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Redefining smart city implementation: A new model for sustainability of smart cities

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Keywords

Sustainable smart city, Smart people, Smart governance, Smart mobility

Abstract

This study addresses a critical gap in smart city implementation by proposing a novel triple helix model that integrates smart governance, smart technologies, and active citizen engagement. While smart city initiatives are widespread, effective execution remains a major challenge. This research examines the smart city environment through the lens of smart government, smart people, and smart technology, revealing a disconnect between ambitious plans and the actual impact of applications. The new model was applied to four metropolitan cities in Turkey and tested using desktop research, analysis of 115 municipal websites based on the McMillan interaction model, and a citizen survey of 1,754 participants. The study presents an in-depth analysis based on detailed examination of the citizen survey and discusses the potential factors affecting awareness and usage by using The Chi Square of Independence Test and Binary Logistic Regression methods to analyze 13 relationships using data from 19 smart mobility applications. The results have shown that smart city initiatives fail to reach their full potential without aware citizens and responsive governance, even with sufficient technology. This research contributes a critical perspective to the smart city discourse, offering a foundational model for future smart city implementations to ensure their success and sustainability.

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Highlights

- This paper examines the discrepancy between theoretical and practical smart city implementation in global and Turkish contexts.
- The triple helix model is proposed to integrate technology, governance, and community involvement into smart city development
- SPSS analysis of survey results identifies factors influencing citizen awareness and usage.

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Akıllı şehir uygulamalarının yeniden tanımlanması: Akıllı şehirlerin sürdürülebilirliği için yeni bir model önerisi

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Anahtar Sözcükler

Sürdürülebilir akıllı şehirler, Akıllı insan, Akıllı yönetişim, Akıllı hareketlilik

Öz

Bu çalışma, akıllı yönetişim, akıllı teknolojiler ve akıllı, aktif vatandaş katılımını birleştiren yenilikçi bir üçlü sarmal modeli önererek akıllı şehir uygulama modellerindeki kritik boşluğu ele almaktadır. Akıllı şehir girişimleri yaygındır, ancak bunları etkili bir şekilde uygulamak zordur. Bu akıllı şehir ortamını eleştirel bir şekilde inceleyerek ve aktif eylem planları ile akıllı şehir uygulamalarının gerçek etkisi arasında önemli bir kopukluk ortaya koymaktadır. Sunulan yeni üçlü sarmal modeli, akıllı şehirlerde akıllı yönetişim ve vatandaşlığı yeniden tanımlayarak, gerçek akıllı kentsel gelişim için teknik benimsemenin ötesine geçen yapılandırılmış bir uygulama çerçevesine olan ihtiyacı göstermektedir. Yeni model, Türkiye'de seçilen dört metropol şehrinde uygulanmış ve kapsamlı masaüstü araştırması, McMillan etkileşim modeline uygun olarak 115 belediye web sitesinin analizi ve 1.754 bireyle yapılan anket temelinde test edilmiştir. Bu çalışma, vatandaş anketinin detaylı incelenmesine dayalı derinlemesine bir analiz sunmakta ve 19 akıllı mobilite uygulamasından elde edilen verileri kullanarak 13 ilişkiyi analiz etmek için Bağımsızlık Ki-Kare Testi ve İkili Lojistik Regresyon yöntemlerini kullanarak farkındalığı ve kullanımı etkileyebilecek potansiyel faktörleri tartışmaktadır. Sonuçlar, akıllı şehir girişimlerinin yeterli teknolojiye sahip olsalar bile, katılımcı vatandaşlar ve etkileşimli yönetim olmadan tam potansiyellerine ulaşamadığını göstermiştir. Araştırma, akıllı şehir tartışmasına eleştirel bir bakış açısı kazandırarak, gelecekteki akıllı şehir uygulamalarının başarısını ve sürdürülebilirliğini sağlamak için temel bir model sunmaktadır.

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Öne Çıkanlar

- Bu çalışma, küresel ve Türkiye bağlamında akıllı şehir uygulamalarının teorik ve pratik boyutları arasındaki tutarsızlığı incelemektedir.
- Teknoloji, yönetişim ve toplumsal katılımı akıllı şehir gelişimine entegre etmek amacıyla Üçlü Sarmal (Triple Helix) modeli önerilmektedir.
- Anket sonuçlarının SPSS analizi, vatandaşların farkındalığını ve kullanımını etkileyen faktörleri belirlemektedir.

İletişim

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INTRODUCTION

In addressing urban challenges through technological innovation, smart cities have emerged as transformative paradigms, enhancing urban livability, efficiency, and sustainability (Castells,1997; Herrschel, 2013, Martin, 2018). Leveraging Information and Communication Technologies (ICT) to improve services, reduce costs, and engage citizens; cities globally adopt smart solutions for transportation, energy, safety, and governance (Hollands, 2008; Dameri, 2013; Cocciha, 2014, Angelidou, 2014). However, implementation is complex. Turkey's early adoption and ambitious plans often fall short, highlighting the need for comprehensive models. Existing models focus on technology without addressing governance and citizen engagement adequately (Leydesdorff, 2011; Arnkil, 2010). This study proposes a holistic triple helix model (Figure 1), integrating technological innovation, governance, and active citizenry.

