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Assessment of the Feasibility of Smart City Indicators Implementation in District 2 of Tehran

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ABSTRACT

Aims In recent years, various studies at the global and national levels have examined various aspects of smart cities. At the international level, the main focus of these studies has been on developing indicators, assessing cities' readiness for smartization, and analyzing the dimensions of smart city implementation. The purpose of this study was to assess the feasibility of smart city indicators in District 2 of Tehran.

Methodology This survey research was conducted using quantitative survey analysis in the fall and winter of 2024 among residents of Tehran's District 2. The research instrument was a researcher-developed questionnaire comprising 37 items across 6 main indicators. A multiple linear regression test was used to analyze the data and assess the feasibility of smart city indicators.

Findings The mean of smart city realization indicators from the participants' perspective was obtained as 4.19±0.39 for smart people, 3.92±0.48 for smart life, 4.11±0.50 for smart governance, 3.52±0.34 for smart economy, 3.38±0.82 for smart transportation, and 4.11±0.35 for smart environment. Smart economy (p=0.0001) had the highest role, and smart life (p=0.048) the lowest, in advancing the goals of the smart city.

Conclusion District 2 of Tehran Municipality is at a desirable level in achieving smart city indicators, especially in the economic, governance, and social participation dimensions. However, the dimensions of smart environment and smart life require a strategic review.

Keywords Smart City; Smart Living; Smart Governance; Smart People; District 2 of Tehran

CITATION LINKS

[Albino *et al.*, 2015] Smart cities: Definitions, dimensions, performance, and initiatives; [Ansari & Mehrotra, 2019] Development of smart cities and its sustainability: A smart city framework; [Anthopoulos, 2015] Understanding the smart city domain: A literature review; [Anthopoulos & Reddick, 2016] Smart city and smart government: Synonymous or complementary?; [Camero & Alba, 2019] Smart city and information technology: A review; [Chourabi *et al.*, 2012] Understanding smart cities: An integrative framework; [Cocchia, 2014] Smart and digital city: A systematic literature review; [Dameri, 2017] Smart city definition, goals and performance; [Dameri & Rosenthal-Sabroux, 2014] Smart city and value creation; [Elah Karmi *et al.*, 2023] Presenting smart city model using startups the case study of district 20 of the Tehran metropolis; [Hoffman, 2020] Smart cities: A review of the most recent literature; [Ismagilova *et al.*, 2019] Smart cities: Advances in research-An information systems perspective; [James *et al.*, 2021] Smart cities: Fundamental concepts; [Jasim & ALRikabi, 2021] Design and Implementation of smart city applications based on the internet of things; [Kézai *et al.*, 2020] Smart economy and startup enterprises in the Visegrád Countries-A comparative analysis based on the Crunchbase Database; [Lacinák & Ristvej, 2017] Smart city, safety and security; [Neirotti *et al.*, 2014] Current trends in Smart City initiatives: Some stylised facts; [Ojo *et al.*, 2015] Exploring the nature of the smart cities research landscape; [Rezapourgatabi *et al.*, 2023] Assessing the feasibility of smart city indicators in the contemporary context of Iranian cities the case study of Babol City; [Riva Sanseverino *et al.*, 2018] A cross-reading approach to smart city: A European perspective of Chinese smart cities; [Sajadian *et al.*, 2023] Assessing the realization of the smart city of Ahvaz according to the current conditions of the key components; [Shami *et al.*, 2023] Evaluation and measurement of indicators of quality of urban smart living in Tehran city; [Sharma & Kanwal, 2023] Smart cities: A worldwide journey into intelligent urbanism and state-of-the-art technologies; [Silva *et al.*, 2018] Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities; [Singh *et al.*, 2022] A decade review on smart cities: Paradigms, challenges and opportunities; [Tavanaei Marvi *et al.*, 2022] Analysis smart city implementation challenges case study: Mashhad; [Zubizarreta *et al.*, 2016] Smart city concept: What it is and what it should be;

