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The Role of Smart City Management in Improving the Efficiency of Urban Resources and Services: Anah Smart City as an Applied Model

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Abstract

Contemporary cities are seeking to improve the efficiency of managing their urban resources and services in shadow of the growing challenges of urbanization, but many of cities in developing countries, including Iraqi cities, still depend on traditional methods of urban management, with the absence of local applied models of smart cities that can be studied and evaluated. This study aimed to apply an Iraqi model of a smart city in the city of Anah, with the aim of identifying the requirements of this transformation and the obstacles Related with it, and clarification its impact on improving the sustainability of urban resource management and services. The study adopted the descriptive-analytical approach in addressing the dimensions of smart cities and their technological tools, in addition to the applied analytical approach in designing and implementing the "Anah Smart City" model, relying on IoT technologies, especially the LoRaWAN network, low-energy sensors, and data management and analysis platforms. A collection of smart systems has been implemented for waste management, urban agriculture, weather station, water, and digital services, and the results of the application showed the role of the proposed model in supporting smart urban management and improving the efficiency of resource and service management in the city of Anah, reflecting its application in Iraqi cities with limited capabilities

Keywords: *Smart City Management, Urban Management, Internet of Things (IoT), Sensors, Smart City Model.*

Introduction

Cities today are witnessing rapid transformations at the global level, and facing major urban challenges in their journey to manage their resources, provide services and improve the quality of life, these transformations coincided with rapid technological developments, and developed countries have begun to invest this technology in improving operations within the urban area, and gradually the concept of smart cities emerged as one of the most innovative solutions to face the growing urban challenges, to include in its essence smart urban management, supported by information and communication technology to enhance environmental and economic sustainability.

Like many cities, the Iraqi cities faced many challenges in resource management and provision of services, in addition its still adopt on traditional methods of urban management, which are not based on live data, which have become necessary for real-time reality analysis and decision-making support, to reach the primary goal of improving the quality of life. Therefore, this study aims to analyze the possible ways to implement smart management and adopt modern technology, and to identify how and what tools available at the Iraqi local level to reach this important transformation, and what are the obstacles facing it. By applying a practical model of an Iraqi smart city, researchers and decision-makers have been able to study its dimensions locally and make the right decisions.

Smart Management of Urban Resources and Services:

It is the process of organizing and distributing resources and services using innovative methods based on modern technology, with the aim of improving the quality of life and ensuring sustainability. It is an integrated management approach that relies on artificial intelligence, the Internet of Things, and smart platform to efficiently manage resources, reducing waste and increasing the quality of life. (Bakheet, 2025, P63) aims to use technology and strategies that focus on improving the quality of life and the efficiency of resource management within the framework of the challenge to keep pace with the

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increase in urbanization and provide opportunities for systematic and integrated management of resources. Cities are also seeking to develop sustainable actions, through technological tools and smart solutions aimed at improving urban spaces. (Jacques et al., 2024, P2) that the success of smart city projects is directly affected by smart management practices, which include (smart planning, smart organization, smart leadership, and smart control). Smart management helps project managers focus their efforts on the right practice to achieve the desired outcome. This includes improving underperforming operations and increasing the chances of project success. (Alshahadeh & Marsap, 2018, P62-63) supports smart technology in urban environments and raises its capabilities in planning and management. It provides a better urban space for economic prosperity, living in a fairer society, a more sustainable environment, and good performance in governance and management. (Yigitcanlar, 2015, P6)

Smart cities

The smart city idea mainly focuses on the use of modern technologies to improve the quality of urban infrastructures and reduce the environmental impact in urban areas. (Dameri, 2017, p116) can be described simply as "a sustainable and innovative city that uses ICTs and other means to improve the quality of life." That is, increasing the efficiency of management, the provision of urban services, and the competitiveness to ensure that the needs of current and future generations are met and for all economic, social and environmental aspects. (Khan et al., 2021, p4) is defined by the ITU-T Smart Cities as "an innovative city that uses information and communication technologies (ICTs) to improve the quality of life, operational efficiency, urban services and competitiveness, while ensuring that it meets the needs of current and future generations in terms of economic development and social, environmental and cultural aspects." (Gotlib et al., 2020, p3) as Giffinger also defined it as "a city that performs well in a forward-looking way in six characteristics: (smart mobility, smart economy, smart governance, smart people, smart living, and smart environment), and is built on a smart combination of processes and activities of independent and conscious citizens." (Giffinger et al., 2014, p11) Smart cities are also characterized by different characteristics (sustainability, quality of life, urbanization, and artificial intelligence). Considering the existence of four main axes of smart cities, namely (society, economy, environment, and governance). (Hassan & Alkinani, 2022, P2) Cognitive maps and intelligent algorithms enhance understanding of urban complexity and support data-driven decision-making. (Hadi et al., 2023, p1) Modern technology plays an important role in smart urbanization in modern cities. Artificial intelligence, ICT, big data, and smart transportation systems are key elements in the development of smart cities. (Hadi, 2024, P184) addition to emerging technologies, including blockchain technology for secure urban transactions, which is expected to revolutionize data security and transparency in smart cities, by providing protected records against tampering, and managing supply chains and financial transactions. (Al-Bari et al., 2025, P1320)