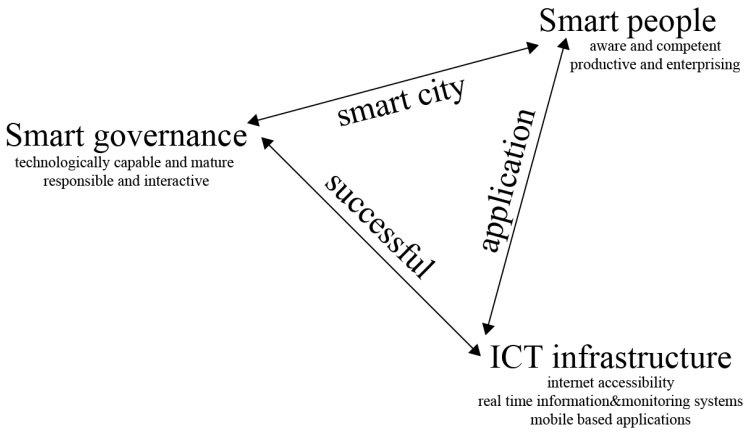

Figure 1. Proposed triple helix model for successful implementation of the smart to the city

The literature on smart cities highlights three crucial characteristics: smart mobility, smart people, and smart governance. Smart Mobility uses ICT to collect, analyze, and transmit data via the Internet, mobile phones, and wireless networks (Orlowski, 2019), improving citizens' quality of life by reducing pollution, congestion, and transfer costs while increasing safety and transfer speeds (Benevolo, 2016; Kalogirou, 2018). Smart mobility applications play a crucial role in engaging citizens, making them an essential component in the study of "smart people." Its success relies on active citizen participation, supported by comprehensive ITS and urban strategies.

Citizen involvement, accordingly, is crucial to the success of smart cities, extending beyond mere political participation (Berntzen, 2016). Active engagement shapes urban governance,

development, and maintenance (Cardullo, 2019; Mora, 2019). ICT, particularly mobile-based tools, enhances this participation, transforming citizens into decision makers and users. Effective smart cities require knowledgeable and skilled citizens. Dameri's study of Amsterdam and Genoa underscores this. Amsterdam's smart city success stems from technological innovation and active citizen participation. Genoa's challenges highlight the need for education and involvement (Dameri, 2014). Various cities demonstrate the importance of citizen participation. London's smart parking service failed due to low public awareness (Peng, 2017). South Korean u-cities emphasize digital technologies suited to their social groups (Shin, 2009). Helsinki promotes citizen participation through open data and competitions (Hielkema, 2012). Despite its collaborative nature, Barcelona's model faces criticism for its limited citizen engagement [29-30]. Technological advancements alone are insufficient without engagement of the citizens (Capdevila, 2015; Gasco-Hernandez, 2015). Lytras and Visvizi assert that end-user awareness and application usage are key to smart city success.

However, in the literature, smart people are defined by qualifications such as lifelong learning, social and ethnic plurality, creativity, open-mindedness, and participation in public life (Giffinger, 2007; Benamrou, 2016; Gupta, 2017). On the other hand, these indicators focus on social rights and democracy, emphasizing education, foreign language skills, and participation in public life. Nevertheless, smart cities must foster civic engagement, creating partnerships between the city and its stakeholders (Paskaleva, 2011). Citizen participation extends beyond political activities and encompasses actions such as reporting urban issues. Cuquis Robledo's initiative to draw attention to 'crappy curbs' in Seattle, USA, in opposition to the 'Complete Street Design' Project by Smart Growth America, exemplifies active citizenship. She used social media to record a video in which she experienced all the crappy curbs. Today, this video is widely shared on social media, with many people from different cities tagging the hashtag to draw the attention of authorities and report all the crappy curbs for fixing. Such actions, facilitated by ICT, demonstrate the importance of citizen engagement. As a result, his study argues that successful smart cities depend on citizens' awareness and ability to use smart applications rather than all social features. Examples from Amsterdam, Genoa, Helsinki, London, and Barcelona show that citizen awareness and engagement are key to smart city success. Despite the lack of detailed discussion on smart people in the literature, this study defines smart people based on their awareness and usage of smart city applications, particularly those related to smart mobility.

Core elements of excellent governance include transparency and responsibility (Bonson, 2012; Bertot, 2010). Good governance in a democratic society requires meaningful citizen involvement in cultural, economic, political, and social life. Traditional participation methods, like public meetings, often fail due to timing and political reservations (Conroy, 2006; Benn, 2000). ICT offers flexible participation times and reduces barriers, enhancing citizen involvement and enabling governments to provide more efficient, cost-effective services (Cowley, 2010; Evans, 2005). E-government, defined as using ICTs to achieve better government, is part of modernization programs in Western democracies (Bonson, 2012; Bertot, 2010).

However, the integration of human-centric smartness with technology is often missing in smart city concepts. Technology alone cannot create smart cities; it must be coupled with citizen engagement to build smart communities. The study, which evaluates e-government capabilities by

examining municipal websites in Turkey, emphasizes that providing ICT tools is insufficient without government responsiveness and enthusiasm for citizen collaboration. Also, citizen survey results indicate that effective smart governance requires authorities to be responsive and interactive with citizen actions. Thus, smart governance requires not only the presence of smart technologies but also the maturity and awareness of government officials in using these technologies effectively, as well as active and aware citizens.

In conclusion, successful smart city implementation requires aware, active individuals willing to use smart applications to take responsibility for improving their city and authorities with smart technology infrastructure who are responsive and interactive on citizens actions, working together to reduce environmental problems, increase energy efficiency, and enhance the quality of life.

MATERIAL METHOD

The main research question of the study is: "How to successfully implement smart to the city?" This question arises from the observation that there are various approaches and conflicting outcomes in global smart city practices. The study aims to consolidate these fragmented perspectives by re-evaluating key definitions and identifying the essential components for a successful implementation.

Due to the interdisciplinary and multifaceted nature of the smart city concept, the study begins by clarifying its scope through a set of guiding questions, ranging from its definition and evolution to its governance and critical components. Through extensive literature review, the study proposes a new triple helix model for smart city implementation, integrating three core actors: smart people, smart governance, and smart technology.

The model redefines smart city characteristics as:

- Smart people: Citizens who are aware, active, and willing to engage with smart applications and city governance.
- Smart governance: Public authorities that are responsive to citizen actions and open to collaboration.
- Technology: A medium facilitating interaction between people and governance.

The study further examines the bilateral (two-way) relationships (Figure 2) among these three components by asking targeted questions about awareness, responsiveness, and the effectiveness of ICT tools, especially within the context of Turkey. These questions assess how well each actor understands and interacts with the others through smart city tools, aiming to validate the effectiveness of the proposed model in enhancing civic engagement and collaborative governance.