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Introduction

Cities, as the main setting for human settlement and agglomeration, have always faced challenges regarding the quality of life of their citizens; challenges that have become more multidimensional as a result of rapid urbanization, the complexity of socio-spatial relations, and the growing pressure on urban infrastructure [Lacinák & Ristvej, 2017]. In response to this situation, numerous ideas and approaches have emerged to improve the quality of urban life. One of the most important of these approaches, which has received great attention since the late twentieth century and especially since the 1990s, is the concept of the "smart city"; a concept built on the use of new information and communication technologies (ICT) to optimize urban services and enhance the efficiency of the urban management system [Chourabi *et al.*, 2012; Ojo *et al.*, 2015]. This concept has evolved from the electronic city to the digital city, the virtual city, and ultimately the sustainable smart city, and today it is regarded as a model for sustainable urban development [Zubizarreta *et al.*, 2016; Silva *et al.*, 2018]. The smart city is not merely a technical and technological framework, but a complex social system in which various actors, including the government, the private sector, public organizations, and citizens, produce and consume information in an interactive process [Camero & Alba, 2019; Kézai *et al.*, 2020]. The function of this system lies in coordinating the various components of the city through data integration, increased transparency, improved service quality, and faster management processes [Sharma & Kanwal, 2023; Singh *et al.*, 2022; Hoffman, 2020]. Various dimensions such as smart transportation, smart environment, smart economy and governance, smart citizens, and smart living have been considered key components of this concept [Ismagilova *et al.*, 2019; James *et al.*, 2021; Jasim & ALRikabi, 2021; Kézai, 2020]. In particular, by creating technological and participatory platforms, the smart city provides the groundwork for improving urban performance, enhancing quality of life, and achieving sustainable development.

In recent years, various studies at the global and national levels have examined different aspects of the smart city. At the international level, the main focus of these studies has been on developing indicators, measuring cities' readiness for smartization, and analyzing the implementation dimensions of the smart city [Albino *et al.*, 2015; Neirotti *et al.*, 2014; Chourabi *et al.*, 2012; Dameri & Rosenthal-Sabroux, 2014]. In Iran, too, numerous studies have been conducted in various fields such as urban startups, smart quality-of-life indicators, and assessments of the feasibility of smart governance or the smart economy [Elah Karmi *et al.*, 2023; Sajadian *et al.*, 2023; Shami *et al.*, 2023]. However, a review of the literature shows that most of these studies have either addressed general, macro-level assessments or focused on one or a few specific dimensions of the smart city concept. Therefore, there is a considerable gap in the integrated and comprehensive analysis of the main smart city indicators at the regional scale and in the real contexts of Iranian cities. This gap becomes doubly important in areas where the implementation of pilot smart city projects has begun.

The city of Tehran, as a metropolis that has paid special attention to the smart city concept in its urban policies in recent years, has witnessed the implementation of various projects in this field. Among these, District 2 of Tehran Municipality, as the first district in which the smart city plan has been implemented as a pilot, is of strategic importance. The existence of technological infrastructure, population concentration, and the specific physical and functional characteristics of this district have made it a suitable case for an objective examination of the feasibility of smart city indicators. This research was conducted with the aim of assessing the feasibility of the key smart city indicators (smart governance, smart economy, smart transportation, smart environment, smart living, and smart citizens) in District 2 of Tehran Municipality.

Methodology

This survey research was conducted using quantitative survey analysis in the fall and winter of 2024 among the residents of District 2 of Tehran, with a population of more than 701,303 people (according to the latest national population and housing census). District 2 of Tehran is the first district in which the smart city plan was implemented as a pilot. The sample size was determined as 373 people based on Cochran's formula (95% confidence level and 5% sampling error), and sampling was carried out using the stratified random method. In this regard, Area 7 of District 2 (Shahrak-e Gharb), which had suitable conditions for implementing the smart city plan in terms of information technology infrastructure and urban services, was selected as the study sample, and 400 questionnaires were distributed and collected there to allow for possible attrition.

The research instrument was a researcher-made questionnaire consisting of two sections: demographic information and smart city realization. Based on library studies and a review of up-to-date domestic and international scientific articles related to the smart city, 37 items were extracted in the form of 6 main indicators:

- Smart people (6 items): creativity, public participation, awareness, skill, education, and flexibility;
- Smart living (4 items): digital health services, service applications, access to digital facilities, and equitable access to urban services;
- Smart governance (5 items): active citizen participation, e-government, political participation, data protection, and privacy;
- Smart economy (8 items): labor market, innovation, sustainability, integration, productivity, competitiveness, e-commerce, and job opportunities;

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- Smart transportation (5 items): smart public transportation, route optimization, internet in vehicles, culture-building, and new transportation systems;
- Smart environment (9 items): walkability, cycling, renewable energies, sustainable transportation, resource management, pollution control, conservation, green urban planning, and access to green space.

