Digital Technology in Urban Management and Spatial Development (Kirkuk City in Iraq - A Case Study)

Dr. Ali Hussein Muhammed Al-Janabi, Farah Hameed Azeez

Center for Urban and Regional Planning, University of Baghdad, Iraq
Email: dr.a.aljanabi@iurp.uobaghdad.edu.iq

Abstracts

The research aims to study digital transformation in city management and spatial development, and the challenges facing this transformation, in order to integrate digital transformation into the requirements of urban planning and development. Many cities face problems of urbanization, overpopulation, and competition for available resources, as well as renewed human needs and the complexities of urban life. The research hypothesis that the use of digital technology as a tool in city management and urban development will contribute to improving the quality of life in the city and provide a decent life for residents. The research adopted the descriptive analytical method in studying the phenomenon by taking advantage of some relevant references and reviewing some international experiences, as well as a field study - by taking the city of Kirkuk in Iraq as a case study. . It became clear from the results of the research that digital transformation in the field of city management and spatial development opens serious horizons for development, growth, and sustainability, and contributes to the better exploitation for available resources and different land uses in the city. There are also major challenges facing this transformation, first and foremost the large investments that must be directed to infrastructure in the field of information and communications technology, in addition to the need to adopt training and educational programs on how to deal with digital technology, whether at the level of institutions or individuals residing in the city.

Keywords: digital technologies, urban management, spatial development, digital transformation.

Introduction

Digital transformation in city management and planning is a phenomenon adopted by many cities in the world, through investment in information and communications technology, in order to achieve the greatest possible extent of meeting human needs and quality of life in the city, so a large part of spatial development processes is directed towards this type of investment. The research problem is summarized in the major challenges facing the effective management of cities and sustainable spatial development, due to rapid urbanization and complex urban systems,

as well as the challenges facing the use of digital technology in urban management and sustainable development of cities.

The research discusses the importance of using digital technologies in city management and sustainable spatial development, allowing an understanding of aspects related to the use and integration of digital technologies in management, planning and development, to meet urban functions. Therefore, the goal of the research was to study the importance of digital transformation in the spatial management and development of cities, and to evaluate the extent of the use of digital technologies in city management and development, by taking the city of Kirkuk in Iraq as a case study, in order to diagnose the most important elements facing digital transformation in urban management. Based on the hypothesis that the use of digital technologies in urban management and sustainable spatial development will achieve a qualitative breakthrough in facilitating this task, and will save a lot of effort and time for government administration and residents alike. The research was followed by a set of conclusions and recommendations, stating the need to direct investments towards infrastructure in information and communications technology on the one hand, and to spread awareness of its use at the level of institutions and individuals.

2. Urban management, development and digital technology:

In this part of the study, the concepts and components of the research topic will be identified, namely urban management, spatial development, and the use of digital technology to support both management and development, leading to a better life in cities that achieves functional efficiency and sustainability of resources and physical components in the city.

2-1 Urban management and sustainable spatial development:

Urban management is a three-dimensional system consisting of planning, organization and management, guided by a set of urban legislation to regulate functional performance and meet sustainable development goals, in a way that meets the needs of residents. The reality of the urban environment at the present time is considered a complex and difficult matter, due to the complexity, multiplicity and diversity of urban systems and functions, as a result of spatial development that included the elements of growth and change (Al-Janabi, 2015, p. 3). Growth is a state rooted in the origin of urban formation, represented by population and the urban environment, while change is linked to the dynamism of urban life and its renewable requirements, technological progress, and the use of modern technologies, in order to achieve quality of life in the city. Hence, the use of digital technology in urban management and spatial development, through investment in both technology (TC) and human resources (HR), is a must to facilitate the requirements for decent living in the city and sustainable growth, Figure (1).

