023).
- *Success metric:* The committee is officially registered, there is a charter and meeting records of the committee, and there is evidence of a sustained annual allocation.

2 *Action 1.2: Enact a Foundational Data Protection Act.*

- *Description:* Draft and pass comprehensive data protection legislation. This law should be principles-based, drawing from international standards like GDPR but adapted to the Iraqi context. It must clearly define:
- *Lawful basis for processing:* Conditions under which government entities can collect and use citizen data (e.g. public task, consent).
- *Data subject rights:* Access, rectification, and erasure of personal data by citizens.
- *Data security and breach notification:* Defined standards of data protection and protocols for breach reporting are also compulsory.
- *Independent oversight body:* A single national data protection authority should be established.
- *Rationale:* This is the single most important action to build public trust and provide legal certainty for private sector investment. It creates the ‘rules of the road’ without which all data sharing is legally perilous.
- *Success metric:* Passage of the law into statute; the independent data protection authority is established and staffed.

3 *Action 1.3: Launch a National Open Data Portal.*

- *Description:* Create a national open data portal with a foundational, government-driven strategy (e.g., data.gov.iq). Each individual ministry should scrub and publish at least five ‘high value’ datasets per ministry in open, machine-readable formats (e.g., CSV, JSON). Sensitive data cannot be used. Other budget figures, census data, boundaries, and civic service locations can be used; and more should be added.
- *Rationale:* This demonstrates cultural transparency and data-sharing with minimal risk. The spurring of civic hacking, academia, and journalism with free access government data is a fundamental growth enabling a hands-on practice for government agencies preparing and distributing data (Wu et al., 2024).
- *Success metric:* Number of published datasets, monthly portal active users, and third-party apps developed from portal data.

4 *Action 1.4: Initiate a National Data Literacy Program.*

- *Description:* Collaborate with national universities and international organisations (e.g., World Bank, UNDP) to design and implement specific training programs. This should cover:
- *Executive training:* For senior roles on the data governance value proposition.
- *Data steward training:* A certified program aimed at phase 2 mid-level officials slated to become data stewards.
- *Technical training:* For IT staff focusing on data, APIs, and foundational cybersecurity.
- *Rationale:* Human capital development is a slow to start fast to grow model. It is important to begin early to develop a cohort of champions and implementers that can drive later phase activities (Wolniak and Stecula, 2024).

- Success metric: The number of trained officials; development and implementation of a data steward program at an Iraqi University.

5.2 Phase 2: unification and capacity building (months 18–36)

Goal: The goal is to transition from a theory-setting stage to a practice stage, starting with setting standards, assigning critical roles, and setting up a few controlled pilot projects.

1 *Action 2.1: Impose Common Data Standards and Algorithms for Public Service APIs.*

- *Description:* The National Steering Committee is to appoint technical working groups to develop and defend data standards for primary strategic sectors in Iraq. The first area to focus on should be:
- *Geospatial data:* Set a standard akin to GeoJSON for all spatial data.
- *Transportation data:* Institute the General Transit Feed Specification (GTFS) for public transport schedules and routes.
- *API Standards:* Implement design guidelines for RESTful APIs to enable seamless interfacing with other systems.
- *Rationale:* This is the technical condition for breaking data silos among disparate systems and ministries and enabling interoperability.
- *Success metric:* Standards in Iraq data published, and an audit revealing implementation in at least two critical ministries.

2 *Action 2.2: Appoint and Empower Data Stewards.*

- *Description:* Based on the trained cohort from Phase 1, formally appoint a Chief Data Officer (CDO) or Data Steward within each key ministry. Their role should be defined in the first place as having custodianship over data values, data quality, metadata management, access controls, and the first point of liaison on requests for sharing data from other ministries.
- *Rationale:* This creates a network of governance that is decentralised yet coordinated in the embedding of accountability and proficiency in the specialist line ministries (Yang et al., 2023; Whaiduzzaman et al., 2022).
- *Success metric:* Official job descriptions and appointments made; the Start of new Data Stewards Council meeting of a recurring or routine nature.

3 *Action 2.3: Establish a Regulatory Sandbox and Pilot Project.*

- *Description:* Designate a geographically bounded subdivision (e.g. the Al-Mansour district in Baghdad or the district surrounding the Erbil Citadel) as a smart city ‘sandbox’. Within this area, impose temporary rules that relax standard procurement and data sharing rules for the integrated test of a specific siloed pilot project (e.g. a multisource framework to optimise the use of energy for streetlights based on data from traffic sensors).