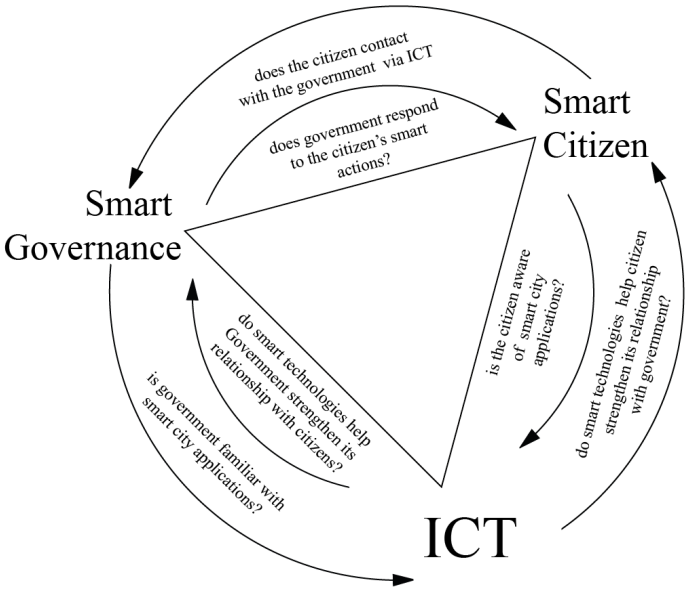

Figure 2. Bilateral relationship between the components of the proposed new triple helix model for the successful application of the smart to the city.

To address the research questions, the study conducted a tripartite analysis (Figure 3) focusing on smart governance, smart people, and smart technologies in Turkey. This involved evaluating the technological capability and awareness across the country and examining smart governance and smart people specifically in four selected cities. The relationship between these components was explored through various questions from the perspectives of technology, citizens, and government.

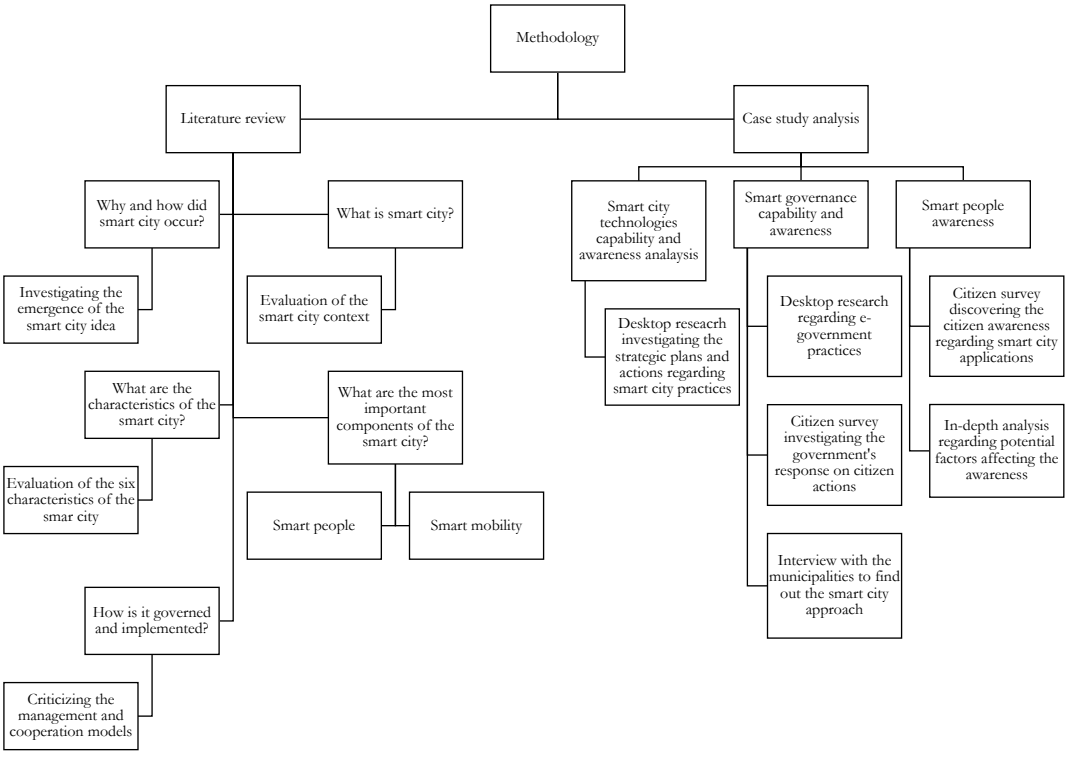

Figure 3. Methodological approach of the study.

Smart technologies capability and awareness analysis (Figure 4) examined Turkey's legislations, policies, and implementations related to smart city initiatives up to the end of 2023 It focused on the Smart Mobility capability, assessing whether Turkey has the intelligent transportation systems listed in the literature. The study also investigated sustainable transportation approaches, such as commute sharing and green vehicle usage.

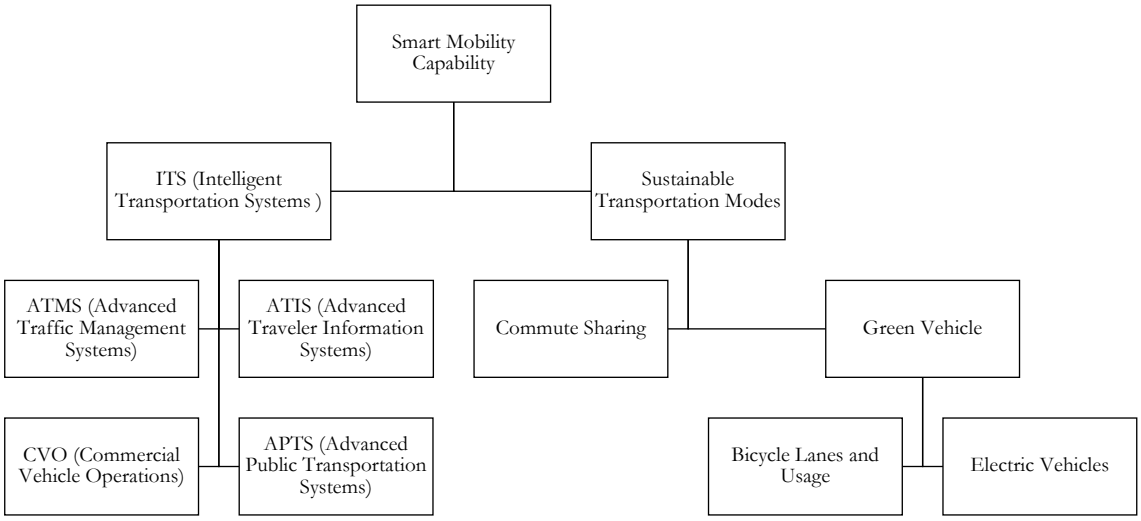

Figure 4. Smart mobility indicators within context of the study to evaluate.