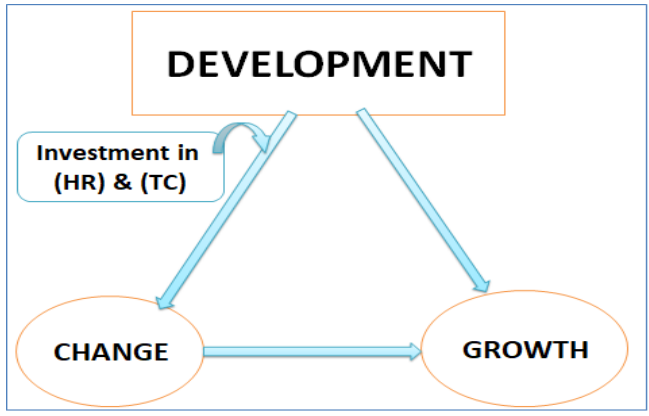


Figure (1) Development, investment in people, technology, and sustainable growth

Source: Prepared by researchers.

2-2 Digital technologies and their characteristics

Digital technology expresses the use of information and communications technology, as well as sensors, applications and programs, through which data and information are collected, transmitted and analyzed using hardware components, systems and software applications (Hamid, 2016, p. 49), which are used in urban management and spatial development, including It achieves better performance of the city's physical components, represented by land uses, as well as urban services, and economic and social activities.

Digital technologies depend on the use of the Internet, advanced wireless communications, and the transfer of information and data and their processing in real time within advanced software systems and infrastructures, Within advanced software systems and infrastructure (Giffinger & Others, 2007, p10-12), the most important characteristics of digital technologies as follows:

- Communication: Communication networks are used, such as the Internet with a high-speed wireless connection.

-Technological integration: It means integrating multiple technologies, such as the Internet of Things (IOT).

-Collecting data to make the right decisions: Data is collected from its sources using digital technologies and sensors, for the purpose of analyzing it according to multiple programs and systems to make decisions about it.

-Sustainability priority: It is adopted and used in environmentally friendly practices such as effective waste management.

- Quality of life for citizens: citizens' participation in digital platforms and access to smart services.

The uses of digital technology have multiple benefits for the environment, citizens, and the city (Albino & Others, 2015, p13-16), summarized as follows:

-Improvement in efficiency, such as simplifying operations, reducing energy consumption and improving the quality of life in the city.

-Creating a sustainable environment, by integrating technologies and practices to reduce their environmental impact .

- Innovation, economic growth, and effective governance.

2-3 Types and components of digital technologies used in urban management and development :

The digital technologies that can be used in cities are many and varied, have multiple benefits, represent a qualitative shift in management and sustainable urban development, and work together to manage the urban system. Below are some of these technologies and their main components.

- Sensor network technologies and the Internet of Things (IOT):

The Internet of Things is a network of physical devices embedded with communication capabilities, software, and sensors. The Internet of Things allows these devices to communicate with each other and with other systems, creating a vast, interconnected network. Here are some of the main uses of the Internet of Things as in Figure (2): (Rejeb & Others, 2022, p7-12).

Figure (2) A picture of the Internet of Things

- Geographic Information Systems (GIS) techniques:

This technology deals with geospatial data, such as urban infrastructure, demographic details, transportation, environment, and land use patterns, in order to store, analyze, and utilize them (Al-Drouli, 2018, p. 8). Its main uses include:

- Mapping land management and urban planning

-Emergency response, disaster management, logistics, and transportation.

- Public health, such as mapping high-risk areas and disease outbreaks.

- Cloud Computing technologies :

Cloud computing means providing computing resources, allowing users to obtain and use these resources on demand, without the need for technical expertise or local infrastructure (Al-Muzain, 2020, pp. 9-13). Some cloud computing technologies, their uses and scope of application can be mentioned as follows:

- Infrastructure as a Service (IaaS): such as virtualization as networking and storage.

- Platform as a Service (PaaS): this technology provides a good environment for developers.

- Software as a Service (SaaS): provides software applications.

- Big data and analytics: provide effective and usable solutions.

- Blockchain technology :

This technology allows a small number of people to maintain a decentralized and shared database, without the need for a central authority, and is a transparent and reliable way to manage many aspects of urban services and infrastructure (Al-Subaie, 2019, pp. 4-9). The potential applications and uses of blockchain technology go beyond digital currencies, as follows :

-Crypto currencies such as Bit coin, Ethereal, and smart contracts that are self-executing contracts.

- Identity management by providing a secure system for managing digital identities and health care.

