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ANALYZING THE FACTORS AFFECTING THE SUSTAINABILITY OF SMART CITY IMPLEMENTATION IN QATAR

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Abstract

The Qatari government has initiated several strategic projects and programs since the introduction of Qatar National Vision 2030. These programs aimed to create smart cities to enhance the living standards of Qatar's residents and meet the demands of the rapidly evolving digital economy. The research seeks to investigate the factors that influence the sustainability of smart city implementation in Qatar. The main factors examined were the IT infrastructure, governance, organizational, and social aspects. The quantitative study used a survey strategy. The researcher recommended that public services be enhanced by utilizing cutting-edge ICT, expanding the capabilities of ICT and smart devices, and promoting the integration of smart city infrastructure, network impact, and user adoption. The research emphasizes the need to incorporate cutting-edge ICT, governance, and citizen participation. These factors, together, impact sustainability, service efficacy, and urban livability. The long-term sustainable development goals, along with empirical evidence from Qatar, can help policymakers and stakeholders understand the technological, social, and operational gaps that exist.

Keywords: Governance, Organizational Factors, Social Factors, Sustainability, Smart City, Qatar.

Introduction:

As part of Qatar National Vision 2030, Qatar is also developing smart cities, which offer numerous benefits to residents' quality of life within a rapidly evolving digital economy (Pal et al., 2023). Qatar also aims to achieve sustainable urban development goals with Lusail and The Pearl smart cities (Sharifi et al., 2024). The 2022 World Cup focused on the digital transformation of Qatari towns, aiming to promote sustainable development and enhance the safety and well-being of citizens (Cochrane & Al Hababi, 2023). The TASMU innovative

Qatar program, started in 2017, is focused on the use of innovative technologies to grow the economy and improve the quality of life in the targeted sectors of health care, transportation, logistics, environment, sports, and public services (Saxena & Al Tamimi, 2018; Strides, 2021; TASMU, 2023).

Lusail Smart City illustrates Qatar's integration of high-tech infrastructure and eco-friendly practices. Its buildings feature modern cooling systems, and waste is transported via an innovative pipeline network to recycling centers. For irrigation, recycled waste is reversed back to the city (Sharifi et al., 2024). Transportation upgrades include a driverless metro connecting Doha and Lusail, which was specifically implemented for the 2022 World Cup (Pal et al., 2023). Qatar ICC in 2014 shadowed the use of technologies in urban planning and service delivery: "Emerging ICT Trends: The Future is Now" envisioned the use of ICT and data in planning urban healthcare, education, transport, and other government services (Ministry of Information and Communications Technology, 2014; Al Ali et al., 2023).

The Qatari government has acknowledged the social and economic benefits of adopting information and communication technology (ICT) and its multifaceted impact. The creation of the Supreme Council of Information and Communications Technology (ictQATAR) in 2004 and its subsequent replacement with the Communications Regulatory Authority (CRA) in 2014 highlight the country’s desire to maintain a tightly controlled sector of ICT (Cochrane & Al Hababi, 2023; The Ministry of Transportation and Communication, 2014). The CRA’s mandate as an independent regulator is to ensure the creation of a transparent and harmonized legislative domain that encourages the adoption of new, innovative, and high-quality services in the telecommunications and postal services and fosters the development of a smart, connected, and cocooned nation (Badran, 2021; Sharifi et al., 2024).

Despite its accomplishments, Qatar's smart cities continue to face challenges on several fronts, including cyberspace and cybersecurity, data privacy, technology diffusion, and unsustainable urbanization (i.e., population growth). All of which require an urban planning response. Qatar's urban planning challenges incorporate elements of innovative urban planning, integrated development, and collaboration. Qatar's response will go a long way in enhancing its regional status in sustainable urban development.