A five-point Likert scale (from "very low" to "very high") was used to measure the responses. The initial version of the questionnaire was provided to a panel of experts and specialists in urban planning and smart cities. After the suggested revisions were applied, the face and content validity of the research instrument were confirmed. In addition, the reliability of the questionnaire was calculated and confirmed using Cronbach's alpha coefficient, which was greater than 0.8.

To analyze the data and assess the feasibility of the smart city indicators, the multiple linear regression test was used. Statistics such as the adjusted coefficient of determination, the beta coefficient, the T statistic, and the significance level were used in the SPSS 27 statistical software to determine the desirability and importance of each indicator.

Findings

Of the respondents, 234 were male (58.5%), 188 were in the 18–64 age range (46.9%), and 124 held a master's degree (31.0%) (Table 1).

Table 1) Demographic characteristics of the research participants ($n = 400$)

Indicator	Number	Percent
Gender		
Male	234	58.5
Female	166	41.5
Age group (years)		
Under 18	92	22.9
18 to 64	188	46.9
Over 64	120	30.1
Education		
Below high school diploma	36	9.0
Diploma and associate degree	83	20.8
Bachelor's	112	27.9
Master's	124	31.0
PhD	45	11.2

The mean scores of the smart city realization indicators from the participants' point of view were 4.19±0.39 for smart people, 3.92±0.48 for smart living, 4.11±0.50 for smart governance, 3.52±0.34 for smart economy, 3.38±0.82 for smart transportation, and 4.11±0.35 for smart environment. The smart economy ($p = 0.0001$) had the greatest role and smart living ($p = 0.048$) the smallest role in advancing the goals of the smart city (Table 2).

Table 2) Results of the regression test of the smart city realization indicators

Indicator	β coef.	T stat.	Tol.	VIF	Sig.	Std. reg. coef.	Adj. R^2
Smart people	0.206	3.63	0.48	2.084	0.0001		
Smart living	0.113	1.989	0.48	2.081	0.048		
Smart governance	0.199	3.4	0.451	2.219	0.001		
Smart economy	0.332	7.018	0.692	1.445	0.0001	0.732	0.722
Smart transportation	0.154	3.126	0.641	1.561	0.002		
Smart environment	0.186	4.306	0.833	1.2	0.0001		

The correlations of all domains of the smart city indicators with one another were positive and significant ($p < 0.05$; Table 3).

Table 3) Correlations of the smart city and its indicators with one another (all were significant at the $p < 0.05$ level)

Indicator	7	6	5	4	3	2	1
1- Smart city	0.436	0.58	0.653	0.691	0.574	0.689	1
2- Smart people	0.306	0.453	0.5	0.616	0.595	1	
3- Smart living	0.152	0.516	0.315	0.63	1		
4- Smart governance	0.333	0.503	0.464	1			
5- Smart economy	0.18	0.363	1				
6- Smart transportation	0.287	1					
7- Smart environment	1						

Innovation, e-government, and active citizen participation were among the most important factors affecting progress in smart city realization. In contrast, public awareness and equitable access to urban services played a smaller role (Table 4).

Table 4) Desirability status of the factors affecting smart city realization in District 2

Indicator		Beta coef.	T value	Sig. level
Smart people	Creativity	0.145	2.412	0.017
	Public participation	0.255	4.166	0.0001
	Awareness	0.078	1.571	0.118
	Skill	0.267	4.575	0.0001
	Education	0.285	4.455	0.0001
	Flexibility	0.132	2.204	0.029
Smart living	Access to e-health and medical services	0.270	4.131	0.0001
	Service applications	0.289	4.551	0.0001
	Citizens' access to digital facilities	0.132	1.892	0.030
	Equitable access to urban services	0.117	1.825	0.042
Smart governance	Active citizen participation	0.377	5.960	0.0001
	E-government	0.442	7.997	0.0001
	Greater willingness for political activity	0.306	5.874	0.0001
	Protection of citizens' data	0.209	3.645	0.0001
	Privacy protection systems	0.164	3.462	0.001
Smart economy	Labor market	0.199	5.401	0.0001
	Innovation	0.476	8.110	0.0001
	Economic sustainability	0.088	2.622	0.010
	Economic integration	0.078	2.284	0.024
	Increased productivity	0.168	5.364	0.0001
	Economic competition	0.155	4.570	0.0001

