

The Impact Of Smart Cities On Urban Development And Sustainability In Worldwide And Türkiye

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Abstract— This study explores how smart cities are shaping urban life and their role in making cities more sustainable. It looks at smart city applications in worldwide and Türkiye, focusing on energy efficiency, waste management, and transportation systems. The goal is to understand how these projects improve urban infrastructure, enhance quality of life, and support economic and social development. The research also considers key factors influencing their success, such as government investment in technology and active citizen participation. The results show that smart city initiatives significantly reduce energy consumption, improve waste management, and make transportation systems more efficient. These projects promote sustainability and contribute to economic growth and better living conditions. However, their success largely depends on how healthy governments invest in technology and how actively communities engage with these innovations. One limitation of the study is its focus on urban areas, as rural communities often have limited access to smart technologies. To make these projects more inclusive, future research should examine how smart city solutions can be adapted to different socio-economic and geographic contexts. Looking ahead, policymakers should focus on strategies that increase public engagement and expand technological access, ensuring smart cities have a more meaningful impact on urban development. Further research on the sustainability, security, and long-term effectiveness of these projects will help maximize their benefits and make cities more resilient and livable for the future. sheet.

Keywords— Smart City, Sustainability, Urban Development, Technology Integration, Citizen Participation.

I. INTRODUCTION

Globalization and technological advances are radically transforming urbanization processes and city life. Factors such as increasing urban population, limited resource use, climate change, and socio-demographic changes threaten the standard of living in urban areas and create difficulties in ensuring sustainable city life [1, 2]. However, in response to these challenges, the

transformative idea of a smart city has emerged, offering a symbol of hope for the future of urban development. With the advent of smart cities, their focus on increasing the efficiency and livability of cities has the potential to revolutionize urban life [3, 4].

Smart cities aim to enhance the efficiency of infrastructure and services through the incorporation of information and communication technologies. These systems significantly contribute to sustainability, environmental protection, economic opportunities, and social participation [5]. They create job opportunities and support economic growth by encouraging social and economic development. Thus, unemployment rates decrease, and local economies are revitalized [6].

In relation to environmental sustainability, smart cities increase energy efficiency, improve waste management, and reduce carbon footprints. This contributes to the preservation of environmental resources and the fight against climate change [7]. In addition, efficiency in infrastructure and transportation systems reduces traffic congestion, facilitates transportation, and improves urban mobility, increasing quality of life [8]. Urban regeneration, environmentalist zero-waste practices [9, 10], the use of sustainable natural materials in social areas [11], and urban awards such as Cittaslow [12] can be given as examples that contribute to environmental sustainability.

Technological innovation is also an essential component of smart cities. These cities develop new solutions by promoting technological innovation, accelerating digital transformation, and increasing the competitiveness of cities [13]. In terms of social participation and services, smart cities create more transparent and effective governance models by increasing the participation of citizens. In addition, they provide better public services to citizens through smart services and increase their living standards [14].

Smart city projects worldwide and in Türkiye have great potential for local governments and citizens, but more research is needed on their effectiveness and sustainability. The gaps in the academic studies concerning smart cities are varied and cover various research areas. While there is significant research on the use of digital and communication technologies in urban systems, issues such as the application of these concepts in Türkiye, citizen participation, and the sustainability of these projects are not sufficiently addressed [15, 16]. More research is needed in these areas to fill the existing gaps and provide a deeper insight into smart city initiatives.

The practical difficulties and obstacles encountered while implementing smart cities have not been sufficiently addressed in the literature. Issues such as data privacy concerns, unequal access to technology, and cooperation need to be examined in more detail, and solution proposals should be presented [17]. There are often studies in the academic literature focusing on the use of technology, but applications in Türkiye, citizen participation, and the sustainability of these projects are not sufficiently addressed. In addition, there needs to be more detailed examinations of smart cities' environmental, social, and economic dimensions, such as efficiency, security, participation, and governance. Additional research is necessary to determine how these factors affect smart city success [18].

