UNIVERSIDADE DA BEIRA INTERIOR
Faculdade de Engenharia

Smart cities in Arabian cultures: Dubai as a case study

Arwa Abbara

Dissertação para obtenção do Grau de Mestre em

Engenharia Civil

(ciclo de estudos integrado)

Orientadora: Professora Doutora Ana Lídia Virtudes

Covilhã, fevereiro de 2017

DEDICATIONS

This master thesis would not have been possible without the help of several people.

First, I would like to express my gratitude to all those who gave me the possibility to complete my master degree, my scholarship 'Plat Form for Syrian students' especially my responsible who has helped me and stood by my side all the time Dr Helena.

This research will not be complete if I did not thank the person who supported and followed me step by step, gave me professional guidance and fundamental points for the development of this document my supervisor Dr Ana.

As well I wish to thank my sweet and lovely family, the one that has always been close to me in every single day especially my Mom Zabia, brother Ameer and sister Dania.

Also I will never forget to thank all people who supported me during my scholar journey in Covilhã particularly Waleed, Saffana and Sara.

Finally, I would love to dedicate my work and thank all the group of University of Beira Interior.

Resumo

Esta Dissertação “Cidades inteligentes em culturas Árabes: Dubai como estudo de caso”, introduz uma abordagem sobre um campo particular da Engenharia Civil, os estudos urbanos. Tem como objetivo apresentar alguns resultados sobre a revisão da literatura, focados em alguns dos principais problemas que as cidades enfrentam, e como é que elas poderão lidar com eles através do conceito de inteligência, incluindo ao nível das infraestruturas, economia, social e ambiental. Tem inicio considerando que alguns dos atuais desafios à escala global, tentando encontrar soluções considerando as sociedades urbanas, são baseados no conceito de ‘cidade inteligente’. Este é um assunto central entre os investigadores científicos, em continuo desenvolvimento, em particular tendo em consideração as sociedades, os países ou as regiões onde está a emergir, tais como o mundo Árabe.

O estudo de caso é centrado no Dubai, uma cidade dos Emirados Árabes Unidos, que é um exemplo onde num curto período de tempo, depois da descoberta do petróleo na década de 1970, um pequeno e desconhecido povoado se tornou numa referência pioneira em termos de requisitos das cidades inteligentes. Assim, esta Dissertação apresenta um enquadramento da informação sobre as cidades inteligentes, os seus espólios e pilares chave, as suas infraestruturas inteligentes e caraterísticas em termos culturais, sociais e ambientais. Os principais objetivos são baseados numa abordagem teórica, desenvolvida de modo a sistematizar detalhes e requisitos sobre as cidades inteligentes, tendo em consideração as características da cultura Árabe. Argumenta acerca do estudo de caso do Dubai, como cidade inteligente pioneira no mundo Árabe.

Entre as principais conclusões, surge a ideia de que os processos de transformação urbana nas sociedades contemporâneas, de modo a assegurar a inteligência do funcionamento dos lugares, pessoas e modos de vida, deve apelar ao uso de TIC / tecnologias de informação e comunicação. Este uso irá aumentar a eficiência acerca dos recursos naturais e promover uma elevada qualidade de vida dos cidadãos. O exemplo do Dubai mostrou que os decisores políticos, têm construído cada setor e parte da cidade, com um desempenho sólido, de modo a alcançar o conceito de inteligência sustentável. Esta cidade é atualmente uma referência nesta matéria, não apenas no Médio Oriente mas também à escala global.

Palavras-chave

Cidade inteligente; Infraestruturas; Requisitos e questões da sustentabilidade; Países e cultura Árabe; Dubai.

Abstract

This Dissertation “Smart cities in Arabian cultures: Dubai as a case study”, introduces an overview of a particular field of Civil Engineering, the urban studies. It aims to present some results about the literature review, focused on some of the main problems that are facing the cities, and how they are dealing with them by a new concept for smartness, including infrastructures, economic, social and environmental issues. It starts by considering that 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”. This is a topic reason among the researchers, in a continuous development, in particular regarding societies, countries or regions where it is emerging, such as in the Arabian world.

The case study is focused on Dubai, a city in the United Arab Emirates, which is an example where in a short period of time, after the oil discovery in the 1970s, one small and badly known urban settlement became a pioneer reference in terms of smart cities requirements. Thus, this Dissertation presents a 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 and requirements about smart cities, regarding the features of the Arabian culture. 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.

Key-words

Smart city; Infrastructures; Requirements and sustainable issues; Arabian countries and culture; Dubai.

مستخلص

يقدم هذا البحث لمحة عامه في احدى مجالات الهندسه المدنيه وهي الدراسات الحضريه , بحيث يهدف الى تقديم بعض النتائج والحلول من الدراسات العلميه اللتي ركزت على المشاكل الرئيسية اللتي تواجه المدن وكيفيه التعامل مع هذه المشاكل من خلال مفهوم جديد الا وهو "الذكاء", بما في ذلك البنية التحتية, الاقتصادية, الاجتماعية, و قضايا البيئة. يبدا هذا المشروع بالاخذ بعين الاعتبار بعض المشاكل الحاليه الداخله باطار العولمة ومحاوله ايجاد الحلول في المجتمعات الحضريه بالاعتماد على مفهوم " المدينة الذكية", ولهذا فان الافكار الجديدة لتحسين المدن وتطويرها احتلت قائمة جدول الاعمال العالمي اللذي يبدو جليا في مفهوم "المدن الذكية". لكن ان هذا المفهوم الناتج عن الباحثين في تطور مستمر ولاسيما فيما يتعلق بالمجتمعات و البلدان و الاقاليم اللتي برز فيها حديثا كالمجتمعات العربية. هذا البحث يركز على مدينه دبي في دوله الامارات العربية المتحدة كمثال حي للمدينه الذكية وبفترة زمنية محدودة بعد اكتشاف النفط فيها عام 1970, فقد كانت واحدة من المدن الضغيرة غير المعروفة والمأهولة الى مرجع رائد في مجال متطلبات الذكاء, وعليه فان هذه الاطروحة تقدم بعض المعلومات الاساسية عن المدن الذكية : اصول واسباب هذا المفهوم, الدعائم لاساسية, البنيه التحتيه, المميزات الرئيسيه على الصعيد الاجتماعي, الثقافي والبيئي. كما و اعتمدت الاهداف الرئيسية للبحث على منهجية معينه للحصول على تفاصل وشروط المدن الذكية بالاعتماد على الحضارة العربيه لمناقشه دبي كمدينة رائددة في العالم العربي . من الاستنتاجات الرئيسيه للاطروحه توضيح فكرة ان عملية التحول الحضري في المجتمعات المعاصرة لتامين" الذكاء" يعتمد فعليا على استخدام تكنولوجيا المعلومات و الاتصالات اللتي تزيد من فعاليه الحفاظ على الموارد الطبيعية وتوفير مستوى عالي للمعيشة لجميع افراد المجتمع. المثال الذكي(دبي) يوضح الدور الفعال لقادتها ببناء كل قطاع وجزء فيها باداء قوي وفعال لتحقيق مفهوم المدينة المستدامة الذكية وجعلها مرجع وايقونه للذكاء ليس فقط في الشرق الاوسط ولكن على المستوى العالمي ايضا.

الكلمات المفتاحية

- لمدينة الذكية: البنية التحتية, المتطلبات, القضايا المستدامة
- الدول و الثقافة العربية
- دبي

INDEX

LIST OF FIGURES

List of tables

List of abbreviations

DAFZ……Dubai airport free zone
DEC……Dubai economic council
DEWA……Dubai electricity water authority
Dh…… Dirham emirate currency
DHA……Dubai healthcare authority
DHCC……Dubai healthcare city
DIFC……Dubai international financial centre
DM……Dubai municipality
DMC……Dubai media city
DSG ……Dubai Smart Government
EPSS……Environmental protection and safety section
GDP ……Gross domestic product
GHG ……Greenhouse gas
ICT……Information and communication technologies
IOT……Internet of things
IT……Information technologies
ITS ……Intelligent transportation system
KHDA ……knowledge and human development authority
KSA……The Kingdom of Saudi Arabia
MENA……Middle East and North Africa
MW ……Megawatt
PV……Photovoltaic panel system
RTA ……Road transportation authority
UAE……United Arab Emirates
UN……United Nation
WMD……Waste management department

Chapter 1. Introduction

1.1 Overview

Nowadays the urban areas are, in general, crossing through what can be called 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 with the increasing awareness and concern about the environmental issues, urbanization and technological development have caused an urgent need of rethinking the way how the construction, the management and the qualification of cities should be achieved. These goals include the economic, social, and environmental sustainability which are sharing to improve thriving culture and this will only be made possible by promoting the city's efficiency, requiring the integration of infrastructures and several services regarding the economic, social and environmental achievements. In modern societies most of the cities and urban areas are facing many difficult challenges.

One of these challenges has to do with the rapidly increasing of the population in the recent decades, when the world has witnessed a sharp increase in urbanization with a number of people dwelling in cities growing exponentially every day. In fact, urban areas are growing by almost 150 000 people per day (AA. VV., 2014d: 3), caused by migration or births, in 2014 (AA. VV., 2014a: 2) more than 54 %of the world's urban population were living in cities according to the United Nations, compared with 30% in 1950 and it is projected to rise by 68% in 2050 (from 3.6 billion to 6.3 billion). Therefore, more than 50% of the world's population will live in cities soon which make a huge pressure on urban infrastructures such as in transportation, housing, water, power, and city services in general. In this sense, there is an urgent need to explore the development and evolution of cities, in order to make them more efficient, i.e. smarter.

Another problem that cities are facing is related with the increasing of greenhouse-gas emissions (GHG), has a result of the human activities. They are responsible for almost all of the increase in greenhouse gases at the atmosphere. In fact, around 70% of global CO_2 (Marchal, V., Dellink, R., 2011: 5) emissions derive from cities, and most of the carbon dioxide is produced by people using energy resources, by buildings, industry and transportation. Consequently, there is the need to encourage people to development a set of good practices related to sustainable strategies for

energy generation and distribution, transportation, water management, urban planning, and eco-friendly (green) buildings, promoting the use of less energy, which causes a lot of CO_2 emission at the atmosphere.

Despite the problems that were mentioned above, since the 1970 with Jane Jacobs in the "Economy of Cities", saying that people are richer because they were living in cities, it is defended that the economic growth is polarized in cities. In fact, the GDP 'gross domestic products' is one of the primary indicators used to standard the health of a country's economy and the largest global cities will contribute most of their GDP global growth. However, at the same time, in many societies and regions of the world the resources are scarce, because any resource has a non-zero cost to consume like (including air, water or fuel). So depending on urbanization density, the demand for these resources will rise, in a context where the planet's natural resources to satisfy these demands are finite.

All these facts are examples that show that cities and megacities are fertile places for the emerging of new kinds of problems such as: scarcity of resources, traffic congestions, and human health concerns, difficulties in waste management, air pollution, or deteriorating and aging infrastructures. All of these issues are among the more basic technical, physical, and material problems of urban areas, and many of them can be reduced through the adoption of scalable solutions that take advantage of information and communications technology (ICT).

The use of ICT can contribute to increase efficiencies, reduce costs, and enhance quality of life of cities dwellers, helping the urban areas to become more efficient in economic, social or environmental terms. The literature reveals that cities that take this approach are commonly referred to as 'Smart Cities'. In fact, to make the cities smarter they should be able to achieve solutions to address all the previous challenges. That's the reason why there is the need that all provided services will work properly, providing communication with nature, such as rivers are connected with oceans, oceans are connected with cities, and these later are connected to countries and so on. In smart cities information can flow rapidly and easily, with the result that every point of the urban area will be engaged in favour of the city as a whole.

The smart cities are not only a topic reason among the researchers, but also among the political leaders and the decision-makers regarding the urban areas. In fact, the literature reveals a continuous development among cities studies in general, and as well in particular regarding societies, countries or regions where this concept is emerging more recently, which is the case of the Arabian countries. Some pioneer examples of smart cities are emerging among the Arabian culture and territories. The case of Dubai located at the United Arab Emirates is an example

where in a short period of time corresponding to 4 decades from one small and badly known urban area became a pioneer reference in terms of smart cities requirements, not only among the Arabian region but also considering the global scale. However, there is a shortage of academic references focused on the study of Dubai as a smart city. The known studies about this city are mainly focused on Dubai's urbanism as a whole (Alawadi, K., 2017), on Dubai's particular zones such as the port-city (Akhavan, M., 2017), or on its urban development process (Pacione, M., 2005; Nassar, A., Blackburn, G. A., Whyatt, J.D., 2014).

Even though in literature there plenty of examples about the background information regarding smart cities, their assets and key pillars, the smart infrastructure and the features in cultural, social and environmental terms, there are only few examples focused on the Arabian world. This fact is a consequence of many reasons after the colonial period including over population, poor infrastructure and unsustainable economy. In this sense, this dissertation wants to contribute to the inversion of this situation, presenting a study of the smart cities topic, having precisely as a case study, the example of Dubai, in order to understand its process of transformation, according to the requirements of a smart city. In fact, in the short period of two decades, after the discovery of the oil in 1970, Dubai has experienced a really fast process of urban development and spatial growth, in order to achieve the smart city requirements.

1.2 Main goals

Regarding the overview presented above, the main goals of this dissertation are mainly based on a development framework, in order to get more details about smart cities requirement, regarding the features of the Arabian culture. It aims to argue around the case study of Dubai as a smart city, in order to understand how a tiny and small urban area, was going through a transformation process, according to the requirements of smart cities in terms of infrastructures, economic, social and environment issues. In fact, the main goal of this research is to take a methodological approach that will enable finding some guidelines in order to answer to the research questions: What does smart city mean in the case of Dubai?

In order to achieve this main goal there is a need of present an approach about the following aspects: How can the concept of smart city be achieved by the urban areas? What does the Arabian culture mean in terms of urbanization process? Which are the main features of the Arab world in general and of each Arabian country in particular, especially of United Arab Emirates where Dubai is located?

Finally, this dissertation aims to present a development framework, comparing some of the very well-known cases of smart cities in the western societies, such as Vienna in Austria or Barcelona in Spain, with the pioneer example of Dubai in the Arabian culture.

1.3 Methodology

This research is designed following an organized set of steps in order to achieve the described goals. Therefore, the defined methodology in this dissertation, used to design and implement a development framework about smart cities, focused on the particular case of Dubai, comprises four phases:

1st phase – Literature review: this step aims to present a literature review based on the research and understanding of ideas about smart cities and their requirements, which have been studied by scholars. It aims to understand how infrastructures, economic, social and environmental issues are important at urban areas scale in order to improve their general efficiency. The efficiency of urban areas at these domains in parallel with the use of ICT is a core issue to turn them as smart cities. Considering the concept of smart city, this dissertation will take in account as a methodological process during this 1st step, an approach coming from a scientific perspective like some materials (books, reports, conference and websites), in order to explain how this primary theoretical data and knowledge can be transferred to the practical example, Dubai. This first main step is studying related works under the concept of smart cities by the main objective which is to conduct a review of the existing literature around them, aiming at develop a theoretical background for the subsequent analysis. Particularly it will be presented here how many different views are associated to this field. In detail, it could be argued that, so far, most of the definitions provided for smart cities and their contents.

2nd phase – Analysis of landmark examples of smart cities in western world: this step aims to search, to identify and to study the features of western cities which are very well-known as examples of smart cities in the world. It will be focused on two European examples, the case of the city of Vienna the capital of Austria and the case of the city of Barcelona in Spain. These two cases were chosen because they represent examples of urban areas where there are for many years a culture of good practices in terms of infrastructures management in favour of high standards of efficiency, social, environmental and economic concerns in order to improve the quality of life of their dwellers.

3rd phase – Analysis of Arabian culture and countries: this step aims to describe the main features of the Arabian culture in particular, regarding to the countries that comprise this region

of the world. The point is to identify and to understand the advances on this culture during the last years in terms of urbanization process transformation. Aspects such as the evolution on the use of ICT, or the evolution on the population living in cities will be considered. This 3rd step aims to collect some data, and to provide a look about the Arabian culture. It will be important to improve information about the Arab countries, in order to try to understand the evolution of the urbanization process, and the surroundings background of the city of Dubai.

4th phase – Approach of Dubai as a pioneer example of smart city in Arabian culture: this step of this dissertation aims to present and to analyse in detail, the case of the city of Dubai in United Arab Emirates. This example is considered as a landmark regarding the features and requirements of smart cities in Arabian world. This analysis will contribute to improve the knowledge about this city, which is still scarce in literature. It will be focused on the improvements of this city in the recent years in terms of infrastructures and the use of ICT, enabling this urban area to reaching high standards of efficiency in terms of several urban indicators such as mobility. These improvements with their performance are having effects in social, economic and environmental quality of its dwellers. In summary this last step of this dissertation will show the feasibility of Dubai as a case study of a smart city.

1.4 Framework

This dissertation is organized in 3 main parts: The first part relates to Chapter 2, which is about the requirements and challenges of smart cities in the contemporary society. It will start at point 2.1 with an approach about the "Assets of sustainability in a globalized urban realm", including the assets of growth of smart sustainable cities, such as the globalization of environmental problems as climate change or sustainable development, the urbanization and urban growth processes, and the advantages of the use of information and communication technologies (ICT) in the urban context. Then this Chapter will present in point 2.2 an approach focused on the "definition of smart city", and the discussion about the concept of smart city, which are considered as pivotal issues of this dissertation. The point 2.3 will be focused on the importance of infrastructures in smart cities and the point 2.4 will talk about some advantages and key pillars of smart cities. The point 2.5 will present a synthesis of the main features of smart cities and finally, the point 2.6 presents two crucial examples if good practices in terms of smart cities in the western societies, the case of Vienna in Austria and Barcelona in Spain.

The second part of this dissertation relates to Chapter 3 "Features of Arabian cultures and countries". This Chapter will provide an overall view about Arabian culture, maps, population

and area for each country. It will start with a general approach about Arabian countries, their demographic evolution and their geographical conditions. The 22 Arabian countries will be divided according to their geographical roots in three main regions: the Levant area in point 3.2.1, the Persian Gulf area in point 3.2.2, and the Al Maghreb region in point 3.2.3. The three most representative countries in each one of these three regions will be analysed in detail.

Finally, the third part of this dissertation relates to Chapter 4 which is entitled "Dubai as a pioneer smart city in Arabian world". It will start with a brief framework approach of Dubai, its history, location and demographic evolution in point 4.1.1 It is concentrate on this case study, Dubai, and its urban development which conclude four main phases, presented in point 4.1.3. The choice of Dubai is based on the reason that this is the most important city in the Middle East, and one of the seven emirates cities that make up the United Arab Emirates. In point 4.2 the analysis will continue focused on the importance of the inclusion of physical and digital infrastructures in the transformation process of the urban area of Dubai, in order to become a pioneer example of a smart city. This is reality not only considering the Arabian World but also at the globalized scale. This Chapter will be concluded with a characterization of the key factors of smart Dubai in point 4.3 in order to achieve the key pillars of its sustainability.

1.5 Literature review

This literature review aims to present an overview based on the bibliographic reference, having as central topic the smart cities concept. It aims to enable to make a clear outline of smart city features into a holistic conceptual reference model, and to show the contemporary research and approaches among the scientific realm about this issue. Nowadays, is generally accepted that the concept of smart city offers a revolutionary vision of urban sustainability. In the 1980s a series of conversations among scholars and practitioners, experts in urban studies, emerged concerning a new idea which was called the computing cities, that should be considered in urban development plans (Harrison, C., Donnelly, I. A., 2011: 2-4). When this term started to being used, the used concept was 'wired cities', which is the seeds of today's smart cities. In the 1990s the smart growth movement arose, supported by new policies for urban planning, based on the idea that urban development decisions have effects on anything related with people's lives, ranging from the personal issues to communication, crucial to the nations success. For instances, aspects such as health, traffic, environment, economic growth, and so on should be considered for helping in the maintenance and development of the attractiveness of cities.

According to the same authors, by the time the term of smart growth was recognized during the mid of 2000 by some technology companies in order to develop complex information system to integrate the operation of urban infrastructure and services like 'transportation, water supply or sewage system. Later on, the smart growth approach has given a way to smart city approach which relies on ICT development and sustainability of urban infrastructures and services (Harrison, C., Donnelly, I. A., 2011: 2-3) In this sense, the evolution of the concept of smart city has its roots in the concept of wired cities, crossed by the concept of smart growth in a first step supported by new urban policies on the behalf of public authorities, and then by the concept of smart growth used on the behalf of technical companies, engaging the private realm. Finally, in the last step of its evolution until nowadays, the concept of smart city relies on the efficient use of ICT tools in order to provide a better quality of life for their dwellers (Fig. 1).

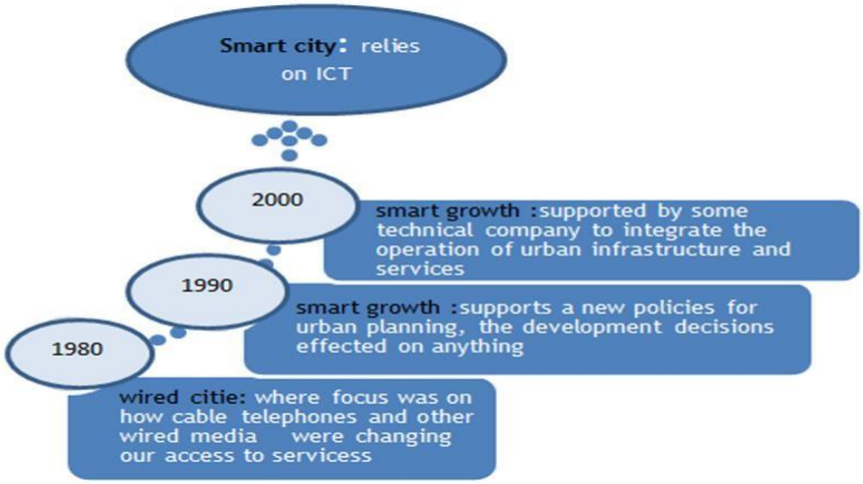

Fig. 1 Evolution of the concept of smart city 1980-2000.

