Digitization of Cities and Its Impact on City Sustainability

Estabraq Shawqi Abd Al-Bari[1] , Nada Khaleefah Alrikabi[2*] , Kareem Hassan Alwan[2] ,
Rasha Abdullah Saadoon[3]

[1] Department of Petroleum Engineering, College of Engineering, University of Baghdad, Baghdad 47251, Iraq
[2] Center for Urban and Regional Planning for Postgraduate Studies, University of Baghdad, Baghdad 47251, Iraq
[3] Department of Agriculture, College of Engineering, University of Baghdad, Baghdad 47251, Iraq

Corresponding Author Email: dr.n.khalifa@iurp.uobaghdad.edu.iq

ABSTRACT

The study examines the critical challenges of rising traffic congestion and environmental pollution in Baghdad, practically in the Karrada district, driven by rapid pollution growth and economic expansion. It evaluates the role of smart urban services in addressing these issues, focusing on their advantages and their potential drawbacks. The research hypothesis that electronic services can significantly reduce environmental pollution by minimising traffic congestion and individual trips, leading to lower carbon emissions. However, it also highlights potential challenges, such as the complexity of using digital tools and the strain on network infrastructure. Using a descriptive and deductive methodology, the study analysis the practical effects of smart urban services in Karrada. The findings confirm the hypothesis, demonstrating that these services enhance residents' quality of life by improving citizen satisfaction, streamlining communication, and increasing the efficiency of public services through e-government platforms. Despite these successes, the study identifies critical obstacles, including limited access to technology, network overload, user difficulties, and concerns over data security. These insights underscore the need for balanced strategies to maximise the benefits of smart urban solutions while addressing their challenges, contributing to sustainable urban development.

1. INTRODUCTION

Electronic payment represents a major advance in facilitating people's daily lives, as it makes financial transactions easier, more convenient and safer, which helps improve the quality of life, saves time and effort, promotes economic development and preserves the environment, as carbon dioxide is responsible for more than 55% of global warming [1], and emphasizes the importance of finding new methods and technologies to meet the challenges of urbanization and modernization [2], as information technology is a crucial tool for managing human affairs in cities [3].

Focusing on smart and innovative components in urban planning emphasizes the priority of enhancing urban services to improve citizens' satisfaction and meet their needs [4-6].

Citizen relations management has been identified as a key objective to understand citizens' needs and enhance service delivery, with the ultimate goal of promoting sustainable development and active citizen participation in urban management [7].

E-commerce is considered one of the first electronic services to appear in cities. The term "e-commerce" emerged in the nineties of the last century after the Internet became a commercial and profitable platform [8].

The rapid expansion of the digital transformation process has led to the reshaping of urban economies and in the provision of services around the world.

Advances in big data analysis and artificial intelligence have increased efficiency in sectors ranging from transport to e-governance, as several cities such as Copenhagen and Seoul have benefited from digital twinning technology in improving resource allocation and for modeling urban growth. These transformations highlight the heavy reliance on digital infrastructures to build sustainable cities.

It is the method of presenting and providing services, information and products that occur via the Internet.

In order for any electronic service to be successful within any website or online store, it must have easy and multiple payment methods that are highly reliable. These matters can greatly affect the amount of use of the service, whether negatively or positively [9].

Many scientific studies have confirmed that if the electronic payment company that the website or store deals with is unreliable; this will prompt a large number of customers and shoppers to retract their decisions to deal with it [2]. Therefore, there must be a security certificate that appears on the site that guarantees the protection of the consumer's data, including his name and credit card number, in addition to the good reputation of the website with which he is dealing [7].

In addition, hearing positive experiences about electronic services and lower costs increases confidence in them, and the number of workers in them expands and increases, as the world is moving in this direction rapidly.

Therefore, modern technology and means of communication can be considered the locomotive of change in many aspects of daily life, and one of the most important aspects of these aspects is electronic payment, which is the main means of financial dealing.

Today, it has become easy to conduct any financial transaction quickly and safely over the Internet, and this has the effect of greatly improving the quality of life [10].

2. METHODOLOGY

This study uses a descriptive and deductive approach to digitization and its impact on the sustainability of cities, and focusing on the Karrada area located in the city of Baghdad.