It is crucial to identify how smart cities are implemented in different geographical regions and cultural contexts along with the factors that impact the success of these applications. In this way, developing smart cities more effectively will be possible by considering cultural and geographical diversity [19]. The strategies and policies to be determined regarding the future advancement of smart cities must be addressed in more detail in the literature. More research needs to be done on how these strategies and policies will be created, implemented, and evaluated [20]. Filling these gaps will make smart cities more effective, sustainable, and livable. Therefore, it is important for future research to address these issues in more detail.

The primary focus of this study is to comprehensively analyze smart city implementations in Türkiye and around worldwide by addressing the definition and components of the smart city model. In this framework, "Smart city applications in Türkiye make positive contributions to the development of cities by improving urban infrastructure", "The use of smart city technologies strengthens the environmental sustainability of cities in Türkiye by increasing energy efficiency", "The active participation of citizens in smart city projects in Türkiye increases the success level of these projects and the effectiveness of sustainability strategies", "Smart city projects increase the quality of life in cities in Türkiye by supporting socio-economic development", hypotheses were created to answer the questions: "How do smart city applications in Türkiye contribute to urban development? How successful are these projects in terms of urban sustainability?" The novelty of the research emerges from the comprehensive

analysis of smart city applications in Türkiye and worldwide and the determination of the improvements they provide, especially in critical areas such as energy efficiency, waste management and transportation systems.

In this regard, the study aims to fill the existing literature gaps and propose innovative approaches and collaborative approaches to enhance the sustainability potential of smart city projects in Türkiye. It is predicted that the research conclusions will enhance developing policies and strategies to evaluate the applicability of smart city projects at a wide scale and encourage citizen participation. Thus, it purposes to guide the applicability of smart city projects on a larger scale and encourage citizens' active participation in these projects.

II. RESEARCH AND FINDINGS

A. Smart Cities in The World and Türkiye

1. Smart City Concept

The concept of a smart city, while having different definitions in the literature, is generally expressed as a city that prioritizes investment in social and relational capital, learns, adapts, and innovates by using technology effectively. This concept is shaped by the creation of an integrated ecosystem in the business, data, application, and technology layers of the people living, working, and visiting in it, and all institutions, values, and assets that provide services to these people. Smart cities are systems that provide information and communication-supported, pluralistic, naturalistic, safe, and integrated transportation opportunities. These systems have a significant impact on sustainability, efficiency, and smart city management in cities. The smart city paradigm is also regarded as a framework that is supported by data and expertise, using new technologies and innovative approaches with cooperation between stakeholders. The advancement of smart cities focuses on the framework of smart mobility, which includes various parameters such as smart mobility, green transportation systems, public transportation, physical security, monitoring, and control systems. In this context, it is stated that smart cities aim to enhance service delivery to citizens by combining technology with urban life, use city resources more efficiently, and use information technologies effectively. Consequently, the framework of a smart city stands out as a perspective that aims to enhance urban quality of life, support sustainability, and increase efficiency by using technology effectively. The definition and application areas of this concept are constantly evolving and are addressed by researchers from different disciplines.

2. Smart City Components

Smart cities consist of various components that are in line to enhance modern urban management and standard of living. These components contribute to cities becoming more effective, sustainable, and livable. Smart cities are essentially evaluated with six components: a) Smart environment, b) Smart life, c) Smart economy, d) Smart governance, e) Smart mobility, and f) Smart people [21]. The essential components and functions of smart cities can be summarized as follows:

a) Smart environment: Supports environmental sustainability and ensures the efficient use of natural resources. This component includes systems that increase energy efficiency, waste management solutions, and air quality monitoring technologies. Smart environment applications aim to reduce environmental pollution, optimize energy consumption, and protect natural resources in cities [22].

b) Smart living: Smart living is designed to enhance the quality of living conditions for city dwellers, offering a more comfortable, safe, and efficient lifestyle. This component encompasses a broad spectrum, from smart home technologies to healthcare services, from security systems to daily life conveniences. Smart living solutions are geared towards improving the living conditions of individuals and enhancing the overall quality of life in cities [23].