The referred evolution process of the concept of smart city along the last two decades of the 20th century has as a result that in nowadays society it became very popular, standing on the top of the political agenda at global scale. Thus, the goal of making the smart cities is an increasingly popular approach around the world, not only in the western region but also in the Arabian parts.

In parallel, this concept is not only attractive for political decision-makers but also among the scientific writings. Several authors are aiming to find a universal definition for smart city but it is still an attempt. Some of these authors are focused on the importance of Information Technologies (IT) for smart city achievements in their definition. For example, Antony Townsend whose 2014 publication book provides an analysis of the recent route of smart cities offers the

one of most summarized definitions of smart city. He defines smart cities as "places where IT is combined with infrastructure, architecture, everyday objects, and even our own bodies to address social, economic and environmental problems" (Townsend, A.M., 2013: 15). Townsend's definition is not narrowly focused, but it's open expansive, given that he determines how it is possible to achieve the main pillars for smart city which are in his opinion the social, economy and environmental efficiency of urban areas.

Other authors, such as Sotiris Zygiaris argue that the term of smart city could be defined by the concentration on some essential points, which should be provided to achieve smartness as green, interconnected intelligent and innovation. He says in one of his articles written in 2012 that a smart city should be understood "as a certain intellectual ability that addresses several innovative socio-technical and socio-economic aspects of growth" (Zygiaris, M., 2012: 5). In fact, he defends that these aspects "lead to smart city conceptions as "green" referring to urban infrastructure for environment protection and reduction of CO_2 emission; "interconnected" related to revolution of broadband economy; "intelligent" declaring the capacity to produce added value information from the processing of city's real-time data from sensors and activators" (Zygiaris, M., 2012: 5). This author goes further arguing that smart cities depends on "city's ability to raise innovation based on knowledgeable and creative human capital" (Zygiaris, M., 2012: 5). In synthesis, terms such as "innovating" and "knowledge" are key pillars in the opinion of this author in order to make cities smarter.

Also some of the researchers who support the idea of smart city noticed that to make a city "smart" there is the need of using smart computing to deliver its core services to public in a remarkably efficient manner. Washburn defines smart city has depending on the use of computing technologies in order "to make the critical infrastructure components and services of a city which include city administration, education, healthcare, public safety, real estate, transportation, and more intelligent utilities, interconnected, and efficient" (Washburn, D., Sindh, U., 2010: 2).

On the other hand, some authors recognize that improving the city performance will be step by step, starting from the urban infrastructures. In this sense, Harrison says that the challenges that cities are facing to be smarter, are based on the connection in between "the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city" (Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., and Williams, P., 2010: 2).

The authors of "Smart cities Ranking of European medium-sized cities" technical report identify the key areas of activities that are related to the concept of smart city, which are the following

aspects: industry, education, participation, technical infrastructure and various soft factors. They stress the concept of associated with an urban area "well performing in a forward-looking way in six characteristics" (Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., Meijers, E., 2007: 10): smart economy, smart people, smart governance, smart mobility, smart environment, smart living built. In summary they consider a smart combination of "endowments and activities of self-decisive, independent and aware citizens" (Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., Meijers, E., 2007: 11).

According to the whole previous study, research and readings, it can be said that in the current societies, cities are facing complex challenges as huge urbanization or scarcity of natural resources that endanger the quality of life enhancement. Moreover, cities are the future of human kind and this is the departure point of thinking about a new concept that can be able to promote the resolution of many current and future challenges in urban areas all around the world, which are the smart city requirements.

In fact, the literature reveals that smart city is a problematic concept, that has come to mean several different things, but that basically could be understood as a new solution for better management of natural resources and physical infrastructures like energy, water, waste, building, transportation and so on, by take advantage of information and communication technology. The use of ICT tools will provide a more intelligent, smarter and efficient management of resources, helping to reduce costs, saving energy, providing quality of life and service delivery for all the citizen, not only for the rich category. Also it will promote the reduction of environmental pollution by supporting innovation and low carbon economy.

Is possible to conclude that smart cities are useful to ensure and provide three main factors to achieve sustainability, firstly economic sustainability which is able to promote a higher productivity feature, secondly the social sustainability in order to ensure the connective between citizen and their major activities. Last but not the least, the environmental sustainability that can be illustrated by the services provided on environmental health. However, to establish the concept of smart city there is the need of integrating all the various cities' systems and to delineate their main characteristics, which couldn't forget the following aspects: smart people, smart governance, smart mobility, smart economy, smart living, and smart environment.

In summary, a smart city is not a concept in the scientific fiction realm, but a reality related to a new trend that has arrived to stay, trying to manage the natural resources in order to let them be more livable, efficient, sustainable and safe for people.

Chapter 2. Requirements and challenges of smart cities in contemporary societies

2.1 Assets of sustainability in a globalized urban realm

The globalization of environmental problems and the rising concerns among societies in general and the scholars in particular around the issue of the sustainable development are having their influence in the cities approaches. Therefore, in the research context that this dissertation will have a look, there are four propositions that can be seen as the seeds from which the concept of smart city or eco-city has grown (Höjer, M., Wangel, J., 2014: 2-3). These four propositions are the following: climate change, evolution of population living in urban areas, sustainable cities, and ICT.

2.1.1 Climate change as a main issue

The contemporary society in this globalized world has several important effects on the environmental realm and in the way of understanding the process of clarifying the major environmental damages. In this context, the goal of achieving a sustainable development is made by several means including economic analysis and policy making. However, it can be said that all-over the last forty years the environmental problems were mainly seen as a local issue created locally and having mainly local effects.

The United Nations (UN) is one of the organizations on the global scale that has been drawing attention to the importance of putting on the top of the political agenda environmental problems, especially throughout the very-well known Brundtland commission report, from 1987, of the World Conference on Environment and Development (AA.VV., 1987a). This report drives the environmental issues around one slogan created to improve the awareness about sustainable development for people which was “think global, act local”. This idea aimed to accentuate clearly the strict points not only to reduce the environmental problems, but also to reduce the social conflicts.

Since 1988 that climate changes related with the global warming is part of an Intergovernmental Panel on Climate Change of the United Nations that explores the causes and the potential effects of climate changes all around the world. These studies have concluded that climate changes are

really caused by greenhouse emissions, which are mainly the result of CO_2 sources such as industrial production, transportation, and more indirectly deforestation. These changes can be seen in the steady rise of temperatures in 1.8° C Celsius from 1970 until 2050, according to the predictions of some authors (Huwart, J. Y., Verdier, L., 2013: 119) (Fig. 2).

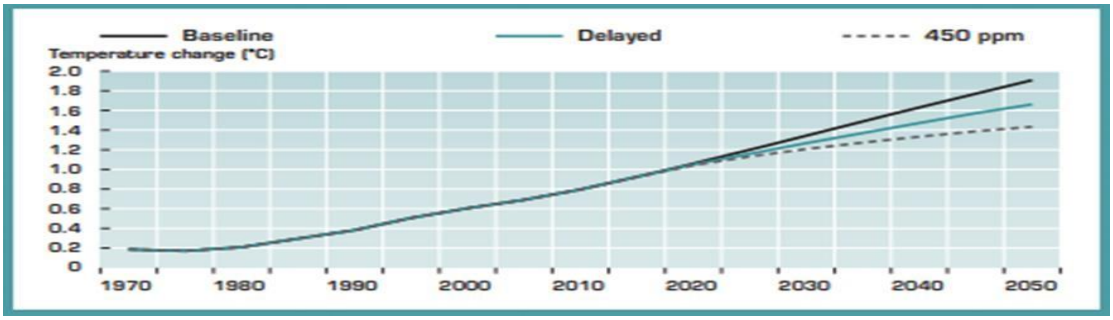

Fig. 2 Temperature change in the world 1970-2050 (Huwart, J.Y., Verdier, L., 2013: 119).

During this period of time, hottest temperatures were in the years of 1994, 2000, 2002, 2003 and 2006. Global temperature will continue to increase, and because of this aspect, the sustainability of the societies in general and of the urban areas in particular, will be depending on the effectiveness and ambition of GHG emissions (Huwart, J.Y., Verdier, L., 2013: 110).

According to climate changes, the indicators of the seasons of the year are changing. For example, in the 1970s, the annual cumulated snowfall was as high as 13 meters, and nowadays is never going above 8 meters. These climate changes problems such as the global temperature increasing should be considered along with other issues. Global warming isn't the only environmental problem in contemporary societies that also have problems related with the following aspects (Höjer, M., Wangel, J., 2014: 2):

- The rapid decline in biodiversity, not only in terms of flora but also in terms of fauna;
- The imbalance in the cycles of nitrogen and phosphorous;
- The acidification of oceans and changes in land use.

All these problems that are affecting the population and the urban areas are at the cutting edge of the discovery of efficient solutions in order to solve them, in this society characterized by an enormous and rapid urban growth, in all countries, regions or continents.

2.1.2 Evolution of population living in urban areas

In the current century and globally, more and more people are living in urban areas. According to a report from the United Nations (World Urbanization Prospects, 2014) the number of inhabitants living in urbanized areas, was about 54% of the world's population in 2014, corresponding to 200 million people living in cities. This number will increase 12.5% (in between 2014 and 2050).

This means that the urban areas of the world are expected to absorb the population growth over the next four decades. The urban population in 2050 is estimated to account 66% of the global population, two times more comparing with the inhabitants of the rural area (34%), which means that the rural population is growing slowly in compared with the urban population. Moreover, and depending on the United Nations Environment Programme and the Sustainable Urbanization Policy Brief (AA.VV., 2014a: 7) suggest that cities contribute to approximately 70% of global energy use and greenhouse gas emissions. However, cities are only occupying in territorial terms 5% of the earth's landmass. This fact explains why cities should provide the basic services to the dwellers and improve all the public services in order to achieve the quality of life for citizens and to provide a more efficient balance for the earth survival.

The following figure (Fig. 3) is useful to explain this urban and rural population evolution in the world, in the recent years. According to this picture, the purple curve refers to the urban population and the blue curve refers to the rural population in between the year of 1950 and the prediction for the year of 2050. It is possible to see the increasing of the population in the urban area from less than 1.000 million to approximately 7.000 million, in the opposite direction in terms of evolution for the rural areas.

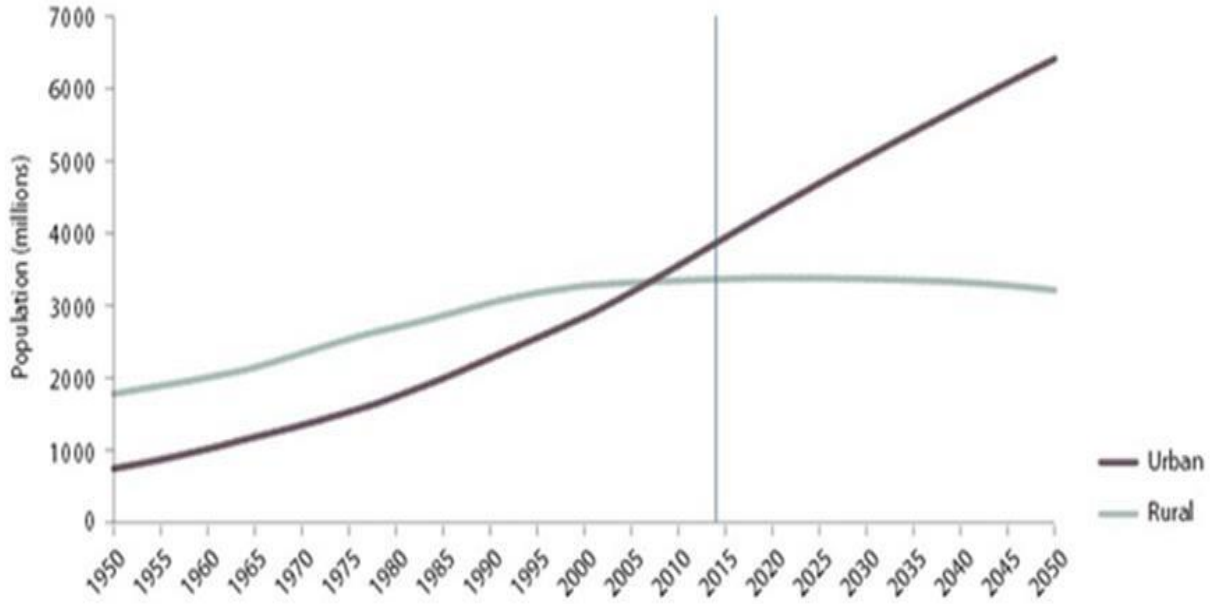

Fig. 3 Urban and ruler population (1950-2050) in the world (AA.VV., 2014a: 7).

In more details the urbanization process will achieve and take a place throughout the population growth, and the expectations about levels of urbanization will vary greatly across regions in the next years for instance. This evolution is expected to have the following features (Fig. 4):

- On the one hand, in the more developed regions and countries, the estimated population living in urban areas, is above of 80% (in 2014). This is the cases of Latin America and the Caribbean, while in Europe is around 73% the percentage of people living in urban areas;
- On the other hand, in the less developed regions like Asia or Africa is expected to be 49% the percentage of inhabitants living in urban areas (in 2014).

Regarding to the above mentioned aspects, as over the coming decades, the level of urbanization is expected to increase in all regions of the world, with Africa and Asia urbanizing faster than the rest. Nevertheless, these two continents are projected to reach 56% and 64% respectively of people living in urban areas by mid-century in 2050 (AA.VV., 2014a: 7).

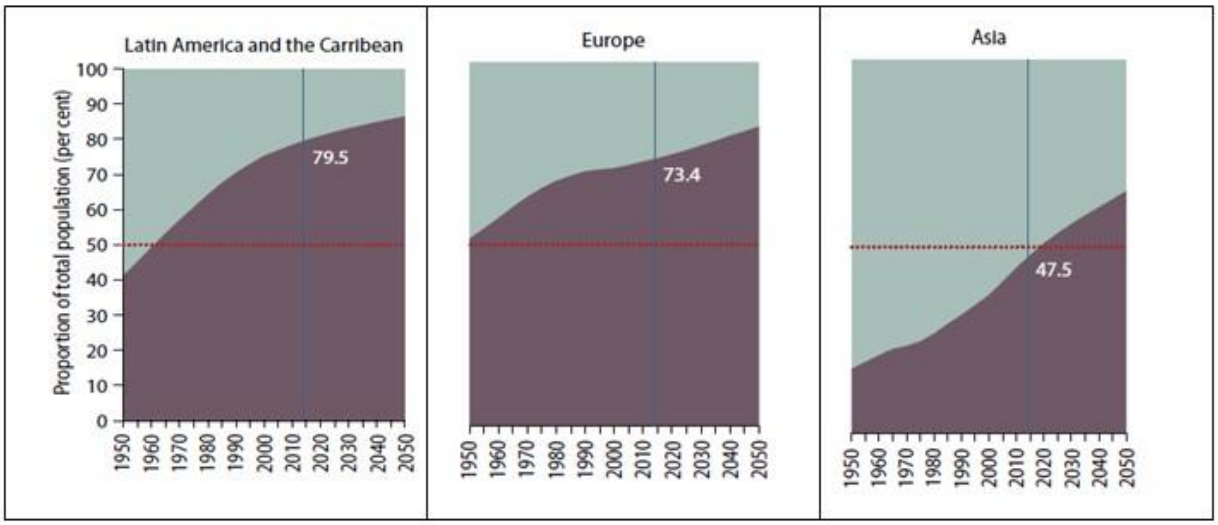

Fig. 4 Urban and rural population evolution (1950-2050): Latin America and the Caribbean, Europe and Asia (AA. VV., 2014a: 8).

In summary, depending on global statistics the world's population will increase in the urban areas more than 66% which means more use of the energy, land and resources. This transformation requires resources for the enormous increasing population until the next 40 years, according to which there is the need of having three earths in order to support the planetary inhabitants as a whole, which is not likely to happen. Thus, the way ahead for urban development is really difficult according to the previous reasons addressed around the urbanization issues to be sustainable.

2.1.3 Sustainable cities

The idea of sustainable cities is coming from the combination of sustainable development and urbanization issues, in order to get sustainable urban development as a prerequisite for urban areas. In the current times, the sustainable city concept has been manifested in several parts of the society education, policy making or business. For example, on educational realm, the sustainable city can be seen in terms of university education, research programs, scientific journals or university researches, to devote addressing the sustainable urban development.

On policy making realm, especially in public sector, sustainable cities are topics in the agenda of international forums, charters and organizations, and in national programs and targets.

Considering the private sector, the sustainable cities have appeared to focus mainly on infrastructures for urban metabolism, such as water supply, energy, sewage system, or waste management within the urban areas.

2.1.4 Importance of ICT

The idea around sustainable development comes from the comprehension to the pressure that is imposed by humankind on the global ecosystem and urbanization process, which is a result of moving people to the urban areas. At the same time, ICT development is commonly realized to be a technological achievement, where could have a symbiosis in between ICT and urban growth. The first emergence of communication technology form was as a telephone and telegraphs, which contributed to support urban growth by facilitated connection between cities and highlighted the importance of ICT development.

The development of ICT has had a massive influence on organizing peoples live, leisure, the way how they work and interact within society (Townsend, A.M., 2013) as well as provided the reduction in cost and huge size of computing to get a number of new products, services and business models, depending on the environmental perspective. Actually the ICT development has scored many unique challenges, such as the following:

- On the one hand, ICT has made it possible to digitalize music and books for instance and has made it possible to communicate without travelling;
- On the other hand, the ICT development has increased productivity, leading to even cheaper products and supporting the consumption society.

Two recent changes in global ICT development and uses are able to provide a basis – but also a challenge – for cities to become smarter (Townsend, A.M., 2013):

- The first is the transition from wires to wireless, including both telephones and internet access;
- The second development concerns the increasing number of devices being connected to the internet, leading to a transition towards an “Internet of Things”.

2.2 Definition of Smart City

The suggestion for computing cities in urban development plans in the 1980s, were the seeds of smart city concept, which can be traced back to at least smart growth movement of the late 1990 onwards.

Nowadays the most attractive and used concept is "Smart City" which draws enormous interest for both, public and private realms, including for the business sectors to generate challenge and make the market interesting for the big companies that have the potential to develop broad solutions involved in ICT infrastructures. Some of these companies are Siemens (with its roots in Germany) and Cisco (with its roots in California) which are aiming to be the electrician and the plumb references for smart cities (Townsend, M., 2013). If the goal is to get the best results to determine the smart city definition there is the need of thinking first of all about the main concepts involved on this definition, and what they mean, which are the following: “smart” and “'city” (Höjer, M., Wangel, J., 2014: 7).

On the one hand, the concept of **smart** in smart city is an instrumental more than normative term, related to the features rather than to the performance of the urban areas. For this reasons the opposite of “Smart” is not considered to be “Dumb”. The term smartness could be used without holding any value that’s what instrumental means. The smartness is prefix label for services, products and product service where ICT plays a major role. Therefore, a smart city is an urban area which is advanced in terms of ICT, using them in the most established and efficient way.

On the other hand, the concept of **city** is as well an instrumental term, which could combine between smart and sustainable aspects in order to keep them in touch. This concept belongs to an empirical category used to determine the types of human structure and environment where smart solutions can be applied to get a more sustainable development. In this sense, the term city is not seen as optional but is taken for granted, based on the assumption that cities can be beneficial to smart sustainable development.

In general, cities should not only provide an effective management for resource infrastructures and public services, but at the same time they should support sustainable environments for their dwellers and a long term of economic growth. These two tasks can be considered as key pillars of cities’ role by becoming smarter.

The aim of improving every part in the city’s system (starting from the infrastructures related with energy, transportation, buildings, education, water supply, health care or public safety) is

the first basic condition in order to generate the integration of the term for smart city. Therefore, what could be considered as a definition of smart city?

Actually, such as happens regarding the concept of city, there is no universally definition for the term smart city. In fact, it means many different things to different points of view or research. This concept is still emerging and various from one city to another, from one country to another or from one culture to another. Consequently, it depends on the level of development of the societies that are being considered. The meaning of smart city refers to the three following requirements (AA. VV., 2015: 5):

- The existence of a set of instrumented facilities, which means that the urban area is ready to capture and integrate the real world data by using tools such as sensors, meters appliances, personal devices, and other similar sensors;

- The existence of an interconnected urban area, which means the integration of data into a computing platform that allows the communication of such information among the various city services;

- The existence of intelligence, which refers to the inclusion in the urban area approach, of complex analytics, modelling, optimization, and visualization services, in order to make better operational decisions, among the city's decision-makers.

In summary the previous requirements associated with smart cities are based on a new model of managing the cities, that applies the generation of information technology like internet, promoting the facilitation and beneficiation of many aspects of urban daily life, such as the industrialization, the urbanization development, the public services, the transportation systems, or the management of traffic flow, for example facilitating the ambulances how to know the best way to arrive in an accident place in a short period of time.

With no doubt the concept of smart city focuses on using ICT in all aspects of the cities' daily life, with specific opportunities and challenges such as those related with big data, or specific domains of application such as smart transportation or smart land use planning.

Despite of the variations there are some features which can be associated with the concept of smart city. A smart city is a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses. It is also a place where there is an "effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and

inclusive future for its citizens" (AA.VV ., 2014 b: 4). A smart city is a place where there is an intensive use of high-tech and advanced digital networks connecting people, information and city elements, through the use of new technologies in order to create a sustainable, greener city, competitive and innovative commerce, and an increased life quality (Bakıcı, T., Almirall, E., and Wareham, J., 2012).

Several authors are sharing the idea that smart cities initiatives try to improve urban performance by using data, and IT in order to provide more efficient services to citizens, to monitor and optimize existing infrastructures, to increase collaboration among different economic actors, and to encourage innovative business models in both the private and public sectors (Marsal, M. L., Colomer, J., Meléndez, J., 2014). Therefore, being a smart city means using all available technology and resources in an intelligent and coordinated manner, in order to develop urban centers that are at once integrated, habitable, and sustainable (Barrionuevo, J. M., Berrone, P., Ricart, J. E., 2012: 50). The application of ICT with their effects on human capital/education, social and relational capital, and environmental issues is often indicated by the notion of smart city (Lombardi, P., Giordano, S., Farouh, H., Yousef, W., 2012).