- *Rationale:* The sandbox allows technologies, governing structures, and civic impacts to be tested in a controlled environment with bounded scale to relieve the pressure of a national level rollout (Yu et al., 2022). It also provides enduring impacts and lessons for wider boring policy formulation.
- *Success metric:* Successful implementation and functioning of the pilot for 12 continuous months; issuance of a lessons-learned document.

5.3 Phase 3: integration and scaling (months 36–60)

Objective: To integrate ministerial data assets into a federated platform and scale successful pilots to other urban centers.

1 Action 3.1: Develop a National Urban Data Platform.

- *Description:* Design a central, federated data platform that does not function as a central repository, but rather a catalogue and broker. It indexes the datasets available at the level of the ministries' platforms (who remain owners and custodians) and provides secured data exchange between authorised systems in the mandates of the APIs.
- *Rationale:* A federated model derives de-centred data storage and ownership from the need to centralise discovery and access, which makes the model more politically and technically feasible compared to a monolithic central data lake.
- *Success metrics:* Platform launch; number of integrated ministries; number of inter-ministerial data exchange requests processed monthly.

2 Action 3.2: Scale Pilot Projects and Develop Advanced Use Cases.

- *Description:* Based on the sandbox learnings, replicate successful pilot projects in other cities, e.g., Basra, Mosul, and Sulaymaniyah. Start funding more sophisticated cross-domain use cases requiring the integrated platform, such as predicting and controlling urban congestion using integrated real-time traffic, weather, and events data.
- *Rationale:* Shows the practical impact of the governance framework on wider areas, and justifies further funding
- *Success metric:* Number of cities replicating the pilots; improved KPIs on scaled projects such as congestion reduction and energy savings.

5.4 Phase 4: optimisation and maturation (months 60+)

Objective: To transition to a continuous improvement model, leveraging the mature data ecosystem for predictive analytics and policy optimisation.

1 Action 4.1: Implement Predictive and Prescriptive Analytics.

- *Description:* Equipped with one and these, city managers can shift and go beyond analytics and respond to the city in machine learning predictive situations about infrastructure and service request forecasting on the city service request platform. Before the infrastructure, the urban data platform can catch the system predicts the chronic overload and actively simulate policy outcomes.

- *Rationale:* This greatly demonstrates the smart city promise: transitioning to urban policy and infrastructure planning in a highly intelligent, resilient, and efficient manner.
- *Success metric:* Predictive maintenance and managed traffic systems; measured reduction in service interruption and response times.

2 *Action 4.2: Institutionalise Continuous Feedback and Refinement.*

- *Description:* Equipped with one and these, city managers can shift and go beyond analytics and respond to the city in machine learning predictive situations about infrastructure and service request forecasting on the city service request platform. Before the infrastructure, the urban data platform can catch the system predicts the chronic overload and actively simulate policy outcomes.
- *Rationale:* This greatly demonstrates the smart city promise: transitioning to urban policy and infrastructure planning in a highly intelligent, resilient, and efficient manner.
- *Success metric:* Predictive maintenance and managed traffic systems; measured reduction in service interruption and response times.

6 Discussion

The suggested framework provides a logical and organised step forward, though how it moves from a concept to an application is likely to be complex. The factors which need to be addressed are woven into the very foundation of the political, institutional, and social contexts of Iraq. These are not simplistic barriers to be ticked off, but instead, multilayered elements which may distort, prolong, or even terminate the initiative ceaselessly. Its successful operation will rely less on the intricate particulars of the schematic and more on whose hands it rests to form an order from this chaos. The first and most important issue is, a lack of dominance on a political level. The initial stage of this framework is correct to aptly suggest the need for foundational legislation and a high profile, high-level oversight committee. The dilemma, however, is the nature of Iraq's bureaucracy, where control of secrets is an age-old source of power and institutional autonomy. The data barriers are not incidental; they are purposeful elements of a carefully constructed system serving determined ends. A steering committee, in the absence of unyielding, and continuous political support from the very summit of the state, will fumble to secure dominance over the passive and active opposition of the ministries which are reluctant to relinquish control, to which the committee will be subject. This resistance could manifest as token compliance appointing figurehead data stewards without authority or publishing low-value datasets while withholding critical information effectively preserving the status quo under a veneer of cooperation.

