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Public Policy in Tehran Toward E-Government Development and Smart City Implementation

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Abstract

This study aims to investigate the impact of board gender diversity on firm performance and risk management, with a focus on the moderating effects of CEO education, CEO power, and institutional investors, in companies listed on the Tehran Stock Exchange. The statistical sample includes 116 companies listed on the Tehran Stock Exchange over the period from 2018 to 2022. The models employed in this study are multivariate linear regression models, analyzed using EViews 10 software. The hypothesis testing results indicate a significant and negative relationship between board gender diversity and financial performance (return on assets). There is a significant and positive relationship between board gender diversity and financial performance (return on equity). No significant relationship was found between board gender diversity and financial performance (Tobin's Q). A significant and positive relationship was identified between board gender diversity and economic performance (market value added and economic value added). Moreover, there is a significant and positive relationship between board gender diversity and non-financial performance (corporate social responsibility). However, no significant relationship was found between board gender diversity and other non-financial performance indicators (innovation, employee growth, internal process factor, customer factor, and learning and growth factor). Additionally, no significant relationship was observed between board gender diversity and risk management (operational risk, reporting risk management, and strategic risk management). There is, however, a significant and positive relationship between board gender diversity and risk management regarding non-compliance with laws and regulations.

Keywords: Board gender diversity, Institutional investors, Performance, CEO power, Risk management.

1. Introduction

In recent decades, the concept of smart cities and the development of e-government have become focal points in global urban policy agendas. As cities grow in population and complexity, traditional governance models have increasingly failed to meet the demands of urban residents, particularly in areas related to service delivery, infrastructure, and administrative efficiency. Smart cities have emerged as a transformative paradigm aiming to integrate information and communication technologies (ICT) into public administration, urban planning, and citizen engagement to enhance the quality of life and optimize resource management. Globally, cities such as Singapore, Barcelona, and Amsterdam have led this shift by leveraging real-time data, digital platforms, and innovative governance models to ensure adaptive and citizen-centered service delivery. These cities have exemplified how technology, when supported by forward-looking policies and institutional reform, can significantly enhance urban sustainability and inclusiveness (Klarić, 2023; Saigal, 2025).

The e-government dimension of smart cities is crucial to this transformation, as it facilitates transparency, accountability, and responsiveness in public administration. Governments across the world have adopted digital solutions to reduce bureaucratic inefficiencies and streamline interactions between state institutions and citizens. From online tax filing and electronic health records to smart transportation systems and participatory budgeting portals, e-government initiatives form the backbone of the smart city infrastructure (Marpaung et al., 2023; Widiastuti & Suryawati, 2021). These platforms do not merely digitize services but also redefine governance by enabling open data access, citizen feedback loops, and agile policy adjustments based on real-time analytics. Countries like Estonia and South Korea have demonstrated how robust digital governance frameworks can elevate the efficiency and legitimacy of state operations, ensuring inclusive access to essential services.

In the Iranian context, the transition to smart cities and the establishment of e-government have been central to national development strategies over the past two decades. While progress has been uneven across cities, the government has shown consistent intent to integrate ICT into urban management, especially in Tehran, the nation's capital and most populous metropolitan area. Early efforts included the formulation of the National Strategic Plan for Information Technology and the development of an e-government roadmap by the Presidential Center for ICT in the mid-2000s. These initiatives sought to align Iran's administrative and service delivery systems with global digital transformation trends and reduce reliance on analog methods of governance (Nazari et al., 2021; Noori et al., 2020). Despite these ambitions, implementation challenges such as regulatory fragmentation, outdated infrastructure, and limited inter-agency coordination have impeded full realization of these digital goals.

Tehran, as the political, economic, and cultural nucleus of Iran, holds strategic importance in any discussion of smart governance. With a population exceeding eight million and a share of more than 14 percent of the country's urban residents, Tehran not only sets the tone for national urban policy but also serves as a testing ground for large-scale reforms. However, the city's rapid growth has brought about complex challenges, including chronic traffic congestion, high pollution levels, overburdened public services, and administrative inefficiencies. These challenges have exposed the limitations of centralized, top-down planning approaches and highlighted the need for more adaptive, citizen-centered governance models (Bayat, 2022; Nazari et al., 2021). Moreover, Tehran's demographic heterogeneity and its status as an economic magnet demand highly flexible and inclusive urban policy frameworks that can accommodate diverse needs and integrate advanced technological tools.

The drive toward smart urban development in Tehran is further motivated by the city's role as a symbolic leader in national innovation. The successful implementation of smart city policies in Tehran is likely to set a precedent for other urban centers in Iran. Accordingly, municipal and national authorities have launched several pilot programs to modernize service delivery mechanisms, including initiatives in smart transportation, digital health services, online licensing systems, and geolocation-based service integration. The Iranian Ministry of Information and Communications Technology has also identified Tehran as a priority city in its smart city strategy, calling for public-private partnerships, innovation hubs, and cross-sectoral coordination to achieve integrated urban transformation (Ghaffari et al., 2023; Majdzadeh et al., 2023). Despite these developments, a significant gap remains between policy design and effective implementation. Much of Tehran's current digital infrastructure is fragmented, and many of its e-government services remain underutilized due to limited public awareness and digital literacy.

Several national initiatives have sought to address these gaps by emphasizing the role of ICT in governance and urban planning. The Fifth and Sixth Development Plans of Iran have incorporated specific chapters on e-government and digital innovation, urging institutions to invest in human capital, infrastructure, and inter-organizational networks. These national frameworks provide legal and strategic foundations for municipal-level reforms but often fall short in operational clarity and performance monitoring. Additionally, local governments, including Tehran's municipal authorities, have occasionally struggled with budgetary constraints and bureaucratic resistance that delay the translation of these policies into practice (Sargolzai & Khodadadi Didani, 2024; Shahzad et al., 2024). As a result, while the strategic vision exists at the national level, its actualization at the local level—particularly in Tehran—has been inconsistent and dependent on fluctuating political will and institutional capacity.

The implementation of smart governance in Tehran has also seen sporadic yet meaningful efforts in specific sectors. For instance, the city has experimented with smart traffic systems using GPS tracking, loop sensors, and video surveillance to

manage urban mobility and reduce congestion (Saigal, 2025). Digital platforms for administrative services—such as obtaining construction permits, filing complaints, and accessing urban data—have also been introduced, albeit with varying degrees of user-friendliness and accessibility. Health services have begun to incorporate telemedicine features and electronic medical records, especially during the COVID-19 pandemic, which accelerated the digital transformation in multiple public domains (Bahrudin & Wahyuningsih, 2023; Shahbazi & Shabani, 2024). However, these efforts often lack systemic coordination, resulting in isolated successes rather than a cohesive smart city ecosystem.

Within this context, the role of public policy becomes paramount in transitioning from fragmented digital services to an integrated smart city model. Smart city development is not merely a technological endeavor but a fundamentally political and administrative challenge that requires rethinking governance processes, resource allocation, and stakeholder engagement. Policy frameworks must not only articulate clear objectives and implementation mechanisms but also foster collaboration between governmental agencies, private sector actors, and civil society. They must also incorporate mechanisms for feedback, evaluation, and policy iteration to remain responsive to evolving urban needs (Nasrulhaq, 2025; Sulistiyo, 2024). Crucially, effective policy must address digital inclusion, ensuring that all citizens—regardless of age, income, or education—have equitable access to smart services and the digital literacy to use them effectively.

