Smart Cities: Towards a Sustainable Urban Model The United Arab Emirates and Algeria as Case Studies -

المدن الذكية: نحو نموذج حضري مستدام - الإمارات العربية المتحدة والجزائر نموذجا-

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***Abstract*:**

This study aims to define smart cities and the key prerequisites for their establishment, as they have become the prevailing trend for many countries worldwide. The creation of this urban paradigm is intrinsically linked to digital transformation and modern technology, seeking to enhance individuals' quality of life, boost service efficiency, and achieve development within a sustainable environmental framework. Smart cities and the green economy represent strategic options that reflect a shift in how an advanced urban model is planned, one that responds to the increasing challenges facing traditional cities while ensuring environmental preservation and curbing the depletion of natural resources. This research attempts to present some experiences with smart cities in the United Arab Emirates ("Masdar City in Abu Dhabi, and Smart Dubai") and review Algeria's experience with the establishent of Sidi Abdellah Smart City.

keyword: Smart Cities, Green Economy, Masdar Smart City, Smart Dubai, Sidi Abdellah Smart City.
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1. Introduction :

Amid the escalating challenges confronting most nations—both developed and developing—in the areas of urban expansion, population growth and its needs, and the increasing phenomenon of rural-to-urban migration on one hand, and climate change driven by rising carbon emissions, energy consumption, and the depletion of natural resources on the other, the world is currently witnessing urban transformations in the field of architectural engineering. These transformations aim to shift from the traditional urban pattern to a civilizational model based on ecological and natural systems. This occurs within the framework of new development models that combine economic efficiency with environmental preservation and securing the rights of both current and future generations. Among these models, smart cities emerge as one of the modern outcomes of the rapid advances in Information and Communication Technology (ICT). These cities have contributed to providing a better and easier life for their residents and have reshaped the urban lifestyle by integrating digital infrastructure with the various economic, social, and service aspects of the city, thereby promoting sustainable economic development.

Many countries have initiated programs to establish green cities by transforming conventional cities into sustainable and eco-friendly ones. The United Arab Emirates (UAE) is considered one of the pioneering countries that adopted the green economy and implemented smart city concepts within its developmental policies. Algeria has also undertaken an experience in this domain with the establishment of Sidi Abdellah Smart City.

- **Research Problem:**

Based on the preceding discussion, the following research problem can be formulated:

What are the mechanisms for transitioning to smart cities? What is the reality of smart cities in Arab countries, specifically the United Arab Emirates and Algeria?

- **Study Objectives:**

This study aims to illustrate the imperative need to transition toward the principles of the green economy to achieve the dimensions of sustainable development and adopt modern planning methods for more advanced and contemporary smart city models. The study also aims to shed light on the experiences of leading Arab countries in adopting smart cities, focusing on the UAE's experience, and identifying the key components and reasons for its success in this endeavor. Furthermore, Algeria's experience in this field is examined, with an attempt to draw lessons from the UAE's experience.

- **Methodology:**

To address the raised research problem, the study relies on the descriptive approach to present the various theoretical aspects related to smart cities and the green economy, as well as the analytical approach to examine and analyze the extent of smart cities' contribution to achieving sustainable development dimensions and improving individuals' quality of life.

2. The Theoretical Framework for Smart Cities and the Green Economy

Smart cities represent one of the most important features of contemporary urban transformation, utilizing digital technology and innovation to enhance the quality of life for residents, achieve well-being, and raise the efficiency of infrastructure within a sustainable environmental framework. Given the global challenges in urban expansion, climate change, the depletion of natural resources, and rising pollution levels, the importance of the green economy emerges.

The green economy is founded on the principles of environmental sustainability, optimizing resource utilization, and providing employment opportunities in eco-friendly sectors.

2.1 The Concept of Smart Cities

In this section, we attempt to review the concept of smart cities, their characteristics, importance, and the prerequisites for their establishment.

2.1.1 The Definition of Smart Cities

The definitions and characteristics of smart cities vary because smart city projects are considered part of a general program for modernizing and contemporary cities. This program includes a modern urban model and pattern that links the requirements of environmental and urban sustainability with modern digital technology to achieve sustainable development and minimize environmental impact. Their designations are also numerous, including "Green Cities," "Sustainable Cities," "Innovative Cities," and "Eco-Friendly Cities"; however, they share the common trait of being cities that utilize digital technology.