Other authors refer that a smart city is a place where IT is combined with infrastructure, architecture, everyday objects, and even our own bodies to address social, economic and environmental problems (Townsend, A. M., 2013: 15). A smart city is a place performing well in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the efficient combination of endowments and activities of self-decisive, independent, and aware citizens. In this sense, a smart city generally refers to the search and identification of intelligent solutions which allow modern urban areas to enhance the quality of the services that they provide to citizens (Giffinger, R., Haindl, G., 2009). A community of average technology size, interconnected and sustainable, comfortable, attractive and secure is a smart community (Lazaroiua, G.C., Roscia, M., 2012).

A smart city is understood as a certain intellectual ability that addresses several innovative socio-technical and socio-economic aspects of growth. These aspects lead to smart city conceptions as "green" referring to urban infrastructures for environment protection and reduction of CO_2 emission, "interconnected" related to revolution of broadband economy, "intelligent" declaring the capacity to produce added value information from the processing of city's real-time data, from sensors and activators. Whereas the terms "innovating", "knowledge" cities interchangeably refer to the city's ability to raise innovation based on knowledgeable and creative human capital (Zygiaris, S., 2012).

As was said previously, the use of smart computing technologies to make the critical infrastructure components and services of a city, includes city's administration, education, healthcare, public safety, real estate, transportation, and utilities which are more intelligent, interconnected, and efficient (Washburn, D., Sindhu, U., 2010: 2).

Two main streams of research ideas could be considered regarding smart cities. The first is that smart cities should do everything related to governance and economy, using new thinking paradigms, such as Participation in decision-making, diversifying economic sectors and providing green economics. The second says that smart cities are all about networks of sensors, smart devices, real-time data, and ICT integration in every aspect of human life (CERTU, L.V., 2012).

In fact, smart cities are considered as territories with high capacity for learning and innovation, which are built in the creativity of their population, institutions of knowledge creation such as universities and research centers, and digital infrastructures for communication and knowledge management (Komninos, N., 2011). Consequently, smart cities are the result of an intensive knowledge and creative strategy, aiming at enhancing the socio-economic, ecological, logistic and competitive performance of cities. Such smart cities are based on a promising mix of human capital (e.g. skilled labour force), infrastructural capital (e.g. high-tech communication facilities), social capital (e.g. intense and open network linkages) and entrepreneurial capital (e.g. creative and risk-taking business activities (Kourtit, K., Nijkamp, P., Arribas, D., 2012). A city connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence, can be considered as a smart place (Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., and Williams, P., 2010: 2) referring to a local entity - a district, city, region or small country, which takes a holistic approach to employing IT with real-time analysis that encourages sustainable economic development (Singapore, 2012).

Finally, regarding the previous definitions around the concept of Smart City as a whole, this dissertation understands that it includes the connection in between human and social capital, with the use of ICT infrastructures, in order to achieve sustainable development. At the same time, it uses ICT in all the resources combined in a sustainable and environmental friendly way, in order to be more intelligent, smarter and efficient. This approach contributes towards less cost, saving energy, providing more services delivery, quality of life, and reducing environmental pollution. All these aspects are supporting innovation and a low-carbon economy.

2.3 The infrastructure of the smart cities

Making the city smart not only means to house citizens, but also provide good conditions and opportunities to improve their personal and entrepreneurial potential. So city should achieve good environmental backed with affordable and efficient infrastructures. Otherwise, it will fail to be smart. Nowadays, smart solutions have risen rapidly and technical solutions exist for all cities. At the same time mobility in current societies, generate intense competition between cities investment, job, and talent to attract companies, skilled residents, and organizations to promote thriving culture (AA. VV., 2014c: 26). However, the biggest challenge of urban areas today, could be considered the way it is possible to implement the best solutions of efficiency in several domains of urban societies?

Improve the smart city by patch work approach is possible while in work step by step as gradual improvements. So, there is the need of starting with providing urban infrastructures for urban areas, enable them to achieve all challenges of their environment as a whole, including in the following aspects: energy, pollution and emission, water, traffic congestion, waste disposal, and safety risks from ageing infrastructures. All these requests will not be possible without smart infrastructures which act in form backbone for city by integration gas distribution, water distribution system, electric grids, public and private transportation systems, or building houses. These actions should be able to create essential value and score sustainable challenges in social, environment and economical terms for residents and citizens.

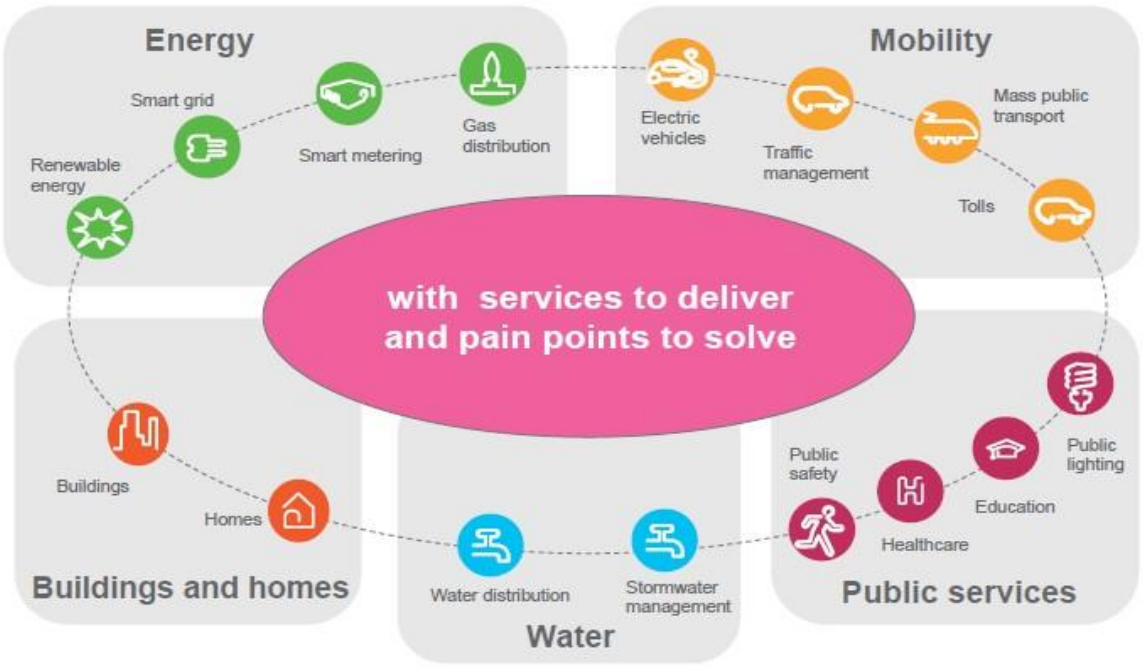

Fig. 5 Operating systems making a city's infrastructures (AA. VV., 2014c: 26).

According to the previous image (Fig. 5) is possible to see the required information to make the city smarter. Basically, it is based on a glimpse on the backbone of the city, which creates the framework for developing infrastructures, taking into account the smartness of the different functions of the cities' infrastructures, such as the following:

- Basic infrastructure energy (gas, electricity), mobility (public transportation or electric vehicles) and buildings;
- Public services education and health care, among other aspects.

The digital infrastructures include broadband, computing, sensors, smartphone and mobiles, networks, and data basics. So, using them, the city can get information about everything that is going on in core aspects for its efficiency, such as traffic flows, vacant parking spaces, energy use, car crashes, or weather conditions, among several other issues. Using smart phones or other smart devices, and by dealing with them, is a smart option for moving around the city. Last and not least the communicative infrastructure aims to create the atmosphere to connect all the people via same language, as standardization within the coding language of digital devices.

Actually, the infrastructure guides are often considering pedestrian paths, cycling lanes and roads, but the connection with smart city should cover three areas: physical, digital and communicative infrastructures.

2.3.1 Smart physical infrastructure

The physical infrastructures consist of the following six aspects, which are explained bellow.

1. Smart Buildings and Homes: buildings play a major role in the physical infrastructure of cities. They are supposed to provide comfort and security for the citizens. Moreover, they describe many different physical systems, such as lighting control system, parking guidance, fire and life safety control systems, energy management and management systems. These systems work together in an optimized and efficient manner. Regarding the example of United States of America, the statistics say that buildings account 36% of total energy use, 30% of waste output, 30% of GHG emissions, 30% of raw materials used, and 65% of electricity consumption. In this scenario, smart buildings could be a good solution, in order to manage all these previously referred systems, allowing saving as much as 30% of water usage, 40% of energy usage, and reducing overall building maintenance costs by 10-30% (AA. VV., 2016a: 15).

2. Smart Mobility and Transport: the strategies for roads, bike lanes or pedestrian paths should be able to promote the reduction of congestion, accidents, a faster growth of greenery and cheaper transportation options, optimizing the overall traffic situation by using intelligent transportation system (ITS). In this field, smart mobility can be divided in three areas: Mass Transit as Tram, Metro, train and buses. Individual Mobility such as: private cars electric vehicles &car sharing. Finally, the intelligent transport systems for both mass transit and individual mobility by using ICT, GPS and free Wi-Fi.

3. Smart Energy: smart energy depends on using sensors, renewable energy sources, observe and optimize energy distribution, advanced meters. It aims to improve the grid operation and usage by balancing the needs of the different stakeholders involved - consumers, producers and providers (AA. VV., 2016a: 22).

4. Smart Water Management: there are over 783 million people all around the world (AA. VV., 2016a: 24) with no access to clean water. By promoting smart water, it is possible to participate in saving water resources, reducing costs and optimizing reliability and efficiency of water distribution. Moreover, it is possible to integrate data / information network with the physical water pipes network, to better manage for water (controlling aspects such as water flow, pressure or leak in pipes).

5. Smart Waste Management: smart waste systems can promote less health risks, providing not only the quality of life for citizens, but also a positive economic impact on the city, through recycling and generate resources from the waste.

6. Smart Healthcare: this issue is a key word related to smart societies, in order to provide health condition for citizens.

Beyond the aspects referred above there are other requirements connected with smart cities (Fig. 8) which are main function for cities.

The first of these aspects is the existence of a community service layer or the life services layer. Usually, this layer works as city administration services which depends on the improvement of legislative framework and includes important services for urban life, such as a police, education and health for residents and dwellers.

The second of these aspects is the existence of one community facility layer or simply the facility layer. This layer drives to infrastructure services provided and used in the city, for example housing, school, building (offices), transportation, or public transport stations. This layer has two essential aspects as a place where services are provided and as a place where services are used.

The third aspect is the existence of one community infrastructure layer or urban infrastructure. This layer provides principally the necessary physical substances for daily life, such as water, waste management, energy (gas electricity), mobility, and information and communication infrastructures, managed by the infrastructure operators (public or private). Moreover, it is where the physical and digital infrastructures meet.

Finally, there is the need of referring that in some societies such as in India, the core of the infrastructures in a smart city should contain many important aspects such as the following listed below (AA. VV., 2015a: 6).

- An appropriate water supply system;
- Adequate urban mobility and public transportation;
- A proper providing of electricity supply and equipment's;
- Effectiveness for health and education;
- A sustainable environment;
- A sanitation, including solid waste management;

- An appropriate providing of housing, including for poor people;
- An affordable security and safety for all citizens especially for women, children and elderly;
- An active IT connectivity and digitalization of data;
- As efficient governance, especially e-governance and citizen' participation, in favour of the availability and quality of ICT infrastructures.

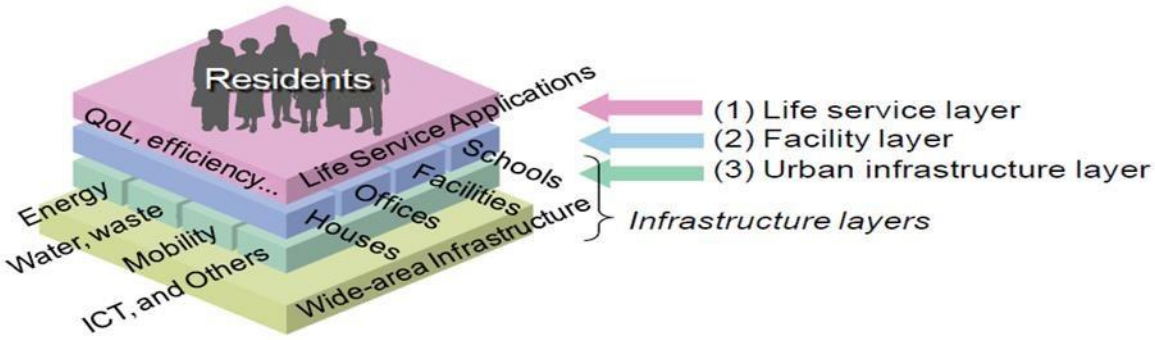

Fig. 6 Model of three layers of city functions (AA. VV., 2016c: 47).

2.3.2 Smart digital infrastructure

Smart cities have many things in order to thrive their condition, trying to make an optimal use of interconnected information available to improve the use of the limited resources (such as oil energy). As well as getting better understanding and controlling of the operations on urban areas (transportation, or water supply among many others) for these reasons the implementation of ICT is a fundamental issue in smart cities development where these tools play a primary role in all of the previous processes, facilitating the aggregation of smart city information for data analysis. ICT are the main cities digital infrastructures that contribute to a smarter performance of urban areas.

Therefore, the management of this information could be useful to create new policies and regulations in order to improve the quality of life for all citizens. Moreover, applying the ICT mean a capacity to computing and providing information in timely manner, for the cities where they can consider and respond according to the best situation. Otherwise they will fall quickly in specific problems, for example the traffic congestion problem (is this case, 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 idea, the use of ICT is a way of give the smart city a new approach, which is related with a predictive city. This is a city where the results for specific events can be predicted, allowing the optimization of quality of life, making the citizens able to be more informed about the situation, and to take educated decisions to the next course of the actions. Consequently, in order to make the city smarter or more predictive, there is the need of identifying specific characteristics of smart city, related with several domains including the following:

- Smart economy;
- Smart people;
- Smart mobility;
- Smart governance;
- Smart environment;
- Smart 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 (Fig. 7).

Fig. 7 Smart City characteristics (AA. VV., 2015b: 10).

Regarding the above scheme, 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, requirement is a short of functionality whose output contributes to a desired outcome, and if achieved, will satisfy a need.

There are many standardization requirements for smart cities that go beyond ICT or that are not involving technology at all. However, the increased propagation of ICT in many areas of everyday life means that even in domains that are not specifically ICT-centered, there are aspects that are nonetheless ICT-influenced. This propagation of ICT helps to transform a city into a Smart

City (AA. VV., 2014c: 8). There is a cycle of transference of the stockholder's needs (Fig. 8), to get the primary requirements to find and create efficient solutions by using ICT.

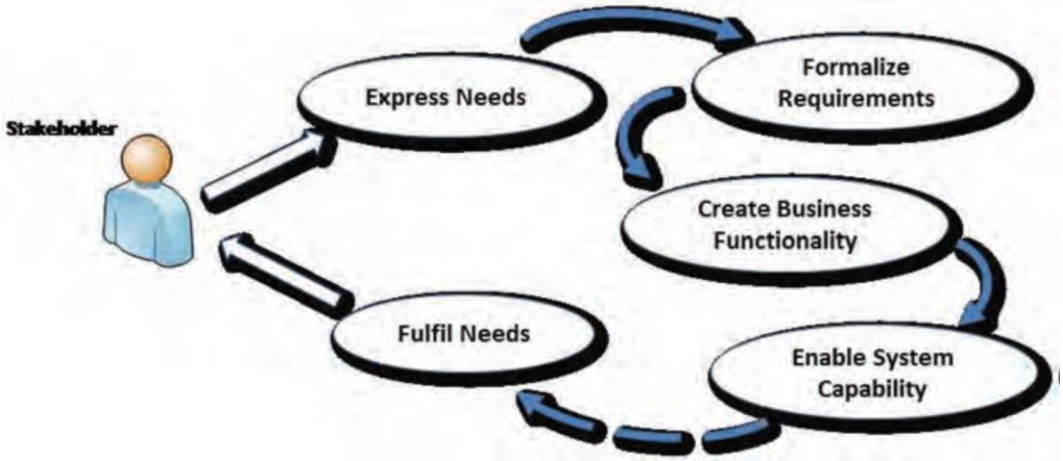

Fig. 8 Cycle of needs, requirements, and fulfillment source (AA. VV., 2015b: 9).

The ICT includes wireless infrastructures such as Wi-Fi networks, wireless hotspots, kiosks, or fiber optic channels. It acts as a glue to integrate all the other elements of smartness of the city by technology as a fundamental platform. Also ICT infrastructure functions as the nerve center and the coordinator of all the different interactions between the various core elements of urban areas. Whatever to achieve a smart city, is possible to develop the ICT and data infrastructure by describe three essential steps: the first one is the propagation of the broadband networks including mobile broadband; the second one is the internet of things by using smart devices and sensors; the third one is to apply the big data for improvement of city' operations (AA. VV., 2016a: 29). These three aspects can be explained in a more detailed way such as mentioning the following contents:

- **Broadband connectivity**: applying smart city technologies is often requiring strength, efficient and affordable broadband network, which are playing a major role in developing urban areas. They concentrate many essential points bridging the digital devices, providing benefits of spreading the smart applications i.e. "smart phone revolution apps with a huge number of apps related to smart cities including, energy, water health, in the same time try to establishing free Wi-Fi access points, and bus with a free Wi-Fi" (AA. VV., 2016a: 30);

- **The Internet of things (IOT)**: as defined by Ashton (Ashton, K., 2009) is "where all objects and equipment in this world will be connected by Internet. And the data generated by all

these things will let the computers know so many things about people" (AA. VV., 2016a: 30). So, the goal of the universal infrastructure of IOT is to connect ICT devices all over the world. However, it is not just about connecting people together, but also tries to open the door for the things to react with one to another. There is an estimated goal that in 2020 there will be 30 billion things (AA. VV.,2016a: 30) with unparalleled IP address all over the world;

- **Big data**: in order to achieve the IOT, there is the need of establishing a center for a big data, which absorbs an extremely huge data and information, that are collected by sensors and devices from the governmental, or public agencies, and from private entities and stockholders (citizens also financiers). A better understanding of big data is useful to predict the future of urban areas performance, and to improve the maintenance and rehabilitation of urban environment.

The above aspects explain why the notion of data and information at the cities' management is now becoming so valuable at the urban scale, as same as water, transportation or electricity power. Finally, it can be said that the city has made up of many physical infrastructure components like buildings, energy, water, or waste, each one of them is a system and made up of subsystems at urban scale, considering all the dwellers or users.

Moreover, the total of these different systems, compose the city as a whole, which is a system of systems, physical and digital. Thus, to improve the city to be smarter there is the requirement of integration t of all these smart infrastructures and ICT, in order to facilitate the cities' processes of management, by the aggregation of all these data streams and systems under a single roof or goal, the improvement of cities' performance in favour of their dwellers.

2.4 Advantages and key pillars of smart city

Such as Albert Einstein used to say, "Necessity is the mother of all innovations". In the contemporary societies, the majority of people live in urban areas. This means more use of natural resources, and public services, and therefore, more needs of efficient solutions in all the aspects of cities' life to get smarter i.e. more efficient of all citizens. One way to understand the necessity of smart cities, is to compare two different situations of a traditional urban area and a smart city, and try to figure out the main differences in between them, such as the listed below, suggested by Lorena Batagan (Table nr.1).

Traditional city	Smart city

Inefficiency of communication with citizens	Good communication with citizens
Inefficient use of resources	Efficient use of resources
Low access to administrative data	Open access to administrative data
A lot of errors in information	Reduced errors of information transmissions
Without support in case of disasters	Increased supports in case of disasters

Table 1: Different aspect in between traditional city and smart city (BATAGAN, L., 2011: 29).

The advantages listed above some elements that made the current societies to think about the importance of the implementation of smart solutions in the cities. All these advantages, comparing with traditional cities are key factors to improve the quality of life through the cities. Although it may take a relatively long time to implement solutions to make cities smart, because some difficulties related with the costs of these new solutions, or the resistance of some citizens which are not aware of the advantages of ICT. But it is necessary to reduce costs of cities' management, to improve efficiencies, and to deliver the quality of life.

Another significant thing that assumes the necessity of smart cities is that they promote the efficiency of urban areas, the connection among people together and the performance of manage infrastructure and resources. The cities that use smart solutions can provide to their citizens, better conditions and qualities of life. For example, the European cities had great effects through the last years on the livelihood for the people, by implementing smart solutions, such as the following (BATAGAN, L., 2011: 27):

- Increasing the employment for both men and women, with different levels of ages and qualifications;
- Increasing the investment levels and innovation of new indicators by improving the conditions of research and work development;
- Reduction of consumption of energy by using sustainable renewable resources, and decrease the emissions of greenhouse gas, this achieve an increased energy efficiency;
- Promoting education levels by reducing dropout rates and increasing the ratio of persons with university degrees or equivalent qualifications;
- Improving community contents by decreasing poverty and eliminating the risk of poverty.

There are considered to be the axes of the application domains, that with few exceptions, can classify as a smart city' requirements. They have to consider and to act at the following aspects of cities' environment:

- Natural resources and energy;
- Transportation and mobility;
- Buildings;
- Living Government;
- Economy and people.

Given that sustainability id is one of the main issues for the nowadays societies, cities' management authorities should try to ensure and improve strategies in order to achieve more sustainable environments, including at the urban scale. According to the Brundtland commission report from the World Conference on Environment and Development the sustainable development is a way of developing countries "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (AA. VV., 1987: 24).

This notion of sustainability is crucial to cover the complete sustainable problems, according to three pillars: economic, social and environmental (Fig. 9). There is the need of achieving a balance between them because if any one of these pillars is weak, the whole system will be unsustainable.