One of the main impediments to effective smart city implementation in Tehran has been the lack of a unified policy vision that integrates different sectors and governance levels. While multiple agencies are involved in digital initiatives, their efforts are often siloed, resulting in duplicated efforts or policy contradictions. This lack of integration hinders the scalability of successful programs and prevents the formation of a coherent urban digital ecosystem (Deandra et al., 2024; Ghaffari et al., 2023). Moreover, in the absence of clear regulatory frameworks on data governance, privacy, and interoperability, different city departments remain reluctant to share information or collaborate meaningfully. Therefore, the transition to a smart urban system in Tehran depends as much on institutional reform and policy coherence as it does on technological readiness.

Globally, cities that have succeeded in becoming smart have done so through a combination of robust digital infrastructure and comprehensive governance reforms. These reforms have included decentralization of authority, enhancement of digital capabilities across public sector employees, and creation of cross-sectoral task forces to monitor progress and resolve implementation challenges. Tehran can learn from such models while tailoring its approach to the unique political, economic, and cultural realities of Iran. Strategic alignment between national policies and local implementation, bolstered by citizen engagement and private sector innovation, is essential to create a sustainable path toward digital transformation in the capital (Dana et al., 2022; Yerznkyan & Фонтана, 2022).

The objective of this study is to explore how public policy in Tehran has influenced the development of e-government and the broader transition toward smart urban systems. By analyzing key initiatives, institutional frameworks, and sectoral interventions implemented in recent years, this research aims to evaluate the extent to which Tehran's policy environment supports or hinders the emergence of a truly smart city. The study also seeks to identify structural barriers and strategic opportunities that can inform future policy design and implementation. Ultimately, this review contributes to the growing discourse on digital governance by offering context-specific insights into the challenges and possibilities of building smart cities in complex urban environments like Tehran.

2. Methods and Materials

This study employs a scientific narrative review methodology with a descriptive analysis approach, aiming to synthesize existing policy frameworks, implementation practices, and theoretical models related to the smart city and e-government transformation in Tehran. Narrative reviews are particularly suitable when a comprehensive understanding of a multi-dimensional topic is sought, especially when existing literature and empirical evidence span various administrative, technological, and social domains. By drawing upon academic literature, governmental documents, urban planning reports, and municipal data between 2020 and 2025, this study examines both the top-down strategies and bottom-up dynamics shaping Tehran's progress toward becoming a smart city. The use of a descriptive analytical framework allows for the interpretation of trends, challenges, and policy impacts in a systematic and contextualized manner, emphasizing depth over breadth. The research

focuses on extracting themes related to policy planning, administrative reforms, digital infrastructure, and citizen-facing digital services within Tehran's public sector transformation.

The materials analyzed in this review include official urban policy documents, strategic national plans, peer-reviewed journal articles, conference proceedings, and validated municipal reports published or accessed between 2020 and 2025. Key primary sources include strategic initiatives such as the national roadmap for e-government services, Tehran's smart city development reports, and records of pilot programs deployed by Tehran Municipality in recent years. These sources were complemented by scholarly research from databases such as Scopus, Web of Science, and ScienceDirect, with a particular emphasis on empirical studies and policy reviews focusing on Middle Eastern smart city trajectories, urban governance, and ICT-enabled public services. Special attention was paid to the most recent publications (2020–2025) to ensure that the findings are reflective of the contemporary landscape and emerging trends in digital governance. Moreover, municipal-level initiatives such as the rollout of online public service platforms, the digitization of urban infrastructure, and smart traffic management projects were reviewed through local Persian-language government archives and translated as necessary to preserve the integrity of context.

The analysis follows a conceptual-theoretical framework that maps the development of smart governance in Tehran through the lenses of administrative innovation, digital transformation, and participatory policy planning. Drawing on recent frameworks in smart city governance, the study identifies and categorizes policy efforts across six core dimensions: smart governance, smart economy, smart people, smart living, smart mobility, and smart environment. Each of these domains is explored through a descriptive lens to examine how Tehran's public policy mechanisms are aligned—or misaligned—with the requirements of a digitally-enabled city. The review process also included an evaluation of the policy effectiveness based on available performance indicators and expert evaluations included in the source materials. Where available, Likert-scale based survey data and strategic assessment reports were interpreted to assess the perceived and actual impact of the smart city initiatives. The collected information was coded and interpreted to trace patterns in policy evolution, infrastructural progress, and digital integration, allowing for grounded conclusions about Tehran's trajectory within the global discourse on smart urbanism. The goal of this analytical strategy is not only to document what has been done but also to evaluate whether these efforts align with international benchmarks and local socio-economic conditions.

3. Theoretical and Conceptual Foundations

Smart cities and e-government represent two closely intertwined concepts within contemporary urban governance, both aiming to enhance the efficiency, responsiveness, and inclusiveness of public service delivery. A smart city is broadly defined as an urban area that utilizes information and communication technologies (ICT) to improve operational efficiency, share information with the public, and provide a better quality of government services and citizen welfare. The term encapsulates the integration of various digital tools into the urban fabric to address challenges such as congestion, environmental degradation, inefficient service provision, and social exclusion. This concept extends beyond mere technology implementation, involving a comprehensive rethinking of how cities are planned, governed, and experienced by their inhabitants (Dewi et al., 2023). It involves the application of digital innovation across sectors such as transportation, housing, energy, waste management, and public safety, transforming urban systems into interconnected and responsive networks.

E-government, on the other hand, refers to the use of ICTs by government institutions to deliver services, engage with citizens, and enhance internal operations. It includes functions such as online tax filing, digital identity systems, e-voting, and the automation of bureaucratic processes. E-government is often considered a foundational layer of the smart city, as it provides the administrative infrastructure upon which smart applications can be developed and deployed (Reza & Azmi, 2021). Effective e-government systems reduce redundancies, lower administrative costs, and promote transparency by minimizing human discretion and digitizing documentation. In this way, e-government and smart cities are mutually reinforcing: while e-government provides the tools for efficient governance, smart cities offer a broader socio-technical framework in which these tools are employed to address complex urban issues (Putra et al., 2021).

Public policy in the digital age plays a pivotal role in steering the development and deployment of smart technologies in urban settings. Unlike in earlier eras where urban planning followed a more linear, top-down approach, modern public policy frameworks must accommodate rapid technological change, shifting citizen expectations, and cross-sectoral interdependencies.

The digital age demands that urban governance become more participatory, data-driven, and adaptive. Policy makers are now expected to formulate policies that not only regulate digital transformation but also harness its potential for solving urban problems. For example, cities like Yogyakarta and Bandung have adopted public policies explicitly designed to support the six pillars of the smart city model—smart governance, smart economy, smart mobility, smart environment, smart people, and smart living—ensuring that digital interventions are not fragmented but systematically embedded into broader urban development strategies (Deandra et al., 2024; Widiastuti & Suryawati, 2021).

Urban governance in this era is characterized by decentralization, transparency, and co-creation with citizens and the private sector. It increasingly relies on digital platforms for civic engagement, such as mobile apps for public complaints, participatory budgeting websites, and open data portals. These tools allow for a new form of interaction between city governments and residents, promoting accountability and trust in public institutions. Furthermore, policies governing digital infrastructure and services must consider issues such as data privacy, cybersecurity, interoperability, and equitable access, reflecting the complex ethical and technical landscape of smart urban development (Klarić, 2023; Shahbazi & Shabani, 2024). Therefore, the design and execution of public policy in the smart city context are not merely bureaucratic exercises but critical determinants of a city's capacity to thrive in the digital era.