- Intelligent transportation systems technologies:

It is a wide range of applications and technologies aimed at supporting and improving the efficiency of intelligent transportation systems. Among its main uses and scope of application are the following (Shanabi et al., 2021, pp. 314-315):

-Traffic and its management systems: managing and monitoring traffic and smart traffic lights and their systems.

-Electronic Toll Collection (ETC).

- Automated vehicle systems such as self-driving vehicles and smart parking and their systems.

2-4 Electronic systems applied in selected international cities in:

Some international cities such as (Singapore, Seoul, Barcelona, Dubai, Songdo) were chosen to describe the digital technologies applied in them as follows:

A- Singapore:

It is known for its advanced urban management, as it has applied digital technologies to enhance its infrastructure (Oswin, 2019), including

• Establishing an electronic system called the Smart Nation Initiative platform.

• It has an advanced Intelligent Transport System (ITS).

• Implemented the Smart Housing system.

B- Seoul/South Korea:

The city was able to take great steps towards digital transformation, as it used digital technologies that enhance the quality of life and urban services for citizens, and among the digital technologies applied (Lim, 2020) are:

•It developed an integrated smart city platform called Integrated Smart City Platform (DAWUL).

•Implemented a smart transportation system.

• Smart Energy Management was implemented.

C- Barcelona/Spain:

It is a pioneering city in digital transformation, as technology has been integrated into various aspects of urban life (Walliser, 2004), the digital technologies applied there are:

•Building the Internet of Things and its infrastructure.

•Implementing the concept of Superblocks, which organizes city streets and reduces traffic.

• The Open Data Platform was launched widely and free of charge.

D- Dubai/United Arab Emirates:

This city enthusiastically adopted the concepts of digital transformation in order to change its urban landscape (Kadhim, 2019), and the digital technologies applied in it were as follows:

•Smart government initiatives were developed.

• It introduced advanced infrastructure and smart transportation.

E- Songdo/South Korea:

It is a smart city that was built and planned with high precision, as the focus was on technology when it was established (Sang Keon Lee, 2016). The digital technologies applied in it were as follows:

•Equipping the city with a large network of sensors (Expansive Sensor Network).

•The presence of an integrated command center (Centralized Command Hub) that takes data and analyzes it.

• Using automated systems for smart buildings to provide advanced safety.

2-5 A comparison between cities that use digital technologies and those do not:

The use of digital technology in cities makes a big difference compared to cities that do not use digital technology, in terms of the work of these cities, as there are clear differences, as in Table (1).

Table (1) Comparison between cities that implement the use of digital technology and those that do not.

Cities that implemented digital technology	Cities that do not implemented digital technology
1- In terms of providing services efficiently	
Cities that use digital technology are often more efficient in providing public services.	It relies on manual procedures, which leads to delays, prolonged waiting time for services to be completed, and inefficiency.
2- In terms of the city's infrastructure	
Digital technology controls infrastructure better .	Cities face difficulties in managing infrastructure, leading to increased congestion and inefficiency in the use of resources.
3- In terms of citizen participation and transparency	
Digital technology enhances transparency and citizen participation .	Cities have difficulties ensuring government transparency and limited avenues for citizen participation.
4- In terms of making decisions based on data	
Digital technology allows the collection of large data that can be used to make correct decisions based on evidence.	Cities have limited insights into data, rely on traditional methods, and thus make ineffective decisions.
5- In terms of the safety and security of the city	
Digital technology enhances safety and security through crime prevention measures, enabling emergency response, and surveillance systems.	Cities that do not have these technical systems face difficulties in coordinating emergency responses or monitoring public places, and their security infrastructure is less advanced.
6- In terms of the economic growth of the city	
Digital technology brings economic growth, innovation and investment.	Cities that do not have the technical systems miss out on these benefits and face difficulties in attracting talent and companies.

Source: Researchers based on the reference: (Yirang Lim, Impacts of Smart City Development: Experience of South Korea, Erasmus University Rotterdam, 2020, pp.78-80).

3. The city of Kirkuk and its use of digital technologies:

3-1 Location, area and population

The city of Kirkuk is the administrative center of Kirkuk Governorate. It is located in the northern and northeastern part of Iraq, at the intersection of longitude (23.44°) east and latitude (28.35°) north. It is bordered to the north by Altun Kupri district and Shawan district, to the east by Qara Hanjir district, to the south and southeast by Laylan district, to the southwest by Taza Khurmatu district, and to the west by Yayji district. It is also bordered to the northwest by Dibis district, map (1).