The first pillar is the economic sustainability, which means the need of achieving high productivity standards in cities, provided by business opportunities, in order to generate wealth care services for cities, and financing the public services. The second pillar is the social sustainability, according to what, is necessary to ensure the existence of connectivity between citizens and cities' major activities. The last pillar of sustainability is the environmental realm that illustrates the efficiency of several services in cities, and the contact with nature, greenery, or low pollution emissions (AA. VV., 2014c: 17). The three pillars of sustainability could be applied to the urban areas' scale as pillars of smart cities, keeping the cities apart from the risk of insolvency in economic, social or environmental terms. If the contemporary cities want to achieve smartness, they have to be sustainable.

Fig. 9 Requirements for achieve sustainability.

In a word, the three pillars of sustainability which can be also applied to smart city requirements are the following (Fig. 10):

- Social + Economic Sustainability = Equitable;
- Social + Environmental Sustainability = Bearable;
- Economic + Environmental Sustainability = Viable.

Only through balancing economic, plus social, plus environmental realms of cities and their communities is possible to achieve a true sustainability and a truly sustainable society.

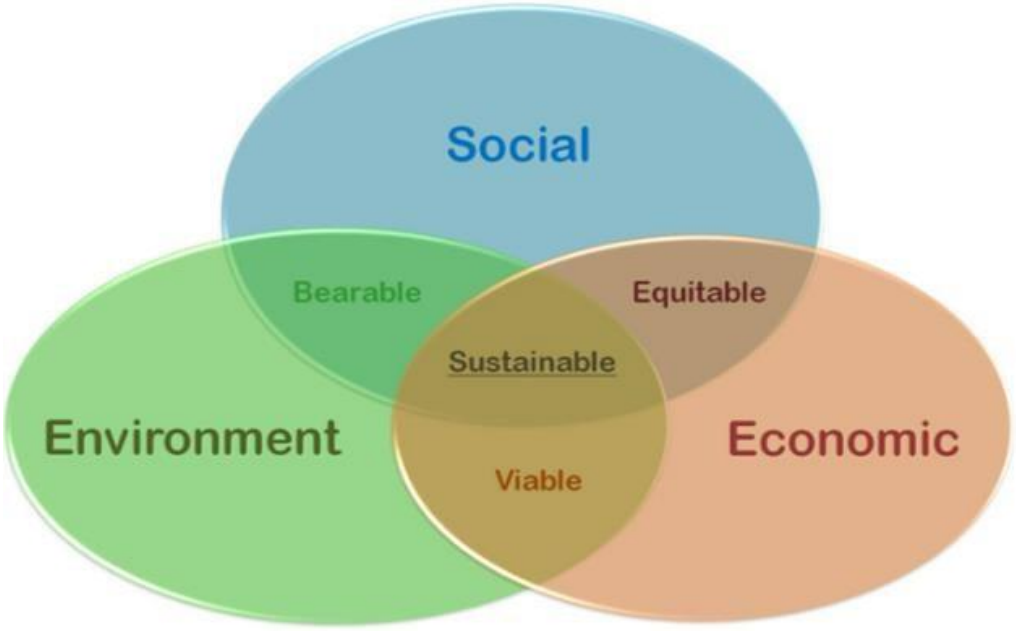

Fig. 10 The three spheres of sustainability (United Nation Environment Program).

2.4.1 Economic sustainability

This pillar ensures the economic growth maintenance, business environment, and wealthy generation capacity of the cities. It represents the gross domestic product (GDP) growth, and provides healthy balance with the urban ecosystem.

The economic sustainable system model tries to define strategies that promote the utilization of environmental and social resources to the best advantages, by insuring and illustrating a fair distribution and efficiency allocation of these advantages. At the same time this model aims to provide the innovation of these resources (environmental and social) in an efficient and responsible way, with the minimal damages for environmental realm, avoiding degradation. In addition to this aspect, the economic sustainability is also associated to the financial realm (AA. VV., 2014d: 18).

In synthesis, the development of the city to be smarter requires a good understanding of the economic fabric of the urban space, and smart solutions providing new approaches to infrastructures financing, and investments in order to improve efficiency in the city structures. According to that, smartness for cities will contribute to economic sustainability, raising the capacity of urban areas and their resilience to react to economic shocks, and to generate economic diversification. In summary, the economic sustainability means a system of production that satisfies present consumption levels without compromising future needs, and without making scarcity in the natural resources (BASIAGO, A. D., 1999: 150).

2.4.2 Social sustainability

This pillar of smart cities, aims to ensure the quality of life for cities' dwellers. This quality of like can be seen in terms of work opportunities, social stability and justice, peace, reduces of poverty, and other grassroots to promote social equality. Nowadays a large number of people are living in congregation places, which cause a lot of problems like social injustice, human inequalities, poverty, or social exclusion for a part of population. Consequently, this leads to a social unrest. Thus, the cities' authorities should be able to rethink about many solutions in order to solve these problems. They can start providing the most basic level of services for citizens, creating strategies to get social inclusion, depending on the cities' services such as public transportation, sanitation, water supply, electricity or telecommunications. These facilities should be affordable and accessible for a wide range of population groups, making citizens the beneficiaries' services. In this aspect there is the need of cities' authorities to increase the resources efficiency and social stability in several domains of the urban life (including the fuel efficiency in transportation, the energy efficiency in network, and building sustainability in term of energetic efficiency). In addition, the current society should move towards a sustainable and integrated way of use different technologies, to make cities more attractive for people, for capital investors and for business in general, in order to generate profits that could be distributed in favour of all the community.

Finally, social sustainable means the ability of society or social system, in providing social wellbeing of a country, city or local community, which should be maintained in the long term horizon of planning territories. At the same time, through social sustainable is possible to establish indicators in order to evaluate the relation between social conditions of inhabitants and environmental conditions (BASIAGO, A. D., 1999: 152).

2.4.3 Environmental sustainability

The environmental sustainability refers to environmental problems regarding the actions done by humankind and their impacts on the planet. This pillar of smart cities ensures and supports the natural resources by reducing the fossil fuel consumption, promoting the renewable energy, supporting the organic farming, the sustainable agriculture and fishing, also recycling and giving a better attention to waste management, or by reducing deforestation.

In the last decades, an environmental awareness is growing in cities for many reasons. The first one is because the resources limitation (fuel needs, water scarcity or non-renewable energy). The second is the need in terms of improving the quality of life, and health care services. The later should be based on the growing awareness applied not only to citizens in general, but also to political authorities, about the economic implication of pollution and its effects on citizens' health, and business attractiveness in the city. There is also the reason related with risk management, which should be flexible with the environmental shocks, dealing with situations such as flooding or heat waves because of the severe climate changes, to achieve a good environmental sustainability is necessary to be aware that societies are consuming natural resources, which are granted and not unlimited. The cities' authorities should be aware of resources scarcity in order to get more efficient in situations of risk. In this scenario, smart cities can provide environmental sustainability by one of the most popular strategies, which is increasing the resources' efficiency in all domains of resources (for example promoting fuel efficiency in transportation, water recycling, or the adoption of new principles to convert waste to energy). There is the urgency to find a set of good solutions and practices, facing some problems such as pollution, by making the rates of waste generation from projects less than the environment capacity, thinking about new resources instead of non-renewable.

The last but not least, environmental sustainability happens when processes, systems and activities are contributing to reduce adverse environmental effects.

2.5 Requirements of smart cities

The understanding of the requirements associated with smart cities is on behalf of the 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 researchers who support clearly the idea of smart city, have noticed as a certain way in which there are no systems operating in an isolated way, in the cities. In this sense, the smartness of an urban area is supported by the organic integration its various systems (like transportation, energy, education, healthcare, food, building, water, public safety, or physical infrastructures).

At the same time some authors are trying to find out the required assets to delineate the features of smart city. Following this idea, the research drives to four possible dimensions (Komninos, N., 2011: 2). The first dimension focuses on the application of electronic and digital technologies and devices, in order to collect and create digital information, which will produce knowledge based on city's scale approach. The second dimension uses information communication technology (ICT) in order to transform the daily life of dwellers in cities, making it easier. The third dimension aims to apply the ICT in the basic infrastructures of cities. Finally, the fourth dimension brings the ICT and people together in order to achieve several goals like human inclusion, good innovation systems and tools in learning and knowledge.

To sum up, there are several fields of activities described in the literature in relation to the term Smart City, including the following: industry, education, public participation, or technical infrastructures. These activities are called soft factors components for smart city. They can be described with more details according to Vito Albino opinion, related with the following contents (Albino, V., Berardi, U., and Dangelico, R. M., 2015: 9).

- Smart industry implies industries in the areas of ICT as well as other industries that are using ICT in their production processes, also for business sector;
- Smart city is used regarding education for inhabitants, producing smart inhabitants in terms of the education grade levels;
- Smart city implies a process of participation in between the city government i.e. local authorities, public administration in general and their citizens.

In this sense, smart city is further the use of ICT in order to provide technical infrastructures and to discuss the use of modern technologies in every day urban life. Therefore, the authors are pointing out six characteristics which can help to develop the city in order to be smarter. These characteristics are called the “smart city wheel” and they comprise the following aspects: (Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., Meijers, E., 2007: 9).

- Smart economy;
- Smart people;
- Smart governance;
- Smart mobility;
- Smart environment:
- Smart living.

For every set of the above characteristics there are a certain number of factors. Each factor is described by a certain numbers of indicators in order to describe the preparedness and use for smart city.

2.5.1 Smart economy

A smart economy is considered to be the base for a smart city and the engine for a new digital society. This model is the core for promoting the development, competitiveness, sustainability, innovation and attractiveness for new investment in the cities. It will provide opportunities in the domain of employment with qualified jobs. This concept requires additional economic discussion, regarding a context of relevance of a sharing economy society, where aspects such as collaboration in between institutions, are depending on economic means, e-business and e-commerce. It requires new products, new services, and new business models, around economic competitiveness. This model of smart economy includes several aspects, such as the following which are described below:

- The existence of an innovative spirit of thinking, focused on economic indicators, such as the gross domestic products (GDP) per head of city’s population;
- The existence of an increasing productivity, not only in terms of quantity of produced products, but also in terms of their quality standards;

- The existence of flexibility on the labour market, able to be integrated in the inter-national market, with the aim of improving the quality of life;
- The existence of an economic image created by business and trademarks, able to apply for the public participation, which is a key factor for a successful smart city;
- The existence of new models and opportunities in business entrepreneurship, in order to create new ways of enriching the daily life of citizens, like through the use of on-line solutions for sell or buy of products, or boosting the self-employment rates.
- To achieve the previous factors, which are the features of a smart economy, there is the need of focus on the areas where they can provide intelligent solutions for cities and their dwellers (Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., Meijers, E., 2007: 11).

2.5.2 Smart people

One key pillar to reach smart cities is to have smart people. There are no smart cities without smart people. This concept means the existence of e-skills, jobs in ICT-enabled working, contributing to the integration of public life, to the connection in between citizens, or to transferring education and knowledge among the people. This goal aims contribute to a better human inclusion, in an opening society towards the globalized world. Although the smart people aspect is not only focused on the qualification or education of citizens. It is focused as well in other factors such as the listed below:

- Attractive for the lifelong learning;
- Research in innovation and flexibility in order to get new job related with ICT, and creativity in order to share knowledge in creative industries;
- Investments in education and healthcare systems;
- Participation, learning and information by digital education, or participation in voluntary work;
- Cosmopolitanism and open mindedness by using ICT and sharing experiences;
- Creativity by sharing people to work in creative industries, focused on in talent respecting the individual skills (Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., Meijers, E., 2007:12)

- High level of qualification, with skills in the use of foreign language, top research centers or top universities.

2.5.3 Smart governance

Governance plays a significant role to strengthen or weaken any competitive process. New models of governance are emerging in order to provide the public participation, supported by a more collaborative approach. This process should be able to provide better information and communication for citizens, creating more responsibility in the decision-making process. This is why ICT is becoming a permanent feature for governance, in order to link governments to the world trends (Virtudes, A., 2016: 1711) based on a smart governance approach. It means to join up within-cities and across-cities governance, and it talks about the future of services towards efficiency. This model aims to apply ICT to facilitate and to support a better planning system of cities and to inform better the discussion around cities management.

At the same time, smart governance is dealing with strategies to improve the quality of public services, and the citizens' participation in the decision-making realm. According to this, the smart governance concept includes aspects coming from the political participation, the functioning of services for citizens.

Regarding the public participation in decision-making process, related to the management of cities, it is understood based on the relationship between politics and inhabitants, which determines the political activity of inhabitants. The public participation includes conflict resolution skills in between public realm authorities and the population in general (Virtudes, A., 2016: 1711).

Good governance should be a transparent process, able to bring equity and rule of law in public agencies for the management of the city. With the use of ICT is possible to keep e-Government on-line availability, displaying information from the political authorities to the public. The latter will be happy, having the feeling of being fighting against corruption. This process of transmission of information through ICT between public authorities and citizens should be present in order to achieve transparency (Virtudes, A., 2016: 1711). In this sense, public and social services where ICT is playing a main role in standards and performances, could be considered more transparent and, therefore, more efficient.

In addition to the previous consideration, good governance practices mean to work more close with the private and public sectors, in order to educate them about stakeholder roles. In

particular, to show them, how policies and business models are necessary for implementing smart city solutions (BATAGAN, L., 211: 30). Finally, good governance is characterized by the principles of sustainability, equity, efficiency, transparency, accountability, security and participation (Virtudes, A., 2016: 1711).

2.5.4 Smart mobility

More than 1 million (Hessel, V., 2015: 6) people die globally every year in traffic accidents, including pedestrians and bikers. More recently, the governments are trying to develop solutions in order to address problems related on mobility, such as traffic jam congestion and accidents by soft mobility issues, i.e. mobility for pedestrians, cyclers and other ways of moving in vehicles free of fuel consumption. These short of policies aim to "start with a new approach to decrease all the previous problems and drive technology for future with clean energy fuelling" (Hessel, V., 2015: 6). They are called a mobility revolution in cities areas.

These concerns with mobility are key tools to achieve the smart city sustainability, providing an efficient and flexible traveling across various modes, booting the use of non-polluting ways of mobility. Therefore, the issue around 'Smart Mobility' is a way of meeting the transportation needs in terms of people and capacity, as well as enhancing economic, environmental, and human resources. It includes an important aspect of local and international accessibility such as the following examples:

- Apply the use of ICT on the infrastructures for transportation, in order to get sustainable, innovative and safe transport systems;
- Encourage using soft mobility ways, such as walking, cycling or bike sharing. At the same time is important to encourage strategies such as the car sharing, or smart mobility cards to reduce carbon emissions, travel time and painful accidents;
- Provide automated and electrified metro ways, which allows short headways and very high capacity of transport, in terms of number of passengers;
- Promote using an advanced parking such as the park and ride, in order to get efficient management of multiple on-street parking spaces, taking the cars away from the city center;
- Encourage local accessibility by satisfaction with access to a qualified public transport network.

In contemporary societies the daily life in cities is characterized by many hours lost every day and every year in congestion problems. Thus, the use of smart mobility solutions, will economize time, and money. In this sense, smart mobility is a powerful tool to achieve a more sustainable future by making transport system networks safer, reducing the cost for individual in particular, and for society as a whole. A lower consumption of resources such as land and fuels, spending less time in traffic, will give to cities inhabitants more time for important things, including cultural and community issues. Therefore, smart mobility supported by the use of ICT, can provide an integrated transport and logistics system, saving time and reducing costs, CO_2 emissions, and improving commuting efficiency.

2.5.5 Smart environment

Smart environment is probably the most important issue in smart city approaches. It relates with the preservation of natural resources, like energy saving, water efficiency, CO_2 emissions reduction, in order to improve the environmental quality of urban areas. It requires a good management of the resources, able to provide a better environment for the future generations. This concept describes the entire thing related to the natural environment, including the following requirements:

- Attractive natural conditions, such us climate amenities, green spaces, or minimum number of sunshine hours per day;
- Environmental protection from scarcity of natural resources, especially in dense urban areas, applying the opinions related on nature protection and support individual efforts for protecting nature;
- Levels of pollution from smog related to the ozone emission, GHG emission, defining strategies for CO^2 emission reduction;
- Sustainable resources management, as efficient use of water, or energy, getting some new resources from recycled waste.

A smart environment means the capacity to generate new solutions to renewing energy resources, which are naturally replenished on a human timescale, such as wind, sunlight, tides, rain and waves.

2.5.6 Smart living

A smart living is another requirement of a smart city. It means more than creating intelligent cities, homes and infrastructures. It also means the capacity for designing systems where people live. The first target for smart living is to provide the quality of life for a wider range of citizens in several aspects such as in the following examples:

- Health conditions as improved productivity of healthcare systems, open access to medical health data, open access to patient data for interoperability of patient records, doctors per inhabitant, life expectancy or satisfaction with quality of health system;
- Education facilities, contentment with access to and quality of educational system;
- Housing quality by using a new concept of green building and satisfaction with personal housing situation of families;
- Social cohesion by connecting people together, providing proper conditions for living and reducing the poverty rates;
- Touristic attractively by determine the tourist locations, such as Museums, Theaters, public libraries or cinema visits;
- Individual safety according to crime rates;
- Proportion of the area for recreational sports and leisure uses;
- Availability of ICT infrastructures, or flexibility of labor market.

A smart living increases the understanding of how people and technology interact by combining sensing with physical action, social behaviour analysis, data analytics, engineering, technology, communication and decision-making. It is an integrated concept and means ICT-enabled life styles behaviour and consumption. Apparently the most common characteristics which outline the dimensions of a smart city are emerging from many points of a smart living such as:

- To try to make a city's networked infrastructure basis, achieving the political, social and cultural efficiency and development;
- To concentrate on business-led urban development and creative activities for the promotion of urban growth;
- Human inclusion of urban residents and social capital focused on in urban development;

- Illustrate the natural environment as a strategic component for the future of cities and humankind.

These characteristics and factors form the framework for the indicators of assessment a city's performance as smart city. The picture bellow (Fig. 11) shows the famous description, representing these characteristics of smart cities, with six main branches of smartness: economy, mobility, environment, living, people, and governance.

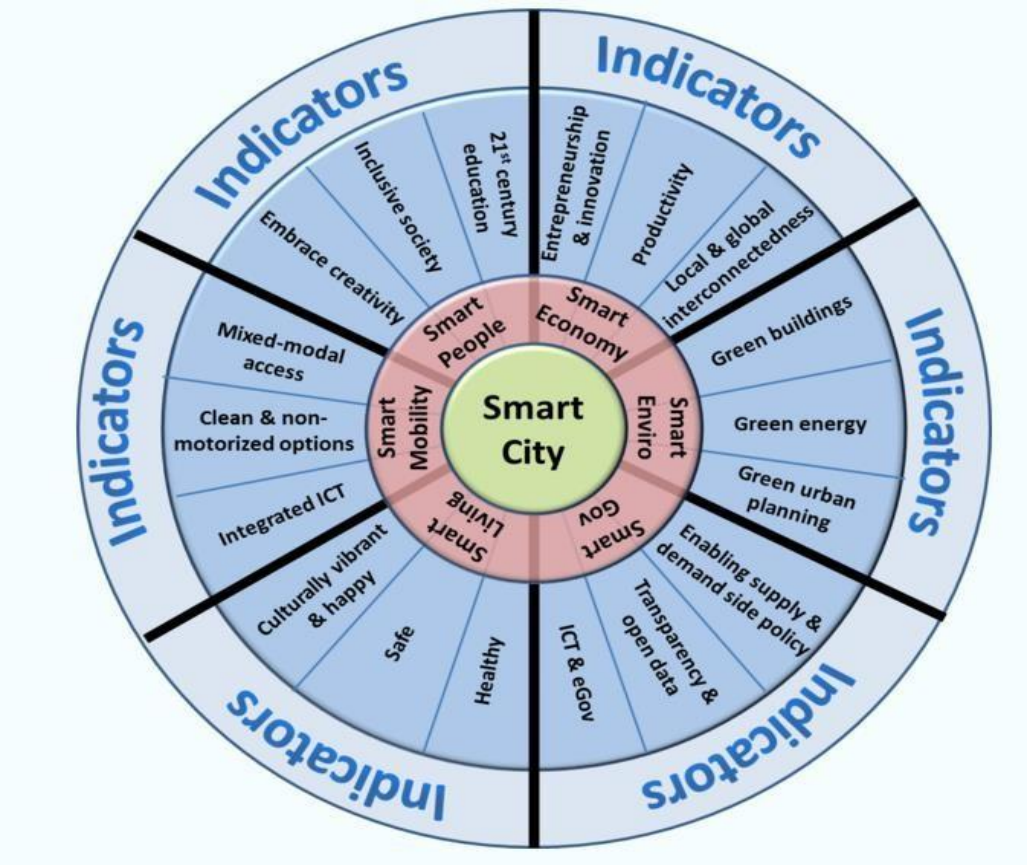

Fig. 11 The smart city wheel (deangelis, S., 2013: 2).

In terms of conclusion and according to the previous study, it can be considered that an urban area to score and get the characteristics of a smart city, based on indicators for evaluating its performance, there is the need of using ICT in all the six represented branches or parts of the smart city wheel.

The smart city features are pushing towards a sustainable environment, a competitive economy reduced levels of pollution, and a general livable way of living for people, promoting soft mobility, and good governance in order to increase the quality of life for citizens.

2.6 Top ten cities on the planet: two pioneer examples

All over the planet there is a list of several examples of cities which are making huge efforts in order to become smarter. They are using ICT to be more intelligent and efficient in the management of resources, resulting in cost and energy savings, improving services delivery and promoting high standards of quality of life, delivering services to citizens. Ultimately, with these measures they are reducing the environmental footprint, supported by innovation and low-carbon economies.

In between the most well-known examples, there is a list (Beaumont, S., 2015) comprising ten cities belonging to Europe, North America and Asia, which is the following:

1. Vienna, in Austria – Europe;
2. Toronto, in Canada – North America;
3. Paris, in France – Europe;
4. New York, in the United States of America – North America;
5. Stockholm, in Sweden – Europe;
6. London, in the United Kingdom – Europe;
7. Tokyo, in Japan – Asia
8. Berlin, in Germany – Europe
9. Hong Kong, in China – Asia;
10. Barcelona, in Spain – Europe.