The conceptual transition from traditional administration to smart systems marks a paradigmatic shift in the way governments conceive of their roles and responsibilities. Traditional bureaucratic models were hierarchical, process-driven, and slow to adapt to change. They often relied on physical documentation, in-person interactions, and siloed data systems that hindered efficiency and innovation. In contrast, smart systems emphasize agility, integration, and real-time decision-making. For instance, rather than processing paper forms for building permits, a smart city might use blockchain technology to automate the issuance of digital permits with instant cross-verification by various departments. This shift is evident in many global urban reforms where cities are leveraging big data analytics, Internet of Things (IoT) sensors, and artificial intelligence to monitor citywide systems and make predictive interventions (Babaiev & Deikalo, 2024; Dana et al., 2022).

In traditional public administration, services were delivered reactively, often without detailed knowledge of citizen needs or systemic inefficiencies. The smart systems approach, however, advocates for proactive governance supported by predictive analytics and continuous data feedback loops. For example, traffic management in a traditional city may depend on static traffic lights and manual observation, whereas a smart traffic system uses real-time data to optimize signal timings and reroute vehicles to reduce congestion (Saigal, 2025). This transformation from reactive to proactive governance necessitates changes in institutional culture, capacity-building for public employees, and the redesign of legal frameworks to accommodate digital operations (Majdzadeh et al., 2023).

The key components of smart urban infrastructure form the backbone of this digital transition and are instrumental in defining the contours of a smart city. Smart governance is perhaps the most foundational pillar, involving the deployment of ICT to enhance transparency, responsiveness, and inclusivity in public administration. This includes digital service delivery portals, online grievance redressal systems, and integrated dashboards for real-time monitoring of city operations. Tehran, for instance, has experimented with digital portals for managing municipal services, although integration across departments remains a challenge (Nazari et al., 2021).

Smart economy refers to the use of digital tools and platforms to stimulate innovation, entrepreneurship, and economic efficiency. This involves fostering start-up ecosystems, enabling cashless transactions, supporting digital marketplaces, and encouraging knowledge-intensive industries. In the Iranian context, smart economy initiatives are also tied to national goals of diversifying revenue streams and reducing dependency on oil exports. Several Iranian cities have begun hosting innovation hubs and incubators to promote digital entrepreneurship, although access to global technologies and financial systems remains limited due to external constraints (Bayat, 2022; Pardede et al., 2023).

Smart mobility focuses on enhancing the efficiency and sustainability of transportation systems through digital integration. It encompasses real-time public transit tracking, ride-sharing platforms, electronic tolling, and intelligent traffic management. For example, cities such as Jakarta have implemented smart bus systems with digital ticketing and GPS tracking to improve commuting experiences (Nasrulhaq, 2025). In Tehran, pilot projects involving sensor-based traffic monitoring and public

bike-sharing apps have been launched to address chronic congestion, although infrastructure readiness and citizen uptake remain ongoing issues (Saigal, 2025).

Smart people refers to the development of human capital through education, digital literacy, and civic engagement. This component recognizes that technology alone cannot make a city smart; it must be complemented by an informed and empowered citizenry capable of utilizing digital tools to their fullest potential. Public education programs, lifelong learning platforms, and digital skills training are crucial here. For instance, Klaten District has pursued smart city goals by integrating e-learning systems into local schools and offering digital training for public employees and residents (dewi et al., 2024).

Smart living and smart environment represent the quality-of-life and sustainability dimensions of smart cities. Smart living includes healthcare innovations such as telemedicine, e-health platforms, and health-monitoring apps, while smart environment involves the use of ICT for pollution control, waste management, and energy conservation. In Tehran, poor air quality has prompted interest in deploying IoT sensors to monitor pollution hotspots and inform policy responses. Similarly, smart grid technologies are being explored to optimize electricity distribution and reduce energy loss (Rohayatin et al., 2023; Vaziri et al., 2023).

Together, these components form an integrated smart city architecture that redefines urban governance and planning. However, the realization of such a model requires more than technological acquisition; it demands visionary leadership, inclusive public policies, and sustained citizen participation. In addition, the unique socio-political and economic context of each city plays a critical role in determining the feasibility and success of smart initiatives. For Tehran, the path toward becoming a smart city lies not only in adopting global best practices but in tailoring those practices to local realities through responsive, transparent, and data-driven public policies (Sulistyaningsih et al., 2023; Yusmanizar et al., 2023).

In summary, the theoretical and conceptual foundations of smart cities and e-government illustrate a complex interplay between technology, governance, and societal needs. They necessitate a reconfiguration of public administration systems and a redefinition of state-citizen relationships. As Tehran aspires to become a smart city, it must confront both the opportunities and challenges inherent in this transition, building a policy environment capable of sustaining long-term digital transformation across its administrative, economic, and social systems.

4. Policy Milestones and Implementation in Tehran

The development of smart cities in Iran, and particularly in Tehran, has been shaped by a series of national policy milestones and strategic documents introduced over the past two decades. The trajectory began formally with the 2004 “Comprehensive ICT Development Plan,” which laid the foundation for a digital government vision. This plan was followed by the “E-Government Roadmap,” which sought to standardize and digitize administrative services across national and municipal levels. These initiatives were reinforced in the Fifth and Sixth National Development Plans, both of which emphasized the integration of ICT in governance, economic development, and public service delivery. Notably, the Sixth Development Plan assigned legal obligations to executive bodies to digitize their services and mandated performance monitoring through digital indicators (Noori et al., 2020). Tehran, as the capital and largest metropolitan area, was positioned at the forefront of these initiatives, benefiting from greater institutional capacity, budgetary allocation, and visibility compared to other cities. However, despite the strategic clarity of national frameworks, implementation in Tehran has encountered uneven progress due to administrative fragmentation and fluctuating political priorities (Majdzadeh et al., 2023).

Several pilot programs have been launched in Tehran to actualize the smart city vision, especially in the domains of banking, healthcare, e-commerce, and administrative reform. In the banking sector, early digital transformation initiatives included the introduction of online banking systems, ATM networks, and mobile payment apps that gradually reduced the dependence on physical banking. These efforts were particularly crucial in improving financial accessibility in a city characterized by high population density and extensive commercial activity (Pardede et al., 2023). In the healthcare sector, the city implemented electronic health records and piloted telemedicine services, especially during the COVID-19 pandemic, when physical distancing and hospital congestion necessitated digital alternatives (Bahrudin & Wahyuningsih, 2023). Public hospitals in Tehran adopted web-based platforms to streamline patient registration and follow-up procedures, and some facilities integrated wearable monitoring systems to manage chronic conditions remotely.

In the field of administrative services, the Municipality of Tehran initiated several reforms through the “My Tehran” digital portal, a centralized platform for accessing over 150 municipal services, including bill payment, permit applications, and citizen complaints. Although this portal represents a significant leap toward administrative efficiency, its usability and interoperability with other national systems remain limited. Many services are still semi-digital, requiring in-person follow-ups despite the presence of online forms. Furthermore, the lack of real-time data integration across departments undermines the platform’s effectiveness in delivering a seamless user experience (Nazari et al., 2021). In parallel, Tehran has pursued digitalization in commerce, encouraging the use of online business registration systems, e-invoicing, and virtual trade fairs. These programs aim to support small- and medium-sized enterprises in leveraging digital tools to expand market access and improve productivity (Margareta et al., 2025).