The International Telecommunication Union (ITU) provided a clear definition stating that a smart city is an innovative city that uses Information and Communication Technologies (ICT) to improve the quality of life, the efficiency of urban operations and services, and competitiveness. These advantages should reflect the satisfaction of the needs of present and future generations regarding economic, social, environmental, and cultural aspects for any city to acquire the attribute of "smart.") (tayeb & Aissaoua , 2024, p. 49)

A smart city has also been defined as a city that operates in an ambitious and innovative manner covering the fields of economy, population, governance, mobility, environment, and living. This

innovation relies on a smart mix of support and active participation from conscious, independent citizens capable of making decisions. (Ahmed & Ouzal, 2021, p. 29)

A smart city is described as a city that possesses the informational infrastructure, information technology, and the latest communication technology techniques to transform the lifestyle and work patterns within the area in creative and intelligent ways, replacing traditional methods. (Zahia & Akli, 2019, p. 12)

This definition shows a focus on the technological aspect as one of the most critical prerequisites for the existence of smart cities; meaning, modern technology and digital innovation play a significant and effective role in improving and modernizing services provided to residents and achieving development. Conversely, it overlooks other elements such as the environmental, social, economic, and urban elements, which are considered important factors complementing the technological component in the transition to the smart city model.

Accordingly, a smart city is one that employs modern techniques of digital technology and smart communications to enhance the quality of life, the efficiency of urban services, and rationalize resource consumption to ensure the preservation of the rights of present and future generations. It is not limited to economic, environmental, and social aspects but also includes the urban or technological dimension, reflecting the nature of contemporary urban transformations.

The transition to smart cities is a strategic choice for many countries globally, especially in light of challenges related to increasing population, the phenomenon of global warming and climate change, and the rising depletion of natural resources. Hence, smart cities emerged as one of the innovative solutions and mechanisms to confront

all these challenges and achieve sustainable urban development. Therefore, it has become necessary to encourage the adoption of smart cities, as they promote the growth of the green economy by enhancing energy efficiency while simultaneously ensuring sustainable development for current and future generations, and contributing to the development of better lifestyles for all.

Smart cities fundamentally rely on the Internet of Things (IoT), in addition to applications, user interfaces (UI), and communication networks. The IoT is a network of computer devices, smart devices, and sensors that can communicate with each other, collect, and exchange vast amounts of data, send this data to a central cloud-based service, process this data, and share it with end-users in a useful way. Linking these devices and using data analytics facilitates the convergence of the city's physical and digital elements, consequently improving the efficiency of both the public and private sectors, achieving economic benefits, and easing the lives of citizens. Other smart city technologies include Application Programming Interfaces (APIs), Artificial Intelligence (AI), cloud computing, machine learning, big data, and machine-to-machine (M2M) communication. (Hachem, 30/09/2025 09:05)

2.1.2 Characteristics of Smart Cities

The establishment of smart cities requires a set of fundamental components, which are listed as follows: (Thabet & Ahmed, 2020, p. 67)

✓ **Smart Economy:** Characterized by a spirit of innovation and creativity, the ability to transform, high flexibility in the labor market, and the capacity to compete locally and globally to achieve balanced and sustainable economic development.

✓ **Smart Society ("Human Capital"):** Represented by the ability of community members to learn using digital models, knowledge, and creativity, high flexibility towards change, and individuals with a high level of experience and qualifications.

✓ **Smart Governance:** The ability to improve public services provided efficiently and effectively, the principle of participation in decision-making and planning, and transparency in administration.

✓ **Smart Environment ("Natural Resources"):** Includes requirements for environmental protection, reducing and controlling pollution levels, a waste management and recycling system, the use of renewable and alternative energies to create a low-carbon environment, and an integrated water resource management system.

✓ **Smart Mobility ("Transport and ICT"):** Smart cities support cycling and walking, provide a fast mass transit system such as the metro to reduce congestion and regulate traffic in a balanced manner, and incorporate smart transport systems.

✓ **Smart Living ("Quality of Life"):** Consists of facilities and activities that work to provide a good life for residents, the provision of high-quality green buildings, healthy food, healthcare services, educational facilities with advanced equipment, and comfortable workplaces.