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Table 4) (continued)

Indicator		Beta coef.	T value	Sig. level
Smart economy	E-commerce	0.189	5.036	0.0001
	Access to job opportunities	0.231	6.305	0.0001
Smart transportation	Access to smart public transport	0.154	2.529	0.012
	Route optimization	0.266	4.239	0.0001
	Internet in public vehicles	0.219	3.748	0.0001
	Culture of using new vehicles	0.322	5.926	0.0001
	Use of new transport systems	0.161	2.873	0.005
Smart environment	Increased walkability	0.125	2.507	0.013
	Increased cycling	0.090	2.101	0.037
	Use of renewable resources	0.245	3.977	0.0001
	Use of public transportation	0.164	3.462	0.001
	Sustainable resource management	0.243	5.049	0.0001
	Pollution monitoring and control	0.032	0.632	0.528
	Energy conservation	0.262	5.715	0.0001
	Green urban planning	0.153	3.135	0.002
	Access to green space	0.085	2.030	0.044

Discussion

The main aim of this research was to identify and assess the feasibility of the smart city approach in District 2 of Tehran. The indicators related to the smart city, comprising 37 items in the form of 6 key criteria—smart people, smart living, smart governance, smart economy, smart transportation, and smart environment—were extracted and analyzed. The findings of the multiple regression modeling showed that the six dimensions were able to explain a major part of the variance in the feasibility of the smart city. This high explanatory power confirms the holistic approach in the modern urban development literature, which regards the smart city not merely as a physical and technological phenomenon but as a complex and multifaceted system [Cocchia, 2014; Anthopoulos, 2015].

A critical analysis of the findings indicates that, in the geographical context of District 2 of Tehran, the "smart economy" dimension, with the highest impact coefficient ($\beta = 0.332$), plays the main driving role in smartization. This economic dominance can be attributed to the specific characteristics of this district, including the high concentration of knowledge-based companies, startups, and modern commercial infrastructure. An examination of the micro-level variables also shows that innovation and access to job opportunities made the largest contribution to this dimension. This finding is consistent with previous studies that regard the creation of economic added value as the driving engine of smart cities [Dameri, 2017]; at the same time, however, it shows that in developing economies, economic and technological priorities are absorbed and institutionalized in the urban context much faster than environmental and social dimensions [Kézai *et al.*, 2020; Rezapourgatabi *et al.*, 2023; Ismagilova *et al.*, 2019; James *et al.*, 2021; Jasim & ALRikabi, 2021].

On the other hand, the strong relationship of "smart governance" and "smart people" with the smart city highlights the importance of the active participation of citizens and of efficient governance structures in achieving smartization goals. This correlation clearly shows that the development of information infrastructure and continuous training of citizens, through tools such as training workshops, cyberspace, and the provision of appropriate internet services, has been able to increase public participation and awareness, and this has made possible the improvement of governance processes and the enhancement of the capabilities of smart people. This result confirms the importance of interaction between the people and the government in the smart city development process and is consistent with similar studies that emphasize the role of education and social participation [Elah Karmi *et al.*, 2023; Rezapourgatabi *et al.*, 2023]. The considerable impact of indicators such as e-government ($\beta = 0.442$) and active citizen participation ($\beta = 0.377$) proves that governance infrastructures achieve the desired output only when they are accompanied by trained human capital that is ready to adopt technology. Owing to its population structure with a relatively high level of education and socio-economic status, District 2 of Tehran has provided a suitable foundation for this convergence. This result rejects the reductionist view of the smart city as a purely infrastructural project and is fully consistent with theories that regard smart government and smart citizens as complementary and inseparable concepts [Anthopoulos & Reddick, 2016]. This finding also supports urban sustainability frameworks that emphasize the centrality of humans in technological development [Ansari & Mehrotra, 2019]. Nevertheless, a critical analysis of the results reveals deep contradictions and challenges on the path to smartization in this district. Despite progress in the economic and governance domains, the smart living dimension had the lowest impact ($\beta = 0.113$). In particular, the low beta coefficient (0.117) and borderline significance level ($p = 0.042$) of the indicator of equitable access to various urban services are a serious warning for urban planners. This is rooted in the spatial gap and physical duality between the northern and southern parts of District 2, where the accumulation of wealth and infrastructure in the north of the district has prevented the benefits of smartization from spreading equitably to all income deciles. This spatial inequality shows that current approaches have not been able to lead to an inclusive improvement in the quality of life, a finding that is consistent with the challenges of implementing smart cities in Iranian metropolises [Tavanaei Marvi *et al.*, 2022] and confirms that technology alone cannot replace policies for the equitable spatial redistribution of resources [Sajadian *et al.*, 2023].