The methodology included a data collection method based on the process of surveying and quantitative and qualitative analysis as a method of evaluating the effectiveness of smart urban services.

1). Survey and sample size: A survey was conducted in the Karrada region that included the residents of the region, business owners and government officials, where 100 participants were selected out of the total population of Al-Karada of 483,050 people.

To ensure the representation of different groups and sectors, the class random sampling method was applied.

The selection of 100 participants was based on the following considerations:

•   Statistical powers: The size of this sample (100 people) provides a margin of error of approximately ± 10% at a confidence level of 95%, in exploratory exclusive studies, it is considered acceptable for the concentration of general trends.

•   Representation of heterogeneity: The sample included a diverse mix of business owners, evaluators and public officials, to ensure that different perspectives on sustainability and digitization services are captured.

•   Resource constraints and feasibility: Conducting surveys in large-scale urban environments (especially in rapidly evolving technological environments) presents financial and logistical challenges. A sample of 100 people that ensures the quality, depth and reliability of the data within the scope of the study.

The survey included three main sections, namely:

• Demographic information, including age, career and access to digital services.

• Visualization of smart urban services and the extent of their use and potential challenges and benefits.

• The impact of urban services on sustainability (effects on environmental pollution, traffic congestion and quality of life for residents).

I used several questions from the Likert scale with multiple choice questions with open responses, to ensure a comprehensive understanding of opinions. The survey was distributed online and manually to ensure accessibility and increased response rate.

2). Techniques used in data analysis: The data collected were analyzed using both quantitative and qualitative methods, as follows:

• Inferential statistics: Regression analysis was applied to extract the relationship between the use of e-services with sustainability indicators (such as reduced traffic congestion and reduced carbon emissions).

• Meta statistics: It was to process data via Excel and SPSS applications to calculate percentages, frequencies and means.

• Qualitative analysis: This includes open responses where they are objectively coded to gain key insights into the user's experiences and challenges.

This approach ensures balanced analysis (although the sample size), and contributes to providing good and objective insights into how digital services affect urban sustainability.

3. THEORETICAL FRAMEWORK

3.1 Digital transformation in cities

Digital transformation has become a vital component in modern urban planning, offering solutions to various challenges cities face, such as traffic congestion, pollution, and inefficient public services [11]. The concept of smart cities focuses on integrating digital technologies into urban infrastructure to enhance service delivery, reduce consumption, and promote sustainable.

Smart urban services include e-government platforms, intelligent transportation, systems, digital payments, and smart grids, all contributing to sustainability by optimizing resources and minimizing environmental impact [12]. For instance, cities like Barcelona and Amsterdam have adopted smart systems to improve waste management, public transport, and energy consumption, resulting in reduced carbon footprint and increased efficiency [13].

In the context of developing cities like Baghdad, integrating smart services can help address persistent issues such as traffic congestion and environmental pollution, which are exacerbated by rapid urbanization and population growth [2].

However, implementing these services requires overcoming barriers related to infrastructure, digital literacy, and cybersecurity [7].

3.1.1 Strategies and policies for smart urbanization
Effective policies are necessary for the purpose of facilitating the transition of cities towards digitization.

Governments have implemented regulations and regulations around the world to improve smart urbanization, in addition to focusing on investment in infrastructure, data management and the work of companies between both the public and private sectors.

• In the European Union, the smart cities market provides regulatory guidance and funding to improve sustainability-based digitization.

• Singapore's Smart Nation Initiative emphasizes integrated data exchange policies and AI-based urban planning.

• The United Nations (SDGs) encourage digital solutions for urban inclusiveness and resilience.

By adopting similar strategies, a region such as the Karrada region can strengthen its electronic infrastructure, facilitate governance, and improve the city's sustainable growth.

3.2 E-services and urban sustainability

E-services have proven effective when integrated into urban

governance, reducing unnecessary travel, simplifying administrative processes, and enhancing citizen satisfaction [14]. Electronic payment has reduced the number of trips to government offices and departments, reducing traffic congestion and thus significantly reducing pollution in fully adopted cities [15]. It has also significantly reduced paper and fuel consumption in a large number of urban centers [16]. Das [17] emphasized the impact of modern ICTs in promoting a green urban approach.