The Technological Foundations of Smart Cities

The huge size of the city and the complexity of its events have created the need to adopt ICTs, and the associated sensors and actuators that are integrated into the city's components through the Internet of Things. To collect and analyze trillions of daily bytes of new data. (Mehmood et al., 2020, P16) Recent technological advancements such as the integration of artificial intelligence with machine learning technologies and sensor systems, enable cities to dynamically adapt to ambient conditions to enhance municipal services and meet changing urban requirements, so this technology and others can reduce latency and remediation and increase adaptability and real-time. (Arshi & Mondal, 2023, P10) The concept of IoT also has the potential to create a data environment within cities, where objects can capture data in real-time and connect it from the physical to the digital world. The objects can be sensors, actuators, elevators, lights, mobile phones, screens, phone apps, wearables, etc. Plus, sensors are getting cheaper, smaller and are increasingly included. (Suzuki & Finkelstein, 2018, p38) Devices can be integrated with their geographic location and evaluated using analysis systems. This method works with many activities such as monitoring cyclists, vehicles, vacant parking lots, etc. Many applications that use IoT infrastructure to facilitate operations are being introduced, such as monitoring air pollution, noise, and vehicle traffic. It provides intelligent management of power distribution and consumption in many conditions. (Arasteh et al., 2016)

Structure of sensing technologies for smart cities

Many models have been proposed to shape modern technologies in smart cities, and the more layers a model has, the more separation between development functions becomes, the more complex it becomes to understand, and the less correlated the architecture model is with the real IoT components. To balance these two extremes, many studies have relied on the 4-layer model of IoT applications in general and smart city in particular. This architecture provides a structure for understanding the smart city system as a whole. (Maheswaran & Badidi, 2018, p9)

Data Collection Layer

It is a basic layer where data is collected in the smart city by IoT sensors. Sensors for data collection are varied, such as humidity, temperature, pressure, and pH level sensors. (Rao & Haq, 2018, P31), smoke sensors, vibration sensors (Touqeer et al., 2021, P11), cameras monitoring the activity of residents, traffic lights, interactive screens, and quality monitoring of services provided such as water, sanitation, and municipal services. These sensors also vary in type, capacity, and quantity depending on the requirements of the smart city. (Maheswaran & Badidi, 2018, p9)

Connection Layer

This layer represents the network infrastructure, transmitting data collected from IoT devices to the data analysis center and transmitting commands from control centers to actuators. It connects smart city devices together and with the other layers. A network is either a wired network (such as fiber optics) or a wireless network such as LTE and LoRaWAN, depending on the availability of these technologies and the requirements of a smart city. LTE networks have wider coverage and higher bandwidth. However, LTE radios and subscriptions are expensive and are only suitable for a limited number of mobile IoT devices. LoRaWAN networks offer broad coverage at a low cost but with a narrow bandwidth. (Maheswaran & Badidi, 2018, p10)

Data Management Layer

In this layer the data collected from the entire city is stored and processed. It provides an interface for monitoring IoT devices. And depends on specialized platforms that offer an integrated management system for collecting and storing status reports from devices as well as a unified platform to control devices with different capabilities. The management layer maintains control over access to devices and data to prevent the misuse of information and services provided by the smart city's digital infrastructure. (Maheswaran & Badidi, 2018, p11) It provides various services to the previous layers and is also able to calculate and process information automatically. It relies on many technologies such as cloud computing and big data processing. (Rao & Haq, 2018, P32)

Application Layer

This layer provides services to the user as needed through a number of applications, such as smart cities, smart homes, smart transportation, smart healthcare, smart public utilities, and others. (Touqeer et al., 2021, P11) In this layer, the vast amount of data collected is presented and used to obtain useful information about the current state of the smart city. Reading the collected data can raise an alarm or warning about some critical event depending on the algorithms applied, applications generally aim to achieve three goals (display, optimization, and forecasting). Data display enables workers to observe and understand reality. Optimization is through the automatic use of resources, where these applications (such as smart lighting and waste management) are self-controlled in response to real-time conditions. forecasting through statistical analysis is used to predict the likelihood of future events. (Maheswaran & Badidi, 2018, p11)