2.1.4 Prerequisites for Smart Cities

For smart cities to commence their work and achieve their objectives most effectively, a set of fundamental mechanisms and pillars must be in place, including: (Nabila, 2021, p. 36.37)

✓ Crystallizing a national strategy for using smart technologies in urban planning.

✓ Developing the basic telecommunications infrastructure.

✓ Providing a suitable legal and legislative environment that keeps pace with these goals and ambitions, encourages the attraction of foreign investments, and preserves intellectual property rights.

✓ Preparing professional human frameworks to develop and use the latest technologies, as smart applications require skills that surpass what educational systems currently offer.

✓ Cooperation and coordination among different entities, both between central and local government sectors, and between the public and private sectors.

Accordingly, it can be stated that establishing a smart city requires two types of conditions: technical and legal:

✓ Technical conditions consist of providing the essential infrastructure for Information and Communication Technologies (ICT), while considering the rapid development of ICT and the consequent necessity of qualifying the human resources working in these sectors and enabling citizens for the effective use of these technologies.

✓ Legal conditions involve issuing the necessary laws and legislation to keep pace with these developments, such as laws pertaining to the protection of information security and confidentiality, laws regulating intellectual property protection, and laws governing electronic signatures and electronic transactions.

The success of a smart city depends on the following:

- Widespread deployment of all ICT components.
- Transparency.
- Engagement and connection of all city residents.

3. Smart Transformation in Arab Cities: Real-World Experiences and Advanced Applications - Reference to the Experiences of the UAE and Algeria -

3.1 The United Arab Emirates' Experience in Smart City Transformation:

The United Arab Emirates is working to transform its economy from one based on natural resources to an economy driven by knowledge, innovation, and technology export through the development of smart cities.

3.1.1 Smart Dubai City:

Dubai is considered one of the most prominent Arab cities in the transformation to a smart city, where innovation and technological development formed the cornerstone of various smart initiatives and strategies. This approach has allowed citizens to access integrated services with high efficiency while promoting the optimal use of resources. This transformation is attributed to the successful experience of e-Government and the expansion of its effective implementation. (Lakhdar & Rimi, March 29–30, 2019, p. 4)

The mobile government has contributed to a paradigm shift that, in a short period, led Dubai to transform most of its facilities into smart organizations by adopting innovative applications. This transformation was not limited to governmental institutions but extended to cover various aspects of individuals' lives in homes, clinics, neighborhoods, transportation, and more. This trend is expected to positively impact the achievement of sustainable development, while preserving the environment and ensuring the well-being of future generations. (saliha & Lahmari, 2021, p. 192)

- **Foundations of Smart Dubai City:**

The Smart Dubai initiative was launched in 2013 by Sheikh Mohammed bin Rashid Al Maktoum, aiming to enhance the quality of life and transform Dubai into a city based on innovation and modern technologies. This initiative relied on a set of pioneering strategies, such as the Smart Government Strategy, the Blockchain Strategy, Artificial Intelligence (AI), and the Internet of Things (IoT), making it an advanced model for digital transformation.

The vision of the smart city is not Dubai's first transformation in a few decades; in 1970, it was a small town on the Arabian Gulf coast inhabited by 80,000 people, transforming into an Emirate within the United Arab Emirates the following year. Over the past two decades, Dubai has become a global economic hub and an example of successful digital transformation with the spread of the Internet. Its GDP is approximately 92 billion USD, and it is one of the fastest-growing urban economies in the world. Dubai aspires to leverage advanced technology to solve its problems, achieve sustainable development, enhance its competitiveness, and improve the quality of life for its residents. (saliha & Lahmari, 2021, p. 194)

- **Dubai's Vision for Building a Smart City:**

In March 2014, His Highness Sheikh Mohammed bin Rashid Al Maktoum launched the "Dubai Smart City Strategy," based on six main axes and encompassing 100 initiatives covering the areas of transport and mobility, infrastructure, electricity, economic services, and urban planning. The strategy aims to transform over a thousand government services into smart services. The most prominent features of the Smart Dubai initiative include: (Thabet & Ahmed, 2020, p. 72.73)

✓ Providing free Wi-Fi service in public places.