However, there are several challenges facing a city like Baghdad in the success of digital services policies, such as lack of infrastructure, limited digital culture among citizens, and cybersecurity [9].

3.3 Smart urban services and quality of life

Quality of life in urban sustainability is a key axis for achieving well-being for residents in terms of accessibility, efficient public services, and providing a good, clean environment by reducing traffic congestion and thus reducing pollution [18].

Smart urban services contribute to achieving this goal by addressing various challenges including traffic congestion, public safety, and waste management in the area [19].

In a study conducted by Alrikabi and Alumery [20], they highlighted the positive effects of smart solutions in promoting public health by reducing air pollution, and stated that carbon emissions from vehicles can be reduced by using smart transportation, by improving traffic flow and reducing idle time.

Electronic health services can also provide easy access to medical care, by reducing trips to and from health centers and doctors, thus reducing traffic congestion and carbon emissions.

Therefore, providing easy access to public services and the efficiency of public services can improve citizen satisfaction in the Karrada area in Baghdad [2].

Therefore, it is necessary to address challenges such as network overload and digital exclusion, to ensure that these services reach all citizens.

3.4 Digital payment systems and economic development

Digital Payment Systems are one of the earliest and most impactful forms of urban digitalization. They have revolutionized how cities manage financial transactions, improving efficiency, transportation, and security in public service delivery [8]. For instance, the widespread adoption of mobile payment platforms in cities like Stockholm and Singapore has led to significant reductions in cash handling costs and improved service efficiency [21].

In addition to reducing traffic congestion and emissions, digital systems also promote economic development by facilitating e-commerce and cashless transactions [7]. These systems empower citizens to access services quickly and securely, thereby increasing consumer trust in digital platforms [9]. However, the success of digital payment systems depends on ensuring data security and user-friendly interfaces.

For developing cities like Baghdad, digital payment systems can play a crucial role in reducing administrative burdens and promoting financial inclusion. Ensuring secure and reliable payment systems is essential for encouraging citizens to adopt digital services [2].

3.5 Barriers to digitalization in cities

Despite the numerous benefits of digitalization, cities face several challenges in implementing smart urban services. The most significant barriers include:

1) Limited Access to Technology:
In many cities, especially in development countries, access to digital tools is not evenly distributed. This digital divide can prevent marginalized groups from benefiting from smart services [1].

2) Network Overload:
Increasing the load on the current Internet network by increasing reliance on digital infrastructure can lead to a decrease in its efficiency or perhaps a complete interruption [22].

3) Cybersecurity Concerts:
Many citizens are still hesitant about using digital services, as they have great fears of their data or identity being stolen when they share their personal information online [8].

4) User Difficulties:
Providing programs and interfaces that are easy to use will increase the number of users of digital services, as digital illiteracy is still a major challenge for those with limited education or the elderly, so providing these easy programs and providing digital educational programs will help in addressing this problem [7].

This requires cooperation between the public and private sectors to solve this problem.

3.6 The role of public participation in digital urban services

Public participation is critical for the successful implementation of smart urban services. Involving citizens in the planning and implementation of digital services increases trust, adoption rates, and service satisfaction [20].

Cities must adopt citizen-centric approaches that prioritize transparency, accountability, and responsiveness in their digital services [20]. This can be achieved through interactive platforms, feedback mechanisms, and public consultations.

In Baghdad's Karrada district, promoting active citizen participation can help ensure that digital services address local and contribute to sustainable urban development (Table 1).

Table 1. The basic features of electronic payment [10, 23]

No.	Advantage	Its Usefulness
1.	Comfort and ease of application	It enables individuals and companies to conduct financial transactions anywhere and at any time, through electronic banking applications and digital wallets.
2.	Safety	Provide protection by using passwords, verification, and encryption, to protect personal information, or hack the account.
3.	Reducing risks	The risk of money being stolen or lost as a result of dealing with paper money. In addition to the ease of tracking transaction records by individuals to detect unauthorized transactions.