c) Smart economy: The smart economy encourages the digitalization of economic activities in the city and innovation. This component includes technology-supported business models, entrepreneurial activities, and solutions that increase economic efficiency. Smart economy applications aim to increase cities' competitiveness and support economic growth [24].

d) Smart governance: Smart governance empowers city managers to make data-based and transparent decisions, thereby enhancing the effectiveness of city management. This component includes data-based management systems, digital platforms, and effective communication methods with citizens. Smart governance applications are instrumental in making city management more effective and improving the quality of public services [25].

e) Smart mobility: Smart mobility aims to optimize urban transportation systems, reduce traffic congestion, and promote environmentally friendly transportation alternatives. This component includes applications such as developing traffic management systems, implementing smart transportation solutions, and integrating public transportation systems [26]. In this way, transportation efficiency in cities increases, and environmental impacts decrease.

f) Smart people: Smart people ensure that city residents receive better services in the fields of education, health, culture, and social life. This component includes solutions that enhance education technologies, health services, cultural events and social interactions. Smart people applications have a vital impact on strengthening cities' social structure by supporting individuals' social and cultural development [27]. The integration of these components allows smart cities to become more integrated, efficient and citizen-focused. Each component plays a significant role in increasing the sustainability and quality of life of cities and allows smart cities to cope with modern urban challenges.

3. Innovative Approaches to Smart City Development

Smart city solutions, which encompass technological and innovative tools, are instrumental in enhancing the effectiveness, sustainability, and livability of cities. These solutions consist of smart communities that can contribute significantly to the development and implementation of cities. A key aspect is the use of these solutions to keep city dwellers well-informed about what is happening in their environment and city, promoting transparency and citizen engagement. The active participation of different groups in the planning and design processes is encouraged [28]. A participatory management approach and transparent management are indispensable elements in smart cities. The design and management processes of smart cities focus on specific features and applications at various stages, covering the elements that directly affect the general functioning of urban areas and the well-being of residents (Table 1).

TABLE 1. SMART CITY SOLUTIONS [29]

Planning Phase	Coordinated and holistic Resources shared Cost savings were achieved Investments are scalable Improved urban planning and forecasting
Infrastructure Phase	Optimized with advanced technology Financial and resource savings were achieved Improved service agreements Built on open standards
For System Operators	Real-time reporting on infrastructure conditions Anticipating and preventing problems More effective distribution of resources Automating maintenance
ICT Investments	Central planning Implementation and distribution to city institutions and projects Provides optimum benefit, maximum value and savings
Citizen Participation	Offering a complete and individual online structure Citizens' easy access and use of services Two-way communication between government and citizen Citizen-oriented special services Citizens' contributions through their access to real-time smart city data and their ability to recommend mobile applications that use the data
Data Sharing	Institutions should be holistic and share data Data shared across organizations and better linked to other data services through open standards Improved results Reducing costs

According to Table 1 obtained in light of this information:

The planning phase includes various features to ensure that cities are managed more efficiently and effectively. By adopting a coordinated and holistic approach, resources are shared, and costs are reduced. The scalability of investments provides flexibility in cities' growth and change processes. In addition, improving city planning and forecasts allows for developing more effective and proactive management strategies.

In the infrastructure phase, system optimization is achieved using advanced technology. Financial and resource savings provide cost-effective solutions. Improved service agreements and infrastructures based on open standards support systems' harmonious and integrated operation. These elements contribute to the durability and sustainability of city infrastructure.

For system operators, real-time infrastructure reporting is ensured, and problems are predicted and prevented. Effective distribution of resources and automation of maintenance processes increase the efficiency of systems and minimize service interruptions.

Information and Communication Technologies (ICT) investments are carried out with central planning and applications for city institutions. These investments are meticulously planned and distributed to provide optimum benefit, maximum value, and savings, ensuring a significant return on investment and reassuring the audience about the strategic use of resources.