The area of Kirkuk city is (127,385) km2. Its population is (1,023,947) people according to population estimates for the year 2020 AD. The city contains 55 residential neighborhoods, 26 of which are located on the western side of the Khasa River, while 29 of them are located on the eastern side of the river (Hassan, 2021, p. 7).

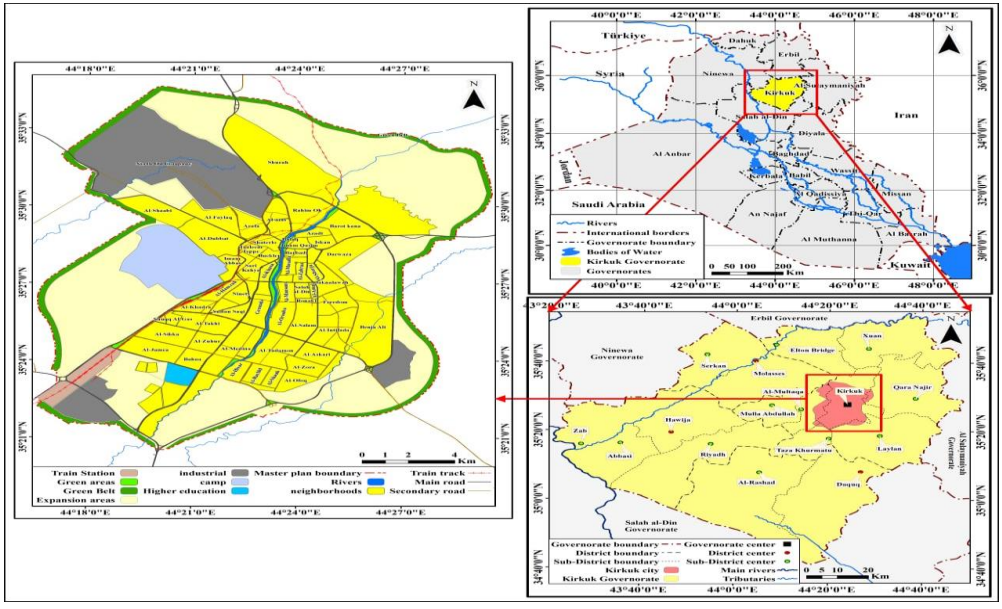
The master plan for the city of Kirkuk was laid in 2014, due to the expansion of the city of Kirkuk significantly in the second millennium, as a result of the attraction of the population to this city, as well as the economic and social activities present in it. The city's basic plan area was 104 km2, distributed among the main land uses. An area of 62 km2 has been allocated for residential use, at a rate of 56.6% of the total planned area, an area of 14 km2 is for industrial use, an area of 13 km2 is for main roads, an area of 11 km2 is for universities and open and green areas, and an area of 4 km2 is for administrative and commercial use (Ajaj, 2005, p. 97).

Internet infrastructure projects in the city :

In recent years, the city of Kirkuk has begun implementing various projects, within the framework of sustainable spatial development, using modern methods and technologies to enhance the digital management of the city. Below we list some of the most important digital technology projects that have been applied in the city of Kirkuk:

- Internet service towers :

The use of Internet services in the city of Kirkuk began in the year 2003, and



Map (1) Location of Kirkuk city

Source: Iraqi Ministry of Planning, Central Bureau of Statistics, based on Arc GIS 10.8 program.