Related Studies and Research Gap

Many local studies in Iraq have discussed with the concept of smart cities from a planning and strategic perspective, while seeking to align it with the urban and institutional reality of Iraqi cities. Hatem Hamdi Hassan's (2019) study examined the possibility of employing smart city technologies to address urban services problems in Baghdad, by proposing digital platforms and sensor systems to support service management.(Hasan, 2019) The study of Al-Mamouri and Al-Najjar (2019) also addressed the applicability of the concept of smart city in Iraq through a case study of Bismaya city as a newly planned city, with a focus on digital infrastructure and advance planning. In the same context.(Al Mamouri & Al-Najjar, 2019) the study of Maryam Khairallah (2022) presented a strategic vision for transforming the city of Basra into a smart city through the implementation of low-cost gradual projects, emphasizing the importance of governance and data in improving urban management.(Kalaf, 2022) The study of Duha Humaid et al. (2024) also discussed the role of artificial intelligence applications in urban management by analyzing the experience of the city of Dubai, while drawing lessons that can be learned in Iraqi cities.(jassim & Kamel, 2024) Despite the importance of these studies and their role in promoting the concept of smart cities in Iraq, they focused on theoretical or planning aspects, or relied on the analysis of external experiences, with a clear absence of applied field studies that provide an actual Iraqi model of smart management based on live data and in realistic conditions characterized by limited resources. Based on this research gap, this study seeks to provide a local applied experience of smart urban management in the city of Anah, as a practical model that can be studied, evaluated, and generalized in other Iraqi cities with similar characteristics and potentials.

Aim of the Study

The main objective of this study is to create an Iraqi model of a smart city by transforming a city into a smart city through the use of modern technology, achieving effective management of urban resources and services, and improving the quality of life. In addition to the sub-objectives of identifying the technology and infrastructure required for the transformation towards smart cities, identifying the problems and obstacles facing this transformation, and the impact of the use of modern technology on improving the management of resources and the quality of services provided to citizens

Study Design and Research Methodology

The study relied on the descriptive-analytical approach in dealing with the concepts of urban management in smart cities, describing the technological tools and techniques used in them, and how to apply the tools of transformation towards smart cities. On the practical side, the empirical applied approach was relied on through the design and implementation of a smart city model and the analysis of the resulting data to evaluate its effectiveness and prove the research hypothesis.

Study Area Description

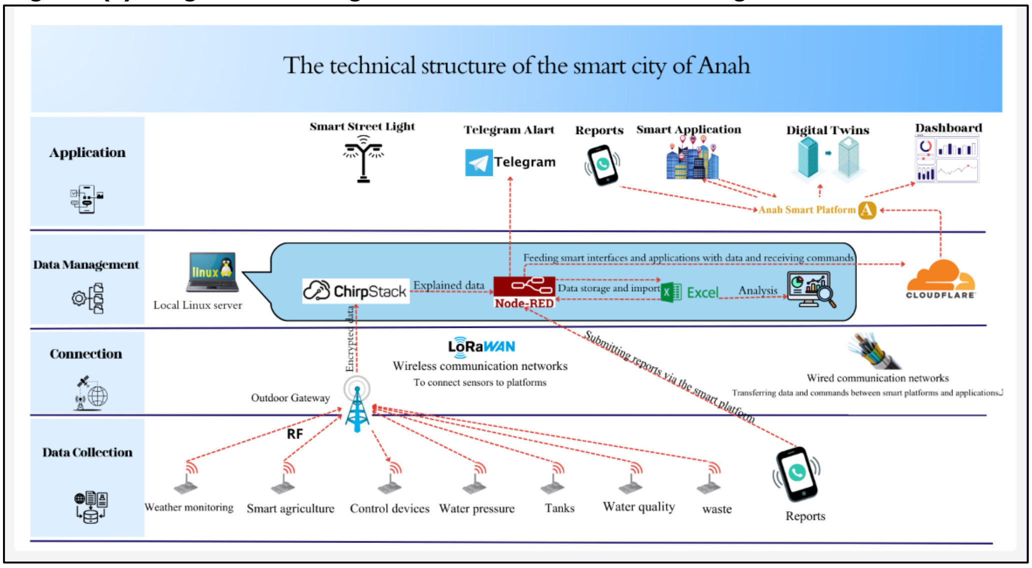
The city of *Anah*, which is one of the cities of *Anbar governorate* and located to the west of it, was selected to conduct the practical study and achieve the goal of the study of finding a live model for an Iraqi smart city, and the preparation of a strategic plan to transform an existing city into a smart city, in addition to the application of a number of smart systems and modern technological tools that it contains. This choice was not arbitrary, but depends on the advanced and distinguished infrastructure at the level of Iraq, in addition to the researcher's knowledge and familiarity with all the details of the city, and the relatively small size of the city, to suit the size of the study and avoid the risks that the researcher may face in relatively large cities.