Research Problem

The concept of the bright city model necessitates substantial investment in information and communication technologies (ICT) and has become a global trend, promising economic and social benefits (Gracias et al., 2023; Huang et al., 2022). Nevertheless, its implementation faces several challenges, most notably the accessibility and affordability of technology, the availability of a trained workforce, and the effective integration of the technology (Lacson et al., 2023). Furthermore, the integration of complex systems and a lack of understanding of the value and functionality of systems pose potential security and privacy risks, which could jeopardize the value proposition of smart cities (Wang & Ma, 2024). Apart from policy, governance, and stakeholder participation, ICT has become a necessary element in the implementation of innovative city projects (Pal et al., 2023; Rocha et al., 2022). Nevertheless, there is a limited number of empirical studies directly related to Qatar, and the few available studies cite secondary sources, highlighting a considerable gap in the literature.

At a basic level, a smart city integrates informational, intelligent, and interactive features of infrastructures that capture and consolidate real-time data from sensors, mobile devices, the internet, and social media to improve and develop environments that are more sustainable and livable (Mutambik et al., 2023; Wang & Ma, 2024). To understand the impact of these improvements, a definition of sustainable urban development must encompass shifts in resource allocation, technology, investment, and institutional approaches that affect both the

present and the future, while balancing the needs of current and future generations (Clement et al., 2023; Huang et al., 2022). Sustainability as a concept in urban development addresses the economic, social, and environmental issues of equity, as well as the sufficient provision of jobs, income, services, housing, transportation, social infrastructure, and spatial equity (White & Burger, 2022). The combination of urbanization, climate change, and other global factors has recently driven the international and, more recently, spatially dispersed phenomenon of smart cities (Gill et al., 2020). Over the last few decades, urban development and sustainable development have emerged as rapidly growing fields of interest in economics, technology, urban planning, and environmental management (Wang & Ma, 2024).

As a result of the lack of understanding, many people view smart cities as a temporary trend instead of a permanent solution. This is why it is necessary to study new city initiatives within the Qatari context, with a focus on sustainability. An all-encompassing framework outlines the key success factors, including sustainable urban outcomes. These include management and organization, governance, technology, people and communities, policy, built infrastructure, the economy, and the natural environment. Qatar's National Vision 2030 prioritizes sustainable development across four dimensions: social, economic, environmental, and human development (Sharif et al., 2024). As urbanization accelerates and the expatriate population expands, operational demands will continue to emerge, and the traditional model of expanding services by opening new branches will fall short (Al Ali et al., 2023; Wright, 2023). Unlike urban centers like Brisbane, which embed technology within urban design practices (Sharifi et al., 2024; Cochrane & AlHababi, 2023), innovative city initiatives in Doha target the hybridization of urban technologies and knowledge economy initiatives.

In Qatar, sustainable development is an ongoing process that intertwines social, economic, and environmental policies through a systems approach (Badran, 2021). Addressing social-ecological problems requires effective governance, transdisciplinary research, and

adaptive management policies (Alshuwaikhat et al., 2022; Bibri et al., 2024). Within innovative city initiatives, challenges include a lack of financing, restricted budgets, insufficient digital frameworks, the absence of partnerships, and concerns regarding citizen privacy and security (Bibri et al., 2024; Frischmann et al., 2023). While there are potential market benefits, a notable lack of empirical research exists on the challenges that arise during the real-world implementation of these initiatives (Dashkevych & Portnov, 2023).

The research aims to contribute to the limited literature on innovative city initiatives in Doha, Qatar, and their implications for sustainable development, providing empirical, localized insights that serve as a basis for future research in the region. These insights also provide a benchmark for research conducted in the Gulf Cooperation Council (GCC) region.

Defining Smart Cities

While the concept of smart cities has been widely debated in the literature, there remains no definitive definition of the term. Some research defines smart cities through the lens of integrated systems in technologies such as smart grids, smart meters, or intelligent transportation systems. At the same time, other studies focus on case studies of transformative urban change. Fundamentally, smart cities advocate the use of technology to enhance urban environments, thereby improving the lives, civic engagement, and sustainable growth of constituents (Sharifi et al., 2024).