Tehran’s transformation into a smart urban environment has also involved government-backed services that directly impact the everyday life of its citizens. One of the most prominent efforts has been the enhancement of public transportation through smart technologies. The Tehran Bus Rapid Transit (BRT) and metro systems now utilize electronic ticketing systems linked to rechargeable smart cards. Additionally, several subway stations and bus terminals are equipped with digital information panels and GPS-based arrival tracking, which help commuters make real-time decisions about travel (Saigal, 2025). These services are supported by centralized traffic control systems that monitor congestion through loop detectors, surveillance cameras, and traffic signal integration. In recent years, pilot projects have introduced intelligent traffic signals that adapt in real time to vehicular flow in busy intersections.

Another notable development is the city's investment in digital mapping systems. Tehran’s urban planning department has collaborated with the ICT Organization of Tehran to create a digital spatial database that supports decision-making in zoning, construction, and infrastructure development. These maps integrate satellite imagery, demographic data, and environmental information to allow more informed urban management. City officials have used this platform to monitor illegal construction, plan public transportation routes, and identify areas for green space expansion (Bayat, 2022). In addition, the city has expanded public access to the internet through free Wi-Fi zones in key public spaces such as parks, plazas, and libraries. While coverage remains limited and connectivity inconsistent, the initiative marks a step toward digital inclusivity, particularly for marginalized populations who lack home internet access (Ghaffari et al., 2023).

Mobile payments have also become increasingly popular in Tehran, thanks in part to government-backed fintech innovations. Several municipal services, such as parking fees, utility payments, and taxi fares, can now be paid through mobile applications developed in collaboration with local technology firms. These applications integrate QR code systems, NFC payments, and user dashboards to track transaction history and monitor service usage. Although adoption varies by demographic and technological literacy, the presence of these digital payment options indicates a clear governmental push toward a cashless urban economy (Deandra et al., 2024). Nevertheless, the city continues to face hurdles related to cyber security, data protection, and user trust, particularly among older populations who are less accustomed to digital transactions.

The shift from traditional governance models to digitally enabled systems in Tehran underscores a broader comparative evolution in urban management. Traditional governance in the city was characterized by bureaucratic hierarchies, paper-based documentation, manual processes, and in-person service delivery. These systems were not only slow but often opaque, subject to inefficiencies and public dissatisfaction. Long queues at municipal offices, redundant paperwork, and the lack of inter-agency communication led to significant delays in service provision and policy enforcement. Such inefficiencies eroded public trust in the state’s administrative capacity and contributed to perceptions of institutional dysfunction (Rohayatin et al., 2023).

Digital transformation, by contrast, introduces a model of governance that emphasizes agility, data integration, and user-centered design. For example, the digitization of construction permit processes allows architects and developers to submit blueprints electronically, track approval status, and receive feedback without visiting municipal offices. This approach not only accelerates administrative procedures but also reduces opportunities for corruption by minimizing discretionary interactions with officials. Similarly, digital dashboards allow city managers to monitor key performance indicators—such as waste collection efficiency, energy usage, and emergency response times—in real time, enabling evidence-based decision-making (Shahzad et al., 2024). The comparative advantage of this model lies in its capacity to deliver public services with greater transparency, predictability, and scalability.

However, the transformation is far from complete. Many of Tehran's digital services function in silos, with limited interoperability between platforms operated by different departments or ministries. For instance, the transport authority's smart card system does not interface with the health department's telemedicine services or the municipality's e-payment platform. This lack of systemic integration undermines the user experience and reduces the potential benefits of digital transformation (Sulistyaningsih et al., 2023). Moreover, the absence of standardized data formats and shared protocols complicates efforts to establish centralized monitoring systems. In this context, the comparative perspective reveals that while Tehran has made substantial strides in adopting smart technologies, its governance model still reflects many elements of traditional administration, especially in terms of organizational culture, hierarchical decision-making, and fragmented policy implementation (Vaziri et al., 2023).

Cities such as Makassar and Klaten in Indonesia have managed to create more seamless smart systems through integrated service portals and cross-sectoral task forces, demonstrating that institutional coordination is as critical as technological infrastructure (dewi et al., 2024; Yusmanizar et al., 2023). Tehran's reliance on standalone digital solutions without a unifying governance framework contrasts sharply with such examples and highlights the need for a comprehensive digital strategy that aligns all municipal departments under a common vision. This includes harmonizing data-sharing protocols, investing in employee digital literacy, and creating legal frameworks that address digital rights and ethical governance (Camorongan, 2023; Shahbazi & Shabani, 2024).

In essence, Tehran's experience with digital transformation illustrates both the potential and limitations of top-down policy-driven approaches to smart city development. While national strategic documents and pilot projects have introduced valuable tools and concepts, the city's implementation record reveals the persistent challenges of administrative inertia, technological fragmentation, and uneven access. Nevertheless, the existence of foundational systems and the increasing engagement of citizens with digital platforms suggest that Tehran is on a gradual but progressive path toward becoming a smarter, more responsive, and more inclusive metropolis. The continuation of this transformation will depend on the city's ability to institutionalize digital practices, foster inter-agency collaboration, and uphold citizen-centric values in its policy frameworks.

5. Model and Framework for Smart Tehran

The development of a smart city in Tehran has gradually taken shape through a phased implementation model that aims to transition the metropolis from fragmented digital services to an integrated and intelligent urban ecosystem. This four-phase model includes Design, Pilot, Inspection, and Integration phases, each of which serves a distinct function in aligning technological innovation with urban governance and citizen needs. The Design phase focuses on identifying key challenges and proposing tailored solutions grounded in local realities. In Tehran, this phase has involved mapping existing infrastructures, analyzing urban pressure points such as traffic congestion and environmental degradation, and formulating digital priorities to improve service delivery. Municipal stakeholders collaborated with urban planners and ICT experts to draft concept notes, policy blueprints, and technical guidelines that would inform subsequent interventions (Ghaffari et al., 2023). The outcome of this phase has typically been a master plan or strategic framework outlining the direction of smart city transformation in alignment with national development goals and international best practices.

The Pilot phase in Tehran's smart city framework is marked by the launch of small-scale experimental projects intended to test the feasibility and effectiveness of selected technologies before citywide implementation. These pilot programs span multiple sectors, including transportation, public health, urban safety, and municipal administration. For example, Tehran has piloted a smart parking system using sensors to detect available spots and a mobile app to direct drivers accordingly, thereby reducing inner-city traffic density and air pollution. In the healthcare sector, telemedicine platforms and electronic prescriptions were introduced in selected municipal clinics to assess user reception and infrastructure readiness (Bahrudin & Wahyuningsih, 2023). In the realm of urban security, pilot surveillance systems with facial recognition capabilities have been tested in high-traffic areas to evaluate their impact on crime reduction and civil liberties.

Following the pilot phase, the Inspection phase involves rigorous evaluation of program performance, citizen satisfaction, and technological interoperability. During this phase, the Tehran Municipality employs a combination of expert reviews, performance metrics, and public feedback to determine whether a pilot project has met its intended objectives. The inspection

process often reveals gaps in integration, user accessibility, or regulatory compliance, prompting adjustments to technical components or policy mandates. For instance, early versions of the Tehran Smart Map—a geospatial tool designed to support urban planning and public navigation—faced criticism due to limited user functionality and outdated data. The inspection phase allowed developers to refine the platform by incorporating real-time updates and enhancing visual interfaces (Bayat, 2022).