- ✓ **Dubai Design District (d3) – The Smartest Spot in the World:** Smart application developers will be able—by providing them with an open network of information systems in d3—to invest in developing innovative mechanisms to facilitate business and increase the effectiveness of their use.
- ✓ **A Five-Dimensional Control and Monitoring Room for the Entire City:** Smart Dubai will include a five-dimensional control and monitoring room, the largest globally, which will be used to track Dubai's transformation into a smart city, in addition to monitoring government projects, service indicators, road conditions, weather, and emergencies, among other things.
- ✓ **Establishment of Electric Vehicle Charging Stations:** Electric vehicle charging stations will be established to promote the concept of eco-friendly cars and contribute to sustainability.
- ✓ **Smart Parking:** The smart parking system eliminates the hassle of searching for an empty space by guiding the driver to the nearest vacant spot.
- ✓ **Live Traffic Monitoring:** Updates and live monitoring of traffic flow assist in planning trips even before leaving home.
- ✓ **Smart Meters and Smart Electricity Grid:** Smart meters will help monitor energy and water consumption in real time. The smart electricity grid will also allow customers to sell surplus solar energy.
- ✓ **The Largest Global Laboratory for Science Enhancement:** The smart city will host the largest global laboratory that facilitates immediate experimental science and research for innovators and innovative companies, enabling them to apply them.
- ✓ **My Window to Dubai Program:** The "My Window to Dubai" program enables the integration of databases and makes them available to everyone, allowing Dubai residents to stay informed and connected with all data related to government entities, schools, hospitals, roads and transportation, sensor systems, buildings, energy, and more.

- ✓ **iDubai Application:** This application, issued by the Dubai Municipality, provides individuals and companies with information regarding municipal services.
- ✓ **Smart Parks:** The "Smart Parks and Beaches" project provides specific information about weather, sea conditions, temperatures, and safety guidelines in the UAE. (Aicha, 2021, p. 29)

3.2 Abu Dhabi's Experience in Developing Smart Cities: Masdar City as a Model:

3.2.1 Planning for Masdar City:

"Masdar City" is one of the world's most sustainable urban communities, featuring a growing low-carbon cluster based on clean technologies, a free zone, a residential area, restaurants, retail outlets, and parks.

Masdar's philosophy in sustainable urban development is based on three pillars of sustainability: economic, social, and environmental. Masdar City embodies a pioneering model for the "Green Footprint" in sustainable urban development. The city works to offer practical and innovative solutions in the fields of water management, enhancing energy efficiency, in addition to reducing waste generation. (Thabet & Ahmed, 2020, p. 69)

3.2.2 Dimensions of Sustainability Applied in Masdar City:

Sustainability is a pivotal goal sought by governments and institutions, as it is a condition for meeting the needs of the present without compromising the rights of future generations to utilize resources. In this context, Masdar City in Abu Dhabi emerged as a leading model embodying the principles of sustainability through the adoption of innovative policies in the fields of energy, environment, and urban planning.

✓ **City Location:** A strategic location was chosen for the city's establishment, built about 17 kilometers southeast of Abu Dhabi City, in an area central to the main transportation network, allowing it to connect with surrounding residential complexes. Its area is approximately 4.6 square kilometers. The city is a center for commercial and industrial businesses specialized in developing and manufacturing eco-friendly innovations. It was constructed in seven phases, relying on the latest technology in clean and safe industries. The Masdar headquarters is powered by photovoltaic panels installed on its roof.

✓ **Residential Area:** Masdar City is planned to be home to approximately 50,000 residents, in addition to hosting about 40,000 daily visitors. Approximately 30% of its area is allocated for residential purposes, distributed across a network of narrow, shaded pathways that connect open public squares on one hand, and homes, schools, restaurants, theaters, and shops on the other. This design was inspired by the urban models of traditional Arab markets and cities.

✓ **Business and Research Area:** 24 % of Masdar City's total area is allocated for establishing an advanced technology cluster operating under a free zone system, ready to attract researchers, specialists, academics, and businessmen. This cluster includes over 1,500 innovative companies, in addition to offices, research centers, and operational units within the city.

