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# Dubai: A Pioneer Smart City in the Arabian Territory

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**Abstract.** Nowadays, one of the main issues that the cities are facing is related with how they are dealing with the challenges toward smartness, including infrastructures, economic, social and environmental aspects. In this sense, some of the current challenges on the global scale, trying to find solutions regarding urban societies, are based on the concept of “smart city”. Therefore, is clear that new ideas regarding the cities improvements, which are on the top of global agenda, could be found at the concept of “smart city”. As the literature reveals, this is a topic reason among the researchers, which is in a continuous development, in particular regarding societies, countries or regions where it is emerging, such as in the Arabian territories. Dubai, a city in the United Arab Emirates, is an example where in a short period of time, after the oil discovery in the decade of 1970, one small and badly known urban settlement became a pioneer reference in terms of smart cities requirements. Thus, this article presents background information about smart cities, their assets and key pillars, their smart infrastructures and features in cultural, social and environmental terms. The main goals are based on a theoretical approach, developed in order to get more details about smart cities, regarding the features of the Arabian territories. It argues around the case of Dubai, as a pioneer smart city in the Arab world. Among of the main conclusions, there is the idea that the urban transformation process in contemporary societies to secure the smartness, should apply to the use of ICT / information and communication technologies. This use will increase the efficiency concerns to the natural resources, and provide a high quality of life for citizens. The example of Dubai has shown that the decision-makers have built each sector and part of the city in a solid performance, in order to achieve the smart sustainability concept. This city is nowadays a reference on this matter, not only in the Middle East but also considering the global scale.

## 1. Introduction

Nowadays the urban areas are, in general, crossing through a revolutionary period, based on the fact that cities are understood as engines of growth for the economy and development of nations. They are considered key elements for the future, playing an essential role in economic and social aspects worldwide, and they greatly affect the environment.

In parallel most of the cities and urban areas of modern societies, are facing many difficult challenges. Among them there is the rapidly increasing of the population, especially in the most recent decades. In fact, urban areas are growing by almost 150 000 people per day [1] caused by migration or births. According to the United Nations, in 2014 [2] more than 54 % of the world’s population were living in



cities, compared with 30% in 1950 and the expected rise in 2050 will be about 68%. Another problem that cities are facing is related with the increasing of greenhouse-gas emissions. In this sense, around 70% of global CO<sub>2</sub> emissions [3] are coming from cities. Thus, most of the carbon dioxide is produced by the use of energy resources, buildings, industry, and transportation. There are as well in the cities, a scarcity of resources, especially non-zero cost to consume (in terms of air, fuel or water), traffic congestions, human health concerns, air pollution, or deteriorating and aging infrastructures. Consequently, there is an increasing awareness and concern about the urbanization issues in general, and in particular regarding the environmental, and the technological development, which is causing an urgent need for rethinking the cities, the way how their construction, management or qualification should be planned, in order to reduce the referred problems.

In this sense, this article is focused on the strategies to achieve the economic, social, and environmental sustainability in cities, by the adoption of scalable solutions that take advantage of information and communications technology (ICT). Indeed, ICT can contribute to increase the efficiencies or urban areas, reducing costs, and enhancing the quality of life of their dwellers. Related to the latter aspect, the literature reveals that cities are seriously focused on improving their performances, based on an approach that is commonly referred to 'Smart Cities'. This tendency is currently a feature of cities' management authorities, not only considering the Western societies but also among other cultures. Therefore, the Arabian territory is not an exception on this matter. Nowadays, some pioneer examples of smart cities are emerging among the Arabian societies, which is the case of Dubai, located in the United Arab Emirates. It is an example where in a short period of time, corresponding to the last four decades, from one small and badly known urban settlement, this city became a pivotal reference in terms of smart cities' requirements, not only among the Arabian region but also considering the global scale. However, if on the one hand this city is very well known at the global scale, on the other hand, its study is a complex process, based on the lack of scientific bibliographic references, comparing with other cities or regions of the globe.