Among these ten examples, this dissertation will be focused on the case of Vienna, the capital city of Austria, because it is the number one of this list, and the case of Barcelona in Spain, because it is the most southern European city in between them. They are both pioneer examples of smart cities in the world.

2.6.1 Vienna as a pioneer example of smart city in Central Europe

Vienna is the capital and the largest city in Austria (Fig. 12). It is very well known as a very livable, smart, and green city as well as the city of Danube (the famous European river). These features make this city very attractive for all kinds of investments, from the businesses sector to the tourists' point of view. In the most recent years Vienna ranks in the top 10 cities list, around the world, with a higher score in the categories of being an innovative city, a regional green city, in terms of quality of life, and digital governance. It has a high standard in terms of quality of life, which not only makes Vienna a smart city but also makes it reaching a good position in many details and indicators for instance such as smart infrastructures which is important for international organizations and companies that are spotted there.

Fig. 12 The map of Austria (AA. VV., 2016f).

Nowadays, Vienna achieved many goals in transportation infrastructures such as the Vienna Main Station; Vienna Wien Mitte Station; that has been one of the most important transport axis in the city and an important point of departure for travellers. Over than 190.000 students are studying at Vienna the high educational system with 9 universities, 5 universities of applied sciences and 4 private universities (Vienna). This fact makes Vienna a city of knowledge, green building concept, smart people and smart living, which applies on the example of the new campus of the Vienna University of Economics and business (Fig. 13).

Fig. 13 University of economics and business – Vienna (https://www.wien.info/en/sightseeing/green-vienna).

In terms of smart mobility, Vienna has one of the best transportation system in the world, with five subway lines, 104 stations on 79 kilometers of tracks, 29 tram routes and 115 bus routes: This infrastructure strives to an increasing numbers of electric buses, integrating modern technology by using smart phone apps, in order to get information about when the next tram or bus is coming. The carbon reduction is encouraged by inviting people to go on walks, bikes, and using public transportation. According to that Vienna is a major European player in terms of smart city technologies.

In terms of smart technology Vienna tries to simplify and improve life, promoting the Free Wi-Fi which is available at numerous public places.

In terms of smart environment, there are currently in Vienna, around 370 eco-friendly cars with hybrid or natural gas-powered engines. There are also green electric taxis, bike charging points, and bike and e-bike rental stations. All these strategies and solutions are making Vienna a city of bikes (Fig. 14).

Fig. 14 Using bikes in Vienna (https://www.wien.info/en/sightseeing/green-vienna).

In addition, Vienna is very well known as a green urban area, because more than half of its metropolitan area is made up of green spaces. There are 280 imperial parks (Vienna) and gardens enriching the cityscape, and it has a total of 2,000 green parks for leisure (Fig. 15).

Fig. 15 Vienna green park (https://www.wien.info/en/sightseeing/green-vienna).

2.6.2 Barcelona as the first smart city in Iberian Peninsula

Barcelona is the first city in Spain known as a smart city (Fig. 16). It is a center of technology and innovation with an open government trying to improve green living spaces. It is among the first cities in the world to insert a solar thermal ordinance (Ancheta, A., 2014) in order to encourage the use of renewal solutions of energy. It is also one of the major examples of urban areas in terms of low-carbon solutions, applying innovative strategies to manage its services and resources, in order to improve citizens' quality of life.

Fig. 16 The map of Spain (AA. VV., 2016).

In adopting all these solutions, Barcelona ranks a high score in the six smart characteristics of cities: people, mobility, living, environment, governance and economy. In a more detailed view, Barcelona is in the first side of smart mobility, based on its Transports Metropolitan de Barcelona, with the new perpendicular bus network, comprising horizontal, vertical and diagonal lines all over the city fabric. Its bus system is focused on urban sustainable mobility with reduced emissions and Barcelona aims to improve the concept of biking which is a sustainable and economical form of transport by providing more than 6,000 bicycles (Ancheta, A., 2014) which are circulating around the city (Fig. 17), supported by biking cards and biking apps.

Fig. 17 The bike lanes in Barcelona (Ancheta, A., 2014).

In terms of smart governance, the administration authorities of Barcelona are providing to citizens' information about all kinds of resources, in order to make their lives more accessible, effective, and in a more democratic way, by opening the door for citizens to participate in public decision-making process. Local authorities provide file reports about city problems like broken street light, collecting garbage, which are sent to a website, being available to all community. Finally, regarding the smart environment as branch of Barcelona as a smart city, some things can be said.

Barcelona has the first legislation type executed in a European city, which is focused on the Solar Thermal issues, in order to organize all new large buildings such as hotels, hospitals, gyms, or swimming pools, to produce their own domestic hot water, and lowering energy emissions. Moreover, actually Barcelona is nowadays trying to find new resources that can provide heating and air conditioning for buildings, by using steam from the incineration process of urban waste. This way is used for heating. Barcelona is also improving the use of seawater for refrigerating for the cooling, which is reducing fossil energy consumption and carbon emissions (Ancheta, A., 2014).

In addition to these strategies, Barcelona finds a new efficient lighting by using LED technology in public system. These lights reduce the costs, and the pollution levels, and optimize energy. The LED power (Fig. 18) works when detecting motion, otherwise they will be switched off. This strategy doesn't make Barcelona a perfect city in all domains of smartness. However, with an overall aging population and an economic recession context, local government has found ways to create jobs and to improve the quality of life for its residents and visitors.

Fig. 18 Intelligent lighting in Barcelona (Ancheta, A., 2014).

2.7 Synthesis of the benefits of smart cities

A smart sustainable city is an innovative urban area that uses ICT and other technologic means to improve the quality of life, the efficiency of urban operation and services, and the competitiveness, while ensuring that it meets the needs of present and future generations. At the same time, it provides respect to economic, social and environmental aspects. So, smart cities have a lot of challenges and purposes ahead. However, with no doubt they should provide the following requirements:

- A better and more appropriate services for all citizens, not only for rich categories, to get the quality of life and progress in terms of lifestyle for them;
- To provide opportunities for a better city governance, encouraging the political and the citizens' representative processes;
- To defend the environmental sustainable and efficiency, to achieve a better life environment of urban areas
- To apply new models of industry which are greener and more people friendly;
- To provide a smarter and more attractive infrastructure system, including two parts, the physical and the digital, tying to apply the ICT in all aspects of daily life;

- To adopt an innovative economy and dynamic finance system, to ensure faster economic growth;
- To provide sustainable homes and buildings i.e. green buildings, with an efficient use and management of the resources such as water, or energy, reducing the problems related to the pollution, as CO_2 emissions, and efficient and sustainable transportation with electric vehicles;
- To promote a better urban planning, development and renewal strategy, to be a more livable place, developing all parts of life quickly, with an effective management for resource infrastructure and public services;
- To support sustainable and long term of economic growth, encouraging community and stakeholders to collaborate in development decisions.

Finally, is possible to imagine a smart city, like 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 city, where the movements of the people and traffic are happening. In the human body, there are five senses which collect all the messages around humans, and send them to the brain, which gives orders to the body. In parallel, in the city, to work with efficiency using ICT is like the urban senses and the big data is similar to the human brain.

Chapter 3. Features of Arabian cultures and territories

In general, the majority of people in the western countries, such as in Europe or North America, don't have an extensive knowledge and information about the Arab world and its countries. They simply are not aware of all details of Arabian cities, their lifestyles, their main conquests after the oil discovery, or the more urgent challenges that they are facing nowadays, in terms of fostering ICT tools or strategies to be smarter. Consequently, this Chapter 3 will have an overview about the Arab world which is called the "Arab nation" that will cover aspects such as the Arab world's geography, population, religion, or several other features of the different countries, and their capital cities, in order to introduce some of the main interesting facts about this region.

3.1 General information

3.1.1 The Arabic language as a key of cultural identity

The Arabian culture refers to the culture in the countries where the official language, tongue language and the first one is Arabic. The Arabic language is one of the six official languages of the United Nations and the fourth most widely spoken in the world, after Chinese Mandarin, English, and Spanish. Arabic is the language of the Qur'an spoken by millions of people. Therefore, the Arabic language is a key factor on cultural identity upon the Arab World. Moreover, Qur'an is the most important aspect that united the Arab countries as a whole culture.

Therefore, the Arabian countries have different traditions and cultures, based on the Arabic language which consists of 28 letters. The writing process in Arabic is from the right to the left side, and it is famous as the Daad language, given that it's the only language in the world that contains the letter Daad. The Arabic is one essential key to opening the door of the histories, cultures and peoples of this vast region of the planet.

The Arabian culture is the cradle of the civilization of urban culture and it plays a major role in in the history of human civilization cultures, because it is one of the most unique cultures, full of rich and diverse communities, groups and places. This wealthy cultural heritage is illustrated by its significant contributions to religion, philosophy, literature, medicine, architecture, art,

mathematics or natural sciences. In territorial terms, the Arab world includes the Middle East and the north of Africa, called MENA. This area has three of the world's major religions, Islam, Christians and Judaism. However, the Islam is the primary religion in the Arab world. Thus, it plays a major role around this region and it has a direct influence on business customs, government rules and daily life of its inhabitants.

The Arab world stretches on the huge following borders:

- from the Atlantic Ocean in the west side to the Arabian Gulf, Gulf of Oman, Zagros Mountains, and Kurdistan in the east side;
- from Mediterranean Sea, Taurus Mountains, and Anatolian Plateau in the north direction to the horn of Africa, and Arabian sea in the south side to the Indian Ocean in the south east side.

In a more detailed view, the extreme point of the Arab world on the east is called Ras al Hadd (AA. VV., 2006: 6), and it's located in the State of Oman. On the west side, the extreme point is the white head, and it's located in the State of Mauritania. Also the extreme point of the Arab world on the north is located in the State of Iraq. The Mediterranean Sea separates the Arab countries in North Africa from the European continent.

3.1.2 The three main Arabic regions

The Arab nation consists of 22 countries (Fig. 19) which are Algeria, Bahrain, the Comoros Islands, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Mauritania, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, and Yemen. Iran and Turkey are not considered as Arab countries. Their primary languages are Farsi and Turkish respectively, but they are Islamic countries.

The Arab World area represents 10.2 % (AA. VV., 2014d) of the planet surface and it stretches across more than 14 million square kilometers. This area is larger than Europe (10.4 million km^2), Canada (10 million km^2), China (9.6 million km^2), the United States (9.6 million km^2), and Brazil (8.7 million km^2) (according to ASBU Official Partnership). About 1/3 of the Arab World refers to the Asian continent, which is called the Mashriq (Sharq in Arabic, which means East). This region comprises the Persian Gulf and the Levant areas. The largest country in the Middle East is Saudi Arabia occupying nearly the entire Arabian Peninsula. About 2/3 of Arab World refers to the African continent known as the Maghreb (Gharb means west in Arabic) with two largest countries,

Sudan and Algeria. The latter is the largest country in terms of area, followed by Saudi Arabia, while the smallest Arab country in terms of area is the state of Bahrain (AA. VV., 2014C).

Fig. 19 Map of the Arab world (in yellow) (Alhadeff, I., 2016).

Regarding the Middle East, it's the home of several of the world's largest deserts, such as the Syrian Desert which stretched into three countries, Jordan, Iraq, and Saudi Arabia. It has many seas, gulfs and rivers, and it shares the Mediterranean Sea with Africa and Europe and the Black and Caspian seas with the Eastern Europe. The majority of its region is characterized by warm desert climate weather, which has very high temperatures during the summer time that can reach dangerous levels with very little rainfall. On the opposite the Levant area has a warm Mediterranean climate, similar to many parts of Greece or Italy.

In political terms there is a great diversity of situation around the Arab World. The politically diverse forms of government in Arabic-speaking countries, such as Algeria, Egypt, Lebanon, Tunisia, Syria, Iraq, Libya and Yemen are Parliamentary Republics. Oman, Qatar, Bahrain, Kuwait, United Arab Emirates and Saudi Arabia are Traditional Monarchies. Finally, Jordan and Morocco are Constitutional Monarchies (AA. VV., 2006: 5).

Actually the Middle East and North Africa (MENA) have a great effect on the globe because they are great petroleum suppliers on the global scale, which equals two-thirds of the world's known oil reserves, close to 60% of earth's oil reserves (AA. VV., 2006: 2). This is a prime reason for the world's attention on the influence of MENA, in parallel as it occupies a strategic geographic position, between tree continents, Asia, Africa and Europe.

The ‘Arabic-speaking countries’ or the ‘Arab world’ comprises a cultural, ethnic, linguistic, religious, and artistic multitude, and richness a diversity grasping the mind and senses. Its unique culture can be very mysterious to the westerners. In fact, there are different cultural perspectives in between East and West regions, such as the listed below (Table no. 2). Also the Arabs are famous in many other things like their hospitality, which is one of the basic values of this society, in parallel to the generosity, that must be upheld, or their concerns regarding the education. This means that the Arab culture places great value on education and literacy of their people. In a word, the Arab region is culturally very rich and full of centuries of history. Through the effects of globalization, it is trying to adopt modern technologies, and promoting more interaction between cultures than ever before.

The eastern prospective	The western prospective
Family is the center of social existence and every things(Family over self also the Arabs are generous, humanitarian, polite, and loyal	Family is important but not central
Time less rigid and this approach relaxed	Time very structured so deadlines must be met
Religion - central in every things	Religion various from one to other (very personal)
Government still confirm of religion	Government aims to protect right and improve started of living
Wealth honoured	Wealth honoured

Table 2: Eastern prospective vs. western prospective (AA. VV., 2006: 12).

From seven billion populations all over the world more than 5% are in the Arab World amounting to 367.4 million in 2014 (Fig. 20), according to the World Bank (Dubai, 2014), this population which counts all residents regardless of legal status or citizenship-except for refugees.

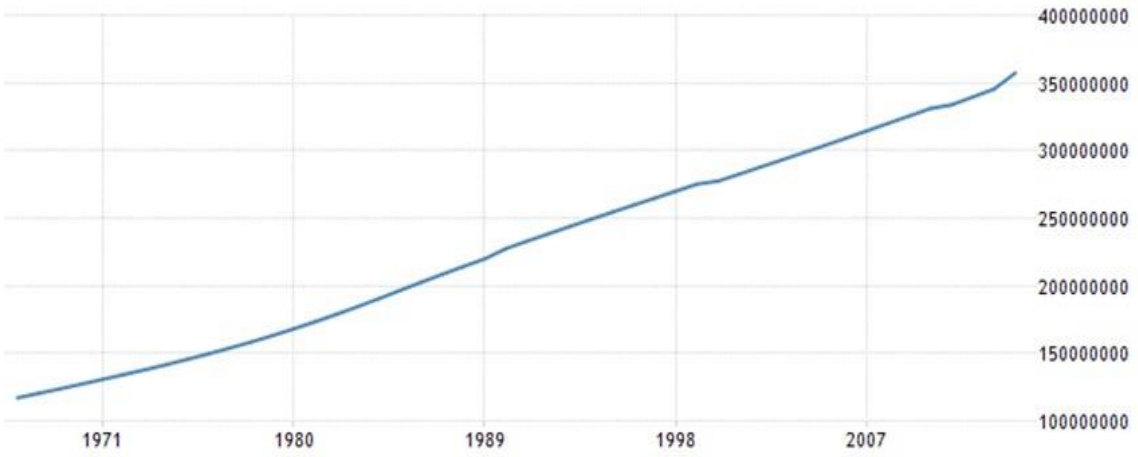

Fig. 20 Population increasing in the Arab World 1970-2014 (AA. VV., 2016e).

3.2 Geographical locations for the Arabian countries

The Arab states composed from Middle East and North Africa is divided into many regions, belonging to the two main areas (Fig. 21):

1. The Mashriq: includes the following areas
    - The Persian Gulf: consists of the oil rich states Saudi Arabia, UAE, Qatar, Oman, Bahrain, Kuwait, and Iraq;
    - The Levant area which includes: Lebanon, Syria, Palestine and Jordan.
2. The Maghreb: includes the following areas
    - The Nile Valley: includes Egypt and Sudan;
    - The Bab-el Mandeb: includes Yemen, Somalia and Djibouti;
    - The Indian Ocean: Comoros;
    - Morocco, Mauritania, Algeria, Tunisia and Libya.

Despite of all these regions, areas and countries that comprise the Arab World are different, with particular features, is important to stress some points about them, regarding aspects such as:

location, area, capital cities, population, growth rate, or GDP (according to WORLD FACTBOOK, 2015) (AA. VV. 2016f).

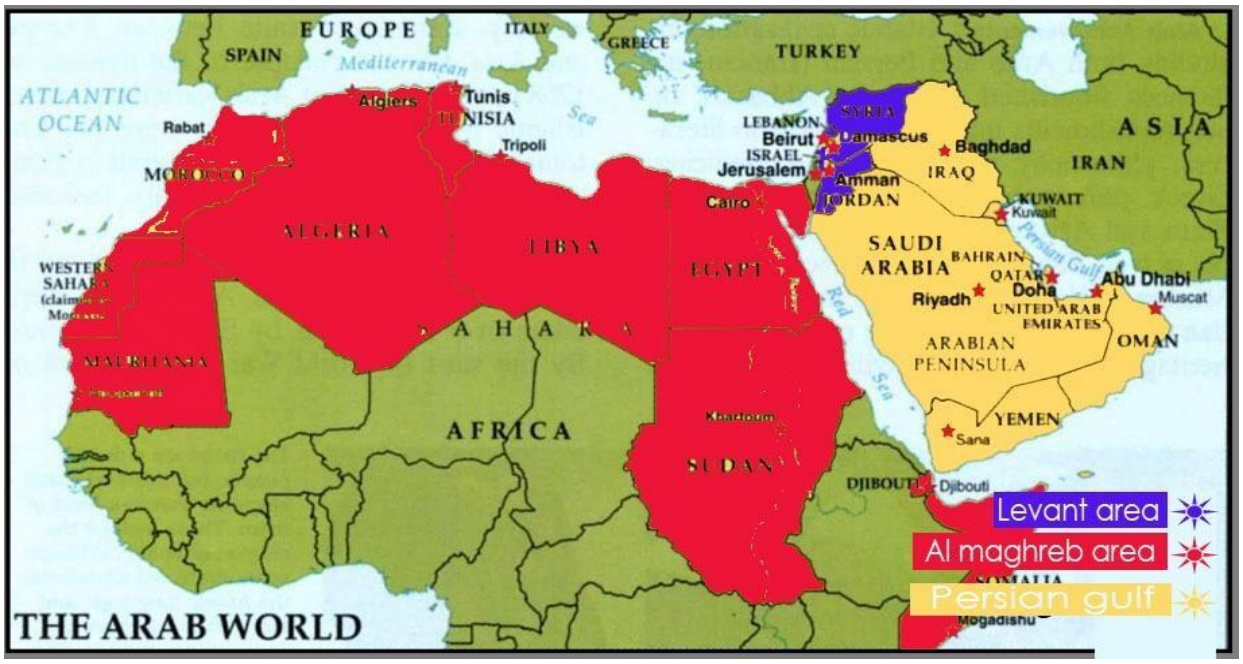

Fig. 21 Main regions in the Arab World (Based on Alhadeff, I., 2016).

3.2.1 The Levant area

The Levant area comprises four countries, which are Syria, Lebanon, Jordan and Palestine. However, given that there is no enough information about Palestine, this part will be focused on the other three countries. The largest country in the Levant area is Syria and Lebanon is known for the use of ICT, having the highest percentage in terms of population using internet

a. Syria

The Syrian Arab Republic is located in the Middle East, bordering in the east coast of Mediterranean Sea, between two countries, Lebanon and Turkey. It has 599 km of borders with Iraq on the east, 83 km of borders with Palestine on the south, 379 km of borders with Jordan, 403 km of borders with Lebanon, and 899 km of borders with Turkey on north. It has also its Mediterranean coastline with 193 km long (Fig. 22).

Syria is primarily a semi-arid area and a desert plateau. The total area its territory is about 185.180 km^2 (divided in 183.630 km^2 of land and 1.550 km^2 of water) (Fig. 34). The lowest point in Syria is in unnamed location near to the Lake Tiberias at 200 m. The highest point is the Mount Hermon with 2.814 meters high. Most of the land of this country is for agricultural purposes, representing 75.8%, 2.7% is for forest and 21.5% other uses.

Fig. 22 Map and flag of Syria (AA. VV., 2016f).

The population in Syria is around 17 million. The average of the annual percentage growth in the population is about 1.56% (July 2015). The climate is Mediterranean where the heat is never excessive, and there is usually some breeze and humidity. The most common natural resources are petroleum, phosphates, chrome and manganese ores, asphalt, iron ore, rock salt, marble, gypsum and hydropower.

Damascus is the capital of Syria located at an oasis fed by the Barada River. It is thought to be one of the world's oldest continuously inhabited cities. It has a wealth of historical sites dating back to many different periods of the city's history.

Since the war Syria is facing a lot of problems in all domains including at the economic level. Its economy continues to deteriorate amid the ongoing conflict that began in 2011, declining by 62% from 2010 to 2014, widespread infrastructure damage, and the reduction in GDP to $55.8 billion while it was $97.5 billion before the war. The internet users equal 4.8 million (26.7% of population). Syria was one of the most beautiful Arabic countries before the civil war, where the culture and the civilization features are very high level and elegant. It combined old cities with old traditions; with new cities where people could find everything they wanted. It was a very nice place for tourism and visit.

b. Lebanon

Lebanon is a west Asian country located in the East Mediterranean. It is bordered by the Mediterranean Sea on the west, Syria on the north and east, and Palestine on the south. Its land boundaries total 484 km, 81 km with Palestine and 403 km with Syria (Fig. 23). Lebanon covers a total area of 10.400 km^2 (10.230 km^2 of land and 170 km^2 of water) (Fig. 34). The lowest point in Lebanon is the Mediterranean Sea at 0 m high. The highest point is Qornet es Saouda at 3.088 meters high. Such as in Syria, also in Lebanon the agriculture land extends until 63.3% of the territory, while the forest comprises 13.4%, and 23.3% are for other uses including for urban areas.

Fig. 23 Map and flag of Lebanon (AA. VV., 2016f).

The population in Lebanon is estimated about 6 million with a population growth rate of 0.86% (in July 2015). According to its location the most common natural resources in this country are limestone, iron ore and salt.