Smart Governance Capability and Maturity Analysis evaluates the smart governance through e-government practices, such as Internet-based services provided by the government using ICT. The study examined 115 governmental websites based on the McMillan interactivity model [47] in four selected cities, focusing on municipal practices. It evaluated the websites' information and interaction capabilities and analyzed the responsiveness of authorities to citizen actions through interaction tools. Additionally, interviews were conducted with departments related to smart city and transportation ap-plications in the four metropolitan municipalities to explore the management of e-government tools and smart mobility applications. This assessment was conducted to measure the maturity of the government in terms of smart governance.

Smart People Analysis evaluates citizens' awareness and usage of smart mobility mobile applications produced by the government namely municipalities, which are crucial for smart city practices. The study also assessed citizens' use of interaction tools to communicate with authorities. An online citizen survey was conducted in four selected cities, reaching 1141 respondents in 2019 and 613 respondents in 2023, to investigate citizens' awareness and usage of smart mobility applications and their interaction with municipal services. The survey data comprised single-item, binary (Yes/No) questions designed to assess constructs such as mobile application awareness, public transportation application usage, and digital municipality application usage. These single-item measures were chosen to capture clear, observable behaviors, for example, whether someone uses a mobile application or not rather than subjective attitudes.

Additionally, the study aimed to analyze factors affecting awareness and usage of smart mobility applications and interaction tools by using Chi-Square of Independence Test and Binary Logistic Regression analyses. It examined 13 variables influencing the use and awareness of 19 mobile applications developed by metropolitan municipalities across four case study cities. The study aimed to explore how socio-demographic factors such as age and education level relate to awareness and usage of smart mobility mobile applications and digital municipality tools that facilitate communication with governmental authorities.

The case study cities— Istanbul, Ankara, Izmir, and Bursa—were selected based on their number of smart mobility applications (Table 1). These cities have more smart mobility applications than other cities, making them suitable for evaluating smart governance and smart people characteristics. Istanbul with almost 16 million population, the most populous city, has 20 smart city applications, including seven related to smart mobility. Ankara, the capital city with almost 6 million population, has 10 smart city applications, with two focused on smart mobility. Izmir has 4 million population, the third most populous city, has eight smart city applications, including two related to smart mobility. Bursa with its 2 million population, an important center for the automotive industry, has three smart city applications, with two related to smart mobility. The study examined smart city actions and applications in these cities to provide a comprehensive understanding of smart city implementation, highlighting the critical role of active citizen engagement and responsive governance.

In this section, it may be necessary to clarify certain terminologies.

- "Digital" refers to citizens' engagement with public service technologies through mobile platforms.
- "Participation" reflects both the awareness of and interaction with mobile services provided by public authorities.
- "Municipality" is defined as the use of mobile applications developed by local governments for service access, such as submitting complaints, making payments, or receiving announcements.

In this context, based on the relevant literature, mobile applications are commonly categorized as follows:

- Public transportation information applications: These are applications used to track public transport vehicles in real time.
- Driver information applications: These refer to navigation-based applications designed to assist private vehicle users with route planning and traffic information.
- Digital municipality applications: These are mobile tools developed by local governments to facilitate communication with citizens, allowing them to submit complaints, make requests, and access municipal services more effectively.

Table 1. Selected smart mobility mobile applications in selected four cities for the smart people analysis.

	Public transportation information mobile applications	Driver information mobile applications	Digital municipality
İstanbul	Mobiett	IBB Yol Gösteren, IBB Cep Trafik, Şehir Hatları, İSPARK, iTaksi İSBİKE Smart Bike	IBB İstanbul IBB Beyaz Masa
Ankara	EGO Cep'te	ABB Trafik	ABB Ankara, Başkent Mobil, Mavi Masa
İzmir	ESHOT Mobil	IZUM	IBB Mobile
Bursa	Burulas Ulaşım	Burulas Trafik	Bursa Cepte

FINDINGS

According to three analyses mentioned above, main findings of the study can be listed as follows:

Smart Technologies Capability and Awareness

The Turkish government has been promoting smart city initiatives since the early 2000s, particularly in the transport sector, aiming to enhance traffic management, safety, and energy efficiency through ICT. The National Intelligent Transportation Systems Strategy Document 2014-2023 emphasizes these goals. However, detailed examinations reveal that many action plans are merely declarative, lacking substantial implementation. The first comprehensive master plan for smart cities began in Istanbul in 2016, and since then, several metropolitan municipalities have partnered with tech companies like Vodafone, Turkcell, and Huawei to acquire necessary smart technologies. In late 2019, the publication of the National Smart Cities Strategies and Action Plan 2020-2023 marked a significant step towards structured smart city development.

Turkey has demonstrated the capability to produce Intelligent Transportation Systems (ITS), including passenger information systems, traffic management systems, public transportation systems, electronic payment systems, driver support, security systems, and fleet management systems. However, the adoption of these technologies is uneven. According to the KENTGES Municipalities Survey Report, which is conducted on, first, 2014 and last 2016 (Figure 5) 23% of Turkish cities, out of 30 metropolitan municipalities, are not using any ITS in 2014. In many major cities, many smart mobility applications are restricted to bus tracking and route planning. A 2016 survey revealed a decline in this rate to 6%, with no further surveys conducted after that year. However, 40% of the cities only have electronic payment and traffic cameras. Only 13% of the cities have implemented all seven ITS application.