✓ **Events and Culture Area:** 8%of Masdar City's area is allocated for cultural activities and community events. This area includes schools, restaurants, theaters, cinemas, shops, entertainment facilities, as well as parks, opera houses, museums, and other facilities dedicated to supporting the city's cultural and social dimension. (tayeb & Aissaoua , 2024, p. 57)

3.2.3 Services and Infrastructure in Masdar City:

Masdar City relied on establishing an integrated and highly efficient infrastructure, supported by the latest smart city technologies

and scientific innovations, thereby enhancing its ability to provide advanced and sustainable services across various sectors, as reflected in the following elements: (tayeb & Aissaoua , 2024, p. 58)

✓ **Roads and Transportation:** The city provided innovative solutions in the transport sector to ensure easy movement and alleviate traffic congestion, by relying on public and private transportation systems, rapid environmental trains, in addition to creating dedicated parking lots for visitors and non-resident occupants.

✓ **Green Fabric:** Advanced strategies were adopted to integrate green expansion into the city's planning through three main patterns: the harmony between open and covered spaces, pedestrian pathways, and water and plant elements. This creates a comfortable, natural environment resembling urban forests and provides protection for residents from the desert climate effects.

✓ **Social Infrastructure:** The city paid special attention to strengthening social bonds by designing attractive pedestrian pathways and multi-use open spaces, equipped with modern recreational and social facilities, alongside providing an advanced communication network that ensures effective communication between residents and visitors.

✓ **Energy and Water Consumption:** The city adopted global sustainability standards by reducing water and energy consumption by up to 40% based on smart designs and highly efficient buildings. It also established a solar power station with a production capacity of 10 megawatts, relying on photovoltaic panels to meet its energy needs.

✓ **Waste Management:** The city adopts a **"Zero Waste" strategy** by utilizing biological waste to produce organic soil and fertilizers, converting a portion of it through incineration to generate additional energy, while industrial waste like plastic is recycled, ensuring the optimal use of resources.

✓

3.1.3 Abu Dhabi Economic Strategy 2030: Towards a Competitive Knowledge Economy:

The Abu Dhabi government launched a long-term strategic plan aimed at restructuring the Emirate's economy toward a knowledge-based one, while gradually reducing reliance on the oil sector as the main source of economic activity. In this context, the "Economic Vision" for the Emirate of Abu Dhabi identified a set of urgent economic priorities, most notably: (Thabet & Ahmed, 2020, p. 70)

✓ Developing an open, effective, and integrated business environment with the global economy.
✓ Adopting disciplined fiscal policies capable of adapting to various economic cycles.
✓ Establishing a flexible financial and monetary market characterized by controllable inflation levels.
✓ Enhancing the efficiency of the labor market by introducing fundamental improvements in its performance.

3.2. The Algerian Experience in Smart Cities (Sidi Abdellah City):

3.2.1 Introductory Overview of Sidi Abdellah City:

The new city of "Sidi Abdellah" is located 25 kilometers west of the Algerian capital, administratively belonging to the Maâlma municipality. It spans an area estimated at 7,000 hectares, of which 3,000 hectares are allocated for construction, and 4,000 hectares for green spaces and protected forests. It was established under Law No. 04-275 to be a model for the modern city and contemporary urban organization.

The new city of Sidi Abdellah is considered the first smart city model in Algeria. It hosts massive housing projects, primarily the Public Promotional Housing (LPA) formula with over 5,000 units, and

the Rental-Sale (AADL) formula with over 44,000 housing units. It was supposed to include technological industrial hubs built to the latest international specifications. (Ilhem, 2021, p. 524)

3.2.2 Mechanisms for Applying the Smart City Concept in Sidi Abdellah:

Algeria, like many countries worldwide, has sought to keep pace with developments in Information and Communication Technology and to implement the smart city concept on the ground. "Sidi Abdellah" city is the most prominent model for this experience. The following is a presentation of what has been achieved in this field: (Ilhem, 2021, p. 523.524)

✓ **In the Field of Transport:** The Ministry of Transport in Algiers launched the "Smart Traffic Signals" project, aimed at alleviating traffic bottlenecks and congestion, covering over 500 intersections. This system contributes to facilitating movement flow and ensuring the safety of vehicles and pedestrians, in addition to enabling drivers to view road conditions in real-time.