The capital city of Lebanon is Beirut, with an estimated population of more than 2 million. It is the largest city in the country and its major urban area, considered the largest and main seaport of the country, also serving as the cultural and administrative center of Lebanon.

The most important features in Lebanon, for instance, from the economic side is its free-market economy, with a strong laissez-faire commercial tradition. The Lebanese economy has some main growth sectors such as banking and tourism. Since the war in Syria, Lebanon has the highest GDP among Levant area countries, corresponding to $83.86 billion, with a real growth rate rounding 2%. Its composition by sectors of origin corresponds to 69.7% for services, 24.7% for industry, and

finally 5.6% for agriculture. The economy fabric includes strong activities such as banking, tourism, food processing, wine, jewellery, cement, or textiles.

In terms of ICT, the internet users in the country equal about 4 million, while the telephone mobile users are 4.4 million (75% of the dwellers as a whole).

Finally, Lebanon is a beautiful country, whether urban or natural, where Muslims and Christians almost equals. It is in general a safe country, where people are educated and most of them are able to speak three languages (English, Arabic, and French). It is known as a liberal and open-minded country, with an amazing weather, in winters it is colder and similar to the south central Mediterranean Europe (such as Italy, France, Greece, or Spain), while in summer it has a wonderful whether, and a beautiful natural landscape.

c. Jordan

Jordan is a Middle East country. It has borders with the northwest part of Saudi Arabia, Palestine and Israel (to the west), Iraq, and Syria in the north (Fig. 24). Its borders comprise 179 km with Iraq, 307 km with Israel, 731 km with Saudi Arabia, and 379 km with Syria. It's stretched in total area about 89.342 km^2 (88.802 km^2 of land and 540 km^2 of water) (Fig. 34).

The lowest place in Jordan is the Dead Sea with 408 meters high, while the highest place is Jabal Umm ad Dami with 1.854 meters high. The agricultural land extends on 11.4% of Jordan's territory, the forest represents 1.1% and the other activities are 87.5% (AA. VV., 2016 f).

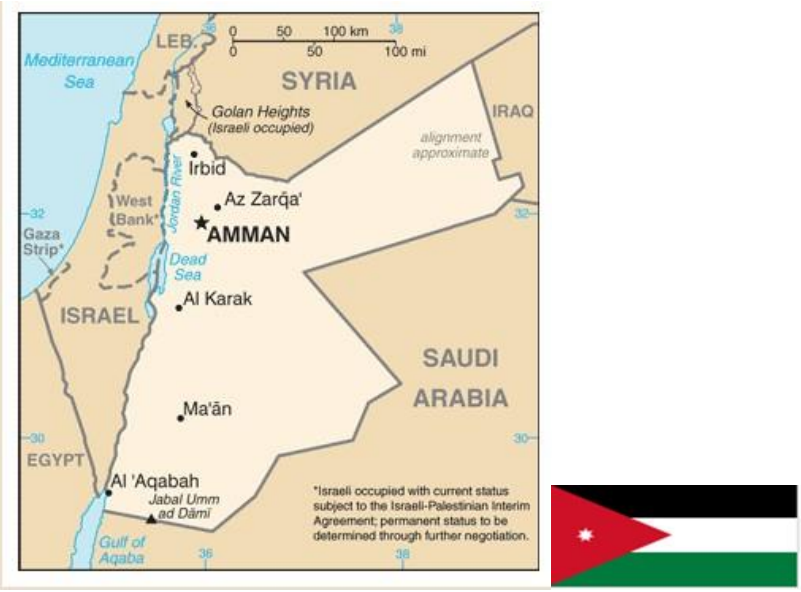

Fig. 24 Map and flag of Jordan (AA. VV., 2016f).

The population in Jordan scored about 8 million, with the population growth rate being about 0.83% (2015). The capital city of this country is Amman.

On the contrary of the majority of Arabian countries, Jordan's economy is among the smallest in the Middle East, with insufficient supplies of water, oil, and other natural resources. These facts underlying to the government a heavy reliance on foreign assistance. Its GDP is the second higher in Levant countries area, corresponding to $82.99 billion, with a really growth rate of 2.9%.

The use of ICT among its inhabitants is not strong. The internet service has improved recently with the increase use of digital switching equipment. There is a growing of mobile-cellular usage in both places, urban and rural areas. This fact is reducing the use of fixed-line services. The internet users arrived to 4.335 million which equal 53.4% of the population as a whole. Jordan is one of the safest countries in the Middle East and it has both, modern and traditional life styles.

d. Final considerations

Considering the three referred countries of Levant area, it is possible to see that they are facing an increasing in the urbanization process as the worldwide. The following schedule will show the percentage of population living within the city between 1950 and 2030 in these three countries (Table no. 3 and Fig. 25).

According to the previous information it is clear that the largest country in terms of area in the Levant area is Syria. It also has the highest population among these three countries, while Lebanon achieves the best rate in terms of GDP, internet users and urbanization.

It is possible to understand that in all these three countries there is a strong growth in terms of urbanization and people living in urban areas. However, the highest rate is in Lebanon, which is twice the growth of Syria in between 1950 and 2030. The population living in urban areas in Syria increases from about 30% in 1950 to about 60% in 2030, which represents the double. In Lebanon this growth is from about 30% in 1950 to 90% in 2030, representing three times more.

Country	1950	1960	1970	1980	1990	2000	2010	2020	2030
Syria	30.6	36.8	43.3	46.7	48.9	50.1	5107	55.5	61
Lebanon	32	42.3	59.5	73.7	83.1	86	87.2	88.6	90
Jordan	37	50.9	56	59.9	72.2	80.4	83.9	86.5	88.5

Table 3: Urban population as percentage of total population in Syria, Lebanon and Jordan 1950-2030 (AA. VV., 2016g).

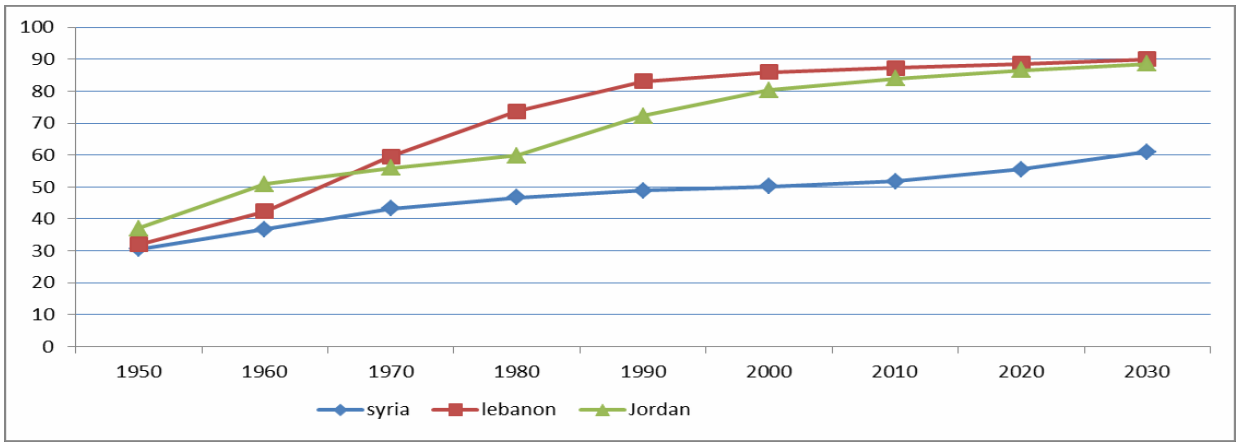

Fig. 25 Urban growths in Syria, Lebanon and Jordan 1950-2030.

3.2.2 The Persian Gulf

In the early 16th century, the Portuguese expansion around the Indian Ocean reached the Persian Gulf coast, in Bahrain. Later on the Portuguese were expelled from Bahrain, but the Persian Gulf region became famous because of the trade and a flourishing commerce with Portuguese, Dutch, French, Spanish and the British merchants. In general, there are from this time, many main ports around this region. One of the most important ports is Jebel Ali Port in Dubai, the case study city of this Dissertation, located in the UAE.

Nowadays, the Persian Gulf consists of seven oil rich states, Saudi Arabia, UAE, Qatar, Oman, Bahrain, Kuwait, and Iraq. Saudi Arabia has the biggest area among these countries and also the highest GDP. Qatar is the country with the highest percentage of population using internet among the entire Arab world.

This section concentrates on some feature of the Persian Gulf area, which includes seven countries. The largest one in terms of area is Saudi Arabia, while the smallest is Al Bahrain. Saudi Arabia is at the top of the list in terms of GDP followed by United Arab Emirates. However, in terms of internet users, Qatar is on the first place of the list among all the Arab countries, not only in the Persian Gulf. The most urbanized country is Al Bahrain followed by Kuwait and then Qatar.

a. Saudi Arabia

Officially known as the Kingdom of Saudi Arabia (KSA), it is the birthplace of Islam and the home to Islam's two holiest shrines in Mecca and Medina. It's located in western Asia from the Middle

East constituting the bulk of the Arabian Peninsula. Its borders are with Jordan, Iraq, Kuwait, Bahrain, UAE, Qatar, Oman and the north of Yemen (Fig. 26). The Red Sea separates its territory from Sudan and Egypt. The Persian Gulf separates Saudi Arabia from Iran. Its land boundaries comprise with Iraq 811 km, with Jordan 731 km, with Kuwait 221 km, with Oman 658 km, with Qatar 87 km, with UAE 457 km, and with Yemen 1.307 km. It has a land area of approximately 2.149.690 km^2 (100% of land with no water area) (Fig. 34). So it is the largest country in the Middle East. The lowest place in Saudi Arabia is the Persian Gulf at 0 meters high, while the highest place is the Jabal Sawda at 3.133 meters high.

Fig. 26 Map and flag of kingdom Saudi Arabia (AA. VV., 2016f).

Population of Saudi Arabia is about 27.7 million, having a population growth rate about 1.46% (in July 2015). The major urban areas of the country are al Riyadh, which is the capital city, Jeddah, Mecca and Medina. Saudi Arabia possesses about 16% of the world's proven petroleum reserves, which ranks as the largest exporter of petroleum, and plays a leading role in Organization of the Petroleum Exporting Countries the petroleum sector accounts for roughly 80% of budget revenues, which is 45% of its GDP, and 90% of export earnings. That's why it is classified as one of the strongest financial economy in the world. The GDP is purchasing power parity of $1.681 trillion with a real growth rate equals to 3.4%.

In the KSA the communication sector has a new modern system including a combination of extensive, coaxial cables, and fiber-optic cables. It has more than 19.2 millions of internet users which is 69.6% (2015 EST) of the country's population the kingdom Saudi Arabia is one of the richest countries in the world and it is geographically the first largest state in the Middle East.

b. United Arab Emirate

The United Arab Emirates, sometimes simply called the Emirates or the UAE is a country in the Middle East, located at the southeast end of the Arabian Peninsula on the Persian Gulf, bordering Saudi Arabia and Oman (Fig. 27). This country is a federation of seven states that has grown from a quiet backwater to one of the Middle East's most important economic centers. The constituents of emirates are Abu Dhabi (which serves as the capital), Ajman, Fujairah, Ras al-Khaimah, Sharjah, Umm al-Quwain, and Dubai. It is stretched on land area of approximately 83.600 km^2 (Fig. 34) with the lowest place in the Persian Gulf at 0 meters high, while the highest place is Jabal Yibir at 1.527 meters high.

Actually the largest city of these emirates urban areas is not the capital; Abu Dhabi; which comprises more than three-fourths of the federation's total land area. Abu Dhabi is the center of the oil industry. However, the biggest city in the UAE is in fact Dubai.

The UAE is considered in the Arab World as one of the most liberal countries in the Gulf, where other cultures are very welcome, and different beliefs are generally tolerated (AA. VV., 2016f).

Fig. 27 Map and flag of United Arab Emirate (AA. VV., 2016f).

The UAE's total population was 5.7 million, having about 2.47% in terms of population real growth (July 2015). The urbanization progress, regarding the expected urban areas, represents more than 85.5% of its population as a whole.

Dubai is the major urban area of UAE in terms of population, with 2.415 million inhabitants living there, Sharjah with 1.3 million is the second, and Abu Dhabi is the third with 1.2 million. Actually before the natural resources (oil, petroleum and natural gas), discovered in the early fifties of

the last century, the UAE's economy was dependent of activities such as fishing, and a declining pearl industry. However, since the oil exports, the country's society and economy have been deeply transformed, and nowadays the UAE has an open economy with a high per capita income and a sizable annual trade surplus. These conditions are contributing to the purchasing power parity accounts around $641.9 billion, with 3% of real growth rate.

In more details the UAE's oil reserves are the seventh-largest in the world, while its natural gas reserves are the world's seventeenth-largest. Also the UAE is a highly developed country in the Arab World, and one of the wealthiest countries in the Middle East. It is an outstanding country with a peaceful and joyful environment. Economically it is one of the best places to live, where there is no tax making, making the families lives easy to reach their financial goals.

c. Qatar

The state of Qatar is located in the Middle East, in the Northern coast of Arabian Peninsula, bordering with Saudi Arabia and the Persian Gulf (Fig. 28). Its land boundaries equal 87 km, having borders with Saudi Arabia. Qatar stretches in total area 11.586 km^2 (Fig. 34), 100% for land. Its lowest place is the Persian Gulf at 0 meters high, while its highest point is Tuwayyir al Hamir at 103 meters high (AA. VV., 2016f).

Fig. 28 Map and flag of Qatar (AA. VV., 2016f).

The population in Qatar scored about 2.194 million with a population growth rate of 3.07% (July 2015). The urbanization achieves 99.2% (2015). Its capital city is Al Doha. In the current century Qatar has prospered with continued high real GDP growth, which is driven largely by the oil and natural gas sectors scoring around $324.2 billion (2015). With a real growth rate of 4.7%, Qatar don't forget its growth in sector such as manufacturing, construction, and financial services, which have lifted the non-oil activities to just over half of Qatar's nominal GDP.

In terms of new technologies and communication, Qatar has a modern system centered in Al Doha which improves the use of internet to more than 96.7% of its population as a whole.

d. Final considerations

The urbanization process in the countries of the Persian Gulf will be appear in the next schedule (Table 4 and Fig. 29), which defines the percentages of population living within the cities, during a period of time of 80 years, in between 1950 and 2030.

All the seven countries of the Persian Gulf have registered a high increasing of their urban population during this period. All of them are going to have more than 70% of their population living in cities in 2030. Iraq is the country with the lowest percentage 71% for obvious reasons, including several years of war and political instability. Kuwait, Bahrain and Qatar are going to be the more urbanized countries in 2030, with nearly 100% of their inhabitants living in urban areas; 98%, 98% and 96% respectively.

Country	1950	1960	1970	1980	1990	2000	2010	2020	2030
KSA	21.3	31.3	48.7	65.9	76.6	79.8	82.1	84.2	86.2
UAE	54.5	73.5	80.6	81.1	79.1	77.4	76.9	78.2	80.5
Qatar	79.2	85.2	88.4	89.4	92.2	94.9	95.8	96.5	96.9
Iraq	35.1	56.5	65.5	65.7	69.7	67.8	66.6	67.8	71.3
Bahrain	64.4	82.3	83.8	86.	88.1	94.6	97.6	98.5	98.8
Oman	8.6	12.4	25.1	44.3	65.4	71.6	71.7	73.3	76.4
Kuwait	61.6	74.9	85.7	94.2	98	98.2	98.4	98.6	98.7

Table 4: Urban population as a percentage of total population, in Persian Gulf countries, 1950-2030 (AA. VV., 2016g).

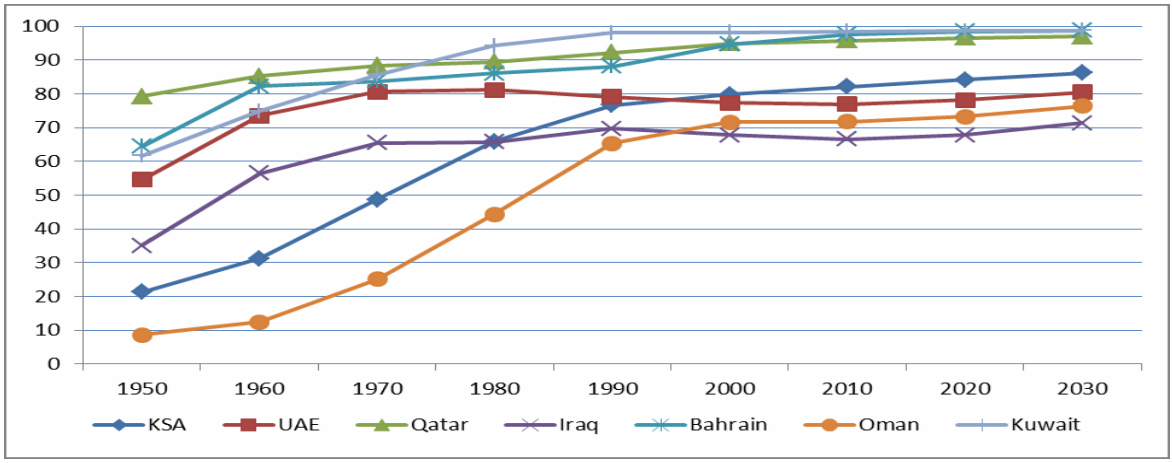

Fig. 29 Urban growths in KSA, UAE, Qatar, Iraq, Bahrain, Oman and Kuwait 1950-2030.

3.2.3 Al Maghreb

In this huge region of the Arab World called Al Maghreb, there are 11 countries. In terms of dimension, Algeria is the largest country in the Middle East and North Africa, and in terms of population, Egypt has the biggest number of inhabitants among the Arab countries.

There are 11 countries in Al Maghreb which are the following: Algeria, Egypt, Morocco, Yemen, Sudan, Mauritania, Tunisia, Libya, Somalia, Djibouti and Comoros.

Therefore, this part of this Dissertation is focused on the third great region of the Arab World, Al Maghreb and its most representative countries; Algeria, Egypt and Morocco.

a. Algeria

Algeria is an Arab country located in the western part of the North of Africa, bordering the Mediterranean Sea, between Morocco, Mauritania, Mali, Niger, Libya and Tunisia (Fig. 30). Its land boundaries comprise seven countries: Libya along 989 km, Mali along 1.359 km, Mauritania along 460 km, Morocco along 1.900 km, Niger along 951 km, and finally Tunisia along 1.034 km. Algeria is stretched on a land area of approximately 2.381.741 km^2 (corresponding to 100% of land) (Fig. 34). Algeria is the largest country in Africa and in the Arab world as well. It has a geographical location between Africa and Europe, and its lowest place is called Chott Melrhir at 40 meters high, while its highest point is Tahat at 3.003 meters high. Based on its localization, its climate is mild, with wet winters and hot and dry days in the summer time (AA. VV., 2016f).

Fig. 30 Map and flag of Algeria (AA. VV., 2016f).

According to the last estimation in 2015 the population in Algeria is 39.5 million with a population growth rate of 1.84%.

Depending on the development in all aspects of the society, most of the Algerian population is moving to live in urban area. Therefore, this country has an urban population of 70.7%, with the capital city Algiers comprising 2.6 million.

In Algeria there are a lot of known natural resources, such as petroleum, natural gas, iron ore, phosphates, uranium, lead and zinc. Actually in the most recent years Algeria's economy achieved the 10th largest place in terms of reserves of natural gas in the world and it is the sixth largest in terms of gas exporter. These facts explain why sector such as the hydrocarbons are playing a major role as a backbone of its country economy.

Algeria's economy aims to attracting foreign investments, bolstering the private sector, and providing adequate jobs for younger Algerians. The purchasing power parity in Algeria GDP is $570.6 billion, with a real growth rate of 3% (2015). The most of the labour force is based on the industrial sector, which represents 58.4% of total economy. Finally, in terms of technologies and communication, Algeria has 15.1 million user of internet, which consists of 38.2% of all its citizens.

b. Egypt

Egypt is a country belonging to the Arab World, located in the northeast part of Africa and the Sinai Peninsula, which forms a land bridge with the south-west Asia (Fig. 31). This reason explains why Egypt is also called a Middle East country. It is bordering with the Mediterranean Sea from north, Sudan from the south, Libya from the west, and across to the Red Sea from Saudi Arabia

and on the Mediterranean coastline. Its borders include the following four countries: Gaza Strip sharing 13 km; 208 km with Israel; Libya is along 1.115 km; and Sudan along 1.276 km. Egypt is stretches in a total area of 1.001.450 km^2 (995.450 of them for land and 6.000 for water) (Fig. 34). The lowest point in Egypt is Qattara Depression with 133 meters high, while the highest place is the Mount Catherine with 2.629 meters high.

In Egypt there are very small areas for agricultural purposes, that don't exceed 3.6% of its area as a whole (AA. VV., 2016f).

Fig. 31 Map and flag of Egypt (AA. VV., 2016f).

In Egypt there was a high increasing of population which counts 88.5 million, with a population growth rate of 2.51% (July, 2015).

Cairo is the capital of this country and the largest city of Egypt. The Greater Cairo is the largest metropolitan area in the Middle East and all over the Arab World.

Egypt has achieved many goals in many aspects of their social and economic development. A sort of business climate, supported by several reforms is on-going in order to attract foreign investors, facilitating the growth. Another strong sector of Egyptian economy relies on tourism because it has a lot of historical places related to the Pharaohs, pyramids and their amazing histories. The GDP of this country is purchasing power parity of $1.048 trillion, with a real growth rate that equals 4.2%. Finally, in terms of technologies and communication, more than 42 millions of people in Egypt are using internet, which equal 35.9% of this country population as a whole. Thus, Egypt is an amazing country with a great history and civilization and the Capital Cairo is considered to be one of the best cities in Africa.

c. Morocco

The kingdom of Morocco is a country in the Maghreb region at the West coast of North Africa, bordering with the North Atlantic Ocean and the Mediterranean Sea, between Algeria and Western Sahara (Fig 32). Morocco has an area of 446.550 km^2 (corresponding to 446.300 km^2 for land and 250 km^2 for water) (Fig. 34). Its lowest place is the Sebkha Tah at 55 meters high; while its highest point is Jebel Toubkal at 4.165 meters high. Morocco has a Mediterranean climate, becoming more extreme in the interior of its territory (AA. VV., 2016f).