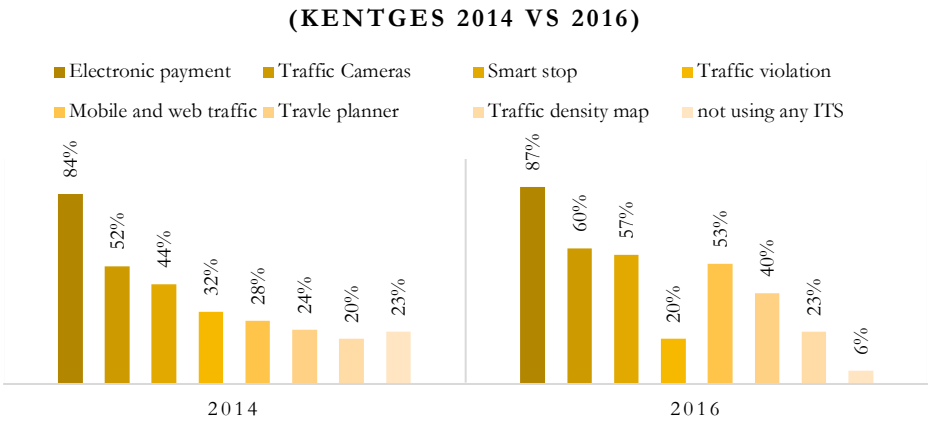

Figure 5. Intelligent transportation systems usage rate in metropolitan municipalities.

Smart Governance Capability and Maturity (who is technologically capable and mature enough to respond to the citizen actions and willing to collaborate with them in city matters)

Turkey has shown strong performance in e-government, with a well-functioning e-government portal and comprehensive municipal websites offering information and interaction. The municipal web page analysis in four metropolitan municipalities, based on the McMillan model of interactivity, revealed high effectiveness in providing information tools (Table 2) such as news and announcements. However, these websites are less effective in offering detailed plans, regulations, budget information, strategic plans, activity reports, council decisions, and performance programs.

Table 2. Information tools in percentages, all municipalities.

	GIS maps and plans	Online documents (pdf)	News and announcements	Multimedia (video/images)	Multilanguage
İstanbul, N=40	90	87,5	97,5	97,5	30
Ankara, N=26	26,9	57,7	100	100	7,7
İzmir, N=31	6,5	90,3	96,8	96,8	16,1
Bursa, N=18	16,7	66,7	94,4	94,4	22,5

Municipal interaction tools (Table 3) are generally effective, with a high usage of corporate email, online transactions, and call centers. However, there is a lack of private staff emails and interactive tools like live chat rooms. Social media activity is high, but responsiveness through these channels is inconsistent.

Table 3. Interaction tools in percentages, all municipalities.

	Feedback		Responsive dialogue		Mutual discourse		
	Corporate e-mail	Staff e-mail	Request complaint suggestions	Online transactions	Social media accounts	Live support	Call center
İstanbul, N=40	72,5	62,5	92,5	95	100	0	97,5
Ankara, N=26	69,2	11,5	65,4	73,1	100	0	100
İzmir, N=31	87,1	6,5	51,6	90,3	100	0	100
Bursa, N=18	88,9	27,8	66,7	66,7	100	0	100

Effective smart governance requires both technical skills and a level of maturity in using these technologies. Based on the survey findings, a significant percentage of the participants (79% in 2019 and 84% in 2023) are not using the government's communication tools. The percentage of participants that use these tools and get solutions is very little (34% in 2019 and 40% in 2023). These statistics suggest that while the government has technical capabilities, there exists a substantial disparity in efficiently using these tools to interact with individuals and address problems (Figure 6).

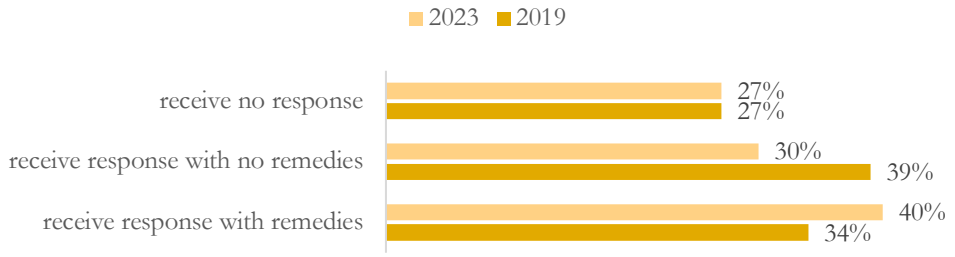

Figure 6. Municipalities' response to interaction tools.

Smart people (who are aware, willing to use smart applications and active citizens)

This section examines the level of knowledge, involvement, and proactive mindset of people in relation to smart city apps developed by metropolitan governments. The research was undertaken using a survey that was carried out in four specific cities (Istanbul, Ankara, Izmir, Bursa) in both 2019 and 2023.

Demographic overview

Both the 2019 and 2023 survey findings indicate a nearly identical demographic picture. Out of the participants, 53% have obtained a bachelor's degree, 29% have completed a postgraduate degree, and 18% possess only primary education. The age distribution indicates that 52% of the population is be-tween the age range of 26-45, 37% are aged 18-25, 10% are between the ages of 46-65, and

1% are 65 years or more. Regarding transportation options, 33% of individuals use public transit on a near-daily basis, while 22% use it a few times each week or year. Additionally, 20% use public transportation a few times per month, and 3% report never using it. Approximately 50% of the participants express a preference for using private vehicles. However, the subway remains the most popular means of public transit, with 81% of respondents in 2019 and 77% in 2023. Following the subway, buses are the second most often used mode of transportation, with 77% of respondents. Minibuses, known as 'dolmuş' in Turkey, are the third most desired mode of transportation, chosen by 38% of respondents. Sea transportation is available in İzmir and İstanbul, although only about 30% of the respondents choose to use it.