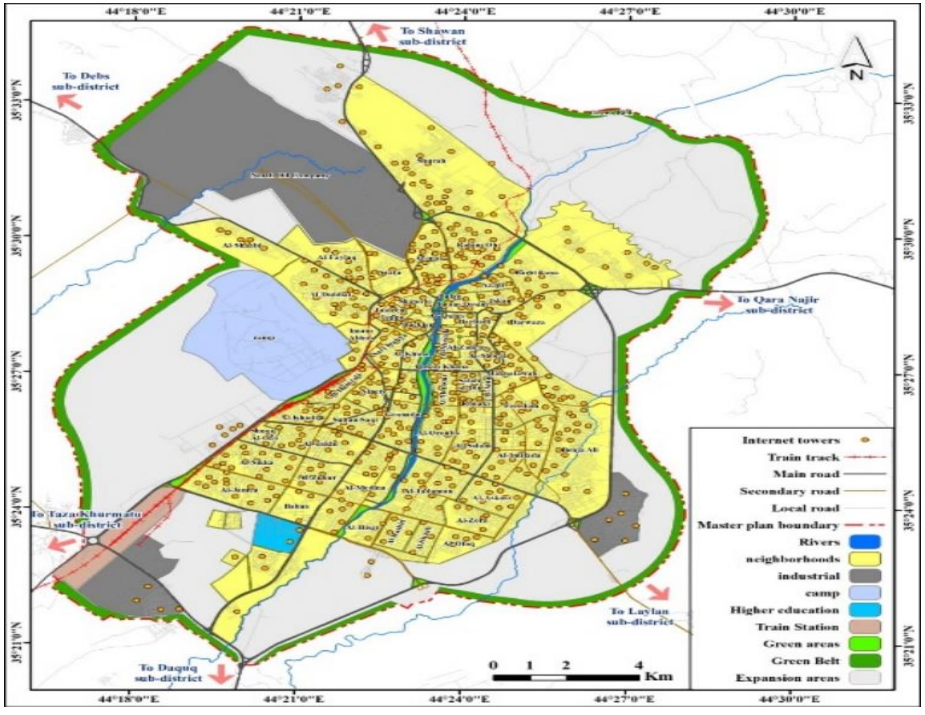
was a limited‹by using Tell landlines in the city. In 2006, the service witnessed remarkable development. Wireless Internet towers were constructed. The number of towers was 15 in the beginning, but the number of towers quickly increased, as a result of the increasing demand for this service, until it reached 247 towers in 2012, then to 732 in 2017, Table (2).

Table (2) Number of towers constructed in the city of Kirkuk for the years 2006-2017

The year	2006	2009	2012	2015	2017
Towers No.	15	58	249	504	732

Source: Qadir, Elaf Shaker Muhammad, Modeling and Analysis of Internet Network Efficiency Maps in the City of Kirkuk, Tikrit University, College of Education for the Humanities, Department of Geography, 2020, pp. 37-38.

It continued to increase without stopping due to the increasing demand for this service. It was also noted that there is a discrepancy in the distribution of towers between the neighborhoods that make up the city, as a result of the difference in area and population, map (2).



Map (2) Distribution of service towers by year 2006-2017

Source: Ministry of Planning, Central Bureau of Statistics, GIS Department, using Arc GIS 10.8 program.

- Optical cable:

It is considered one of the spatial development projects for the city of Kirkuk, as one of the formations of the Ministry of Communications carried out the process of establishing optical cable in all areas of the city (FTTH) fiber to the home, directly implemented by a company affiliated with the national project (Earthlink), where the completion of the project reached 40 % in the third stage, as the first and second stages included established the main line, and some of its branches which are called (rings), in addition to 300 cabins of these, 100 cabins and 13 rinks were completed in the areas of the southern side of the city, and other cabins and rinks were installed in areas such as Rahim Aw, Shoraw, Al-Nasr, Al-Askari, and Al-Qadisiyah, by digging what is called the last mile, to a depth of 18 cm (Khurshid 2023, p. 1).

- International Access Gateway Project (IGW):

The city of Kirkuk has been approved as one of the sites for distributing the Internet service entering Iraq, as one of three cities: (Baghdad, Basra, and Kirkuk). The idea of this project is to connect international access gateway devices at all border crossings, to control the Internet bandwidths leaving and entering Iraq, in order to collect All Internet bandwidths, and then distributed to licensed distributors in Iraq (Directorate of National Card Affairs, 2017, [https://www.nid-moi.gov.iq]). Figure (3) shows one of these sites.

Figure (3) is a picture of the IGW project.

Source: Iraqi Ministry of Communications, General Company for Communications and Informatics, 2022.