The final stage, Integration, represents the systemic deployment of successful pilot initiatives across the broader urban framework. This phase seeks to standardize technologies, embed digital services into municipal workflows, and create a shared ecosystem among different departments. In Tehran, the integration of digital permit systems into the city's construction regulation process has reduced approval delays and improved transparency in the real estate sector. Moreover, interoperable platforms for environmental monitoring and waste management are being synchronized with emergency response systems to provide real-time alerts and enable proactive governance (Nazari et al., 2021). The integration phase also includes institutional capacity-building efforts, such as training programs for public employees and digital literacy campaigns for residents, to ensure sustainable use of new technologies.

Table 1. Four-Phase Model for Implementing Smart City Strategies in Tehran

Phase	Key Activities	Expected Outputs	Example Projects in Tehran
Design	Urban needs assessment, feasibility studies, digital vision development	Strategic master plan for smart services and infrastructure	Tehran Smart City Roadmap, My Tehran portal blueprint
Pilot	Sector-specific testing of digital services in limited urban zones	Prototype platforms, citizen feedback, baseline performance data	Smart parking, telemedicine in municipal clinics
Inspection	Technical performance evaluation, user satisfaction surveys, expert reviews	Recommendations for improvement, interdepartmental integration plans	Public reaction analysis, Tehran Smart Map assessment
Integration	Citywide rollout, digital workforce training, policy alignment	Unified digital services, embedded governance processes	e-payment integration in transport, full e-burial service launch

In developing its smart city framework, Tehran has also turned to benchmarking and global best practices to inform its policy design and implementation strategies. Learning from cities that have achieved high levels of digital maturity, Tehran's planners have explored models such as Estonia's national ID system, which allows seamless authentication across government portals and private platforms. This model has influenced Tehran's efforts to unify citizen data across services ranging from tax filing to health care, although privacy and interoperability remain challenges (Shahbazi & Shabani, 2024). In terms of infrastructure, South Korea's investment in high-speed fiber optic networks and public Wi-Fi has served as a blueprint for Tehran's gradual expansion of internet coverage in public areas, transport hubs, and educational institutions (Klarić, 2023). Benchmarking has also extended to educational reform, with Tehran seeking to replicate e-learning platforms that have been successfully implemented in cities like Singapore and Helsinki. Although Tehran has introduced online education portals at the municipal level, gaps in content quality and internet access have limited their reach.

The city's benchmarking process is not merely about imitation but about adaptation—translating successful foreign experiences into locally viable policies. This involves taking into account Iran's specific socio-political constraints, such as limited access to global tech markets and evolving regulatory norms. For example, while digital payment systems in cities like Stockholm and Amsterdam rely on international banking protocols, Tehran has had to develop indigenous fintech solutions compatible with domestic financial regulations and security concerns (Deandra et al., 2024). Similarly, while other cities use cloud-based data storage solutions from global providers, Tehran's smart city development has necessitated investment in local server infrastructures due to cybersecurity and data sovereignty considerations (Sargolzai & Khodadadi Didani, 2024).

A key feature of Tehran's smart city strategy is the adoption of digital indicators and classification of smart services into specific categories that reflect core urban functions. These indicators serve as both performance metrics and planning tools, helping authorities monitor progress and identify bottlenecks. Services are typically grouped under categories such as local life, business, information, safety, and interaction. The "local life" category includes digital utilities management, smart waste collection systems, and community health monitoring tools. For example, the deployment of sensor-enabled bins in several districts of Tehran allows real-time monitoring of waste levels, enabling efficient collection routes and reducing operational costs (Rohayatin et al., 2023). The "business" category covers e-commerce support platforms, business license e-portals, and fintech applications that streamline economic activities for both formal and informal enterprises (Margareta et al., 2025).

The "information" category addresses digital literacy programs, public information dashboards, and open data repositories that enable civic engagement and research. Tehran's municipal website offers downloadable datasets on land use, air quality, and budget expenditures, fostering transparency and academic analysis. The "safety" category encompasses smart surveillance systems, early warning alerts for natural disasters, and digital coordination centers for emergency response. In terms of "interaction," the city has launched participatory governance apps that allow residents to vote on neighborhood projects, report issues like potholes or vandalism, and participate in digital town halls (Yusmanizar et al., 2023). While each category represents a specific function, they are interconnected, and progress in one often catalyzes improvement in others.

To unify these fragmented efforts into a holistic vision, Tehran has adopted a strategic model known as "Model 3-2," which encapsulates the six internationally recognized smart city dimensions—smart people, smart governance, smart mobility, smart environment, smart economy, and smart living—within three overarching governance layers: technological infrastructure, regulatory frameworks, and participatory mechanisms. "Smart people" represents the human capital component, emphasizing education, innovation, and civic participation. Tehran has launched several digital literacy campaigns targeting youth and elderly populations to bridge the digital divide and promote equitable access to smart services (Mulyadi & Zein, 2024). "Smart governance" refers to the use of ICT in planning, regulation, and service delivery, with platforms like "My Tehran" serving as flagships for digital administrative reform.

"Smart mobility" focuses on sustainable and efficient transportation, combining traditional transit with innovations such as shared mobility, GPS-integrated buses, and dynamic traffic signal control. "Smart environment" includes green infrastructure, pollution control technologies, and water management systems. Tehran has piloted IoT-enabled sensors to monitor air quality and provide alerts during high-pollution days, a crucial step in a city often plagued by smog (Vaziri et al., 2023). "Smart economy" integrates digital entrepreneurship, support for start-ups, and innovation clusters that aim to reduce reliance on oil revenues and stimulate non-oil sectors. This dimension is supported by municipal innovation hubs and e-commerce accelerators that offer mentorship, funding, and networking opportunities (Dana et al., 2022). Finally, "smart living" captures public health, safety, housing, and cultural dimensions, all of which are increasingly supported by digital platforms, from telehealth services to virtual cultural festivals.

These six pillars, supported by three governance layers, form a robust conceptual framework that allows policymakers to prioritize investments, align departmental objectives, and track long-term outcomes. For instance, the technological infrastructure layer ensures that physical and digital connectivity are available, while the regulatory framework layer sets legal standards for data protection, interoperability, and accountability. The participatory layer ensures that residents are not passive recipients but active contributors to the city's development, fostering a sense of ownership and community.

In conclusion, Tehran's model and framework for becoming a smart city reflect both ambition and pragmatism. Through a phased implementation strategy, global benchmarking, and a structured categorization of digital services and smart city pillars, the city is gradually transforming its urban management paradigm. While challenges remain—particularly in the realms of policy coherence, technological integration, and social inclusion—the framework provides a strategic foundation for Tehran to evolve into a more intelligent, responsive, and sustainable urban system. Future success will hinge on continuous adaptation, stakeholder collaboration, and unwavering commitment to aligning technological progress with the values of transparency, equity, and public service.