Smart mobility awareness and usage

The study disclosed unexpected findings on the awareness and use of smart mobility applications (Table 4). Half of respondents were not aware of the existence of public transportation information apps in their city in 2019. Although, by 2023, awareness had increased to 73%, the use rate of the applications un-likely to exceed 60%.

Table 4. Application awareness and usage ratios.

			2019	2023
Public transportation information applications	**Aware**	**All respondence**	%51	%73
		Among the frequent users	%59	%90
	Using	**All respondence**	%47	%57
		Among the frequent users	%25-all the time %68-sometimes	%38-all the time %48-sometimes
Driver information applications	**Aware**	**All respondence**	%20	%27
		Among the frequent users	%45	%19
	Using	**All respondence**	%18	%8
		Among the frequent users	%7-all the time %85-sometimes	%3-all the time %85 sometimes

Citizen Participation and Interaction with Government via ICT

Although municipalities have various digital platforms for interaction, including websites, email ser-vices, call centers, mobile applications, and social media links, citizens show low engagement. The survey revealed that a majority of respondents do not visit municipal websites or use the provided in-teraction tools to share complaints and suggestions. Only 8% of the respondents were aware of the fact that the municipalities have the mobile application for all the services they provide, and only 13% of the respondents were using those applications in 2019. Over the course of four years, the usage of the application has increased by 60% among those who are aware of it, but the overall awareness ratio has only increased to 31%.

The literature demonstrates the crucial role of application usage in smart city applications. However, there is a direct correlation between application awareness and its usage. The cross-

tabulation of the application awareness and usage relationship (Table 5) revealed that the majority of the respondents do not use the smart application as they do not know the application, especially in driver information applications and digital municipalities.

Table 5. Cross tabulation of awareness and usage relationship among all respondents.

Mobile application awareness and usage crosstabulation city-by-city in percentages		Users		Cities selected for the case study	Non-users			Mobile application awareness and usage crosstabulation city-by-city in percentages
Public transportation information applications	awares	45,1	10,1	Istanbul	0,7	5,8	awares	Public transportation information applications
			25,7	Ankara	3,5			
			4,6	Izmir	1,6			
			4,7	Bursa	0,0			
	Non-awares	8,7	7,5	Istanbul	15,6	40,4	Non-awares	
			0,3	Ankara	9,3			
			0,6	Izmir	6,1			
			0,3	Bursa	9,5			
Driver information applications	awares	11,7	7,1	Istanbul	1,8	5,3	awares	Driver information applications
			1,9	Ankara	1,9			
			2,5	Izmir	1,7			
			0,2	Bursa	0,0			
	Non-awares	11,7	8,7	Istanbul	16,4	71,4	Non-awares	
			0,9	Ankara	34,1			
			1,1	Izmir	7,7			
			1,1	Bursa	13,2			
Digital municipality (metropolitan municipality) applications	awares	4,7	0,5	Istanbul	0,5	3,3	awares	Digital municipality (metropolitan municipality) applications
			0,6	Ankara	1,2			
			2,7	Izmir	1,5			
			0,9	Bursa	0,0			
	Non-awares	8,5	5,6	Istanbul	27,2	83,6	Non-awares	
			1,2	Ankara	35,7			
			0,9	Izmir	7,9			
			0,8	Bursa	12,7			
Total respondents 1741 smart phone users								

Through smart government analysis, it has been seen that every municipality has its own websites, all of which do well in transmitting information and offering efficient communication mechanisms. In order to request information or to voice concerns or opinions, residents can get in touch with any metropolitan municipality through one of these services, such as email services, phone centers, mobile apps, and social media linkages. Nevertheless, the citizen awareness survey reveals that most respondents are unlikely to visit municipal websites (Table 6), despite the fact that these websites are generally seen as user-friendly and clear (the complexity of the websites does not seem to be a deterrent for non-visitors).

Table 6. Digital municipality awareness and usage.

		2019	2023
Digital Municipality (applications)	**Aware**	%8	%31
	Using	%13	%45
Visiting municipality web site	**Visiting**	%32	%46

Additionally, there are citizen lines such as Mavi Masa in Ankara, Beyaz Masa in Bursa and Istanbul, and HİM in Izmir. These lines have their own email services, contact centers, and social media profiles to facilitate the submission of various claims and viewpoints. Nevertheless, the majority of respondents in the citizen survey indicated a lack of preference for using the available contact mechanisms to express their complaints and suggestions (Figure 7). Put simply, they are failing to engage in civic affairs by neglecting to voice their complaints or recommendations.

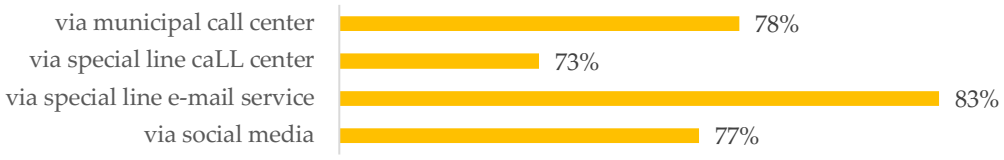

Figure 7. Non-use of municipal interaction tools in percentages.

The Digital 2023 Global Statshot Report reveals that in January 2023, 83.4% of Turkey's population are connected to the internet, while 73.1% of the entire population engage with social media platforms. In early 2023, the active cellular mobile connections in Turkey account for 95.4% of the total. In early 2023, the number of Twitter users in Turkey amounted to 18.55 million. However, when examining the level of engagement by municipalities on social media platforms, particularly Twitter, which is the primary means of connection, the percentages are very low (Figure 8).