The concept of a "Points-Based Driving License" was also introduced, which relies on the electronic deduction of points from drivers who violate traffic rules. The personal information of the offending driver is transferred to a central database at the Ministry of Interior for accurate and transparent follow-up.

Furthermore, the Ministry of Transport established an "Electronic Portal" dedicated to professionals, such as bus and taxi owners, and owners of contracting and execution companies, to submit accreditation and license applications electronically, thus avoiding queues in front of public administrations and reducing bureaucracy.

✓ **In the Field of Trade:** The Ministry of Trade launched Electronic Registers with the aim of modernizing the sector. This will allow for combating fraud and forgery through an encrypted code containing all the trader's data, eliminating complex procedures and preventing traders from facing long queues inside Commercial Register centers.

✓ **In the Field of Housing:** Thanks to the electronic registration process for housing applicants, especially in the "AADL" formula, the Ministry of Housing managed tens of thousands of requests, carrying out verification, updating, and site selection in a relatively short time.

✓ **On the Investment and Social Level:** Many creative young people contributed to establishing **start-ups** and developing digital applications beneficial to society, including services for "taxi services, online education, digital shopping, and e-restaurants."

✓ **On the Technological Level:** In June 2018, an "Official Technology Center" was launched in Algiers aimed at transforming the city into a smart city. This project, which the Wilaya (Province) initiated at the end of 2018, is expected to include around "300 start-ups" that will participate in developing smart solutions and services.

✓ **Renewable Energies:** Algeria launched ambitious programs in the field of renewable energies, especially solar energy, as part of a strategy aimed at valuing sustainable resources. The government approved the "National Program for the Development and Promotion of Renewable Energies" in 2011, and then issued a "Modified and Complementary Version" of this program in February 2015.

✓ **Waste Recycling in Algeria:**

❖ **Quantity of Waste Produced:** Algeria produces approximately 13.5 million tons of household and similar waste in 2024, and the amount of household waste per capita per day is estimated at about 0.76 kilograms per person daily.

❖ **Economic Value of Recycling:** The market value of recyclable waste increased from about 92 billion dinars in 2020 to about 207 billion dinars in 2023. The National Strategy estimates that the

valorization and recovery of waste will lead to an economic value of 88 billion Algerian dinars from recovered waste.

❖ Legislation and Ongoing Projects: Projects for the selective sorting of household waste have been registered in several provinces, and there are new units and factories, including a unit for recycling tires and plastic waste in Bouira, which also contributes to creating job opportunities.

Currently, the recycling rate (recovered waste) is relatively low. For example, it was mentioned that valorization constitutes about 9.83% of the total waste produced in 2024. The government is betting on reaching a 30 % recycling rate in the coming years. (Algerian Press Service (APS, (2025, March 6)

Conclusion:

Arab countries vary in their path toward smart city transformation; while some countries have achieved advanced steps in this field, similar to the experience of the UAE (Dubai and Abu Dhabi), others, such as Algeria, are still at the beginning of this journey. This transformation is met with a range of challenges, most notably: high illiteracy rates and weak human element involvement in the process, lack of clarity in visions and strategies, limited budgets and lack of funding, in addition to the obsolescence of urban infrastructure. Consequently, the embodiment of the smart city model remains a complex path that requires continuous time and effort and cannot be achieved overnight.

Research Findings:

➢ For the smart city experience to succeed, pre-emptive strategies must be drawn up that provide a future vision for smart cities by involving citizens and opening the door to their individual and collective initiatives, as well as closing the gaps found in global smart

city experiences in a manner that ensures the highest degree of success for the experience.

- While the vision is clear, goals are set, and the smart strategy is established in the United Arab Emirates, the situation is different in Algeria, where a kind of ambiguity and a lack of clarity in the vision, goals, and strategies prevail.

In light of the results achieved, we offer the following recommendations:

- Establishing and developing a smart applications portal to facilitate the smart transformation process.
- The necessity for Arab countries in general, and Algeria in particular, to focus on the human element and make it the basis and an active component of the transformation process through raising awareness and promoting smart cities.
- Arab countries, including Algeria, should gradually transition to smart cities while considering their specific circumstances and the various challenges they may face, and they must benefit from the experiences of successful Western countries.

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