Table 2. Classification of Smart City Service Categories in Tehran's Framework

Service Category	Core Features	Examples from Tehran Initiatives
Local Life	Enhancing daily urban services through digital means	Smart waste collection, e-burial platform, utility payment apps
Business	Supporting economic activity and entrepreneurship via digital tools	E-commerce registration, mobile POS, digital procurement auctions
Information	Facilitating access to city data and public resources	Tehran open data portal, digital property records
Safety	Promoting urban security and resilience using smart surveillance and alerts	CCTV with AI, pollution alerts, earthquake response networks
Interaction	Fostering citizen participation and communication through digital platforms	Participatory budgeting, public complaint apps, e-town halls

6. Challenges and Barriers to Smart City Development in Tehran

Despite significant strategic efforts and pilot programs, the path toward full smart city realization in Tehran has been hindered by a variety of complex and interrelated challenges. One of the most pressing barriers is the city's rapid urbanization and the demographic transitions associated with it. Tehran continues to attract a significant share of Iran's internal migration, resulting in a population that exceeds eight million residents in the metropolitan area alone. This constant influx has placed extraordinary pressure on the city's housing, transportation, healthcare, and educational systems. More critically, Tehran is simultaneously witnessing an aging population trend, with increasing numbers of elderly citizens requiring tailored digital services, such as accessible e-health platforms and mobility assistance systems. The digital divide between younger, tech-savvy individuals and older, less digitally literate populations creates a major obstacle in the widespread adoption of smart technologies (Mulyadi & Zein, 2024). As smart cities rely heavily on citizen engagement with digital platforms, the lack of inclusive design and digital literacy programs targeting the elderly significantly impairs user-centered service delivery in Tehran.

Environmental degradation adds another formidable challenge to smart city development in Tehran. The city regularly ranks among the most polluted capitals globally, particularly during winter months when air stagnation exacerbates emissions from traffic and industry. Data from municipal environmental monitoring systems indicate alarmingly high levels of particulate matter and nitrogen dioxide in several districts of Tehran, posing serious public health risks and reducing quality of life. Although the city has made efforts to deploy sensor-based monitoring and has introduced electric bus prototypes, these initiatives remain limited in scale and effect (Bayat, 2022). Tehran's topographical location—situated in a basin surrounded by mountains—further intensifies the accumulation of air pollutants. Moreover, unsustainable construction practices, limited green infrastructure, and inefficient waste management systems contribute to land and water degradation. These environmental pressures demand smart urban planning tools that can optimize zoning, monitor pollutants in real time, and enforce sustainable development guidelines, yet such systems require extensive inter-agency coordination and regulatory support that are currently lacking (Rohayatin et al., 2023).

Economic constraints have also played a pivotal role in stalling Tehran's smart transformation. National economic instability, exacerbated by international sanctions, fluctuating oil revenues, and inflationary pressures, has severely restricted municipal budgets and disrupted technology procurement. High-tech infrastructure projects, such as broadband expansion, public data centers, or IoT-based waste systems, demand substantial upfront investment that Tehran's urban administration struggles to afford consistently. This financial pressure is further aggravated by the migration of skilled labor, especially tech professionals and system engineers, who often seek better opportunities abroad due to economic uncertainty and limited professional advancement at home (Dana et al., 2022). The resulting brain drain undermines the city's capacity to innovate, scale, and maintain smart infrastructure systems. Even when foreign partnerships are proposed to support technology transfer or co-investment, political and regulatory complexities often hinder their realization, reducing the scope of international collaboration in Tehran's smart city agenda (Shahbazi & Shabani, 2024).

Infrastructural, regulatory, and administrative challenges continue to constrain Tehran's ability to operationalize its smart city vision. Many of the city's core infrastructures, including electricity grids, transportation networks, and sewage systems, are outdated and incompatible with the requirements of integrated smart systems. For example, the city's legacy electricity grid is not equipped to support smart meters or dynamic load-balancing systems, making the implementation of a smart energy grid particularly difficult. Similarly, the existing road and traffic signal infrastructure does not allow for efficient synchronization with AI-driven traffic management tools, leading to underutilization of intelligent transportation systems (Saigal, 2025). Regulatory fragmentation further complicates this landscape. Multiple agencies—municipal, provincial, and national—have overlapping jurisdiction over urban services, leading to redundant initiatives, conflicting mandates, and delayed decision-making. The absence of standardized regulations for data sharing, digital privacy, and system interoperability prevents departments from integrating their platforms and limits the scalability of successful pilot projects (Sargolzai & Khodadadi Didani, 2024).

Administrative culture in Tehran also poses a substantial barrier to innovation. Traditional bureaucratic structures favor hierarchical decision-making and risk-aversion, which are antithetical to the agile, iterative, and experimental nature of smart

city development. Many public servants lack the technical training or digital mindset necessary to implement and manage ICT-driven solutions effectively. Although some training programs have been introduced, they remain insufficient in reach and depth to catalyze institutional transformation. Furthermore, the limited inclusion of citizens in planning processes—especially through digital participatory tools—results in low trust and weak adoption of available smart services (Yusmanizar et al., 2023). Without a cultural shift that values transparency, collaboration, and responsiveness, even the most advanced digital platforms will fail to gain traction or achieve sustainable outcomes.

To gain further insight into these multifaceted barriers, expert panels and citizen surveys have been used to evaluate Tehran's smart city readiness and performance. In a recent Likert-scale-based survey conducted among urban planners, ICT professionals, and policy analysts, respondents were asked to rate Tehran's smart city dimensions on a scale from 1 (very poor) to 5 (excellent). The highest-rated domain was smart mobility, with an average score of 3.2, largely due to the expansion of metro lines and electronic ticketing systems. However, smart environment scored the lowest, with an average of 2.1, reflecting the persistent problems of pollution and limited green infrastructure. The survey also highlighted moderate performance in smart governance (2.8) and smart economy (2.6), indicating that while foundational efforts exist, significant gaps remain in strategic alignment, infrastructure, and digital inclusion (Majdzadeh et al., 2023).

Expert panel evaluations have reinforced these findings. In one such forum organized by the Tehran Urban Innovation Center, panelists pointed to the absence of a unified data governance framework as a critical weakness. Participants stressed that while several departments collect valuable urban data—ranging from traffic flow and waste levels to citizen service usage—these datasets are rarely shared across departments due to institutional silos and the lack of data standardization protocols (Ghaffari et al., 2023). The panel also emphasized the need for legislation that protects personal data while facilitating responsible data use for urban planning and decision-making. Another theme that emerged from expert discussions was the importance of citizen engagement. Panelists observed that without proactive inclusion of citizens in smart city discourse, from app development to policy review, public participation would remain superficial, undermining the democratic and adaptive potential of smart governance models (Deandra et al., 2024).

In sum, the development of a smart city in Tehran is challenged by a convergence of demographic pressures, environmental crises, economic instability, and institutional fragmentation. While Tehran has taken meaningful steps in digital service delivery and urban innovation, these initiatives often operate in isolation, constrained by systemic barriers that limit their scope and impact. Addressing these challenges requires a holistic strategy that not only invests in infrastructure and technology but also fosters regulatory coherence, administrative reform, and inclusive policy design. As Tehran continues its journey toward smart urbanism, it must prioritize equity, sustainability, and resilience to ensure that the benefits of digital transformation are both far-reaching and enduring.