In terms of citizen participation, it encourages citizens to have easy access and use of services by offering a complete and individual online structure. By establishing two-way communication between the state and citizens, special services focused on citizens are offered, and contributions are encouraged through mobile applications that provide access to real-time data.

Data sharing, on the other hand, includes holistic data sharing between institutions and data integration with open standards. This approach not only ensures better correlation of data services and improved results but also significantly reduces costs, instilling confidence in the financial efficiency of the smart city model.

These stages and features make smart cities more efficient, sustainable, and citizen-focused. Integrating these elements in city management and planning processes enables smart cities to provide practical solutions to modern urban needs.

4. Smart City Projects and Applications in the World

Smart city projects worldwide aim to improve city management and quality of life with technology and innovative solutions. Many countries with smart city applications stand out in this field (Table 2). These examples show how smart cities develop with technology and innovative solutions and how they improve city life. Each country has developed different strategies according to specific needs and goals [30].

TABLE 2. SMART CITY APPLICATIONS BY CONTINENT AND COUNTRY

<p><u>America Continent</u></p> <p><u>Brazil/Rio de Janeiro</u></p> <p>-Project Type: City Management</p> <p>-Project Phase: Operations Center: Urban data such as security, transportation, energy, and disaster management are monitored instantly.</p> <p><u>Chile/Santiago</u></p> <p>-Project Type: Energy Management</p> <p>-Project Phase: Alternative energy sources are encouraged.</p> <p><u>USA/Las Vegas</u></p> <p>-Project Type: Water Management</p> <p>-Project Phase: Water networks are monitored for leaks.</p> <p><u>USA/San Francisco</u></p> <p>-Project Type: Energy Management/Environment and Waste Management</p> <p>-Project Phase: Smart Grid System: Electricity is produced from renewable sources. Smart street lamps with LED bulbs are used, and 80 percent of the</p>	<p><u>Singapore/Singapore</u></p> <p>-Project Type: Environment and Waste Management/Health and Accessibility</p> <p>-Project Phase: Traffic congestion is measured with cameras and GPS devices, and the vehicles causing it are taxed. Traffic lights stay on longer for elderly and disabled individuals using specific cards.</p> <p><u>Europe Continent</u></p> <p><u>Sweden/Stockholm</u></p> <p>-Project Type: Energy Management/Infrastructure Management</p> <p>-Project Phase: Tax deductions are provided to those who install energy control systems in their homes and workplaces. Roads and bridges are monitored with cameras and sensors.</p> <p><u>England/Leeds</u></p> <p>-Project Type: Infrastructure Management</p> <p>-Project Phase: Robots are being developed for the repair of underground cables and pipes and for the maintenance of street lights.</p> <p><u>England/London</u></p>
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<p>garbage is recycled into the economy.</p> <p><i>USA/California/Santa Cruz</i></p> <p>-Project Type: Security Management</p> <p>-Project Phase: A smart system that analyzes police records has been developed to monitor the city's security needs in real time.</p> <p><i>USA/Boston</i></p> <p>-Project Type: Security Management</p> <p>-Project Phase: Explosives are detected with electronic acoustic sensors.</p> <p><i>USA/New York</i></p> <p>-Project Type: Information Access</p> <p>-Project Phase: Smart street lamps and telephone booths are being converted into information centers.</p> <p><i>USA/San Diego/Florida</i></p> <p>-Project Type: Environment and Waste Management</p> <p>-Project Phase: Smart and LED street lights are used.</p> <p><i>Asia Continent</i></p> <p><i>South Korea/Songdo</i></p> <p>-Project Type: City Management</p> <p>-Project Phase: Electricity consumption, traffic density, and excessive waste accumulation are controlled.</p> <p><i>South Korea/Seoul</i></p> <p>-Project Type: Environment and Waste Management/Health and Accessibility</p> <p>-Project Phase: eCube Lab's monitoring system collects waste and recycles materials, while the health of elderly and disabled individuals is monitored via smartphones and tablets.