## **2. Smart cities' main features**

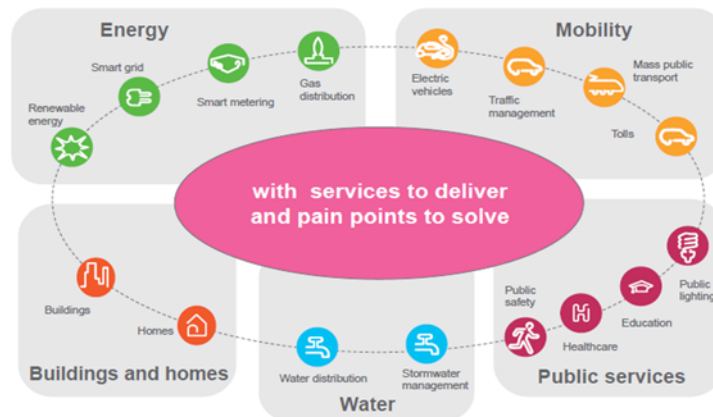
Smart cities are coming from the combination of sustainable development and urbanization issues, in order to get a sustainable urban development. On the one hand, the concept of Smart related to city is an instrumental more than a normative term, related to the features rather than to the performance of the urban areas. The smartness is a prefix label for services, products and product service where ICT plays a major role. While City is as well an instrumental term, which could combine between smart and sustainable aspects in order to keep them in touch, it's related to the human structure and environment where solutions smart can be applied to get a more sustainable development [4]. Actually, among scholars there is no universal definition for smart city. In fact, it means many different things to different points of view, but with no doubts smart city focuses on using ICT in all aspects of its daily life. At this point, several authors are sharing the idea that Smart city is a place where IT (information technology) is combined with infrastructures, architecture, everyday objects, and human beings, to address social, economic and environmental problems [4].

### *2.1. Smart infrastructures*

The goal of improving urban areas into smart cities is not supported by patch work approach, but by working step by step as a gradual improvement, starting with providing basic urban infrastructures to achieve environmental challenges, such as low levels of pollution, and gashouse emissions, or waste disposal.

Consequently, smart infrastructures act in form backbone for city, allowing the combination in between physical, digital and communicative issues. The physical feature involves basic infrastructures related with energy (gas or electricity), mobility (public transportation or the encouraging of the use of electric vehicles), buildings, water (distribution or rain water management, public services, such as education and health care, among other aspects. The digital infrastructure includes Wi-Fi broadband, ICT devices (wireless hotspots, computing, sensors, smartphone, mobiles, or networks), and data basics.

This one will contribute to a smarter performance and functionality for the physical one by improving the use of the limited resources (such as oil energy) as well getting better understanding and controlling of the operations on urban areas (transportation, or water supply among many others) [5] (Figure 1). The communicative infrastructure aims to create an atmosphere of connecting people via the same language, as standardization within the coding language of digital devices.



**Figure 1.** Operating systems making city’s infrastructures by ICT [1].

ICT are fundamental issues in smart cities which capture and collect the information from each part of urban area by using smart devices (sensors, or meters among others), in order to integrate these data into a computing platform for data analyse. In fact, the management of the information could be useful to create new policies and regulations in order to improve the quality of life for city’s dwellers. Moreover, applying the ICT means a capacity to computing and providing information in timely manner, let them management authorities to consider and respond properly, according to the best situation. Otherwise they will fall quickly in specific problems. For example, related to the traffic congestion in cities, if the information is provided in a real time and accurately, citizens can take an action before the problem begins to escalate, and try to solve it rapidly. According to that, the use of ICT is a way of give the smart city a predictive approach, where the results for particular events can be understood, allowing the optimization of quality of life, making the citizens able to be more informed about the situation to take educated decisions. All of that will be done by identifying specific characteristics of smart city, related with several domains including the following: smart economy, people, mobility, governance, environment and living.

In all these previous aspects, ICT plays a main role. Thus, to collect data and to produce information about these characteristics will be an important skill to know the particular needs of a city and their dwellers (Figure 2).



**Figure 2.** Mapping smart city’s features.

In this sense, is possible to conclude that the term city needs by its dwellers, is related to something desired or deemed necessary, which is more often expressed as a general concern or a desire, which is a sort of functionality whose output contributes to a desired outcome, and if achieved, will satisfy a need. In fact, the ICT need the three following main tasks for implementation [6]: broadband connectivity which is playing a major role in developing urban areas, concentrating many essential points in order to bring digital devices, providing benefits of spreading the smart applications i.e. smart phone revolution apps related to cities, including energy, water or other issues, establishing free Wi-Fi

access points (including in public transports); the Internet of things (IOT) which is playing a major role in order to achieve the goal of the universal infrastructure by IOT, connecting ICT devices. This is not just about connecting people together, but also to try to open the door for to react with one to another; and big data which is playing a major role because the goal of getting IOT is depending on the need of establishing a centre for big data, storing huge data information that are collected by sensors and devices from urban area. The better understanding for this data will predict the performance of urban areas, allowing to improve the maintenance and rehabilitation of urban environment.