Table 3. Key Challenges Hindering Smart City Development in Tehran

Challenge Area	Description	Consequences	Examples in Tehran
Rapid Urbanization & Demographics	High population density and aging residents require diverse, inclusive smart services	Digital divide, overloaded infrastructure	Uneven access to telehealth, low elderly digital adoption
Environmental Degradation	Persistent pollution and resource stress due to outdated urban systems	Public health risks, sustainability concerns	High PM2.5 levels, insufficient green zones
Economic Constraints	Budget limitations and restricted access to international markets and technologies	Limited scalability, brain drain	Migration of tech professionals, stalled infrastructure projects
Infrastructural Limitations	Legacy systems incompatible with smart technologies	Inability to integrate smart utilities or transportation systems	Outdated electrical grids, analog traffic control systems
Regulatory and Administrative Gaps	Fragmented policies and lack of legal frameworks for data governance and digital integration	Service overlap, low interoperability	Misaligned smart service platforms, slow legislative response
Citizen Engagement Deficit	Lack of participation and digital literacy among various social groups	Low adoption, mistrust in smart systems	Underused e-platforms, minimal civic input in smart

7. Strategic Approaches and Policy Recommendations

As Tehran continues its complex journey toward becoming a fully realized smart city, it becomes increasingly evident that technological deployment alone is insufficient. Strategic success in this domain requires a coherent blend of integrated policymaking, robust legal frameworks, and vision-oriented governance. Integrated policy formulation ensures that smart city

initiatives are not implemented in isolation but rather woven into the broader tapestry of national development plans, urban management strategies, and socio-economic agendas. One of the most critical components of such integration is the alignment of digital transformation goals with urban sustainability, public welfare, and infrastructural resilience. Fragmented policymaking has long hindered smart city development in Tehran, as overlapping mandates among ministries and local bodies often result in disjointed implementation and resource misallocation (Ghaffari et al., 2023). To address this, Tehran's strategic approach must prioritize a governance model where cross-sectoral coordination is institutionalized, enabling smoother data exchange, harmonized performance metrics, and shared accountability frameworks.

Complementing integrated policy, legislation plays a central role in regulating the digital transformation process. Clear, enforceable laws on data protection, digital rights, service interoperability, and public-private partnerships are essential for building trust among stakeholders and reducing implementation friction. In Tehran, the lack of standardized legal norms for digital platforms has led to inconsistencies in service delivery and hindered scaling across city departments. Legislation that defines the scope of digital service delivery, establishes cybersecurity protocols, and clarifies institutional responsibilities will offer much-needed stability and predictability to the smart city ecosystem (Shahbazi & Shabani, 2024). Moreover, by ensuring that legal instruments remain adaptive to technological advancements, policymakers can future-proof Tehran's digital infrastructure while protecting civil liberties in an increasingly data-centric society.

Vision building is another indispensable pillar of Tehran's smart city strategy. A shared, long-term vision acts as a guiding compass for all stakeholders involved in the digital transformation journey. This vision should articulate Tehran's aspirations not merely in terms of technological prowess but also in its commitment to equity, sustainability, and quality of life. For instance, initiatives like the "Tehran 1400" roadmap have laid out preliminary goals for sustainable urban mobility, digital governance, and smart environmental monitoring. However, these efforts must be continually updated and reinforced with measurable outcomes, stakeholder feedback, and community engagement to retain relevance and momentum (Deandra et al., 2024). Without a unifying vision, smart city projects risk becoming fragmented or overly technocratic, disconnected from the lived experiences and evolving needs of Tehran's residents.

In an effort to evaluate the feasibility and impact of various strategic options, policymakers in Tehran have employed analytical tools such as pairwise comparisons, often within the framework of multi-criteria decision analysis (MCDA). These tools allow decision-makers to weigh the relative importance of different interventions by comparing them two at a time, based on predefined criteria such as cost, social impact, scalability, and administrative feasibility. For example, a recent evaluation exercise ranked smart mobility initiatives higher than smart environmental monitoring systems, primarily due to the former's more immediate impact on traffic congestion and air quality improvement (Saigal, 2025). Similarly, pairwise comparisons helped determine that integrating digital payment systems with public transportation networks offers greater short-term benefits than investing in blockchain-based administrative services, which require a longer gestation period and more complex regulatory frameworks. Such comparative evaluations provide empirical grounding for strategic decisions, reducing the risk of misaligned investments and policy fatigue (Majdzadeh et al., 2023).

Central to any smart city strategy is the role of citizens, who are not just beneficiaries but essential contributors to successful urban transformation. Citizen participation, digital literacy, and inclusivity are indispensable factors in ensuring that smart city services are accessible, relevant, and impactful. Tehran must move beyond passive consultation and embed participatory governance mechanisms in its digital platforms. These may include online forums for policy feedback, citizen report cards for evaluating municipal services, and participatory budgeting tools that allow residents to propose and vote on neighborhood-level projects (Yusmanizar et al., 2023). Equally important is the promotion of digital literacy programs that cater to different demographics, especially the elderly, women, and marginalized communities who may lack the skills or confidence to engage with digital services. Without a deliberate push toward inclusivity, smart city initiatives risk deepening existing socio-economic divides rather than bridging them (Mulyadi & Zein, 2024).

To bolster local strategies, Tehran can draw valuable insights from international best practices in smart city development. In Tallinn, Estonia, the deployment of a nationwide digital ID system has streamlined public and private sector services, allowing citizens to vote, pay taxes, and access healthcare entirely online. Tehran can adapt this model to create a unified digital identity platform that links residents to various municipal services, from property taxes to medical records, enhancing both

convenience and administrative efficiency (Shahbazi & Shabani, 2024). In South Korea, smart education platforms have revolutionized remote learning, especially during the COVID-19 pandemic. Tehran's educational institutions can replicate these efforts by developing interactive e-learning platforms that are accessible on low-bandwidth networks, ensuring continuity in public education regardless of external disruptions (Klarić, 2023).

Barcelona's experience with open data initiatives also offers useful lessons for Tehran. By making urban data publicly accessible, Barcelona has empowered researchers, startups, and civic groups to develop innovative solutions for city challenges, ranging from traffic congestion to energy consumption. Tehran can follow suit by launching a centralized open data portal where anonymized datasets from transport, health, utilities, and urban planning departments are published in machine-readable formats (Ghaffari et al., 2023). This would not only promote transparency but also stimulate the local tech ecosystem by providing raw materials for innovation. Another relevant model is Singapore's focus on predictive analytics in governance. The city uses data from sensors, cameras, and mobile apps to forecast issues such as disease outbreaks and infrastructure failure. Tehran could benefit from similar predictive tools in areas such as air quality monitoring, emergency services deployment, and infrastructure maintenance planning (Dana et al., 2022).

Recent municipal initiatives in Tehran also demonstrate promising steps toward localized innovation and service modernization. One such example is the city's e-burial service, which enables citizens to manage funeral arrangements digitally. This service includes online death certificate issuance, grave reservation, and memorial notifications, significantly reducing the bureaucratic burden on grieving families. The initiative has been well received for its sensitivity and efficiency, particularly during the pandemic when social distancing measures were in place (Deandra et al., 2024). Another notable project is the historical building registry system, which uses digital mapping tools to document, preserve, and promote Tehran's architectural heritage. This system not only supports urban planning and cultural preservation but also enhances tourism by making historical data publicly accessible through interactive web platforms (Bayat, 2022).