</p> <p><i>Japan/Tokyo</i></p> <p>-Project Type: Energy Management</p> <p>-Project Phase: The eco-city produces zero carbon dioxide and uses 100% LED bulbs for street and home lighting.</p> <p><i>China/Xinjiang</i></p> <p>-Project Type: Health and Accessibility</p> <p>-Project Phase: "Panic buttons" allow quick access to elderly, disabled, and sick individuals.</p>	<p>-Project Type: Environment and Waste Management</p> <p>-Project Phase: London's Tube Trains are integrated into the energy network for environmental friendliness and energy recycling.</p> <p><i>France/Paris</i></p> <p>-Project Type: Energy Management/Transportation Management</p> <p>-Project Phase: Under the Smart City Paris 2050 Mountain Towers Project, air pollution is controlled, and vehicle use in the city is reduced through bicycle and electric car rentals.</p> <p><i>Netherlands/Amsterdam</i></p> <p>-Project Type: Transportation Management</p> <p>-Project Phase: Through the "Mobypark" smartphone application, empty parking spaces can be rented by those in need.</p> <p><i>Spain/Barcelona</i></p> <p>-Project Type: Transportation Management/Water Management</p> <p>-Project Phase: Named the smartest city of 2015 for smart environment and smart transportation. Irrigation systems in parks and gardens are monitored from a central location.</p> <p><i>Spain/Santander</i></p> <p>-Project Type: Information Access</p> <p>-Project Phase: Information on traffic density, air pollution, and discount shopping is delivered to residents via smartphones.</p> <p><i>Austria/Vienna</i></p> <p>-Project Type: Transportation Management</p> <p>-Project Phase: Public transportation card fees are calculated separately based on the type of transportation and distance, benefiting consumers.</p> <p><i>Denmark/Copenhagen</i></p> <p>-Project Type: Environment and Waste Management</p> <p>-Project Phase: Street lamp poles are used for air pollution measurements.</p> <p><i>Middle East Continent</i></p> <p><i>United Arab Emirates/Dubai</i></p> <p>-Project Type: City Management</p> <p>-Project Phase: Mobile e-Government, driverless electric cars, smart parking, smart grid, and smart environment projects are in progress</p>
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The cities and projects listed in the table show how smart city applications are diversified globally and in which areas these applications are concentrated. The fact that each city focuses on different project types and stages reveals the versatility of the smart city framework. The cities in the table host different types of smart city projects. The project types are generally divided into main categories: urban management, energy management, environment and waste management, transportation management, security management, information access, and health and accessibility. This diversity shows that smart cities must be developed comprehensively and that each city offers solutions in different areas according to its priorities. Energy and environmental management projects have an important place in many cities. For example, In Tokyo, the "Eco-city" project aims to produce zero carbon dioxide and uses 100% LED lighting. In San Francisco, energy management is carried out with a "Smart Grid System" and LED street lights. In Copenhagen, streetlights are used to measure air pollution. These projects reflect the efforts of cities to contribute to environmental sustainability and increase energy efficiency. Transport management and information systems have been designed to enhance the efficiency of cities and provide better services to their citizens.

In Amsterdam, the “Mobypark” application allows empty parking spaces to be rented via smartphones. In Barcelona, irrigation systems in parks and gardens are monitored centrally. In New York, smart streetlights and telephone booths have been converted into information centers. These projects aim to make urban transportation more intelligent and integrated. Health and safety management projects offer solutions to enhance safety and health of city residents: In Seoul, the health of the elderly and disabled is regularly monitored via smartphones and tablets. In Santa Cruz, a smart system that analyzes police records monitors the city’s security in the moment. In Xinjiang, “panic buttons” are used to reach the elderly and disabled quickly.