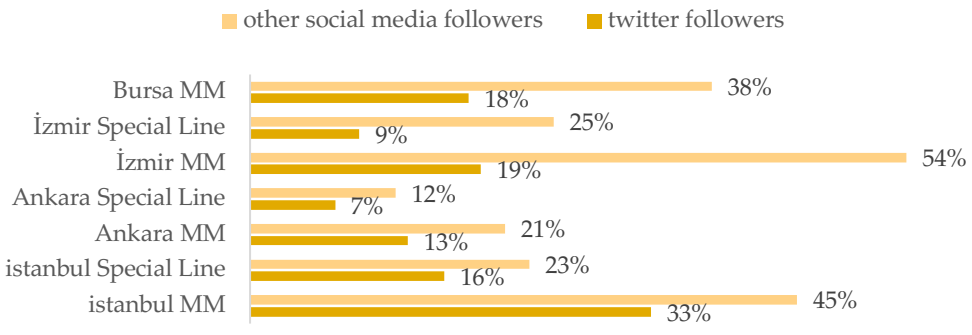

Figure 8. Social media followers for the municipalities city-by -city.

In summary, the findings indicate that there is little interest among individuals in digital municipal ser-vices, as seen by the low level of awareness and use of municipal mobile applications. Furthermore, they lack interest in accessing the municipality's online sites or using interaction tools when necessary.

Citizen Awareness of the Smart City Concept

The survey also evaluated residents' understanding of the smart city idea. The findings indicated that 69% of participants had a deficiency in understanding or carried inaccurate information on smart cities. Significantly, 75% of individuals with inaccurate information have a high level of education, whereas 91% belonged to younger age groups (18-45 years). Notwithstanding this limited comprehension, 90% of participants hold the belief that investment in smart cities is essential, indicating that the idea is largely viewed positively.

The results suggest that while there is a widespread desire to adopt smart city efforts, there are notable deficiencies in knowledge and participation that must be resolved. The primary objective should be to prioritize improved communication and education on smart city apps in order to boost their use and engagement. Furthermore, it is essential to cultivate a culture of engaged citizenry and promote environmentally conscious mobility practices in order to effectively execute smart city initiatives in Turkey.

In-Depth Analysis of the Factors Effecting the Awareness and Usage

This section, as mentioned before, focused on identifying the factors that influence the awareness and usage of smart mobility applications and digital interaction tools, utilizing Chi-Square of Independence Tests and Binary Logistic Regression for data analysis. The relationships in question were examined in two parts. First, the analysis focused on Smart Mobility Mobile Applications, categorized into two groups: public transportation information applications and driver information applications. This section aimed to understand how age and education level influence application awareness and usage. Second, the study examined the effect of age and education level on the awareness and usage of digital municipality tools that facilitate citizen government interaction.

Table 7. Comparison table.

Applications		Education level			Age groups			
		Primary	Bachelor	Postgraduate	18-25	26-45	46-65	65-over
Application awareness	Public trans. infor.	3	1	2	1	2	3	0
	Driver information	3	2	1	3	2	1	0
	Digital municipality	0	0	0	2	0	1	0
Application usage	Public trans. infor.	2	1	0	1	2	3	0
	Driver information	1	2	3	0	0	0	0
	Digital municipality	1	2	3	0	0	0	0
	Municipality web site	1	2	3	1	0	2	0
Municipality interaction tools usage	Municipality call center	1	2	3	0	0	0	0
	Special line call center	1	2	3	0	0	0	0
	Special line e-mail	1	2	3	1	0	2	0
	Social media	1	2	3	0	0	0	0
0: There is no significant relationship / 1: More likely to be related / 3: Less likely to be related								

Factors Affecting Smart Mobility Mobile Applications Awareness and Usage

Based on the study findings, there is a positive correlation between the degree of education and awareness of application.

- Public transportation information applications are more likely to be known by bachelor's and postgraduate degree holders than elementary education graduates. Still, postgraduates are less informed than bachelor's degree holders (bachelor's degree > postgraduates > elementary education).

- Driver information mobile applications awareness, on the other hand, increases according to the education level (postgraduates > bachelor's degree > elementary education).

It is not clear why those with a postgraduate degree are less likely to be aware of the public transportation application than the driver information applications compared to those with a bachelor's degree. It may be argued that those with a postgraduate degree correspond to relatively older and possibly wealthier citizens, who do not use public transportation, but use private vehicles. Hence have no interest in public transportation information applications but have more interest in driver information applications.

The study findings also revealed that application usage seems to be related to education level too.

- Public transportation information applications are more likely to be used by bachelor's degree holders than elementary education graduates. Postgraduate degree holders are not significant in using those applications (bachelor's degree > elementary education > postgraduates).

- Driver information mobile applications are more likely to be used by the elementary education graduates than both postgraduates and bachelor's degree holders (elementary education> bachelor's degree> postgraduates).

Those applications used in the study produced by the municipalities. However, there is lots of driver information application produced by private companies such as Google map, Maps by Apple, Moovit, Trafi and such. As a scope of the study, citizens were asked to write the driver information application they use. 99% of the respondents who named the private applications mentioned above, are either bachelor's degree or post graduate degree holders. It can be concluded that individuals with higher levels of education are more willing to use private applications, while those with lower levels of education may either be unaware of these applications and therefore not use them, or they may prefer government ap-plications.

Based on the study findings, application awareness seems vary from age to age.

- Public transportation information applications are more likely to be known by age groups 18-25 years than the age groups 26-45 and 46-65 (18-25 > 26-45 > 46-65).

- Driver information mobile applications are more likely to be known by age groups 26-45 and 46-65 than age groups 18-25. Also, age groups 46-65 are more likely to be aware of those applications than age groups 26-45 (46-65 > 26-45 > 18-25).

According to the driver information applications awareness relationship, it is reasonable to infer that those aged 18–25 is likely to be students and are more likely to use public transportation compared to those aged 26–45 and 46–65. The 26–45-year age group is comparatively younger and has a higher preference for using public transportation compared to the 46–65-year age group.

The study findings also revealed that application usage seems to be related to age.

- Public transportation information applications are more likely to be used by age group 18-25 years old than age groups 26-45 and 46-65 (18-25 > 26-45 > 46-65).

- Driver information mobile applications: there is no real evidence that the driver information mobile application usage is different for people who have different age.

Furthermore, public transportation information mobile application awareness and usage seems to be affected from people's public transportation usage frequency (Table 8). We can say that those who are using public transportation 5 to 7 days a week and few times a week are much more likely to know about and use the public transportation information mobile application.