3-3 Some digital technologies applied in the city of Kirkuk

- Application of Intelligent Transportation Systems (ITS)

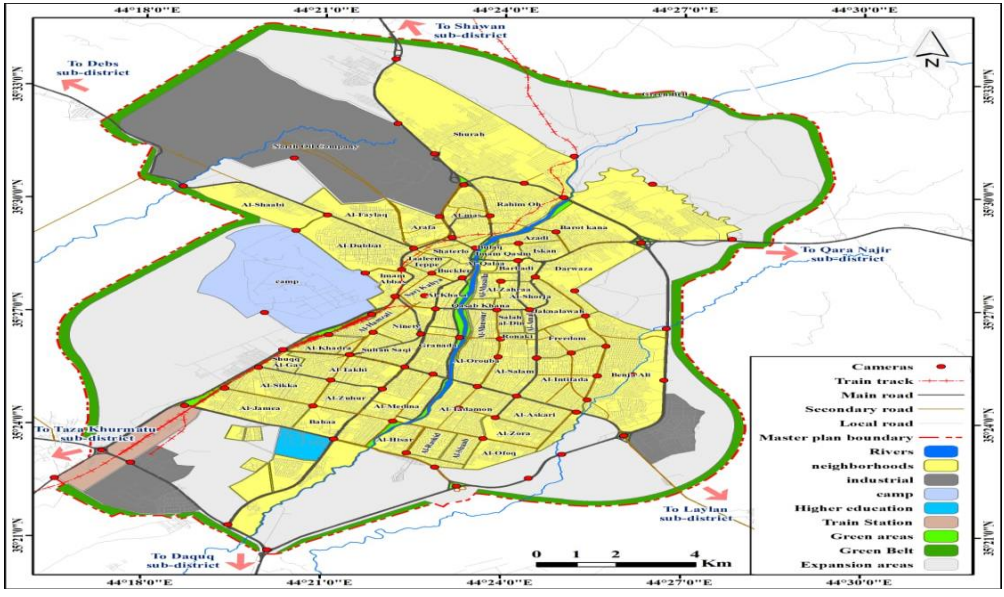
One of the technologies of the intelligent transportation system, which is the (point-to-point) system, was applied on the road linking Kirkuk-Erbil. This system aims to train vehicle drivers

in the city on how to navigate the roads in a civilized and safe manner, reduce road accidents and organize transportation movement. Figure (4) shows a picture of one of the surveillance cameras on the road.

Figure (4) An image of the camera system application (point to point(

Source: Erbil Traffic Directorate, 2023.

This system works with new technology. The two cameras in the device help to know the distance traveled by the vehicle driver, how he behaved, and whether he adhered to traffic instructions or not (Kurdistan Regional Government, 2024, [https://gov.krd]). the map shows (3) Distributing surveillance camera points on the roads and streets of Kirkuk city.