These projects aim to enhance the well-being of residents in cities and to improve emergency management. Infrastructure management projects are implemented to advance and sustain the existing infrastructure in urban areas effectively: Robots have been developed in Leeds to repair underground cables and pipes. Water networks are being monitored for leaks in Las Vegas. These projects ensure that city infrastructure is managed more sustainably and effectively. The various cities in the table show how smart city applications differ globally and that each city develops specific solutions according to its priorities. For example, while air pollution control and bike-sharing projects are implemented in Paris, projects on traffic congestion and accessibility have been developed in Singapore. In conclusion, this table shows that smart city projects are diversified worldwide and that cities develop applications in various areas according to their characteristics. Each city aims to provide a more efficient, sustainable, and citizen-focused life by offering smart solutions in different areas, from energy management to healthcare.

5. Smart City Applications in Türkiye

Smart city applications in Türkiye are of great importance to enhance the operational efficiency of urban areas, improve the standard of living and ensure sustainable growth. These applications offer critical solutions for cities to cope with modern challenges such as increasing population and irregular urbanization (Table 3).

TABLE 3. SMART CITY APPLICATION EXAMPLES AND NUMBER OF PROJECTS IMPLEMENTED IN TURKISH CITIES [31, 25]

City	Number of Projects	Application Example
Konya	132	Smart Tourism Guide Application
Kocaeli	68	Smart City Web Portal
Bursa	61	Metropolitan Municipality GIS Application
Sakarya	47	Green areas Smart irrigation System
Gaziantep	37	Traffic Signaling Task Management
Izmir	36	Geographic Cemetery Information system
Kutahya	35	Smart Stops
Manisa	17	Smart Stop System
Canakkale	13	360 City Guide
Balikesir	11	Smart Stop Energy Management
Antalya	8	Smart City Management Platform
Kayseri	7	Metropolitan Municipality Smart Intersection
Hatay	7	Smart Stop
Istanbul	6	Metropolitan Municipality Smart Parking Management
Sanliurfa	6	Solar Powered Signaling
Malatya	6	Metropolitan Municipality Smart Bicycle Sharing System
Edirne	5	Edirne Advanced Biological Wastewater Treatment Plant
Diyarbakir	5	E-Zoning System
Corum	5	Dynamic Intersection System
Aydin	3	Plan Automation Application
Trabzon	3	Trabzon Transportation Mobile Application
Nigde	3	E-Zoning
Mugla	3	Soil Fertility Map CBS Application
Eskisehir	3	Smart Stop Passenger Information System
Amasya	2	Smart Bike App
Tekirdag	2	Corlu Integrated Solid Waste Management Facilities
Mardin	2	Metropolitan Municipality 3.5 Mwe Solar Power Plant
Denizli	2	Traffic Management System
Ankara	2	Smart Waste Collection System

Elazığ	1	Dynamic (Smart) Intersection Control System
Rize	1	AKOS (Smart City Automation System)
Kırklareli	1	Electronic Ticket System
Kastamonu	1	Free Wifi Hotspots
Karaman	1	City Information System
Isparta	1	City Guide (Keos)

This table shows the number of smart city projects and sample applications implemented in various cities in Türkiye. Smart city applications in Türkiye offer a comprehensive range of services, from city management to environmental management, from public transportation systems to information systems. The data in the table shows how much different cities invest in smart city projects and which projects they focus on. Konya has the highest number of projects, with 132 projects, while the number of projects in other cities remains lower. This shows that Konya attaches great importance to smart city projects and has developed various applications. Project types vary significantly between cities. For example, while tourism-oriented projects such as the “Smart Tourism Guide Application” are at the forefront in Konya, information management systems such as the “Smart City Web Portal” are prominent in Kocaeli. There are geographic information systems and green space management projects in cities such as Bursa and Sakarya. This diversity shows that each city develops projects according to specific needs and priorities.

Infrastructure and environmental management projects have an essential place among project types. Projects such as the "Green Areas Smart Irrigation System" in Sakarya and "Smart Bus Stop Energy Management" in Balıkesir contribute to the environmental sustainability goals urban areas. Such projects support the aim of smart cities to use resources efficiently and sensitively in an environmental way.