In one word, the communicative infrastructure aims to create the atmosphere of connecting all the people via the same language, as standardization within the coding language of digital devices.

### 2.2. Key pillars of smart cities

A smart city not only means a good management of infrastructures and applying to modern technology in everyday of urban life, but also should provide the sustainability identity as a main requirement for current societies. According to the Brundtland commission report from the World Conference on Environment and Development, published in 1987 the sustainability is a way of boosting the development of countries and cities, “that meets the needs of the present without compromising the ability of future generations to meet their own needs” [7]. This notion of sustainable development is crucial to cover the complete cities’ problems, according to three pillars: economic, social and environmental (Figure 3). Thus, there is the need of achieving a balance between the referred pillars, and if any one of them is weak, the whole system will be unsustainable.



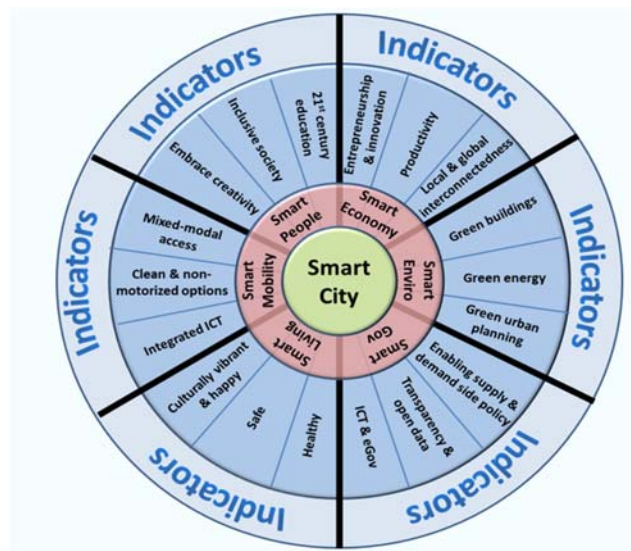
**Figure 3.** Requirements for achieving cities’ sustainable development.

The first pillar of sustainable development of cities is focused on the economic aspect, which means the need of achieving high productivity standards in urban areas, not only for present consumption but also for the future generation. The economic diversification is provided by business opportunities, in order to generate wealth care services and financing the public services. The second pillar of sustainable development of cities is the social issue, according to what, there is the need to ensure the existence of connectivity between citizens and cities’ major activities, by securing a wide range of customer services for all with high efficiency. The third pillar of sustainable development of cities is the environmental realm that illustrates the environment protection needs from the scarcity of natural resources, in order to create new renewable energy from waste recycling or from nature (sun lights, tides, or wind), to improve greenery in cities, or low pollution emissions [1]. These three pillars of sustainable development could be applied to the urban areas’ scale as requirements of smart cities, helping them, to be apart from the risk of insolvency in economic, social or environmental terms. If the cities want to achieve smartness, they have to be sustainable to consider these pillars.

### 2.3. Smart cities’ requirements

The understanding of the requirements associated with smart cities is on behalf of the following question: How can the cities be smarter? The best answer that should be given is based on the identification of the high-impact areas of improvement for the cities. These areas are correlated with the characteristics of the urban areas. Therefore, the authors are pointing out six characteristics which can help to develop a city in order to be smarter. These characteristics are called the “smart city wheel” (Figure 4), which comprises the following aspects [8]: **a. smart economy** by existence of innovation spirit and entrepreneurship, high productivity (not only in terms of quantity but also related to quality),

flexibility in the labour market by reducing trade barriers, and open the door for local and global market; **b. smart people** by increasing the investments in the education system, to promote the long-life learning with e-skills using ICT, organizing people and the connectivity between them, making a rapid transfer of information in between cities' authorities and their dwellers, and also embracing creativity by sharing knowledge; **c. smart governance** by keeping the services of management of cities' authorities online, using ICT as an open data accessible to public participation, promoting more responsibility of users, as a signal of transparency; **d. smart mobility** by ensuring the intelligent transportation system, with ICT on the infrastructure, turning the vehicles into more free fuel consumption (i.e. electric), increasing the capacity of this system in terms of the number of people with automated metro subway system, or promoting the use of soft mobility ways, such as cycling, waking or car sharing; **e. smart environment** which relates to the preservation of natural resources, like energy saving, water efficiency, CO2 emissions reduction, finding green resources of energy, more attractive for the natural conditions, supported by a green urban planning approach; **f. smart living** which is related to the design of systems where people live, by investing in public services, such as education or healthcare systems, boosting the city to be more attractive for dwellers and visitors, and at the same time getting more security and safety for particular layers of their inhabitants, such as children or elderly people.