Smart fleet tracking is another domain where Tehran has made advancements. The city's municipal fleet, which includes waste collection vehicles and emergency response units, has been equipped with GPS trackers and route optimization software. These tools have reduced fuel consumption, improved service reliability, and enabled real-time response to citizen complaints lodged via mobile apps. In addition, the Tehran Municipality has experimented with digital auction platforms for public tenders, increasing transparency and reducing opportunities for corruption in procurement processes. These platforms allow businesses to submit bids online, track evaluation status, and receive contract notifications, thereby streamlining one of the most opaque aspects of municipal administration (Margareta et al., 2025).

Collectively, these case examples reflect Tehran's growing capacity for digital governance and service innovation. However, their long-term success depends on systematic scaling, consistent funding, and supportive policy environments. The strategic direction must now shift from isolated successes to holistic transformation, emphasizing integration, inclusivity, and impact measurement. As Tehran continues to build its smart city identity, the convergence of legislative clarity, visionary planning, and empowered citizen participation will be vital in shaping a future that is not only technologically advanced but also socially just and administratively resilient. This journey requires more than just digital infrastructure; it calls for a cultural shift toward openness, experimentation, and accountability in public service delivery.

Table 4. Strategic Policy Directions for Advancing Smart City Development in Tehran

Strategic Focus	Core Action Items	Intended Outcomes	Example Initiatives in Tehran
Integrated Policymaking	Align smart projects with national development plans and municipal mandates	Reduced duplication, increased efficiency	Tehran Smart City Master Plan (under review)
Legislative Reform	Enact clear regulations on data privacy, digital services, and interoperability	Enhanced trust, streamlined service delivery	Draft framework for smart data governance
Vision Building	Define long-term, shared objectives for all stakeholders	Unified direction, stakeholder alignment	"Tehran 1400" roadmap
Citizen Participation	Implement digital platforms for engagement and participatory governance	Increased legitimacy, higher adoption rates	Participatory budgeting platform, e-consultation portals
Digital Literacy & Inclusion	Train vulnerable and underrepresented groups to access and use digital platforms	Reduced digital divide, wider access	Municipal digital literacy workshops for the elderly
Adaptive Governance	Use feedback loops, pilot evaluations, and real-time monitoring to adjust strategies	Continuous improvement, agile policy response	Post-pilot adjustment of smart parking and mapping services
Global Best Practice Adaptation	Benchmark against international smart cities, adjust for local context	Increased effectiveness, global alignment	Localized adaptation of ID-based service access and e-

8. Conclusion

The transformation of Tehran into a smart city represents a multifaceted journey that intertwines technology, governance, urban planning, and citizen engagement. This process is not simply a matter of adopting new digital tools or upgrading infrastructure; it demands a paradigm shift in how the city is managed, how services are delivered, and how citizens interact with public institutions. The narrative of Tehran's smart city development is one of ambition tempered by complexity, driven by the necessity to respond to rapid urbanization, environmental pressures, and evolving public expectations.

Over the past two decades, Tehran has laid important groundwork through national strategic documents, municipal pilot programs, and targeted digital initiatives. The city has demonstrated a growing awareness of the importance of information and communication technologies in addressing long-standing urban challenges. Smart governance platforms, digital transportation systems, e-health applications, and urban mapping tools are gradually reshaping the delivery of services and the operation of city systems. These efforts reflect a growing institutional capacity and a willingness among policymakers to align Tehran with global trends in urban innovation.

Yet, despite these promising developments, Tehran's progress toward becoming a truly smart city remains uneven. One of the central challenges lies in the fragmentation of policy efforts and the lack of a unified strategic framework that integrates various initiatives under a common vision. Many digital services continue to operate in isolation, with limited interoperability across departments and minimal coordination between municipal and national institutions. This fragmentation not only undermines the efficiency of public service delivery but also limits the scalability and sustainability of successful pilot projects. Without an integrated approach, the full potential of digital transformation remains unrealized.

In addition to institutional fragmentation, Tehran faces significant infrastructural and socio-economic barriers. The city's aging utility networks, congested transportation systems, and inadequate data management platforms hinder the implementation of smart technologies at scale. The economic constraints imposed by fluctuating municipal budgets and broader national economic conditions further exacerbate these limitations. Moreover, the migration of skilled professionals in search of better opportunities outside the country has created a gap in the human capital required to drive innovation and maintain complex digital systems.

Demographic shifts and environmental degradation present additional layers of complexity. Tehran's rapidly growing and aging population demands inclusive and adaptive services that cater to a wide spectrum of needs and capabilities. At the same time, the city's high levels of pollution and environmental stress call for immediate and intelligent responses, such as predictive monitoring systems, green infrastructure planning, and sustainable energy solutions. These challenges require a governance model that is not only technologically sophisticated but also responsive and participatory.

A crucial factor in Tehran's smart city evolution is the role of its citizens. Without public trust, engagement, and digital literacy, even the most advanced technological systems are likely to fail. True transformation requires a cultural shift toward greater transparency, inclusivity, and co-creation. Citizens must not be treated merely as users or consumers of digital services but as active stakeholders in the design, implementation, and evaluation of smart city initiatives. Strengthening this participatory model will not only improve service outcomes but also foster a sense of ownership and accountability among residents.

Policy recommendations for Tehran must therefore focus on creating an enabling ecosystem that aligns technology with governance, legislation, and social inclusion. Key strategic priorities include the development of a comprehensive smart city master plan that consolidates existing initiatives, sets clear goals, and outlines implementation roadmaps across various sectors. This plan must be backed by supportive legislation that protects digital rights, ensures data privacy, and encourages innovation through public-private partnerships. Equally important is the need to invest in digital infrastructure and human capital, ensuring that city departments have the tools and expertise to manage and sustain digital systems effectively.

Another strategic imperative is the adoption of adaptive governance mechanisms that allow for experimentation, learning, and real-time course correction. Rather than rigid top-down planning, Tehran's smart city strategy should embrace flexible frameworks that accommodate innovation and feedback. These mechanisms can take the form of regulatory sandboxes, innovation hubs, and cross-sectoral task forces that bring together experts from government, academia, industry, and civil society to solve complex urban problems collaboratively.

To ensure long-term impact, Tehran must also establish robust monitoring and evaluation systems. These systems should include clear indicators to measure performance, citizen satisfaction, and equity in service delivery. Regular assessments can help identify what works, what needs improvement, and how resources can be better allocated. Transparent reporting and data-sharing practices can also enhance public trust and encourage community participation in governance.

Tehran's experience offers valuable lessons for other cities navigating the complexities of digital transformation in the Global South. It illustrates the importance of context-sensitive policymaking that takes into account political, economic, and cultural realities. It also underscores the necessity of balancing technological ambition with social equity, ensuring that smart city developments do not widen existing disparities but instead promote inclusion and empowerment.

As Tehran looks to the future, it must continue to build on its strengths while addressing its weaknesses with resolve and creativity. The vision of a smart city is not a destination but a continuous process of adaptation and improvement. It is about creating a city that listens, learns, and evolves—a city that uses data not just for control but for care; that sees innovation not as a luxury but as a necessity; and that values its citizens not only as users of technology but as co-creators of a shared urban future.

By fostering a governance culture grounded in collaboration, transparency, and forward-thinking, Tehran can overcome the barriers it currently faces and chart a more sustainable, inclusive, and intelligent path forward. The smart city project in Tehran, while still in its developmental phase, has the potential to redefine urban life for millions of residents, turning everyday challenges into opportunities for transformation. This requires political commitment, institutional agility, and above all, a collective determination to imagine—and build—a better city for all.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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