Social, economic, and environmental growth, with real-time adjustments to urban structures, is the formal definition of smart cities (Sharifi et al., 2024). Thus, the use of information and communication technology (ICT) is closely tied to the Internet of Things (IoT). Most advanced cities in the world have adopted these systems, exemplified by New York, London, Paris, and Tokyo, as well as Amsterdam, Dubai, and Stockholm (Sharifi et al., 2024).

Globally, the importance of investments in innovative city initiatives continues to grow exponentially. In the case of China, innovative city development is a government-led initiative aimed at incorporating technology into restructuring the economy, enhancing labor efficiency, and addressing environmental challenges such as pollution, energy consumption, and other issues (Filho et al., 2024). China is also planning to develop 100 smart cities. The objective is to drive socio-economic development, enabled by technology that facilitates digitally interacting with citizens in Bengaluru and other Indian cities (Clement et al., 2023). Notwithstanding the above, it remains a matter of consensus among scholars that a smart city and its features lack a definitive explanation. The various stakeholders in smart cities describe them using terms like efficient, sustainable, inclusive, or competitive; however, none of these attributes is present in all of them (Alshuwaikhat et al., 2022).

The proliferation of different perspectives is mainly due to a lack of consensus on defining the coordinates that a smart city should incorporate. Corporate behemoths like IBM and Cisco advocate for a technology-centered approach, deeming advanced ICT as a panacea for urban challenges, such as congestion and waste management (Blasi et al., 2022). In contrast, human-centered 'social cities' discourse, like that of Barcelona, embeds 'social capital, education, and participatory governance' (Fabrègue & Bogoni, 2023). The lack of definitional consensus in framing smart cities reveals the differing perspectives and complexity the field entails.

Discussion of definitions also involves the shifting history of the words used to describe urban centers. The terms "digital city," "knowledge city," and "intelligent city" have slowly evolved and been integrated into the unified concept of the "smart city," which has more recent dimensions of technological and human integration (Rocha et al., 2022; Wang et al., 2024). However, even today, the meaning of the term varies depending on the location. For example, Europe tends to incorporate carbon reduction activities into the core of its innovative city plans.

In contrast, North America focuses on technology-driven approaches, which are primarily controlled by the private sector (Oke et al., 2022). Thus, the need for a comprehensive and coherent definition that considers technology, sustainability, and integrated top-down and bottom-up civic governance remains a requirement for future research (José & Rodrigues, 2024).

Emergence and Development of Smart Cities

The transition to smart cities can be explained by systems theory, due to the interrelatedness of the different subsystems within cities. Lom and Pribyl (2020) demonstrated that while traditional cities had utilities and systems for housing, sanitation, and transportation, these tended to function as independent and isolated entities. The case of smart cities is different; there is interaction between subsystems, enabled by the subsystems' abilities to communicate through digital means and the provision of real-time data (Meddeb & Handforth, 2022). An example of this integration is transport systems that can communicate with energy provision systems through smart grids. This interaction will facilitate the optimization of transportation and resource consumption.

The institutionalization of ICT-assisted governance primarily drives the shift to integrated subsystems and interdependence. The adoption of e-governance models has transformed the way cities are managed, enabling policymakers to utilize real-time data for informed decision-making and regulatory processes (Wright, 2023). These changes reflect a broader redefinition of government structures, where traditional regulatory controls are superseded by, and in some cases, wholly replaced by technologically enabled processes. Digital governance means that city management no longer relies solely on physical infrastructure, core transportation, and communication networks, but also encompasses digital infrastructure and online platforms for citizen engagement (Wang & Ma, 2024).

According to Mutambik et al. (2023), the smart city must be understood at the nexus of three main components: technological systems, human systems, and institutional systems. Technology provides the fundamental infrastructure for connecting data and digital resources. However, technology alone cannot spawn a functional smart city. The people must be able and willing to engage actively in the governance processes, and the institutions must adopt policies that are sustainable and inclusive. In this sense, smartness is a process that constantly evolves as a city becomes responsive to newly emerging, challenging technological, social, and ecological frameworks (Mutambik et al., 2023).