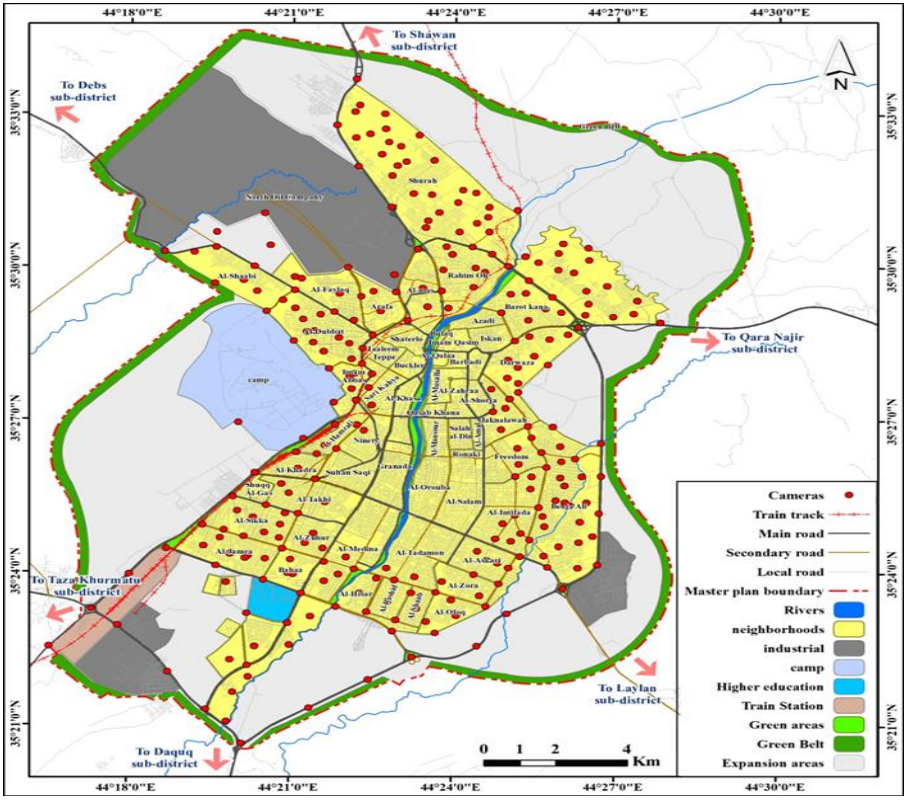


Map (3) Distribution of surveillance cameras on the roads and streets of Kirkuk city.

Source: Researchers using the Arc GIS 10.8 program, and relying on the Ministry of Planning, Central Bureau of Statistics, GIS Department.

- Safety and security control systems:

The city of Kirkuk has adopted the theme of improving safety and security services, which contributes to creating a stable and sound environment in the city, through the application of digital technologies that enhance control of safety and security in the city. These systems include the use of modern surveillance cameras with video analysis technology, which monitor public places, the city's entrances and exits, and notify the authorities of suspicious activities. It is clear from Map (4) the distribution of surveillance cameras, and their spatial distribution starting from the outskirts of the city as a first stage and then gradually moving to Within the city, according to priority, with the aim of tracking and addressing cases that disrupt urban safety and security.



Map (4) Simulating the distribution of safety and security cameras for Kirkuk city.

Source: Using the Arc GIS 10.8 program, based on the Ministry of Planning, Central Statistical Organization, GIS Department.

3-4 Technical applications in governance and the Internet of Things:

- Electronic passport: The city of Kirkuk, like other Iraqi cities, adopted the electronic passport system, to enhance efficiency and security, and the possibility of

communicating with citizens to provide government services via the Internet. Thus, citizens can apply for a travel passport through a special form prepared for this purpose via the Internet.

- Decision support systems and data analysis:

The analysis of data from various sources and decision support systems was adopted. This leads to improving the process of city planning and urban development, as well as providing services and improving resources. Examples of this topic include the electronic portal of the Kirkuk City Office, to provide its government services, complete citizens' transactions, and appoint to government jobs, through electronic links prepared for this purpose, which It reduces effort and time and achieves integrity in work.

- National card system:

The city of Kirkuk launched the national card system in 2017. Citizens' transactions were received directly through the electronic reservation system. These projects are considered indicators of the government's efforts to transform from a paper government to an electronic government that completes citizens' transactions electronically and quickly (Directorate of National Card Affairs, 2017).

- Fueling technology :

The electronic card system has been activated for the purpose of refueling. A number of fueling stations in the city of Kirkuk have been equipped with an electronic payment device when supplying vehicles with fuel via an Internet connection (Khalaf, 2022, p. 1).

- Application areas in the Internet of Things (IOT):

Digital technologies were used in the field of water and electricity in the city of Kirkuk, as part of investment processes in urban development (Abd Almonem & Al Janaby, 2024).

- In the field of electricity:

Integrating Internet of Things technologies with smart electricity meters for the purpose of enabling the infrastructure to measure and examine energy consumption at the same time, and determine the actual demand for it in the city through demand response monitoring programs and dynamic pricing, which contributes to developing the use of electricity and its distribution throughout. City. Thus, the use of the Internet of Things in the electricity sector of the city of Kirkuk contributed to improving the flexibility, efficiency, and monitoring of the energy infrastructure, leading to more sustainable and reliable energy services for the city.

- Water and sanitation :

In the city of Kirkuk, Internet of Things technology is used through smart devices to measure the amount of water consumed, detect leaks, and monitor water consumption, which improves the management of water distribution and ensures its equitable access to all residents of the city, by integrating smart meters with remote operation of pumps and valves . .

IoT sensors can also be used in rural areas around Kirkuk, to monitor groundwater levels and quality in wells. This ensures long-term sustainability of groundwater.