4.	Save effort and time	Banking operations and bill payments can be performed in just minutes through smartphones. This will save a lot of effort and time and allow users to carry out the rest of their activities and work.
5.	Flexibility and diversity	There are several electronic payment methods that an individual can choose according to his needs, such as: bank transfers, digital wallets, credit and debit cards.
6.	Preserving the environment	Achieving environmental conservation by reducing the consumption of ink and paper used in paper bills and checks, which reduces environmental pollution and resource consumption.
7.	Promoting economic development	Economic growth is achieved by encouraging e-commerce and facilitating local and global commercial transactions.

3.7 Future trends in digital urbanization and sustainability

The future of digital urbanization is shaped by data-driven governance and advanced sustainability goals, as well as emerging technologies. Several trends are expected to define the next stage of smart cities:

1) Predictive analytics or so-called artificial intelligence:
Artificial intelligence-based city management systems will rely on enhancing decision-making, allowing for prediction of infrastructure failure or success, and will also impact improved energy use and emergency response times [1].

2) Blockchain technology for secure urban transactions:
This technology is expected to revolutionize data security and transparency in smart cities, by providing tamper-resistant records, supply chain management and financial transactions [2].

3) 5G and the expansion of the IOT networks:
The deployment of 5G networks will allow for ultra-fast connectivity, improve real-time monitoring, navigation of self-driving vehicles, and provide smart traffic systems [3].

4) Digital twinning and smart infrastructure:
It is expected that cities will adopt digital twinning technology in a big way to create virtual copies of virtual urban environments, to expand effective urban planning, improve energy use, and disaster management systems [4].

5) Integration of sustainable technology and the circular economy:
Digital platforms will facilitate circular economy initiatives, where consumables will be recycled, while reducing resource consumption, through models that support sustainability and rely on artificial intelligence [5].

In addition to moving cities entirely towards digital ecosystems, addressing digital concerns, equality, and regulatory frameworks will be very important.

The future of urban sustainability depends on the balance between technological advances and comprehensive, environmentally responsible policies.

4. MATERIALS AND METHODS

4.1 The study area

4.1.1 Geographical location
The study included the eastern Karrada area, which is considered one of the old and famous neighborhoods in the city of Baghdad, located on the eastern side of the Tigris River on the Rosafa side.

4.1.2 Area and population
It consists of 20 residential areas with an area of 19,800,000 m^2. Its population is 483,050 people (Figure 1).
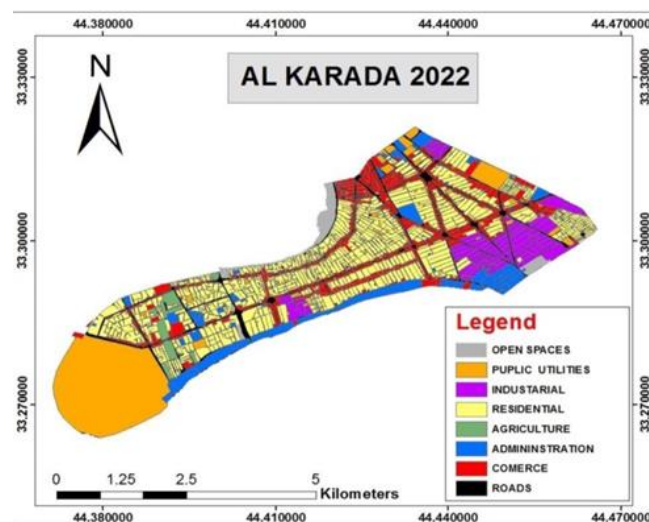

Figure 1. Land use map in Al-Karada area [24]

4.1.3 Electronic payment services in Eastern Karrada
The electronic payment services in the Eastern Karrada region included several aspects:

1) E-Learning:
   a) Displaying students' results in baccalaureate exams.
   b) Electronic application for registration in Iraqi governmental and private universities and institutes, and distance learning in international universities.
   c) Study and education via the Internet: There are integrated programs used to create, present, track, and report on courses, and applications to facilitate the student's access to appropriate references, and provide test preparation services, in addition to providing audio books, summary booklets, video clips, and private lessons from specialized professors.

2) E-commerce:
Sellers tend to display their products in electronic applications over the Internet so that customers can buy from them using the Souq platform as an intermediary, as these applications provide many international brands.

Several companies in this field started with food delivery services and ended up delivering various things.