The general technical structure of the Anah Smart City Project

The technical architecture of the project is based on an integrated communication system based on *LoRaWAN* technology, which includes sensors and a central gateway. The portal receives the sensor data and transfers it to the local server (computer) that includes the data management platform known as (*ChirpStack*), which is responsible for managing the devices, following up on their operational status, and receiving data in an encrypted form from them, to decrypt and send it directly to the (*Node-RED*) platform, which is also located within the local server, and its task is to receive data from various sources for the purpose of processing and analysis real-time, displaying it on data dashboards or storing it in (*Excel*) files and generating alerts through the (*Telegram*) application. The local system is connected to the internet via the *Cloudflare* platform to ensure secure access to the control panel from outside the local network using the official scope of the project (https://smart-anah.org), allowing users and administrators to follow the systems from any external network and not just the local network within the organization.

In order to ensure the optimal application and integration of the components of the smart city, the technical structure has been organized into four layers, these layers are fully compatible with the theoretical aspect, as each of these layers has a specific function that it performs through a number of specialized tools as shown in Diagram (1).

Diagram (1) Diagram showing the structure of the technologies used in Anah Smart City



Source: Researcher's work

First Layer: Data Collection

It is a basic layer in the construction of a smart city, and it includes all devices and sensors that collect data from the environment, as data collection is the primary goal of this layer. The devices used were of the (*Dragino*) type, which are characterized by their wide support for LoRaWAN frequencies and bands, the most important of which is the local frequency *EU868*, which is compatible with the West Asia and Southern Europe region, it's very low power consumption and long-lasting battery life of up to 5 years with the possibility of recharging, so it is suitable for long-term use without frequent maintenance. The sensors used are to measure water quality, measure the level, distance, and dimension of any object in the environment, measure and monitor water quality, leaks in the network, motion and pressure sensors, and other devices that can be adapted as needed. Its cost is reasonable compared to the high performance it offers. Suitable for the size of a city, it offers coverage of up to 15 km in open areas and 5 km in cities with tall buildings or natural barriers. A number of sensors have been relied on in smart systems that will be explained in detail.

Data Collection Tools and Techniques

Urban data was collected through a set of smart systems that were implemented within the Anah Smart City model. It relies on sensors that periodically collect data and send it to the central system, enabling real-time monitoring, reflecting the operational reality of urban services, and providing a supportive database for analysis and evaluation. These systems include:

Water Pressure System

Three precision pressure sensors have been installed at selected locations of the network to record measurements continuously, the type of device is (PS-LB) from the *Dragino* brand and it is dedicated to measuring the pressure of liquids and gases, the devices have been installed in different areas of the city of Anah. It is programmed to record one read every 30 minutes and send it to data management platforms. These sensors monitor the performance of the water distribution network in real time to detect deficiencies and discrepancies in pressure and to achieve social justice in its distribution, in addition to early detection of malfunctions that may affect the supply of water to citizens, as the areas of failure or leakage in the network can be identified immediately after their occurrence through lower pressure than usual.

Water Quality System

It aims to ensure the safety of the water distributed to citizens and monitor any changes in its quality in real time. The system consists of a main transformer (*WQS-LB*) of the Dragino brand and a number of sensors are connected to it to measure many properties of water, and what has been adopted at the moment are three sensors to measure (pH, turbidity (TS), oxidation and reduction (ORP)) and the main transformer and the three sensors are installed in the tank of the central Anah water project, where the main transformer automatically collects readings from the three sensors, takes one reading every hour according to what was previously programmed, and sends them to data interpretation platforms and its treatment.

Smart Tank System

Three ultrasound sensors (*LDDS75-LB*) were used to measure the distance between the top surface of the water and the roof of the tank to accurately determine the water level, the data is sent every 30 minutes to data analysis and processing platforms that display the level of each tank in the form of graphical indicators with the current filling ratios and the volume of water available in cubic meters.