World urbanization challenges, including population growth, climate change, and dwindling resources, have also driven the movement toward smart cities. Constraints on city services are increasing at the same time city populations are growing. Urban centers must reduce the carbon footprint of the services they provide to accommodate a growing population. As a result, Information and communication technology (ICT) is seen as a way to help cities increase operational efficiencies, reduce waste, and attain sustainable economic growth (Sharifi et al., 2024). This urban policy shift represents a shift in technological innovation planning and a transformative view of cities as integrated living systems that must strike a balance between economic and ecological priorities.

Components of Smart Cities

While concepts regarding smart cities may vary, there are still foundational elements to which all scholars attribute the understanding of the concept. A widely referenced approach outlines a framework of six dimensions: smart living, intelligent people, innovative governance, smart environment, smart economy, and smart mobility (Rcha et al., 2022). Other depictions of the framework may expand, contract, or alloy the descriptive categories, yet they all fundamentally acknowledge the need to amalgamate technology with the social, ecological, and economic spheres.

Smart living highlights the benefits of technology to the health and overall well-being of people from various perspectives, including healthcare, education, safety, and culture (Lacson et al., 2023). Technologies in this area serve purposes such as telehealth, home care assistance, disease surveillance, and education systems supporting distance learning. During a crisis, such as a pandemic, a city's digitized public services and enhanced accessibility allow it to respond to citizen needs with greater efficacy. For this to occur, a government must address efficiency expectations alongside citizens' demands for equity and inclusiveness, to avoid a backlash (Wright, 2023).

One essential aspect of innovative governance is the use of ICT to enhance the effectiveness of public administration, promote transparency, and foster citizen engagement. Through various digital reporting mechanisms, e-governance interfaces, and open data repositories, the public is granted opportunities to interact with public officials (Mutambik et al., 2023). These mechanisms support accountability and encourage co-governance. However, risks of digital exclusion and cyber threats must be addressed with the creation of inclusive and safe infrastructures (Bibri et al., 2024).

Innovative environments and mobility deeply intersect. While the latter focuses on improving transport networks, reducing economic and environmental costs, and adopting sustainable mobility, the former includes developing smart grids, smart meters, and automated ecological waste management systems (Frischmann et al., 2023). These tools help achieve ecological goals, including reducing pollution, enhancing the resilience of urban areas, and optimizing utility services. Consequently, the systems designed with innovative technologies improve safety, reduce congestion, and promote sustainable travel. Initiatives in smart mobility include intelligent traffic management, multimodal transportation planning, and automated waste management systems.

Ultimately, intelligent economies utilize innovation to optimize productivity, foster sustainability, and stimulate entrepreneurial activities. Al Ali et al. (2023) note that digital frameworks, e-commerce networks, and flexible employment structures are gaining importance within contemporary metropolitan economies. Yet, poorly regulated flexible employment models, along with digital exclusion (Clement et al., 2023), remain unresolved challenges. The above explains why the five interrelated components present the case that smart cities are not determined by the advanced technologies available, but by their capacity to weave different forms of innovation into the fabric of urban living.

Smart City Applications

Practical applications of innovative city concepts can be observed in various domains, including health, governance, the environment, mobility, energy, infrastructure, safety, and education. The use of IoT, artificial intelligence, and big data technology, which facilitate the collection, processing, and utilization of data in real-time, makes these applications possible (Sharifi et al., 2024).

Transforming service delivery in healthcare involves utilizing remote patient monitoring and predictive analytics to enhance patient care and outcomes. Patients utilize IoT-enabled devices to monitor their health, and AI predictive algorithms analyze data to anticipate disease outbreaks and inform public health responses (Huang et al., 2022). In governance, similarly, innovative technology enables real-time management of resources and interaction with citizens. Transparency is enhanced through open data resources, and e-government service delivery reorganizes bureaucratic processes, thereby improving efficiency (Ziosi et al., 2022).