This trend is important in urban sustainability, as it directly affects carbon emissions and transport patterns, by reducing the need to go to grocery stores and restaurants, that is, reducing individual trips, and thus reducing traffic congestion and carbon emissions. But it also raises concerns about increasing orders for delivery vehicles, which could offset some of the environmental benefits (Figure 2).

Understanding these dynamics is critical to the development of balanced digital urban policies.
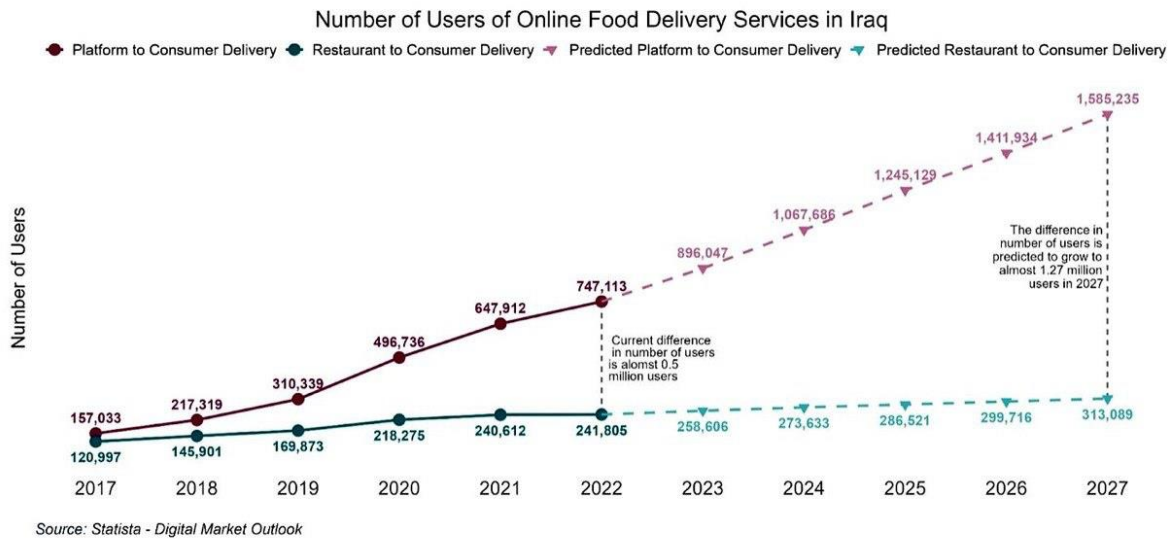
Figure 2. Growth of online food delivery users in Iraq and its impact on urban mobility in Karrada [25, 26]

3) Health care sector:

The digital healthcare sector includes:

    a) Information providers, which represent educational and cognitive platforms for patients and health care providers, through which patients can request other information or opinions.

    b) Providing Telehealth services, who provide medical consultations using digital technologies.

    c) Platforms for interacting with patients that connect them to health care providers to follow up on acute cases such as surgical interventions in their later stages.

    d) Remote monitoring services devices in the form of wearable devices with sensors that allow doctors to monitor the patient's condition, and an emergency notification/communication network to enable doctors in multiple specialties to communicate with each other in cases of necessity.

    e) Online booking service, which allows patients to review the doctor's recommendations, book an appointment online, and give their opinion about their experience [27].

4) The financial sector:

In 2023, the Central Bank of Iraq initiated the execution of Council of Ministry Resolution No. (23044) of the same year. This resolution focuses on promoting electronic payment systems across both government and private sectors to support this transition and minimize reliance on cash for collections and commercial activities, aiming to protect money from risks such as damage, theft, or fire.

5) Travel and tourism sector:

The electronic payment system (POS) was implemented on 5/27/2023, as the General Company for Iraqi Airlines announced the start of work on it for the purpose of booking and issuing travel tickets with the central reservation system and customer relationship management.

6) Agriculture sector:

Digital transformation in the agricultural sector is divided into three categories, as follows:

    a) Weather alerts and additions and electronic automation.

    b) Market platforms, remote sensing and monitoring technologies, electronic supply chain tools for diseases and pests, farm management platforms and price forecasting technologies.

    c) Agricultural robotics and improvements, production forecasting tools, and controlled environment farming [28].