Smart Waste System

It aims to improve the efficiency of the waste collection process and reduce operational efforts by monitoring the level of container filling using ultrasound-based sensors, through the sensor (*LDDS75-LB*), and 9 large waste containers with a capacity of 8 m^3 distributed in different areas of the city in commercial, industrial and service areas, the sensor has been installed in the container ceiling to measure the distance between the surface of the container and the level of waste in it, and this information is updated with each new reading received from the sensor for each 30 minutes as programmed in advance.

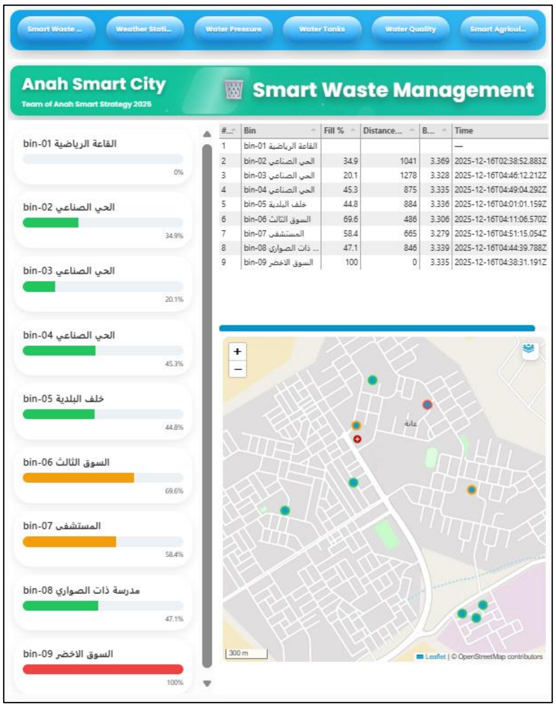


Figure (1): Data display board for waste containers.

Smart Weather Station

The station consists of a main transformer (*WSC2-L*) and its sensor attachment (*WSS-09*) that measures a range of variables such as temperature, humidity, atmospheric pressure, noise, solar radiation, wind speed and direction, and dust levels and particulate matter suspended in the air. and (*WSS-08*), which measures the amount and rates of rainfall. The station was installed on a metal base above the Anah Municipality building, to provide an open location that is not affected by tall buildings and to avoid the impact of shadow or obstructions on measurements.

Image (1): Weather Station.

Source: Researcher's Work

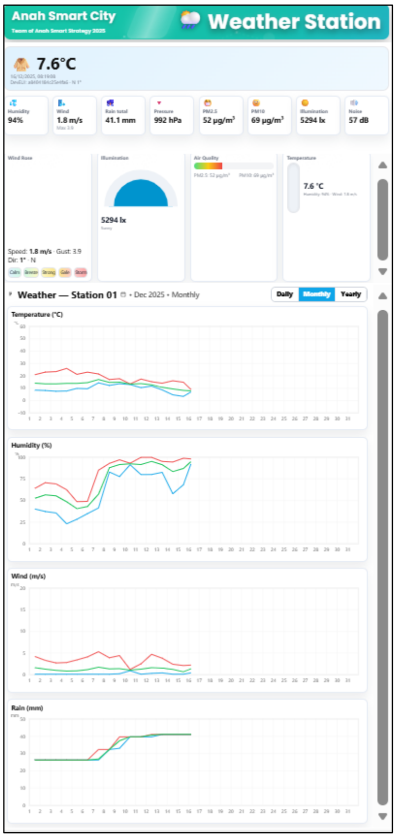


Figure (2): Weather data display panel.

Source: Researcher's work

Smart Agriculture System

This system relies on soil moisture and temperature sensors to determine the actual need for watering. Through a sensor (*LSE01-8*) that measures soil moisture and sends data to the platforms to be analyzed and displayed on the data dashboard, these readings are updated with each new incoming reading within 30 minutes as previously programmed. Three sensors were installed in different locations of the gardens of the Anah city, the first in the arboretum of Anah municipality, the second in the central carrot of the entrance to the city, and the third in the gardens of the guest house as shown in Figure (3).