Within the context of climate change, the relevance of innovative environmental applications cannot be overstated. Smart grids, precision agriculture, and intelligent waste management systems help conserve resources and lower ecological impact (Ruijer et al., 2023). For instance, precision agriculture operates ecosystem protection enhancement, higher yield

attainment, and resource management through AI and IoT automation of resources (fertilizer and pesticide). The disruption of congestion and associated emissions by autonomous vehicles, intelligent traffic systems, and ride-sharing systems reflects the futuristic approach to addressing contemporary mobility problems (Frischmann et al., 2023).

Improved safety and security through intelligent surveillance and emergency response systems, which intercept and act on AI-suspected anomaly detections while responding to real-time emergency alerts, allows proactive and dynamic management of public space security (Beck et al., 2023). IoT sensors enable the preventive maintenance control and active management of public infrastructure risks through the structural health monitoring of bridges, roads, and buildings (Rocha et al., 2022).

Educational applications of innovative technologies include adaptive learning and advanced predictive analytics, which personalize instruction and enhance engagement (Secinaro et al., 2022). These instances support the assertion that smart cities' advanced infrastructure encompasses transformative everyday life applications that alter the interactions of citizens with the health system, administration, education system, and one another.

Criticism of Smart City Concepts

The smart city phenomenon has garnered broad acceptance, particularly within scholarly, political, and business contexts, and has also received considerable critique. Imaginative city ventures were initially framed as purely technological solutions to some urban challenges, with very little consideration given to the social and environmental aspects. Subsequently, criticisms began pointing out the overemphasis on the technological side without fully considering the social and environmental impacts and challenges. For instance, Dashkevych and Portnov (2023) note that numerous cities self-identifying as smart have failed

to incorporate the sustainability frameworks of the United Nations' Sustainable Development Goals (SDGs).

A standard critique of the smart city approach is its technocentrism, which treats technology as the ultimate goal rather than a means to an end. It equates the solving of challenges such as traffic congestion, waste disposal, and environmental degradation to the deployment of digital systems without the related socio-political and cultural dimensions (Echebarria et al., 2021). There is a Dutch saying that translates to English, 'to watch the tree and lose the forest.' Such technocentric models may focus on socio-political inefficiencies, concealing the deep structures of inequality. For example, enhanced surveillance technologies may disproportionately improve safety for some citizens while exposing others and provoking a sense of control (Beck et al., 2023).

Critiques have also emerged regarding the openness of innovative city initiatives. The digital divide persists as a problem, as not everyone has the necessary resources, knowledge, or confidence to engage with digital technologies. This means the innovative city framework could widen inequalities, rather than diminish them (Badran, 2021). These critics also point out that many initiatives fail to take into account the interests of local communities, as many smart city projects are influenced by private interests, resulting in a commercially oriented perspective of urban life and the exclusion of urban residents from the democratic processes of city life (Blasi et al., 2022).

Increased calls to deliver a more seamless vision of smart cities are driven by the resilience critiques. New ICTs and the infrastructure that supports them, including energy-hungry data centers and rapidly obsolete digital devices, work against the very ecological benefits that smart cities aim to deliver (Filho et al., 2024). Such critiques have sparked hopes that the new wave of digital urbanism will integrate advanced technologies with active social

policies, civic engagement, and new forms of urban ecological balance (Alshuwaikhat et al., 2022).

Challenges in the Implementation of Smart City Projects

The move from theoretical frameworks to practical implementation has showcased various issues during the development of smart cities. These issues can be classified into three primary categories: pragmatic and policy issues, socio-cultural issues, and technology issues (José & Rodrigues, 2024).

Government Policies and Regulatory Challenges

A lack of coherent regulatory frameworks is one of the most significant barriers to implementing smart cities. The integration of several spheres, such as telecommunications, energy, transport, and healthcare, each of which presents its own unique challenges and regulations, makes the consolidation process complicated. Creating and maintaining a holistic governance structure can be highly complicated. Regulators are tasked with ensuring that service providers compete with one another, as well as developing equitable frameworks for spectrum and resource allocation, and promoting cross-systems interoperability (Mutambik et al., 2023).