**Figure 4.** Smart cities' wheel [9].

According to the previous studies, the main conclusion that can be considered is that urban areas to score and to get the features of smart cities, should be based on indicators for evaluating their performances. Therefore, there is the need of using ICT in all referred branches or smart cities' wheel [10].

On the one hand, is possible to imagine a smart city, like the physical approach of a human body. Such as the buildings activities in the cities are like the muscles in human body, the green areas are similar to the lungs, because they help to clean the air, and to give the oxygen to breath. The veins and arteries in the human bodies are like the streets and roads in the cities, where the movements of people and traffic are happening. On the other hand, in the human body, there are five senses which collect all the messages around humans, and send them to the brain, in order to let it gives orders to the body. In parallel, in the cities, to work with efficiency using ICT is like to pay attention to the urban senses, where the big data about urban areas is similar to the human brain, which will give indications about the best options which should be taken in consideration, for the best performance of cities.

### **3. Dubai as a smart city in Arabian territories**

#### *3.1 The urban growth of Persian Gulf*

The smart city concept is emerging recently in the Arab world. Consequently, there are no many examples of smart cities around this territory. Despite of that, the Arab countries are facing a high increasing in the urbanization process especially in the Persian Gulf regions, including the wealthiest states, such as the United Arab Emirates (UAE). Many Arabian cities were passed through a deep process of spatial transformation. In a short period of time they have transformed from nearly nothing in terms of urban areas, from a little more than a strip of desert into the densest and most modern places of the world. In this process of urban transformation, the use of ICT, was a key factor. However, in other areas of the Arab world, such as at the Levant and al Maghreb regions, the spatial transformation is facing a high urbanization process, but still on the traditional and historical way, with no strong evidences of the smart cities main features.

In this sense, the city of Dubai, which is nowadays one of the most important smart cities of contemporary societies, not only in the Arab world, but also considering the global scale, is a pioneer example. It is one of the seven emirates of UAE, which were gathered since to the early decade of 1970 [10]. It is situated along the southern coast of the Persian Gulf on the Arabian Peninsula. It also shares the borders with Abu Dhabi, Sharjah and the Sultanate of Oman.

Dubai has a surface of 4150 km<sup>2</sup> of land, 38% of which designated for development [11], and it has the creek area which runs south from the Arabian Gulf for 13 km long. Nowadays, this area is stretched to 17 km dividing Dubai into Deira in the east and Bur Dubai in west [12]. It has an interesting and varied history. Over a period of about half of a century this city state has progressed from a small village for fishing community and pearl diving purposes on the Arabian Gulf, to a cosmopolitan and significant twentieth-first century city. Currently, it is one of the world's most preeminent business centre, and a vital commercial and trade city. Also, it has witnessed a high increasing in terms of population mainly because of two reasons, which are the decline in the infant mortality rate based on better healthcare services, and the economic expansion based on the oil industry development [9].

#### *3.2 The 'Dubaization' process*

Dubai has been received the most attention from scholars, because of its efforts related with its quick urbanization process, which was known as 'Dubaization' [11], which means the very rapid process of urban development, corresponding to an 'instant' urbanization, embracing ideas coming from the economic liberalism, including several mega projects, and iconic architecture landmarks on a massive city scale. In the particular case of the city of Dubai, this process of 'Dubaization' can be organized in four steps, according to the following aspects [13].