7) Media and entertainment sector:

It includes booking cinema and stadium tickets and knowing show times [28].

8) Housing sector:

There are a large number of platforms operating in the electronic housing market, as they connect many entities with each other, such as residential property owners, buyers of residential units or tenants, and services for examining and verifying tenants.

This platform helps homebuyers connect with equity lenders and developers, to facilitate sale, purchase or rent transactions [28].

9) Traffic sector:

The electronic payment system (POS) was implemented on 1/5/2024 in all directorates affiliated with the General Traffic Directorate to facilitate all vehicle registration transactions and grant driving licenses.

Gradually, the cash payment process will stop completely, according to the General Traffic Directorate.

10) Ministry of interior:

Working with the electronic payment system currently includes booking the unified national card, and booking passports and airline tickets [29].

**4.2 Methods**

This study employs a descriptive and deductive research methodology to assess the impact of smart urban services on urban sustainability in the Karrada district. The methodology integrates both qualitative and quantitative approaches, ensuring a comprehensive evaluation of digital transformation in urban settings. The study aims to identify key benefits and

challenges associated with smart urban services, utilizing structured survey methods and statistical validation.

The research aims to assess the impact of smart urban services by highlighting the benefits of electronic processes in civil services and their influence on urban quality of life. It explores both the positive and negative outcomes of these services, with the ultimate goal of enhancing human well-being in a city like Baghdad. The study focuses on reducing environmental challenges and fostering citizen engagement in urban management through the integration of digital solutions, aiming to create a sustainable urban environment.

To gather data, a quantitative research approach was employed, aligning with the study's objectives and natural. Electronic survey was distributed to users of public electronic service applications. The study sample consisted of 100 participants from the eastern Karrada district in Baghdad, drawn from a total population of 483,050 in 2024. Of this population, 260,289 individuals were aged 18 and above. A purposive sampling method was used rather than random selection (Figure 3, Table 2).
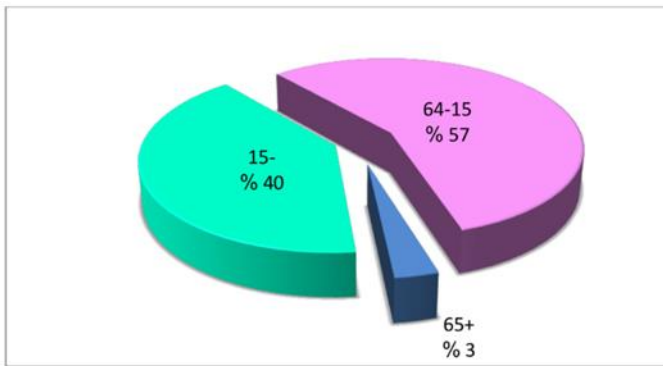
Figure 3. The age structure of Iraqi population in 2020
Source: Iraq's population estimates for 2020/Directorate of Population and Labor Force Statistics, November 2020/p. 10

4.2.1 Data collection method

Data were collected by distributing questionnaires online, and recruiting a sample of 100 people from the eastern Karrada region.

A structured questionnaire was developed incorporating a five-point Likert scale for quantitative responses and open-ended questions for qualitative insights. To enhance accuracy and clarity, a pilot test was conducted on a small group before full-scale distribution. The survey was distributed via both online platforms and in-person interactions to maximize accessibility and response rates. Special attention was given to ensuring proportional representation of various demographic and occupational groups.

Justification for Sample Size: The sample size of 100 participants was determined using Cochran's formula, ensuring a ±10% margin of error at a 95% confidence level. While a larger sample could enhance statistical power, logistical constraints and resource limitations necessitated a focused sample. Stratified random sampling was employed to guarantee diverse representation from different social and professional backgrounds.

The study found that 82.7% of participants use electronic payment methods in their transactions. The primary motivations cited for using these services were:

- 61.4% of respondents stated that electronic payments save time and effort.
- 20.5% indicated that using digital transactions contributes to fuel consumption reduction.
- 20.5% believed that e-payments help in environmental preservation.
- 38.6% considered e-payments easy to use.
- 20.6% reported that digital transactions help in cost reduction.
- 29.5% highlighted the availability of the service 24/7.
- 18.2% stated that they are compelled to use electronic payments due to external factors.