More than the political problems is the challenge of the human capital and the financing of the framework. The framework itself is defined by a paradox; the first phases of its implementation depends on the existence of capable people to zeon the legislative processes, set the standards, and supervise the management of the platforms. However, a fundamental objective of the framework is to construct that very capability. There is an urgent and critical reliance on foreign consultants, who are very costly to depend upon. The strategy has to make the decision from day one to aggressively focus

on knowledge transfers to the core group of civil servants and professionals. Professions and civil servants: the Iraqi core group must be mentored, and there must be embedded mentorship in the ‘train-the-trainer’ programs. The government, even with the depleted talent pool must compete against the private sector and the international job market. That talent must be retained with logical career paths and competitive pay. The finances of the framework pose a very fundamental challenge. Budgets that are squeezed because of competing priorities and volatile oil revenues, governance, training, and policy seem very lopsided against great infrastructure investments. The effort should thus be seen not as something which will cost money, but one which will save money. Its believers must perform calculation after calculation to show that putting money into data rules for the water ministry, say, will cut down on the money lost from leaks and, in so doing, will pay for itself and free money for other use. Without such an easy way to see how money will be made, the purpose will be on shaky ground.

Finally, and maybe most important, there is the hard part of having the right to exist and the trust of the public. In the time after war, the way the government gets data and what they do with it is seen with doubt. Passing a Data Protection Act, even though it is a law, is not good enough to create trust. We need to be clear about what is happening and show that there is a good reason for it. Just one big problem with data or one case of data being used to watch people can cause the public to lose trust forever and cause them to do something very strongly that may stop the smart city plans all together. Also, if we focus only on online services, it may make things worse by making some groups of the people have less and less and be left out because they do not know business or do and do not have the ability to connect online. The good things about using data like less power cuts, clean water, less traffic should be for everyone, not only the very skilled ones. So, plans on how to do things should include clear talks with everyone, an independent body to watch what is going on, and a promise to solve the biggest problems the city faces. It also means that the real challenge is not the way, but how to balance the rules, the people, and what is done. The framework is a start point, but to get the real goal, be brave enough to make the right changes, plan well, and always try to show people what they can get from the whole process.

7 Conclusions

7.1 *Unique contributions of the study*

This research provides a pivotal departure from the conventional techno-centric discourse on smart cities in the Iraqi context. Its unique contributions include:

- a The study redefines the primary barrier to smart urbanism in Iraq, shifting the focus from ‘tangible infrastructure deficits’ (e.g., electricity and broadband) to the ‘intangible regulatory vacuum’. It identifies the ‘data gap’ as a structural rather than a technical failure.
- b Unlike ‘one-size-fits-all’ global models, this paper proposes a modular, incremental roadmap designed specifically for fragile institutional environments. It prioritises ‘legal muscle memory’ through a Data Protection Act and Open Data Portals as non-negotiable precursors to high-tech integration.

- c A significant contribution lies in reframing data governance not as an administrative overhead, but as a strategic asset capable of optimising federal resource allocation and reducing systemic waste in public service delivery.

7.2 Research limitations

Despite the strategic robustness of the proposed framework, several inherent limitations must be acknowledged:

- a The framework's success is hyper-contingent on a consistent, high-level political mandate to dismantle ministerial data silos. In a volatile political climate, the transition from 'data hoarding' to 'data sharing' remains a significant risk.
- b There is a recursive challenge where the initiative requires high-level professionals to manage the very systems intended to build that same local capacity. This creates a temporary yet critical dependency on international consultancy and a risk of 'knowledge shielding'.
- c The transition from legacy paper-based records to digitised, interoperable ecosystems faces deep-seated bureaucratic stagnation that a theoretical framework can identify but cannot unilaterally resolve without a broader social evolutionary shift.

7.3 Future research directions

To build upon the foundational blueprints laid out in this study, future research should explore:

- a Empirical longitudinal studies are needed to measure how the launch of Iraq's first open data portals affects local SME innovation and academic research output.
- b Future inquiries should investigate the psychological and social dimensions of digital trust among Iraqi citizens, specifically regarding how transparent data governance influences public acceptance of smart surveillance and utility monitoring.
- c Targeted research into specific urban pain points such as water scarcity or traffic management could demonstrate the 'proof of concept' for the framework by showing the direct ROI of data integration in a single, high-impact sector.

Ultimately, the transformation of Iraqi cities is a socio-technical evolution. By deploying data governance as the foundational layer of smart city investment, Iraq can move beyond reactive technology adoption toward a proactive, integrated, and trustworthy urban future. This strategic pivot allows Iraq to bypass the configurations of advanced nations and chart a unique, context-aligned path toward urban intelligence.

Declarations

All authors declare that they have no conflicts of interest.

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