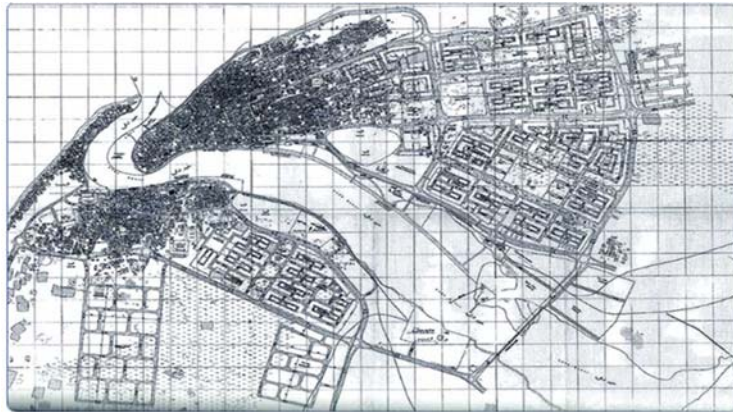
##### *3.2.1 First phase (1900-1955) – low urbanization period*

The first phase of Dubaization took place along a period of about fifthly years, in between 1900 with the beginning of the 20<sup>th</sup> century and 1955, with the discovering of the oil. This phase corresponds to the pre-oil discovery in Dubai or to the pre-industrial era of this city. It can be called the low urbanization period, which was characterized by the absence of spatial planning instruments, strategies or proposals to guide the modest urban development, having a slowly urban growth. At the time Dubai was a small urban settlement bordered by the desert.

##### *3.2.2 Second phase (1955-1970) – compact urban development period*

The main feature of the second phase of Dubaization process can be called the compact urban development, along a period of nearly two decades in between the middle of the 1950's and the decade of 1970. In terms of spatial planning, the landmark of this phase was the first Master Plan of Dubai, from 1960, which was prepared by the British architect John Harris (Figure 5), on the behalf of Sheikh Rashid bin Saeed Al Maktoum, when the estimated population of the city was about 40.000 inhabitants. This Master Plan was designed in order to provide a new road system for the city, supported on a zoning

propose, in order to be the spatial planning guide for the growth process, based on the identification of the city centre area and the several different land-uses of the new urbanization expansion.



**Figure 5.** John Harris's first Master Plan of Dubai from 1960 [14].

### 3.2.3 Third phase (1970-1990) - planning for suburban growth period

The third phase of Dubaization process can be called planning for suburban growth period, starting in the early 1970, when the oil reserves discovery was taking place as a strong financial income to the city. In spatial planning terms, in 1971 [10] a new and more ambitious Master Plan of Dubai was designed by John Harris, considering the city as a whole, including a provision for ring roads around the urban area and a radial street network to the suburbs (Figure 6). It was also proposed the construction of the Shindagha Tunnel beneath the river creek Dubai, in order to connect the area of Bur Dubai to the area of Deira.

In 1972 the central urban area of the city was expanded to the east part of the creek Dubai, until about 2.3 km distance, and to the west part, until 0.7 km distance. Also in this period, there were two main ports that were established along the shore of Dubai. The Rashid port was extended towards the south part of the city, and the Jebel Ali port was built a bit time later, in 1980. The latter area had witnessed, in 1985, the emerging of the very well-known Jebel Ali free zone in commercial and financial terms, which is nowadays one of the main business centres in Dubai [12].



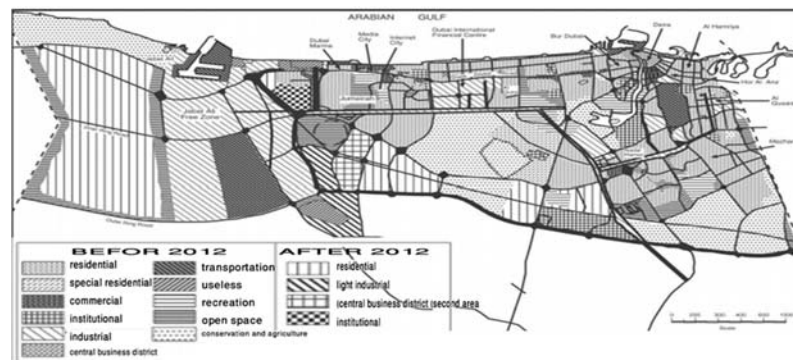
**Figure 6.** John Harris's second Master Plan of Dubai from 1971 [15]. A. Deira area; B. Bur Dubai area



### 3.2.4 Fourth phase (1990-nowadays) – urban globalization period

The most recent phase of Dubaiization process comes until nowadays, since the decade of 1990. It can be called the urban globalization period. In fact, since the early 1990 that the political authorities of Dubai, are responsible for the spatial planning instruments and strategies, in order to guide the urban development process of the city [10]. During this period, they are boosting several strategies in order to planning the economic and physical development of the urban area. The ‘Dubai Urban Area Strategic Plan 1993-2012’ is one their most iconic instruments (Figure 7), which among other things is proposing the following goals in terms of urban development: to absorb the urban expansion areas by providing more lands to meet the current and the future needs for residential, industrial and commercial uses; to extend the transport network and the infrastructure facilities, including to the suburb areas; and to promote an economic growth, to support the investment in the urban space and on its qualification.