Table 2. The estimates of Iraq's population and urban-rural ratio for the year 2020 [30]

Governorate		Urban		Rural		Total
		Male	Female	Male	Female	
0	Total	1,152,213	1,890,039	1,260,610	973,312	4,276,174
11	Duhouk	505,820	504,415	175,0757	177,707	1,360,217
12	Nineveh	217,718	164,148	789,933	751,150	1,922,215
13	Sulaimania	964,400	960,250	177,133	179,933	2,217,171
-	Halabja	47,886	47,747	3,354	4,468	114,555
14	Kirkuk	629,260	619,550	221,940	217,344	1,688,094
15	Arbil	822,650	808,750	168,884	163,147	1,953,431
21	Diyala	420,980	422,521	449,001	439,878	1,729,238
22	Al-Anbar	482,790	459,380	472,640	453,370	1,868,180
23	Baghdad	7,940,401	6,968,606	5,553,636	5,117,000	25,562373
24	Babil	521,170	527,390	577,670	551,600	1,177,830
25	Karbala	432,410	429,300	212,210	210,920	1,459,087
26	Wasit	443,020	435,820	297,190	284,040	1,459,087
27	Salah Al-Deen	387,750	377,920	468,600	455,800	1,689,078
28	Al-Najaf	550,580	557,530	229,760	217,001	1,548,871
31	Al-Qadisiya	391,650	387,360	291,150	286,200	1,356,360
32	Al-Muthanna	201,700	191,640	228,070	235,100	856,517
33	Thi Qar	710,100	702,610	395,110	397,320	2,205,462
34	Misan	430,660	424,640	157,000	155,720	1,206,462
35	Al-Basra	256,000	230,580	281,730	282,280	6,059,228

Conversely, 17.3% of respondents reported not using or avoiding electronic payment methods, with the main concerns being:
• 28.6% feared bank card theft or fraud risks.
• 7.1% expressed a lack of trust in digital payment security.
• 7.1% were concerned about additional charges imposed on e-transactions.
• 21.4% reported internet connectivity issues as a barrier to digital payment adoption.
• 42.9% stated that they simply do not need this service.

These findings illustrate the growing reliance on digital financial services while simultaneously highlighting key barriers that hinder full adoption, particularly in terms of security concerns, infrastructure reliability, and public awareness.

4.2.2 Data analysis techniques
The collected data were analyzed using a combination of quantitative and qualitative methods, ensuring a balanced and in-depth assessment of digital service adoption in urban sustainability.
• Inferential Statistics: A simple linear regression analysis was conducted to assess the relationship between the usage of digital services and sustainability indicators such as traffic congestion reduction and decreased carbon emissions.
• Descriptive Statistics: Using SPSS and Excel, frequency distributions, means, and standard deviations were calculated to identify patterns and trends.
• Qualitative Analysis: Open-ended survey responses were analyzed through Thematic Coding Analysis, allowing the extraction of common themes related to user experiences, barriers, and opportunities in smart urban services.

5. DISCUSSION

The results of this research confirmed the effective role of smart solutions in improving the quality of life in cities, increasing the efficiency of public services and seeking to achieve environmental and economic sustainability. The research showed that the integration of the electronic system, especially the number payment system, has contributed significantly to the speed of completing transactions, reducing administrative burdens, and improving the user experience.

Key benefits of digital transformation in smart cities:
1) Improving the standard of living and community services
Through automation with the adoption of advanced and smart systems, government entities were able to improve services and make them more efficient and faster, reducing daily trips to complete transactions. This has reflected positively on the satisfaction of the population with services and the relief of pressure on public government facilities.
2) Minimizing environmental impact while promoting sustainability
The research indicated that digital transformation has contributed to reducing dependence on fossil fuels and thus reducing carbon emissions resulting from unnecessary trips. However, more detailed studies will still be needed in accurately measuring environmental impact, such as calculating the rate of reduction in carbon emissions as a result of reduced traffic and then improving resource management.
3) Rationalizing financial costs and increasing efficiency economically

Smart services have helped reduce operational costs by reducing the use of paper, enhancing the efficiency of service delivery, and improving the disbursement of financial resources.
4) Achieving transparency and increasing your confidence in government institutions
The adoption of electronic systems led to achieving transparency in transactions and reducing administrative corruption, which worked to enhance citizen confidence in public service institutions.