Governments face a unique challenge in integrating wireless technology and smart cities. Government spectrum resource management must consider high demand in relation to limited resources. The massive integration of wireless networks in smart cities will require the incorporation and real-time processing of vast amounts of data (Rocha et al., 2022). Furthermore, equitable monopolistic control and access to resources must be avoided to foster innovation. The public's interests can be compromised when a few powerful corporations control the markets and service provision, especially in the context of Fakhimi et al. (2021)'s innovative city development.

Data governance employs yet another crucial challenge. The collection and utilization of citizen data analytics in smart cities raises concerns of data ownership, privacy, and protection. Regulations must strike a balance between the issues of open data, interoperability, the cross-border flow of data, and the safety of citizens' rights. The absence of clear and robust regulations in the area of data governance remains one of the primary reasons for the stalled and/or convoluted deployment of smart cities globally (Gracias et al., 2023).

Social, Cultural, and Demographic Challenges

Alongside legislative challenges, the obstacles to smart cities' development derive from social and cultural factors, as well as the inequitable distribution of benefits across demographics. Opportunities for e-participation emerge through digital platforms and e-governance; however, those without digital literacy, skills, or internet access can be silenced or excluded from participation and the political benefits it offers (Dashkevych & Portnov, 2023). This suggests that promises of participation and the inclusive smart city concept may, ultimately, exacerbate social inequities and deepen fissures in the social fabric. The challenge of innovative city initiatives is to promote citizen participation as actively engaged citizens. Tools for e-democracy and collaborative urban planning, such as Decidim and Fab Labs, are designed to encourage citizen participation. However, critics claim that these platforms require technological literacy and are, therefore, inherently exclusive to socioeconomically privileged individuals (Fabrègue & Bogoni, 2023). Additionally, social inequities are exacerbated as innovative city initiatives are developed in the context of gentrified, upgraded housing, which often displaces economically vulnerable and low-income populations (Voelz et al., 2023).

Another cultural challenge relates to how citizens trust technology. People express skepticism regarding differing technologies due to fears surrounding privacy, bias, and state surveillance (Strides, 2021). Predictive policing and credit scoring, for instance, reinforce

discriminatory bias (Ruijer et al., 2023). These challenges clearly demonstrate the need for ethical frameworks to ensure the fair and accountable use of urban surveillance systems.

Technological Challenges

Though technology is the foundation for smart cities, it also creates significant challenges. The data generated by smart city IoT devices and applications is of considerable volume and requires adequate storage, processing, and cybersecurity infrastructure to support its management. Cities that lack these capabilities struggle to implement even the simplest innovative systems (Bibri et al., 2024). In addition, municipalities, especially in developing regions, find it extremely costly to rehabilitate and modernize their outdated infrastructure to integrate innovative technologies (Bilal et al., 2021).

In high-tech urban environments, such as smart cities, security and privacy become critical challenges. The interconnected devices that smart cities depend on can become targets of cyberattacks. Hackers may penetrate urban infrastructure systems, such as traffic control, power distribution, and even health care systems, and unleash catastrophic consequences by compromising entire systems (Gill et al., 2020). Without appropriate security measures, the risks of substantial disruptive damage and loss of public esteem will determine the investments made in counterbalances.

The absence of standardization is yet another technological challenge. The interoperability of various systems and devices is often deficient, leading to inefficiencies and the wasteful use of resources. Cities may contract with different vendors, which can lead to siloed systems that fail to unlock the full benefits offered by integration (Huang et al., 2022). This problem will be addressed by establishing open standards and cooperative structures that prioritize interoperability as a primary long-term goal.

Overcoming Challenges of Smart City Implementation

Nonetheless, there are still many proposed strategies to enhance the success of smart cities initiatives. One important strategy is the creation of collaborations and partnerships across diverse sectors. In the case of smart cities, PPPs are essential to the development and financing of these projects because municipal governments usually do not have the resources and the required technical know-how to implement these initiatives by themselves (ElKholei & Yassine, 2019). The most substantial value of these PPPs lies in the innovation sustainability that the partnerships can achieve by combining the resources of government, industry, and academia.