The construction for the real state and tourism purposes, started to be a main issue for Dubai’s authorities, in the decade of 1990 [12]. One of the examples of this strategy is the Jumeirah beach extension, which is a resort with the shape of a palm-tree, known as Jumeirah Palm Island, located over the sea of the Arabian Gulf. According to the same reference, another case is the Burj Al Arab hotel, which was built a bit later then Jumeirah Palm Island, in between 2000 and 2011, being an artificial island as (Palm Deira, World Islands, Palm Jebel Ali and Dubai Waterfront) with the appearance of new 68 km<sup>2</sup> of urbanized land, added to the total terrestrial area of Dubai.



**Figure 7.** Dubai urban areas Strategic Plan 1993-2012 [10].

### 3.3. Identity of Dubai as a smart city

The main identity of Dubai as a smart city is the inclusion of physical and digital infrastructures, connecting the citizens. This strategy consists of having smart buildings, smart transportation, smart energy, smart water supply system, smart waste management, and smart healthcare. Related to smart buildings, Dubai applies many strategies which focus on adopting new policies and technologies to make building more energy and water efficiency, and environmental friendly, with CO<sub>2</sub> emission reduction, improving the security and the comfort for the residents. Dubai has recently launched the green building rating system called al Safat, which classifies facilities under the Platinum, Gold, Silver and Bronze categories. Consequently, all constructed buildings in Dubai after 2014 should address at least the minimum rate, i.e. bronze, in order to be able to receive the planning permission. By doing this, Dubai is waiting a reduction of 7.3 million tons of CO<sub>2</sub> emissions over the next five years [16].

Related to smart transportation, Dubai’s road transportation authority (RTA) is putting many strategies on practical terms, involving roads, bike lanes, reduction of congestion (traffic jams and accidents), in order to promote a faster, greener and more save transportation system. This system is connected with ICT improving an intelligent transportation system. RTA provides a wide range of e services with smart applications (smart parking, smart drives, smart Salik etc.), and improves several kinds of public transportation, including for people with special needs. An example is the Metro subway system of Dubai, which is the longest automated metro network in the world, with 70 Km of tracks, serving 49 stations [17]. Related to the smart water & energy management, Dubai Electricity and Water

Authority (DEWA) is committed to secure a sustainable approach to energy and water usage by a Smart Grid strategy, which aims to generate renewable energy coming from solar power for housing, by installing photovoltaic solar panels on the rooftops, installing smart meters in public & private sector for monitoring the actual consumption, and provide infrastructures for electric cars. Finally, related to smart healthcare, the vision of Dubai's smart city will push the government to build additional sophisticated healthcare infrastructures and to adopt smart healthcare initiatives to provide the best access to the city's dwellers to the healthcare services with high quality by applying ICT solutions, such as the smart healthcare project which provides smart app for all the information and healthcare services on mobiles also make all the internal operation with the administrative work paperless [18].

#### 4. Conclusions

One of the most important conclusions about the urban transformation process of Dubai towards a smart city is the fact that only the fourth phase of its urban development, which took place since the decade of 1990, was not based on planning strategies for new housing developments. Its main feature was an urban development focused on the touristic purposes, such as the artificial palm islands, and the big infrastructures like the airport or the Dubai's industrial city.

The main urban expansion of Dubai occurred since the decade of 1970, after the huge discoveries of the oil reserves. The city expanded its urban fabric from the sea shore to more interior (i.e. more far away from the Arabian Gulf) lands. This expansion occurred whether to the north region or to the south. Since then, Dubai has witnessed a great economic growth, depending on a rapid urbanization process, known as "Dubalization" which has turned the desert into a dense and modern residential, commercial, sports and touristic spot. Therefore, Dubai is a pioneer example of a smart city in the Arab world, and a global leader by its territorial transformation process. This place, which was not much than a strip of desert was turned into a bustling metropolis and one of the world's most modern cities, by the vision of its government, which is adopting a unique smart city approach, focused on applying smart infrastructures, whether physical or digital, with an efficient management for water, energy, good conditions for the healthcare, mobility or housing quality. In Dubai, a wide application range of ICT is available, with good communication systems, where intelligence and information can flow rapidly.

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