Public transportation and information systems also have an essential place. Applications such as "Traffic Signaling Task Management" in Gaziantep, "Geographic Cemetery Information System" in İzmir, and "Smart Bus Stop Passenger Information System" in Eskişehir are projects aimed at improving intra-city transportation and information flow. These projects aim to increase the daily operational efficiency of cities. The table shows that smart city applications are additionally encompassed in some small cities. For example, projects such as "AKOS (Smart City Automation System)" in Rize and "Electronic Ticket System" in Kırklareli show that smart city technologies are also implemented in these cities. These applications in small cities ensure that technology is spread to a wider audience and that efficiency is increased in each city.

The table shows examples of innovative projects such as the "Metropolitan Municipality 3.5 Mwe Solar Power Plant" in Mardin and the "Smart City Management Platform" in Antalya. These projects aim to use advanced technology in cities' energy management and general management processes. As a result, this table reveals the interest and diversity of smart city projects in cities in Türkiye.

The number of projects and application examples shows how each city adopts and implements smart city technologies according to its needs and priorities. In addition, these projects contribute to cities becoming more efficient, sustainable, and quality-of-life smart cities. As part of this study, the impacts and effectiveness of smart city projects in Türkiye on urban sustainability were examined in detail. The research is supported by an extensive literature review and data obtained from various cities. The obtained data show that smart city applications throughout Türkiye provide significant improvements, especially in the optimization of energy use and the development of waste management processes. The integration with information and communication technologies (ICT) is at the center of these improvements.

The research has revealed that smart city projects increase the quality of life in urban areas by strengthening technological infrastructures and increasing citizen participation. However, the effectiveness of the projects varies according to geographical and demographic factors. According to the research, the achievement of smart city applications largely relies on the investments made by local governments in these areas. However, socio-economic barriers and infrastructural deficiencies limit the potential of these projects. The study documents that certain smart city projects need to catch up regarding sustainability and participation. Problems such as limited access to technology in low-income areas and low citizen participation in these projects reduce the effectiveness of these projects.

The study's findings show that smart city applications can effectively increase urban sustainability, but this effect is heterogeneous across cities. These findings emphasize that smart city projects can improve the quality of city life but that more comprehensive strategic planning and policy developments are needed to realize this potential. Expanding and deepening the scope of such projects can serve as an important transformation tool in Türkiye's urban transformation.

III. CONCLUSION

This study examined in depth the benefits of smart city projects in Türkiye to sustainable urban development. The findings show that smart cities have the ability to improve the efficiency of urban systems in areas such as energy efficiency, transportation, and waste management. These projects also have the potential to increase the quality of urban life and contribute to socio-economic development. However, it has been observed that the success of these projects varies according to geographical and demographic factors.

The study's results highlight the pivotal importance of information and communication technologies in enhancing energy and resource use. Moreover, the study identifies citizen participation and robust technological infrastructure as the key elements that support the effectiveness of these projects.

The importance of technological investments and participatory management models, which are frequently emphasized in the literature, is parallel to the findings of this study. When the applications explicitly made for Türkiye are compared with global examples, they clearly show how local dynamics shape technology adaptation.

Among the study's limitations, technological access and infrastructure deficiencies, especially in rural areas, are important. This situation limits the effectiveness of smart city projects, especially in developing regions. In addition, demographic diversity and inadequate analysis of regional characteristics have created difficulties in generalizing and drawing conclusions about the projects' success. These limitations may affect the general validity and applicability of the findings and may lead to misleading conclusions for policymakers.

It is recommended that future research should conduct comparative analyses of smart city projects in regions with different demographic characteristics. In addition, strategic policies and programs should be developed to increase citizen participation in the projects and expand technological access.

In conclusion, this study emphasizes that smart city projects can have significant impacts on urban infrastructure and quality of life in Türkiye, but more comprehensive strategies and policies should be implemented to maximize this impact. Expanding the scope of smart city projects will continue to play an important role in urban transformation processes.

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