Another strategy emphasizes the importance of high-quality ICT infrastructure. In fact, smart cities cannot function without high-quality telecommunications and cloud computing networks, as well as robust cybersecurity systems (Al Ali et al., 2023). Investments in these areas of ICT infrastructure must be accompanied by training municipal staff and citizens in the required ICT competencies. These initiatives will not only promote the operational efficiency of ICT systems but also help reduce the digital divide and enhance the inclusivity of services (Bilal et al., 2021).

Regulatory innovation is equally vital. Within the context of specific objectives for a smart city, flexible approaches to policy innovation can mitigate the challenges of data interoperability, privacy, and competition among service providers (Esashika et al., 2021). Processes for technical standardization, the provision of open data, and governance mechanisms that promote data transparency and accountability will foster trust. Cities that succeed in these approaches will be able to take the socially responsible innovation their citizens deserve.

Lastly, a smart city will not be considered smart if it is not developed with a focus on sustainability. Incorporating planning for renewable energy systems and energy-efficient

technologies alongside environmentally sustainable urban development remains central to the smart city's long-term objectives (Frischmann et al. 2023). A smart city aligned with a global sustainability agenda will be resilient, mitigate adverse environmental impacts, and provide benefits to future generations in a socially equitable manner.

Theoretical Foundations of Smart Cities

The development of smart cities has different theoretical perspectives. The most common of these is systems theory. This theory approaches complex systems composed of interdependent subsystems, including utilities, housing, sanitation, transportation, and governance. In contrast to traditional cities, where these subsystems functioned independently, smart cities integrate these subsystems into an interconnected network through information and communication technologies (ICTs) and data-driven processes. Integration, interoperability, and feedback loops should be sought as the primary drivers of resilience and sustainability in urban ecosystems (Meddeb & Handforth, 2022).

The third perspective, and most relevant for the current research, is socio-technical theory, which focuses on the interrelations of technological systems, people, and institutions. It argues that smartness is not an absolute quality of a city, and that urban systems change only through the interrelations of innovation, governance, and the people. For urban advancement, both political will and technological systems are necessary, but they are insufficient alone without the involvement of the people (Mutambik et al., 2023).

Moreover, sustainability frameworks that encompass the social, environmental, and economic dimensions have been utilized to analyze the integration of smart cities into global frameworks, including the UN Sustainable Development Goals (SDGs). From this perspective, smart cities are viewed as technologies that advance climate adaptation, social equity, and economic competitiveness, rather than innovations (Sharifi et al., 2024).

Lastly, the knowledge-based theories of urban development provide an invaluable historical reference for smart city scholarship. Previous iterations, such as “knowledge cities” and “intelligent cities,” focused on human capital and the knowledge economy as the primary catalysts for urban transformation. These models, which have shaped the contemporary framework of smart cities, integrate digital technologies with human and institutional resources to boost urban development and competitiveness (Rocha et al., 2022; Wang et al., 2024).

Conclusion

There remain some gaps in the research on smart cities literature. First, and undoubtedly foremost, is the question of definition. Most academics, decision-makers, and business actors approach smart cities from very different conceptual frameworks. Some emphasize the ICT components, while others include governance, and even more, the gaps in these conceptual frameworks. This is the basis of the gap in the literature, specifically in terms of cohesion and the lack of corroborating comparisons across studies.

Second, and more importantly, is the technocentric focus of the literature. Most studies focus on efficiency, infrastructure, and innovation, while the social and cultural aspects are just as, if not more, important and, in this case, are often ignored. This creates the risk of exclusivity and inequity, and, in extension, relates to the digital divide, specifically the lack of research on those at the bottom of society. Those on the margins of society are unlikely to possess the skills, access, or even the will necessary to engage with digital technology. Smart cities are inequitable, not un-inequitable.