A noteworthy point in the findings is the less favorable status of the "smart living" indicator, which indicates challenges arising from the inappropriate distribution of electronic and digital services across the district. In particular, comparing the northern areas, with a

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higher density of facilities and welfare services, with the southern areas shows that the imbalance in access to technology and electronic services has caused the smart living indicator to be assessed, overall, at a moderate rather than a fully favorable level. While emphasizing the need for an equitable distribution of resources and infrastructure across the district, this issue also highlights the necessity of formulating targeted geographical policies. This finding is in line with the results of studies that have addressed the unequal distribution of digital urban services and its effects on the quality of life [Sajadian *et al.*, 2023]. The analysis of the beta coefficients showed that innovation, e-government, active citizen participation, and the culture of using new vehicles make the largest contribution to achieving the goals of the smart city. This clearly reflects the alignment of the district's approaches with new global trends in smart urban development, which emphasize strengthening collective intelligence, providing efficient electronic services, and reducing dependence on private transportation. On the other hand, indicators such as pollution monitoring and control and access to digital facilities were unable to show a significant effect on smart city realization in this district, which makes a review of current policies and increased investment in these areas unavoidable.

The most challenging finding of this research lies in the "smart environment" dimension. While the indicators related to "energy conservation" showed a positive effect, the vital indicator of "pollution monitoring and control" was assessed as completely lacking statistical significance ($p = 0.528$). Given the major problem of air pollution in Tehran, the ineffectiveness of this indicator in smart city realization indicates a deep disconnect between smart urban tools and the resolution of environmental super-crises at the local scale. This disconnect is consistent with the criticisms leveled at imported smart city approaches that are implemented without regard to local ecological crises [Riva Sanseverino *et al.*, 2018]. The lack of significance of the environmental awareness indicator also confirms that urban management has focused solely on the physical development of public transportation and has neglected cultural and environmental capacity-building. One of the limitations of this research was access to official documents and plans for the smartization of urban management, which could have enriched the analysis.

In addition, the speed of technological change and innovation in the field of urban smartization has created challenges for the stability and sustainability of indicators and programs. Accordingly, it is suggested that future research use advanced data analysis technologies such as machine learning and artificial intelligence to identify the influential factors more precisely and to develop more practical strategies for smart city development.

Overall, the findings of this research show that the realization of the smart city approach in District 2 of Tehran has a positive trend but faces challenges in the distribution of services and in some indicators. Therefore, serious attention to strengthening governance infrastructure, increasing public participation, developing equity in access to digital services, and strengthening environmental domains are important policy priorities on the path to smartization in this district. It is suggested that future studies pay special attention to developing multidisciplinary and interdisciplinary methods so that the various dimensions of the smart city can be examined more comprehensively and in greater depth. The use of new data analysis technologies such as machine learning, data mining, and artificial intelligence can help identify hidden patterns and complex relationships among the indicators and offer more efficient solutions. In addition, future research can develop comparative studies and inter-regional analyses by expanding the geographical scope of the study and comparing several districts or cities. It is suggested that future studies, in direct cooperation with urban management institutions and with access to up-to-date data and official documents, provide more practical analyses and more precise policy recommendations. Furthermore, an emphasis on analyzing the long-term effects of smartization approaches and examining the interaction among social, economic, and environmental factors within the smart city framework can contribute to a better understanding of urban development processes and sustainably improve the quality of life of citizens.

Conclusion

District 2 of Tehran Municipality is at a favorable level in terms of the realization of smart city indicators, especially in the economic, governance, and social participation dimensions; however, the dimensions of smart environment and smart living require strategic review. Success in realizing the smart city requires a balanced approach to all indicators, especially universal digital services and environmental sustainability.

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