Fig. 32 Map and flag of Morocco (AA. VV., 2016f).

According to the last estimation (July 2015) Morocco has a population of over than 33.3 million, with 1% of population growth rate and about 57.1% of them are using internet. The majority of its population is concentrated in urban areas, representing 60.2% of total population of this country. The principal urban area is the capital, al Rabat. Such as many other countries in the Arab World, Morocco is as well characterized by many natural resources, for example phosphates, iron ore, manganese, lead, zinc, fish and salt. All of the previous resources play a crucial role in Morocco's economy which includes other sector such as agriculture, tourism, aerospace, or textiles. The purchasing power parity of the country if $273.5 billion, having 4.5% of real growth rate. Morocco can be considered a rich, and beauty country, with a deep history, and one of the closest countries in the Arab World to the European nations.

d. Final considerations

The next schedule will illustrate the urbanization process and the population living in cities in the countries of Al Maghreb area, during the period of 80 years, in between 1970 and 2030 (Table no. 5 and Fig. 33).

This part of the Arab World registered in 1970 the lowest rate in terms of urbanization among all its countries. On one hand, countries such as Mauritania, Yemen, Comoros or Sudan had at the time around 5% of people living in cities, 3.1%, 5.8%, 6.6% and 6.8% respectively. This means that at the time, all most everybody in these countries was living in rural areas. On the other hand, some countries have registered an amazing growth in terms of urbanization, given that their starting points were really low.

In 2030, in all of them the percentage of people living in urban areas will be over than 50%. Djibuti and Libya will register the highest scores, with 90% and 92% respectively.

country	1950	1960	1970	1980	1990	2000	2010	2020	2030
Algeria	22.2	30.5	39.5	43.5	52.1	59.8	66.5	71.9	76.2
Egypt	31.9	37.9	42.2	43.9	43.5	42.5	43.7	47.7	53.9
Morocco	26.2	29.3	34.6	41.3	48.4	55.1	61.9	67.8	72.7
Yemen	5.8	9.1	13.3	16.5	20.9	25.4	29.4	34.8	41.7
Sudan	6.8	10.7	16.5	20	26.6	36.1	45.2	53.2	60.7
Mauritania	3.1	6.9	14.6	27.4	39.7	40	41.4	45.4	51.7
Tunisia	32.3	37.5	44.5	51.5	59.6	63.4	67.2	71.1	75.1
Libya	19.5	27.3	45.1	67.9	78.6	83.1	86.3	88.4	90
Somalia	12.7	17.3	22.7	26.8	29.7	33.3	37.5	43	49.9
Djibouti	39.8	50.3	61.8	72.1	76	83.3	88.1	90.6	92
Comoros	6.6	12.6	19.4	23.2	28.2	33.8	40.4	47.7	55.1

Table 5: Urban population as a percentage of total population, in Al Maghreb countries, 1950-2030 (AA. VV., 2016g).

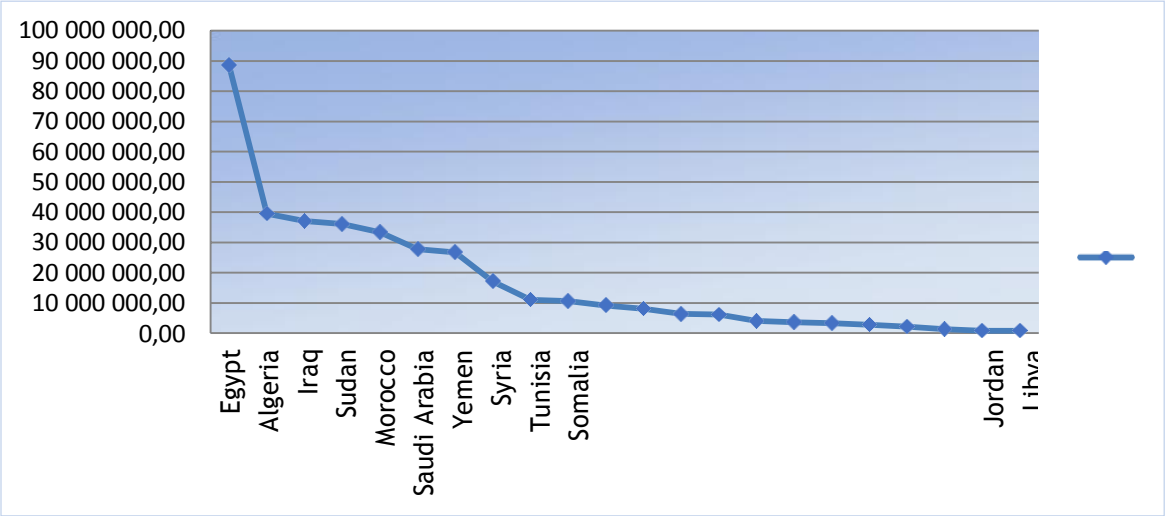

Fig. 33 Urban populations in Algeria, Egypt, Morocco, Yemen, Sudan, Mauritania, Tunisia, Libya, Somalia, Djibouti and Comoros 1950-2030.

The following last figures of this Chapter shows a resume of all Arab countries in terms of their territorial dimensions (Fig. 34) and in terms of their inhabitants in 2015 (Fig. 35). As this Chapter refers previously, the biggest country in the Arab World is Algeria and the smallest is Bahrain and the most crowded country in terms of population is Egypt and the less crowded is Comoros with the lowest number of inhabitants.

Finally, as referred along this Chapter previously, in the last figure (Fig. 36) there is a representation of the number of internet users among the Arab World countries. This feature is a good indicator in order to understand the level of technology that is available in these countries. Therefore, the figure shows that Qatar scored the highest rate in internet users among Arab countries, in opposition to Somalia with the lowest rate.

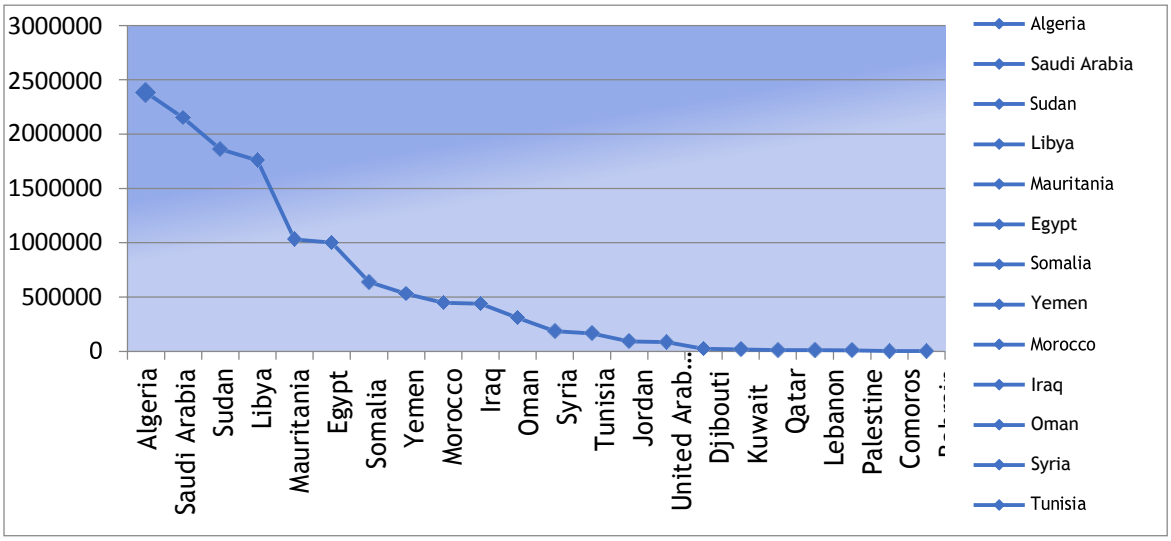

Fig. 34 The area for each country in the Arab country.

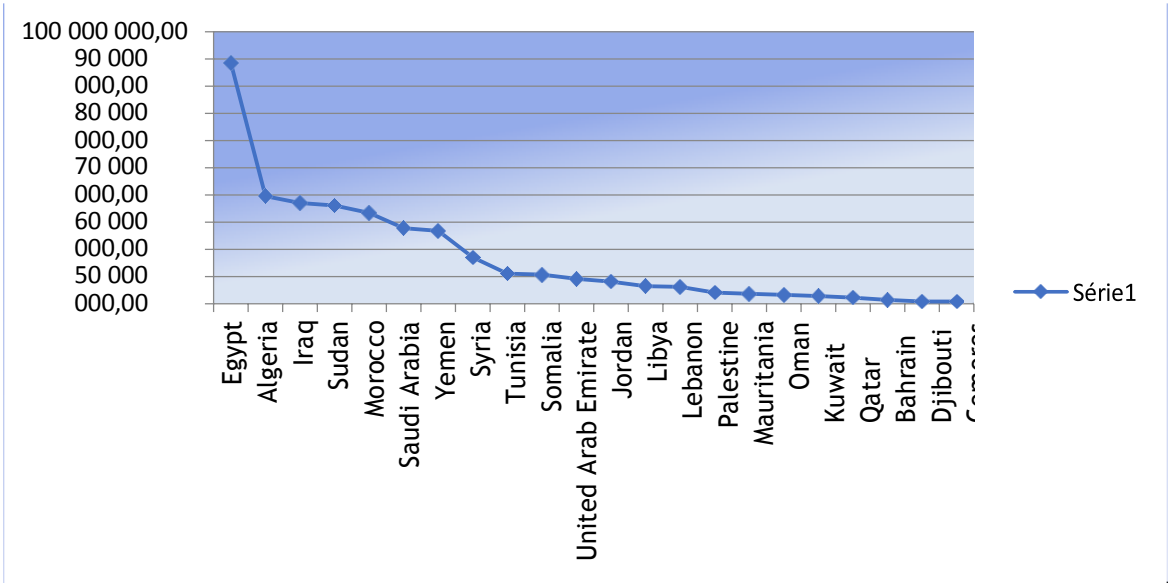

Fig. 35 The population in each Arab country in 2015.

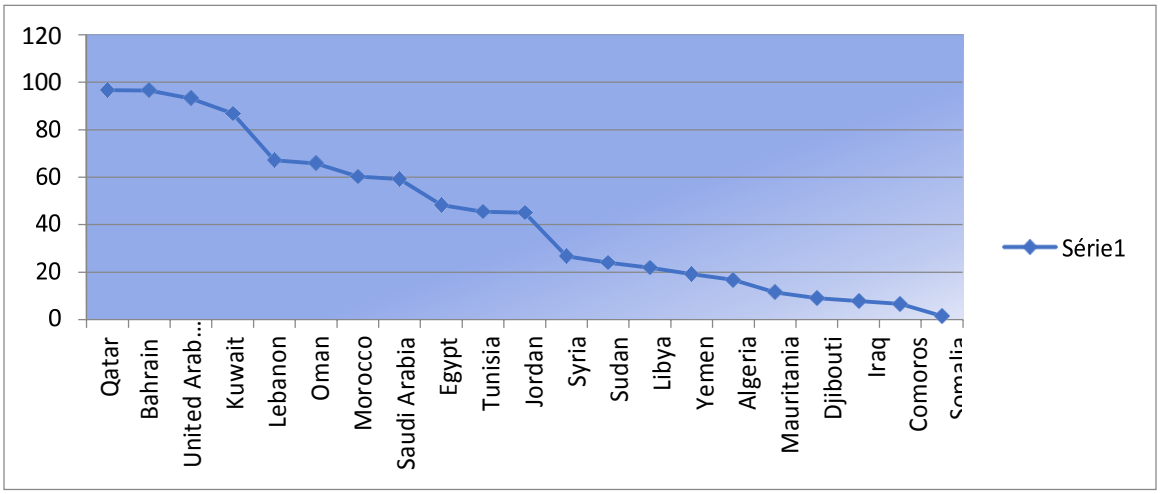

Fig. 36 The percentage of internet users in each Arab country in 2015

Chapter 4. Dubai as a pioneer smart city in Arabian world

4.1 Dubai's localization, population and urban development

4.1.1. Location, population and urban development

Dubai is located in the Middle East in the beautiful, stunning and wonderful Arabian Gulf. It is one of the seven emirates of UAE, which were gathered and constructed in 1971' (Pacino, M., 2005: 256). It is the most populated city of the emirates, situated along the southern coast of the Persian Gulf on the Arabian Peninsula (Fig. 37). It also shares the borders with Abu Dhabi in the south part, Sharjah in the northeast, and the Sultanate of Oman in the southeast. The Emirate of Dubai is the second largest emirate in the UAE after the Emirate of Abu Dhabi, with an area of 4150 km^2 of land, 38% of which designated for development (Alawadi, K., 2016: 3). Its area is equivalent to approximately 5% of the area of the UAE as a whole, comprising the urban area and the desert part (Fig. 38).

Dubai has the creek which runs south from the Arabian Gulf for 13 km long and nowadays stretched to 17 km (Nassar, A. K., Blackburn, A., Whyatt, D., 2014: 51) dividing the city into two main parts, the al Deira to the east, and the bur Dubai to the west. Arabic is the official language, but the English is very common as well. Islam is the official religion however other religions can practice their religious rituals.

Fig. 37 Location of Dubai on the world map (based on google maps).

Fig. 38 a - Dubai map with urban expansion (red line); b - Dubai map with desert area (black line) (based on google maps).

Dubai has an interesting and varied history. Over a period of about half a century the city state of Dubai has progressed from a small village for fishing community and pearl diving purposes on the Arabian gulf, to a cosmopolitan and significant twenty-fist century city. Nowadays, it is one of the world's most prominent business centre, vital commercial and trade city. It is in contrast with the major Western cities. In this case the transition process from a pre-industrial to an industrial and to a post-industrial status occurred in a short period of time over a period of about five decades. Dubai has undergone a similar transformation in only fifty years (Pacione, M., 2005: 255). Therefore, it has received the most attention from scholars, because of its efforts related with its quick urbanisation process, called "Dubaization". In aspiring to dominance, Dubai pioneered the race towards a fast development in the Gulf area. Dubai is a single example at the global scale of urban development, well known as an "instant" urbanism, because it was really quick its urban development process (Alawadi, K., 2016: 353).

4.1.2. The evolution of population

The population growth curve for Dubai takes the form of an outspread with a slow initial growth from 10.000 inhabitants in 1900 to 59.000 in 1968 (Pacione, M., 2005: 257). Thereafter, the city entered to a period of rapid population growth. By 1985, the number of residents had risen to 370.788 and the population has continued to grow, increasing to 689.420 in 1995 (Pacione, M., 2005: 257) to over than 2.2 million in 2013. In 2015 it reached to 2.4 million representing an annual growth rate of over 6.5%.

This rapid population growth of Dubai in the recent decades can be explained as the result of two main factors. First of all, it was the result of the great and significant immigration, boosted initially by the economic expansion of the city, based on the oil industry development, after

discovering a large oil reserve. This fact has created a demand for labour and expertise that could be only satisfied from abroad. Secondly, there was a natural increase of the population rates, based on the decline in infant mortality rates. According to the last statistics for government of Dubai (according to Dubai Statistics Center, 2016) the number of permanent residents is 2.4 million, while the number of workers in this Emirate from those who residents outside the Emirate and temporary residents equals 1.1 million. In the period between 1968 and 2013 (Fig. 39), Dubai's population has increased until nearly 2.5 million.

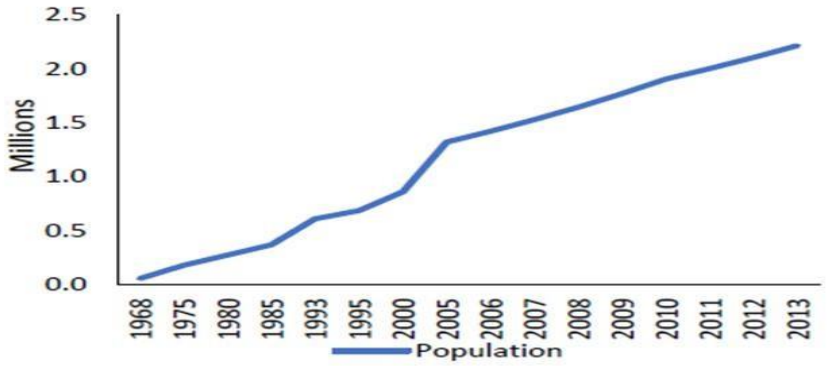

Fig. 39 Development of the number of population in Dubai 1968-2013 (Dassani, N., Nirwan, D., Hariharan, G., 2015: 9).

4.1.3. Urban growth in Dubai

In Dubai, the increasing of the population has occurred at the same time as an increasing of the urban area. The government of Dubai has adopted a form for urban design strategies, in order to have a more effective deliver in terms of city's environment, social, and economic development. This model called "Dubaization" embraces the ideas coming from the economic liberalism, includes several mega projects, and spectacular architecture landmarks on a massive city scale (Alawadi, K., 2016: 353). The authors are identifying four major phases of the urban development Dubai (Alawadi, K., 2016: 354), which are the following:

- First phase 1900-1955 – low urbanization period;
- Second phase 1955-1970 – compact urban development period;
- Third phase 1970-1990 – planning for suburban growth period;
- Fourth phase 1990-nowadays – the urban globalization period.

a. First phase 1900-1955 – low urbanization period

From 1900 until 1955 (the year when the first oil reserve was discovered) Dubai was characterized by a period of a low urbanization. This was an era with a slow urban growth, due to the constraints of the economic growth. Therefore, the population growth was low as well. This phase corresponds to the pre oil discovery in Dubai or to the pre-industrial era of this territory.

This is the first phase of the urbanization process of the city of Dubai, and the only one which was characterized by the absence of spatial planning instruments, strategies or proposals. It happened for the period of about five decades, which corresponds to the first half of the 20th century, when the first discoveries of the oil on this territory had just started.

b. Second phase 1955-1970 – compact urban development period

During the period comprised in between 1955 and 1970 there was a compact urban development process in Dubai, based on its first Master Plan from 1960 prepared by the British architect John Harris (Fig. 40). This Master Plan was design in order to provide a new road system for the city, supported on a zoning propose for the urban area, based on the identification of different land uses. Finally, it was proposing the creation of a new town centre. During this period the Dubai Municipality was established in order to be responsible for the administration and the co-ordination of all municipal services.

This second step of the urban development in Dubai refers to the first spatial planning measures, proposed to the city expansion. It comprises a period of about 15 years until 1970.

Fig. 40 John Harris's first Master Plan of Dubai from 1960 (Akhavan, M., 2016: 347).

c. Third phase 1970-1990 – planning for suburban growth period

A third phase can be identified with the urban development of Dubai, which is comprised in between 1970 and 1990. It corresponds to a period of planning rules focused on the suburban growth, in an economic and social context of deep changes, due to the discovery of the main oil reserves. These main discoveries took place in the early of 1970. In 1971 (Pacione, M., 2005: 260) a new and more ambitious Master Plan was designed for the city as a whole. This plan was considering several proposals, including a provision for ring roads around the city and a radial street network to the suburbs (Fig. 41). It was also proposing the construction of the Shindagha Tunnel beneath the river creek Dubai, in order to connect the area of Bur Dubai and the area of Deira. This connection implied the construction of two new bridges over the referred river.

In 1972 the central urban area 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 which was built in 1972, and extended towards the south part of the city, the Jebel Ali port which was built a bit time

later, in 1980. The latter area witnessed the emerging in 1985, of the very well-known Jebel Ali free zone in commercial and financial terms, which is nowadays one of the main centers in the city of Dubai (Nassar, A. K., Blackburn, A., Whyatt, D., 2014: 55).

In the decade of 1990 Dubai witnessed a rapid urban expansion by the spatial spread of the urban fabric, based on several and diverse development projects.

This third step of the urban development in Dubai comprises a period of 20 years, until the decade of 1990. It was focused on the definition of several spatial planning strategies, in order to foster the roads system and therefore the urban growth.

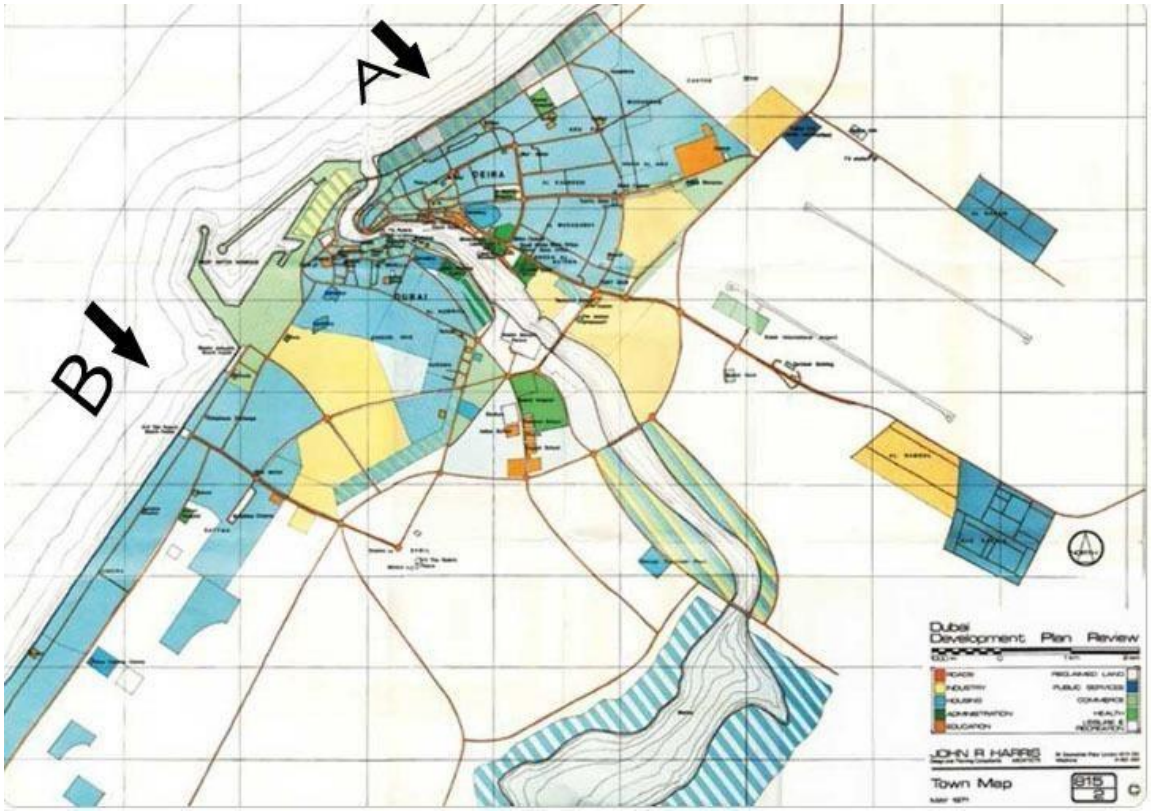

Fig. 41 John Harris's second Master Plan of Dubai from 1971: A - Daira; B - Bur Dubai.

d. Fourth phase 1990-nowadays – the urban globalization period

Since the decade of 1990, that the world is living the globalization era and Dubai is not an exception related to this issue. In fact, since the early 1990 that the political authorities of Dubai, responsible for the spatial planning and for the urban development (Pacione, M., 2005: 260) are boosting several strategies in order to guide the economic and physical development of

the city. In a period of approximately twenty years, their planed the "Dubai Urban Area Strategic Plan 1990–2012" (Fig. 42). Therefore, the twenty-first century key challenges of Dubai include the following aspects:

- To absorb the urban expansion by providing more lands to meet the current and future needs for the residential, industrial and commercial uses;
- To extend the transport network and the infrastructure facilities, especially to the suburb areas;
- To promote an economic growth and to support the investment in the urban space and its qualification.