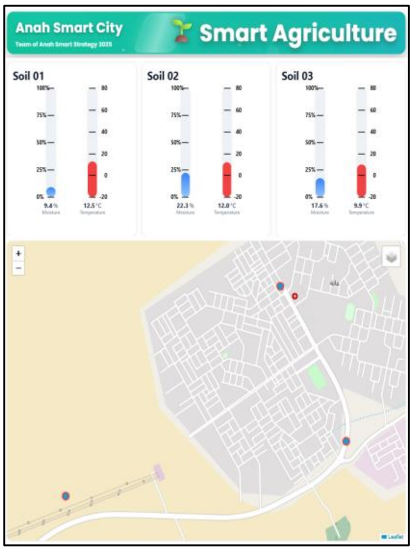


Figure (3): Soil moisture sensors

Source: Display panel within the Anah Smart Platform

Smart Lighting System

A location was chosen within the parks near the government complex and its large mosque to illuminate the walkways in these parks with smart lighting, 30 light poles with a height of 3m and leaving distances of (10-12) m between the poles, each pole contains three LED lamps with a capacity of 100 watts. It relies on a motion sensor to control the lighting; it senses motion at a distance of 12 meters as well as sensing the intensity of light. Since the environment requires a certain percentage of light and not complete darkness, the idea was to install the sensor so that it controls two of the lamps and leaves the third within the same light pole continuously lit, to provide a light ratio that provides safety and maintains the suitability of the surrounding environment for animals. The lights stay on for 3 minutes after the movement stops and then stops. This mechanism differs from traditional poles that rely on all three lamps to run throughout the night without any adaptation to the actual level of use of the place.

Second Layer: Connection

Among a number of technologies, LoRaWAN technology has been adopted due to its specifications that meet the needs and privacy of its city, in terms of coverage up to 15 km, low power consumption, and data transfer, although it is as low as 50 Kbps per second, but it meets the needs of its city even with future expansion. In addition to relying on the optical cable internet service (wired communication technology) as a basic infrastructure for data transfer, wider deployment of smart applications and access to the users.

Third Layer: Data Management

This layer represents the central mind that manages everything related to data and tasks to be carried out automatically using the computer and without human intervention, as it is the process of receiving data from sensors, which are usually encrypted, and decrypted using servers and software platforms, where it is processed, stored, or transferred to user interfaces to benefit from or analyze them to issue alerts and commands to devices to carry out certain tasks, and among the tools that have been used to carry out the tasks of this layer are the following:

1. **Computer (Local Server):** The use of a computer to work Local Server running the Linux system that provides a suitable environment for platforms to work and perform certain functions in data management, in addition to storing data continuously.
2. **Chirpstack Platform:** It provides a service for managing terminals and data in the LoRaWAN network, which is characterized by being open source and for an unlimited number of sensors and gateways for free, and provides many important and basic functions in the (LoRaWAN) network, the most important of which are: integration between gateways and sensors, and receives data in an encrypted form to process and interpret it to convert it into readable data, and transfer it after interpreting it to the (Node-RED) platform to perform more operations on it such as storage, analysis, display, alerts, and others.
3. **Node-RED:** It is a free software tool specialized in dealing with data and performing many important functions, such as receiving interpreted data from the Chirpstack platform, storing the data contained in Excel files, and designing dashboards to display the data in a graphical way in the form of indicators that are updated when a new reading arrives. And send automatic alerts when critical values are exceeded, to smartphones via the Telegram Bot.

Fourth Layer: Application

The visual part of the user is the "Smart Anah Platform", which is a website that will be developed into a smartphone application (https://smart-anah.org) in the future and performs a number of tasks, including: displaying the dashboards created through the Node-RED platform, providing a service (report) to submit reports of any deficiencies in a particular service, as well as the service of obtaining an electronic building permit, developing other services in the future and expanding them to automate them, such as services. municipal, educational, health, commercial, and others, in addition to displaying information about the city such as historical information and tourist information such as tourist sites in the form of a comprehensive tourist guide.

Challenges faced by the implementation of smart systems

1. **Weak telecommunications infrastructure:** The application of smart technologies faced the problem of weak internet and frequent outages, which poses a challenge to the continuity of the system's work and the performance of its various functions.
2. **Unwillingness to change:** The lack of interest of the officials of the departments and the cadres in charge of the service, because of this change, they believe that it will put more tasks and responsibilities on them, especially since it did not come from higher authorities.

3. **Limited financial resources:** The project faced challenges related to the limited funding available to service institutions, which necessitated reducing the number and type of sensors used and relying on open-source software instead of off-the-shelf commercial solutions.
4. **Lack of local expertise specialized in such technologies:** There was no access to local companies specialized in the work of IoT networks at higher levels of smart buildings, as well as data management platforms such as Chirpstack, which forced the researcher to self-learn and rely on artificial intelligence in operating settings and writing codes.
5. **Cybersecurity Challenges:** Government institutions, especially service organizations, lack specialized cadres in cybersecurity and data management. This required consideration of security aspects when designing the system.
6. **Awareness of the concept of smart cities:** At the beginning of the project, the project faced a lack of awareness of the importance of smart transformation, which required efforts in consolidating the idea and attracting the attention of officials.
7. **Legislative and regulatory challenges:** The lack of regulatory frameworks to support the transition towards smart cities and the use of data in urban management, which constitutes an obstacle to the official expansion of these experiments, and the apology of institutions for implementing some smart initiatives.