Table 8. Awareness effect on usage among the frequent users of the public transportation modes.

	Awareness	Usage
5-7 days a week	1	1
Few times a week	2	2
Few times a month	3	3
Few times a year	4	4
0: There is no significant relationship / 1: More likely to be related / 4: Less likely to be related		

Factors Affecting Active Citizenship Attitude

Although there is no real evidence that digital municipality awareness is related with the education level, but age seems has an effect. Individuals in the age range of 46-65 are more likely have knowledge about digital municipality compared to those in the age range of 18-25. Nevertheless, those with a basic education degree are more likely to use digital municipality services compared to those with a bachelor's or postgraduate degree. This time age has no effect on using digital municipality service. On the other hand, municipality web site visiting preference seems to be related to age and it seems that people who are between 46-65 years old are more likely to visit municipality web site than those who are between 18-25 years old. When it comes to act in urban affairs, individuals who have bachelor's degree and elementary education degree are more likely to use citizen lines than those who have postgraduate degree. Also people who are between 46-65 years old are more likely to use citizen line services than those who are between 18-25 years old. There is no real evidence that use-friendliness have a relation with the digital municipality usage. Therefore, it can be concluded that older citizens are more likely to show interest in urban affairs and municipal operations due to their increased use of municipal websites and interaction tools.

However, there is a negative correlation between being an active citizen and education, as the degree of education increases, interest in urban affairs drops.

CONCLUSION

In order to effectively implement a smart city, it is crucial to emphasize the role of individuals as informed and active citizens who are willing to use smart city applications, take responsibility of urban problems and collaborate with a technologically advanced government that is responsive to the needs of its citizens. Based on the extensive field study undertaken, it is clear that the production of smart city technologies is not sufficient. According to the survey results, there is a lack of understanding of the smart city idea and smart city applications, even in urban environments where these applications are commonly seen. Furthermore, it is determined that there is little motivation towards using smart city applications. Also, there is a notable lack of enthusiasm in assuming responsibility for the city as an active citizen.

This research has uncovered an urban challenge within the framework of smart cities. In order to achieve a successful smart city application, it is crucial to enhance both the awareness and use of smart city applications, as shown in numerous examples found in the literature. An in-depth investigation was conducted to uncover how it may be boosted. The analysis examined 13 distinct interactions among 19 smart applications. The survey findings indicate a tenuous correlation between users and the smart city applications. The analysis of citizen survey findings revealed several aspects regarding the awareness and use of smart city applications. In light of all these findings, the study can propose the following solutions to the problem of user disconnections.

1. The implementation of smart practices relies on smart technology, which should not be restricted to a few cities. Nationwide implementation of smart city techniques is necessary.

2. In a smart city, citizens are expected to be active and autonomous, taking responsibility and participating as creative individuals in urban affairs via non-political involvement. The survey's findings indicate a significant lack of interest in active citizenship. Therefore, it is essential to promote and motivate citizens to actively engage, contribute, and provide innovative ideas for the improvement of their community.

3. Furthermore, it is essential for authorities to show responsiveness and interactivity in order to foster citizen encouragement. The smart city expects that the government will collaborate alongside with the active citizens. Both metropolitan and local governments must take responsibility for implementing smart city principles and actively engage with citizens.

4. The awareness of the application has a direct impact on its use, as shown by the findings of the citizen survey. Individuals that have knowledge about the program are more likely to use it. Therefore, it is essential for local officials, namely the municipalities responsible for developing smart apps, to focus on promoting these applications in order to enhance public awareness.

5. Furthermore, the findings indicated a significant correlation between the amount of education and the level of awareness about smart city applications. Individuals with a higher level of education are likely to have knowledge about urban applications. Therefore, to increase public knowledge, municipal authorities should guarantee that the release of the product is adequate and accessible to all individuals. They must actively participate in propagating and marketing the apps

6. The study findings revealed a negative correlation between the degree of education and the use rate of applications. Despite holding a high level of education, individuals are less likely to choose to use an application. The usage of smart city tools is essential for ensuring the sustainability of smart cities. Therefore, municipalities must ensure that the smart city tools they develop adequately address the demands and specific requirements of all users.

7. User-friendliness has a positive impact on usage. If an application is simple to use and understood, it is more likely to be selected for use. Therefore, it is essential to prioritize user preferences and ensure that smart apps and tools are universally available and easily accessible.

8. Furthermore, those who often use a certain mode of transportation are more likely to use the corresponding transportation application. Therefore, people only use the application when they have a need for it. Therefore, product releases must prioritize the needs and preferences of the target audience.

9. The findings indicate a lack of enthusiasm among younger individuals, namely those aged 18-25, about urban affairs. Nevertheless, those age groups are characterized by high levels of creativity and productivity, making them very valuable for addressing urban affairs. In this scenario, municipal authorities ought to try to attract the interest of the younger generation and actively request their cooperation.

10. Furthermore, the findings indicated that there is a negative correlation between education level and interest in urban affairs. However, the situation should be reversed when considering smart people. As the level of education in a smart city rises, there should be an anticipated growth in both the understanding of smart city applications and the sense of duty for the city. On the other hand, municipal officials should actively engage with the more educated populace and collaborate with them to create and enhance ap-plications.

Based on the data analysis, it is evident that application producers, particularly those affiliated with local authorities (as private enterprises do their own research), should prioritize user preferences. An investigation should be conducted to see if consumers of their products are using or satisfied with those applications. Otherwise, the city would be filled with unused smart apps, thereby becoming a metropolis filled with abandoned smart application waste.

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Araştırma etik standartlara uygun olarak yapılmıştır.

All procedures followed were in accordance with the ethical standards.

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Author Contribution Statement | Yazar Katkı Beyanı

AUTHOR: (a) Idea, Study Design, (b) Methodology, (c) Literature Review, (e) Material, Resource Supply, (f) Data Collection, Processing, (g) Analyses, Interpretation, (h) Writing Text, (i) Critical Review

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