3-5 Challenges facing the use of digital technologies in the city of Kirkuk:

There are many challenges facing the use of digital technology in urban management and development in the city of Kirkuk. They were diagnosed through field research and meeting with the city administration staff/informatics department with the aim of identifying these challenges, and they can be summarized as follows:

1- Infrastructure for digital technologies: the city of kirkuk suffers from a lack of infrastructure which capable of effectively applying digital technologies in the city, that requires large investments in technologies.

2- Lack of institutional awareness in applying digital technologies. This can be overcome through training and applied practices, and it also requires a large investment in human resources.

3- Lack of popular awareness in applying and benefiting from digital technologies: which requires awareness programs for citizens adopted by both the public sector and the private sector, to establish a societal culture that believes in digital transformation.

4- Data security and privacy: The large volume of data required by the use of digital technologies, and its collection from various sources, raises many concerns about its privacy and security. Which requires providing adequate protection for it, and following protocols within cloud computing activities, which also requires huge investments.

5- The administration and governance of the city of Kirkuk is subject to many changes, which does not provide a comfortable investment environment.

6- The ethnic diversity of the city's population, as well as the great disparity in living and cultural standards, which affects in one way or another the arrangement of priorities and convictions in the application of digital technologies.

Conclusions:

1- Digital technologies are an integrated combination of physical resources (hardware) and systems, applications, and programs (software). It is integrated with the city's measuring and sensing devices, to collect, transmit and analyze information, and then make decisions about it in real time .

2- Spatial development represents the two elements of growth and change, so investing in digital technology will lead to a comprehensive process of change in efficiency, accuracy, and speed in performing urban activities (service, economic, and social), as well as increasing the productivity of resources in the city, achieving advanced levels of growth. And enhances sustainability.

3- The use of digital technology is an additional and complementary element to urban management and spatial development, represented by the use of information and communications technology, as an effective tool to increase efficiency and reduce effort and time.

4- Digital technology is a tool for change in the performance of urban, economic and social activities, by controlling the sectors of services, energy, traffic, infrastructure and the environment.

5- The use of digital technologies enhances the interaction and participation of community members in decision-making in management and sustainable spatial development, considering the population and their activities as the starting point in collecting information on which decisions are made.

6- Global experiences of cities that use digital technology confirm that they are more efficient in performing their urban functions, productivity and economic growth, and more sustainable, than cities that do not use digital technology.

7- It became clear through the field study that the city of Kirkuk is still in its first beginning in using digital technology in administration and development, and it was a successful beginning in terms of partial use in governance, the Internet of Things, some services, energy, traffic, safety and security, as well as the use of some Internet applications. .

8- The field study of the city of Kirkuk also confirmed that there is a significant weakness in the infrastructure for digital technologies, and they are almost non-existent in some of the city's urban activities.

9- The use of digital technologies in the city of Kirkuk faces a number of challenges that can be summarized as follows:

- Lack of institutional awareness at the level of individuals working in government administration.
- A large segment of the city's population does not interact with the application and benefit from digital technologies.
- The peculiarity of the city of Kirkuk is the constant change in administration due to ethnic diversity and competition to rule the city, which does not provide a comfortable investment opportunity for the city.
- Variation in popular convictions in the application of digital technology due to differences in cultural and ethnic levels and standard of living.

Recommendations:

1- Adopting digital technology in cities as an effective tool in integrating planning, management, spatial development, and cooperation and coordination among stakeholders to achieve integrated results, through the following:. .

- A comprehensive review of the criteria and legislation of urban management, in line with the use of digital technologies.
- Directing investments in resources, and everything related to spatial development, towards a balance between achieving economic efficiency, social justice, and sustainability.

- Enhancing environmental sustainability and achieving the best efficiency in providing services to residents, with a high level of productivity.

2- Emphasis on the use of digital technologies in spatial management and development, whether for existing cities or those that are being developed.

3- At the level of the city of Kirkuk, and the cities that are still in the early stages of using digital technology, there is a need to direct development and investment in the following areas:

- Information and Communications Technology (ICT) infrastructure.

- Developing the skills and capabilities of city administration workers, and teaching them how to deal with modern digital technologies.

- Preparing awareness programs for city residents through the media, clubs, and free courses on how to deal with digital technologies and their software applications, as they are an essential stakeholder.

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