Operational Performance Results

This section presents the results achieved from the implementation of smart management systems in Anah city, based on the actual data collected through sensors, dashboards, and digital alerts during the operating period. These results were derived from comparing the reality of services before implementation, which relied on traditional methods, with their reality after the adoption of smart systems based on real-time data.

Table (1) Comparative KPIs for Assessing Smart Urban Management in Anah City

Indicator (KPI)	Traditional Style	Smart Style	Impact of Optimization
Monitoring	Monitoring based on field tours and manual reports.	Continuous real-time monitoring via sensors and dashboards.	Provide real-time visibility into the status of resources and support early intervention.
Quickly detect issues	Late detection of faults.	Early detection via live readings and live alerts.	Reduce latency and improve processing efficiency.
Decision Making	Decisions based on experience and personal discretion.	Decisions backed by real-time data and clear indicators.	Wise decisions and reduce randomness.
Human effort	Full reliance on human effort.	Partial automation of monitoring and alerting.	Rationalize human resources and direct them to more effective tasks.
Response	Irregular and delayed response.	Instant response via live smart alerts.	Improving Service Safety.
Transparency	Limited access to information.	Data availability via dashboard.	Enhanced transparency and ease of follow-up.
Rationalization of consumption	Uncontrolled consumption of water, energy and sterile materials.	Control based on actual need and accurate data.	Optimal use of water, energy and sterile materials, with 59% reduction in street lighting.
Reduce operational costs	High costs associated with fuel, field tours and continuous operation.	Reduce melasma through intelligent control and alerts.	Reduce field trips, fuel consumption, and operating equipment only when needed.
Big Data	Limited and irregular paper records.	Cumulative and structured digital data.	Support for time analysis, understanding of changes and future planning.
Environmental impact	Potential waste accumulation, indiscriminate	Improving waste management, water	Improving the city environment, the health of the residents and reducing carbon emissions.

	consumption of water and energy.	quality and resource conservation.	
Analysis with AI	Lack of data intelligence.	Analyze big data using artificial intelligence.	Analyze big data to improve processes, especially waste collection and forecasting methods.

Source: Researcher's work

Table (2) Operational Assessment of Smart Urban Systems Implemented in Anah

Smart System	(Traditional Style)	(Smart Style)	Impact of improvement and evaluation
Water Pressure Monitoring	Eye monitoring and late notifications, which may take more than 24 hours	Real-time data, dashboards and instant alerts	Improve the speed of fault detection, achieve fairer water distribution, reduce leak detection time to 30–60 minutes
	Difficulty in accurately locating defects	Accurate identification of low-pressure areas or leaks	Reduce field follow-up time and improve maintenance efficiency
	Lack of demand analysis	Identify peak times and non-need	Improved pumping management and scalability for future automated control
Water Quality Monitoring	Manual laboratory tests performed once a day or as needed	Real-time continuous monitoring with 30-minute readings and instant alerts	Reducing the risk of non-conforming water reaching citizens
	Manual recording of readings.	Cumulative digital recording and storage.	Improving historical tracking of water quality.
	Uncontrolled consumption of sterile materials	Controlling chlorine and alum ratios	Optimized use of materials and reduced waste
	Greater need for human resources	Reduce the required human resources	Improve Operating Efficiency
Smart Tanks	Monitoring with old mechanical or in-kind monitoring, with some tanks difficult to access	Continuous monitoring of filling rates and real-time alerts	Reduce the risk of flooding or scarcity
	Lack of accurate knowledge of the size of the vault.	Storage Limitation in Cubic Meters.	Improving the calculation of sterile material ratios.
	Heavy reliance on human effort	Reduce the human effort required	Increasing Operating Efficiency
Smart Waste Management	Irregular lifting rounds based on eye observation	Upload based on fullness data and alerts.	Reduce the number of trips and operating costs.
	Greater fuel consumption and human effort	Optimize fuel and resource consumption	Raising economic efficiency
	Lack of analytical data	Big data on quantities, locations and times	Improve future planning
	Potential waste accumulation	Timely processing	Improving hygiene
Smart Weather Station	Manual measurements every 12 hours and paper recording.	Measure more than 12 items every 30 minutes and digital storage	Providing continuous detailed data
	Not publishing data	Open dashboards and alerts	Promoting transparency