5.1 Challenges faced by smart cities

Despite the many advantages shown by the research, there are still some obstacles that must be addressed in order to achieve a more comprehensive digital transformation, including:
• The digital divide and technical challenges
There are still a number of users who are unable to fully benefit from digital services, either due to their lack of electronic experience or limited access to technological tools. Therefore, training and awareness programs must be provided to ensure comprehensiveness in digital transformation.
• Technical infrastructure
Cities need to develop communication networks and make them more efficient, expand the Internet, while improving computing capabilities, to ensure the continuity of smart services.
• Information security and privacy concerns
Some groups still refuse to use electronic services due to information security and data protection concerns, which requires the provisions of security systems to maintain the confidentiality of electronic transactions.
• Pressure on electronic infrastructures
Increasing reliance on smart services increases the pressure on telecommunications networks, which affects the quality of services and thus causes technical problems that prevent the full use of smart solutions.

The need to expand the scope of research to include new aspects of the smart urban environment.

While this research focused on the electronic payment system, there are many other aspects in the smart urban environment that require a lot of research, such as: Expanding Smart Urban Solutions Beyond Digital Payments.

While digital payment systems play a significant role in enhancing urban efficiency, other crucial smart city elements must be explored further to create a comprehensive and sustainable digital urban environment.
1) Smart grids and energy optimization
One of the critical components of digital urban transformation is the implementation of smart grids, which help balance electricity distribution through real-time monitoring and automated load management. These systems reduce energy waste, integrate renewable energy sources, and improve overall power reliability. In cities like Copenhagen and Amsterdam, smart grids have played a major role in enhancing energy efficiency and reducing carbon footprints. Karrada's power infrastructure could benefit from similar implementations, addressing frequent power shortages and promoting energy sustainability. However, the deployment of smart grids faces challenges related to infrastructure costs, technical expertise, and policy integration.
2) IoT-based traffic management for sustainable mobility

Traffic congestion is one of the biggest challenges affecting urban sustainability. IoT-powered traffic management systems use real-time sensors and adaptive algorithms to dynamically adjust traffic flow, reduce congestion, and optimize public transport efficiency. In Singapore and Stockholm, these systems have significantly decreased idle time, fuel consumption, and pollution levels. Implementing a similar model in Karrada could help mitigate peak-hour congestion, lower emissions, and improve the overall commuting experience. However, the effectiveness of IoT-based traffic solutions depends on digital infrastructure, government investment, and public adoption of smart mobility technologies.

3) AI-driven governance for enhanced public services

Artificial Intelligence (AI) is increasingly shaping urban governance, enabling cities to provide more efficient, transparent, and data-driven public services. AI applications in predictive analytics, automated decision-making, and e-governance platforms have transformed cities like Dubai and Barcelona, making government services more accessible and responsive. For Karrada, adopting AI in urban governance could improve decision-making efficiency, streamline bureaucratic processes, and enhance citizen engagement. However, this transition must address data security concerns, regulatory challenges, and the need for AI literacy among public administrators.

Future research should explore how integrating these additional smart city elements can complement digital payment systems, creating a more sustainable, interconnected urban environment.

6. CONCLUSION

The results of the research confirmed the validity of the hypotheses put forward in the Karrada area, as they proved that smart urban services had a positive and direct impact on the quality of life of residents. It has demonstrated its ability to enhance citizen satisfaction by saving time and effort, reducing environmental pollution, reducing operational costs, while reducing dependence on fossil fuels, and reducing the rate of unnecessary movements within the city.

The research also proved that the adoption of digital systems in the provision of services within cities was not just an improved technical method, but an essential element for achieving sustainable development, by improving the efficiency of urban management and raising the sustainability of resources. Based on the above, this research reinforces the importance of adopting smart solutions on a large scale, but with the need to address the challenges associated with infrastructure and data security with digital inclusiveness, in order to ensure maximum benefit from such technologies in the future.

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