The absence of governance and regulation constitutes another critical gap. Smart cities depend on the collection and analysis of vast amounts of interlinked data. Consequently, the literature on governance of such data, privacy, bias in algorithms, and cybersecurity remains relatively thin. The issues of data ownership, the ethics of governance, and the dominant narratives arguing governance frameworks need a ‘fine’ overhaul, remain purely interstitial

and in need of deep academic attention (Dashkevych & Portnov, 2023). Relatedly, despite a dominant theme in the literature being sustainability, the lack of critical analysis on the negative environmental impacts of ICTs (e.g., energy-hungry data centers, e-waste, the climate impact of digital devices) remains striking (Filho et al., 2024).

Lastly, the literature reveals a considerable geographical bias. Most research centers on Western and East Asian contexts, particularly in Europe, North America, China, and Singapore, and pays limited attention to the Middle East, Africa, and the Global South. This situation fundamentally weakens the generalizability and validity of research, underscoring the need for more context-sensitive and comparative frameworks (Voelz et al., 2023; Huang et al., 2022).

In combination, these themed absences suggest the desirability of a more integrated and comprehensive research agenda that combines technological advancement with social equity, the integration of civic governance, and sustainability. Closing these gaps will enable future research to articulate a more effective understanding of smart cities and their role in facilitating sustainable urban development.

The Lusail and Pearl Smart City projects in Qatar represent a substantial part of Qatar National Vision 2030, which aims to advance ICT to foster improvements in quality of life, sustainability, and economic development (Pal et al., 2023; Sharifi et al., 2024). The use of technology in the formation of the TASMU Smart Qatar Program is designed to promote effective public service delivery and urban living improvements in the sectors of healthcare, transportation, logistics, and the environment (Saxena & Al Tamimi, 2018; TASMU, 2023). The infrastructure of smart cities captures and analyzes real-time information and data from connected devices, urban sensors, and social media to support decision-making and planning in urban centers (Mutambik et al., 2023). Despite the progress made, problems persist in several areas, including ICT equity, affordability, a trained workforce, technological convergence, as well as cybersecurity and data privacy (Wang & Ma, 2024). The issues of sustainable urban

development should be addressed and long-term success secured through an understanding of the economic, social, and environmental challenges that interlock (White & Burger, 2022).

Significant smart city development continues to depend on the integration of public policy, citizen participation, and adaptive entrepreneurial networks. Through innovative governance, the deployment of participatory open data sets, and the development of crowdsourced tools, the willingness to engage in social market behavior is advanced, resulting in the positive redistribution of value in the streams of utilities, healthcare, and transportation (Alshuwaikhat et al., 2022; Wang & Ma, 2024). The balance between centralized and decentralized governance, along with clear operational frameworks and committed leadership in silo public agencies, will contribute to optimizing service delivery (Frischmann et al., 2023).

The use of ICT as a technology, rather than an end in itself, will enable citizen Shin to innovate with the outcome of participatory and sustainable urban development, rather than top-down development of urban areas. Unlike other major metropolitan areas, the Qatari context benefits from limited empirical research, highlighting the importance of understanding innovative city initiatives, the barriers to these initiatives, and the extent to which these initiatives support sustainable development goals (Dashkevych & Portnov, 2023; Pal et al., 2023). The literature identifies the main challenges of innovative city implementations related to IT infrastructure, governance, and organizational and social factors. These factors influence the challenges associated with IT infrastructure, governance, organizational factors, and social factors, which in turn impact the sustainability of innovative city implementations in Qatar. The researcher recommends testing the influence of IT infrastructure, governance, organizational factors, and social factors on the sustainability of smart city implementation in Qatar using quantitative or qualitative methods. The research emphasizes the need to incorporate cutting-edge ICT, governance, and citizen participation. These factors, together, impact sustainability, service efficacy, and urban livability. The long-term sustainable

development goals, along with empirical evidence from Qatar, can help policymakers and stakeholders understand the technological, social, and operational gaps that exist.

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