	Not monetizing data	Integration with other systems.	Support for smart decision-making
Smart Agriculture	Eye monitoring and periodic watering that does not depend on actual need	Real-time soil moisture data and alerts	Improving plant health
	Random water consumption	Watering depends on actual need	Rationalizing water consumption
	A great human effort	Reduce human effort and remote control	Increasing Management Efficiency
Smart Lighting	Daily Consumption of Conventional Shaft 3.6 kW/day	Daily Smart Pole Consumption 1.49 kW/day	59% Energy Saving
	High operating cost	Reduce energy costs	Economic feasibility
	Higher carbon emissions	Reduce emissions of ~150 tons of CO_2 per year (for 300 columns)	Positive environmental impact
	Traditional lighting	Smart lighting while maintaining security	Improve sustainability and safety
Smart Anah Platform	Relying on in-person reviews, paper correspondence, and unstructured communication between citizens and service agencies	A centralized digital platform (smart-anah.org) that allows secure external access to services and dashboards	Standardize access to services and data and improve digital management efficiency
	No interface to view live data	Publicly available dashboards, including those intended for decision-makers and researchers	Supporting data-driven decision-making and enhancing transparency
	Reporting faults is done manually or orally	Digital Service (Report) with Attached Photos and Coordinates	Accelerate the reach of reports, improve response and document cases
	Construction permits procedures are done on paper	Submitting building permit applications electronically and following up on them through the platform	Simplifying procedures and reducing time and effort for the citizen and the competent authority
	Sporadic and uninvested data	Digitally collect and store big data	Big Data Analysis and Future Planning Support
	Absence of real-time alerts	Instant alerts via Telegram Bot for various systems	Accelerate decision-making and reduce latency
	Don't display data	Interactive data display system with timelines and live maps	Improve temporal and spatial analysis of data

Source: Researcher's work

Discussion

The study reflects a conceptual shift in the management of urban services at the local level in Iraq, represented by the transition from traditional management models based on eye observation to smart management models that adopt modern technological tools, producing big data that supports quick and appropriate decision-making and the improvement of urban processes. The results of the study indicate that the integration of digital monitoring systems into urban management contributes to the realignment of the relationship between planning and operation, as decisions become more linked to the actual temporal and spatial context of services. This shift reflects the ability of intelligent models to reduce the time, effort, and costs required to operate and respond, through continuous data rather than relying on discontinuous estimates or subsequent responses.

The study also shows that the effectiveness of smart management does not necessarily require complex technical solutions or high investments, but rather is related to the degree of integration of the system and its ability to transform raw data into usable operational knowledge. The role of open-source platforms and low-cost solutions is highlighted here as tools available to empower developing cities and adopt smart management models without the need for financial and technical allocations beyond their capacity. In addition, the applicability of smart management in developing cities requires a gradual transition in implementation, a focus on the most pressing sectors, and the testing and development of solutions in a cumulative manner. This approach reduces the risks associated with universal application.

Despite the value of this model, its results remain governed by their spatial and temporal context, which warrants caution when generalizing them to other cities that differ in their institutional structure or technical capabilities. However, the conceptual framework provided by the study provides a knowledge foundation on which to build in future studies and expand the scope of application or incorporate more advanced levels of analysis and artificial intelligence.

Conclusion

This study presented an applied model of smart city management based on the use of real-time data as a central tool to support urban decision-making, in the context of an Iraqi city with limited financial and technical capabilities. Experience has shown that the shift towards smart management is not related to the adoption of advanced technologies per se, as it is related to the realignment of urban management mechanisms around data and the integration between digital monitoring and enterprise operation. The adoption of smart sensor-based systems and low-power communication networks is also a practical and viable solution in developing cities, especially when implemented in a gradual and targeted manner towards priority service sectors. This approach reflects the possibility of moving from traditional management based on discretion and personal experience to a more reliable urban management based on knowledge and live data, without the need for massive investments or complex infrastructure.

This study also contributes to providing an unprecedented actual field experience at the Iraqi local level, which goes beyond the prevailing theoretical and planning proposition, and provides a basis on which to build in subsequent studies, including the development of more integrated intelligent management models. The study's core value lies not only in its applied results, but also in the conceptual framework it proposes to understand smart transformation as a long-term management and organizational pathway, rather than just a limited technical project. Emphasizing that the adoption of smart management in developing cities can constitute a qualitative leap in improving the efficiency of managing urban resources and services and promoting environmental sustainability, provided that it is integrated within clear institutional frameworks and developed in line with the local specificities of each city.

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