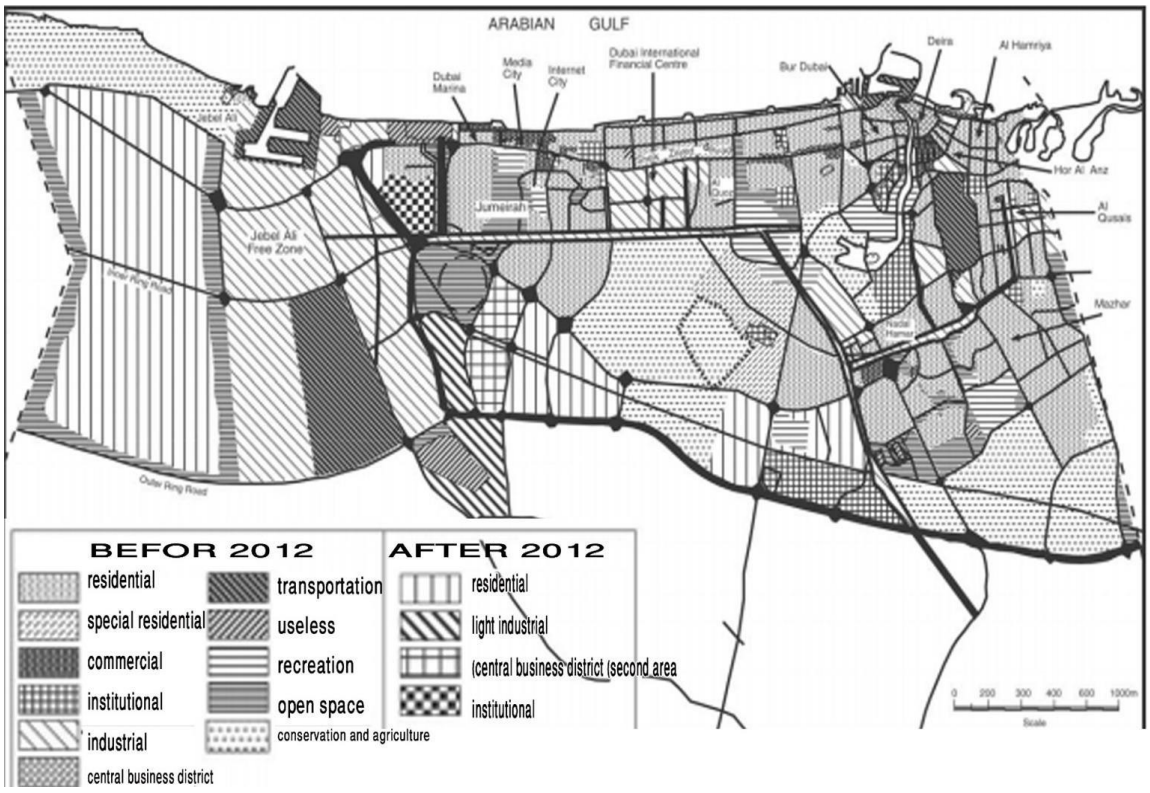

Fig. 42 Urban areas in the Strategic Plan of Dubai 1993-2012 (Pacione, M., 2005: 263).

The period comprised in between 1992 and 1998 (Nassar, A. K., Blackburn, A., Whyatt, D., 2014: 55) is known by the construction focused on the real estate and tourism purposes, which began during this time. One of the main examples is the Jumeirah beach extension, a resort with the shape of a palm tree, known as Jumeirah Palm Island, located over the sea of the Arabian Gulf.

Another case is the Burj Al Arab hotel, which was built a bit later, during 2000–2003, being an artificial island as well.

More recently, between 2003 and 2011, there are even more extensive changes in Dubai near to the coastline with the appearance of new 68 km^2. This area was added to the total terrestrial area of Dubai Emirate, by several offshore reclamation projects in the Arabian Gulf. By 2011 approximately 11 km^2 of the marine environment had been converted to urban areas, through artificial islands.

Nowadays, there are approximately 57 km^2 being converted to sand, comprising a set of new four artificial islands, which are still under development (Palm Deira, World Islands, Palm Jebel Ali and Dubai Waterfront) (Fig. 43).

In 2008 two new big infrastructures were built in Dubai. One was the Al Maktoum International airport and the other one was the Dubai industrial city.

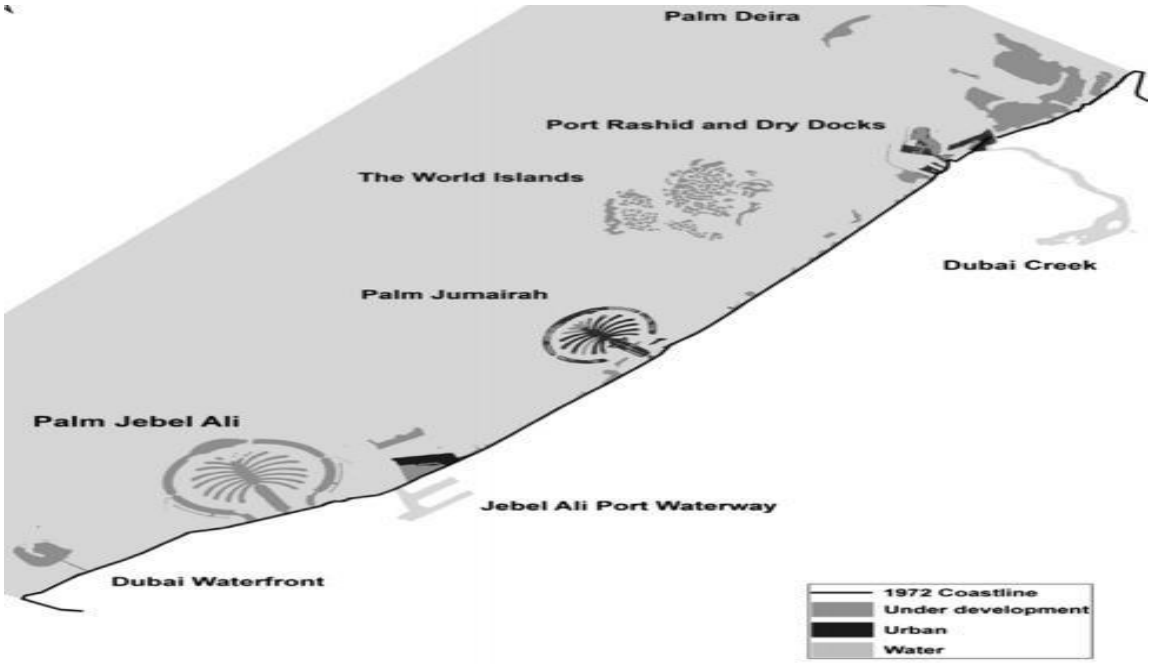

Fig. 43 Dubai's costal development by 2011(Nassar, A. K., Blackburn, A., Whyatt, D., 2014: 57).

In summary the fourth phase of the urban development in Dubai took place since the decade of 1990 and it is still ongoing. On the contrary with the previous phases, this fourth step is not based on strategies of planning new housing developments. Its main features are the urban

developments focused on the touristic purposes, such as the artificial palm islands and the big infrastructures such as the airport or the Dubai industrial city.

e. Synthesis of the urbanization process in Dubai

The main important changes in the process of urbanization in Dubai can be explained in two or three main ideas. The main urban expansion 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 region as well (Fig. 44).

Since then, Dubai has witnessed a great economic growth, depending on a rapid urbanization process, known as "Dubaization" which has turned the desert into a dense and modern urban, residential, and commercial, sports and touristic spot.

Nowadays, Dubai is a very popular destination for tourism and a pivotal economic centre among the Arabian world. Therefore, the political authorities, including the government of Dubai are aiming to transfer Dubai into a 'Smart City' by implementing new strategies, and policies focused on a smart infrastructures system and a smart governance framework.

In this sense, Dubai is one of the few cities in the world which has adopted a unique approach in order to turn into a smart city. Thus, the Dubai's smart city strategy includes over 100 initiatives around transportation, communication, infrastructures, electricity network, economic services and urban planning. As well a plan to transform 1.000 government services into smart services (Dassani, N., Nirwan, D., Hariharan, G., 2015: 8) is being prepared. This project aims to encourage the collaboration in between the public realm authorities and the private sectors, in order to achieve several targets, which were defined in the six 'smart' focus following areas:

- Smart life;
- Smart transportation;
- Smart society;
- Smart economy;
- Smart governance;
- Smart environment.

These aspects are considered the key works in order to improve the quality of life of the inhabitants of Dubai, embracing innovation, and making this city more efficient, seamless, safe, delivering an enriching the urban experiences, through the use of smart technologies. These strategies are supposed to be able to make Dubai the happiest city on the earth. The main strategy to achieve this goal relies on the three basic following principles:

- Communication;
- Integration;
- Cooperation.

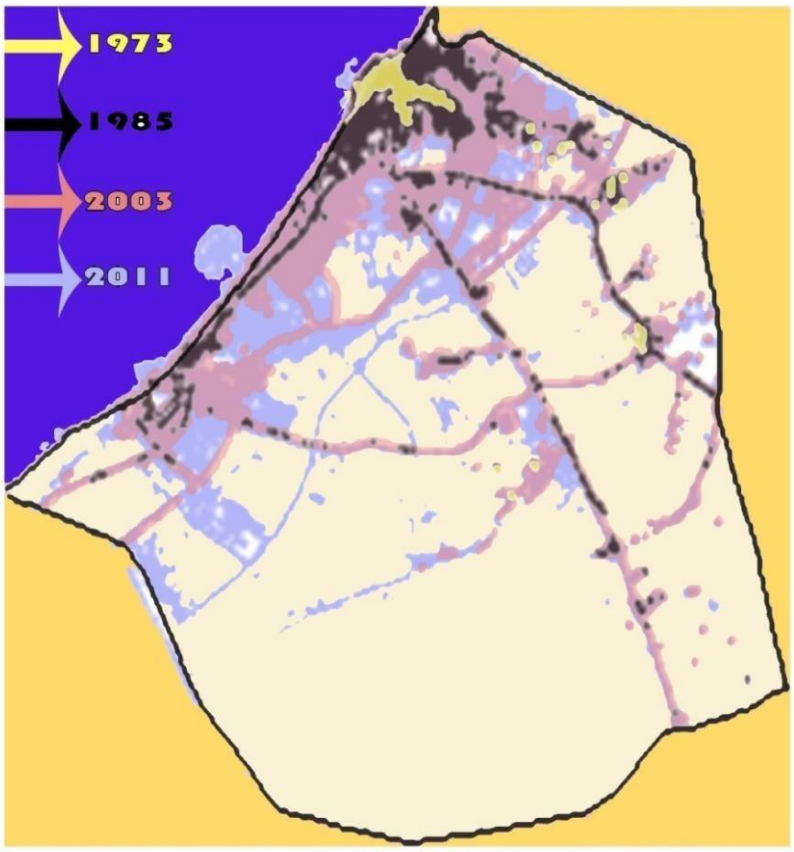

Fig. 44 Evolution of urban development in Dubai (1970-2011).

4.2 The inclusion of physical and digital infrastructures

Depending on the information that was mentioned before in Chapter 2, the smart infrastructures should provide great environment in cities backed with an efficient infrastructures network, which means the capacity to achieve the challenges of city environment, in terms of qualification of natural resources (including water, or energy), avoiding congestion, pollution, and dealing with the management of water disposal, and aging infrastructures.

On the city's scale, the infrastructures should cover three areas of knowledge: the physical, the digital and the communicative fields. In this sense Dubai is already integrating these areas, given that the physical infrastructure aims to connect digital and citizens. It consists of smart buildings, smart transportation, smart energy, smart water, smart waste management and smart healthcare. Therefore, this part of this Dissertation, will illustrate how Dubai is dealing with urban infrastructures in order to achieve smart solutions.

4.2.1. Smart buildings

According to the world business council sustainable development, buildings are consuming 32% of global energy and are responsible for 19% of carbon emission' (Dassani, N., Nirwan, D., Hariharan, G., 2015: 18). Thus, Dubai applies many strategies which focus on adopting new policies and technologies to make building more energy, water efficiency, and environment friendly, with $C0_2$ emission reduction, reducing the amount of waste produced and improving the security and the comfort for the residents.

Firstly, Dubai aims to apply to the integration of a building management system served by heating, ventilation and air conditioning with the help of technologies such as the IOT in order to have more intelligent buildings. This system includes the following aspects:

- A Centralized Lighting Control Systems which can control the lightning until the daily life controlling the use of energy by defining the shade and the sun positions;
- A Security Automation Systems and a Fire Automation Systems: with anti-theft alarm and surveillance system;
- An Energy Management System and a Water Management System.

In 2010, the Dubai Municipality introduced a set of codes that promotes the use of energy saving systems, natural lighting systems and green building materials. At the same time, it is implementing unified building codes for new buildings by collaboration with "Leadership in

Energy & Environmental Design" certified projects. In this aspect, 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, i.e. bronze requirement in order to be able to receive a permit. As well buildings that have already been certified as green, have to apply again for a rating certificate. By applying al Safat system on the buildings, Dubai is waiting to have a reduction of 7.3 million tons of carbon dioxide emissions over the next five years. Producing the same effect of planting 36 million trees, reducing the consumption of electricity by 20%, water consumption by 15%, carbon dioxide emissions by 20%, and waste production by as much as 50% (Saseendran, S., 2016: 1).

Regarding ICT, the municipality of Dubai has developed a smartphone application (called green buildings) to explain the laws, terms and conditions of green buildings in a simple language. Related to buildings, it is providing a unique system for Enabling Home Monitoring, Security, Safety and Air Conditioning Management, music system, switches security, intelligent lighting control system to save energy, parking guides, temperature control for save energy and many other development systems by using special apps on mobiles or tabs in order to control these systems remotely.

Dubai has as most iconic building of sustainability in the region, the "Pacific Controls Building" (Fig. 45), which is the first platinum rated green building in the Middle East and 16th in the world. It has an integrated building automation system that uses both wired and wireless sensors, controls and IOT. The building features include an IP backbone with control for access, audio and video cameras, elevators, fire alarms, solar thermal for air condition, photovoltaic cells for lightning and water efficient equipment. It houses the company's research and development activities and will also remotely monitor facility services for the public and private properties in the region.

Fig. 45 The first platinum rated building in the middle east pacific control building in Dubai (Architizer website 2016).

4.2.2. Smart transportation

Dubai announced several plans to transform itself into a Smart City. But Smart transportation is one of the biggest game changers of cities, essential towards the development of a Smart City. In this sense Dubai's government is focused on provide requirements for roads, transportation, and traffic to get a more efficient and integrated transportation systems. These requirements fall on the shoulders of Dubai's road transportation authority (RTA), which aims to put 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 also connected with ICT improving an ITS.

Some of the most important ongoing programs in Dubai related to RTA in the domains of reduce congestion, fuel consumption and CO_2 emissions are the following:

- RTA works on road networks, and wireless technology to make road signs communicate data and give drivers real-time updates on road conditions. This technology opens the door to intelligent telematics services that aims to improve drivers' safety and provide them with traffic information. So that optimized routes can be suggested to shorten time and reduce fuel consumption and CO_2 emissions (Zameer, S., 2014: 1);
- RTA has put in place several solutions including the development of public transportation, launching 150 e-services, 23 of them through smartphones. This is an effort to curb congestion (Zameer, S., 2014: 1).

Important aspect of planning at RTA is to mitigate the effects of pollution and to help promote a greener environment. Thus, RTA is contemplating introducing a car sharing service as part of its efforts to reduce emissions and decrease the number of cars on the roads (Colman, T., 2015: 1). The Dubai Supreme Council of Energy launched the Dubai Green Mobility initiative to create a low-carbon economy and to promote the use of hybrid cars and electric vehicles. There are 100 charging stations already set up across Dubai in 2015 (Wam, 2016: 1).

In order to encourage using the public transportation and sharing car, RTA improves several kinds of public transportation for citizens, including with special needs. They include the Metro subway system of Dubai, which is the longest automated metro network in the world, with 70 Km of tracks, serving 49 stations (Fig. 46). These stations offer connections to city bus routes. All stations are enclosed, with air conditioned and elevated walkways. Other public transportation systems in the city is the Dubai tram, the city buses, and the taxis (Acuto, M., 2010: 275).

RTA is also responsible for the following programmes:

- To launch an ambitious strategy for smart self-driving transport, using driverless car, is part of Dubai's strategy to become the smartest city in the world. By 2030, 25% of all transportation trips in this city will be smart and driverless (Wam, 2016: 2);

- RTA aims to encourage cycling in residential areas by providing a safe environment and cycling paths, connecting communities to beaches, malls and parks. They are as well connected to metro and tram stations, enabling people to be connected. So RTA is on target to deliver 900 kilometers of cycling paths in the next years (Dassani, N., Nirwan, D., Hariharan, G., 2015: 15), with interlinked community tracks as a key part of the project (Badam, R. T., 2015);

- RTA is encouraging more people to use their smart phones and internet channels to carry out transactions like registration of vehicles, renewal of driving licenses, and a series of other applications that can be processed without visiting the RTA's customer centers (AA. VV., 2016g);

- RTA offers 173 services that help people to complete transactions with a smartphone. The apps available on all smart phone platforms include Smart Drive, Wojhati, Smart Salik, Smart Parking, Smart Taxi, Drivers and Vehicles, and Public Transport (Dassani, N., Nirwan, D., Hariharan, G., 2015: 15);

- RTA provides smart parking apps to let people have the experience of finding parking space smoothly and easily by adding sensors in parks. This system tells to the drivers as they entered a street if there are parking spaces available or not.

Fig. 46 Metro of Dubai (Sequeira, J., 2015).

RTA is trying to reduce the accident road deaths by the several following means:

- Curbing the speed for drivers by installing speed sensors across the fleets of taxis, over 9.000 vehicles on Dubai's roads. This system issues a ticket and if the driver doesn't respond within 60 seconds, the driver will receive an alert to slow down (Jacotine, S., 2014);

- RTA is launching a new surveillance plan including more mobile cameras integrated with an array of modern technologies such as telecommunication systems, solar power panels, and movement remote sensors. These cameras will send instant images to control centres about the current traffic condition of roads. They will put road violators under tight spot, calculating the volume of traffic congestion on main roads and highways, detecting abnormal traffic patterns, and revealing the congestion generated by high traffic volumes. Also this system includes lanes control signs installed all over the main roads, alerting drivers about the road condition in advance, particularly on highways, and sudden congestion by directing them to alternative routes (AA.VV., 2016b).

Finally, considering the statics of Dubai, the annual loss of time and fuel due to traffic congestion, was estimated at around Dh5 billion for 2005. However, the RTA projects have had a positive bearing on the economy of Dubai with savings in time and fuel exceeding Dh87 billion between 2006 and 2014 (Colman, T., 2015: 1). On the other hand, according to the RTA smart phone apps have helped to reduce 8.100 tonnes of CO_2 emission in 2015 (AA. VV., 2016g) the driverless strategy will contribute to generate economic revenues and savings of up to Dh22 billion a year (Wam, 2016: 2).

4.2.3. Smart energy and water management

Water and energy are the most basic, essential and precious resources that are why the governments across the region have woken up to the importance of energy efficiency and water management in developing a sustainable growth path. So Dubai Government has outlined an ambitious strategy to secure a sustainable approach to energy and water usage and take advantage of its location in the sun belt.

Dubai Electricity and Water Authority (DEWA) which is a part of Dubai's government committed to establish, manage, operate, and maintain electricity generation, water desalination plants and power and water transmission and distribution networks in Dubai.as well DEWA aims to meeting customer satisfaction and promoting Dubai vision through delivery of electricity and water services at the world class level of efficiency, safety and environment by many projects:

- DEWA installed smart meters for customers to monitor their power and water use in real time;
- Good management for the waste water by recycling all this water and use it again in many things (as Irrigation of parks) and encouraging the collection and re-use of rainwater to reduce the demand for potable fresh water;
- DEWA is committed to achieving the strategic objectives of the Dubai Integrated Energy Strategy in 2030 which deployed in 2011 to set the strategic direction of Dubai towards securing sustainable supply of energy and enhancing demand side management (water, power and transportation fuel) to generate 71% of its total power output from natural gas (Fig. 47), 12% from nuclear power, 12% from clean coal and 5% from renewable energy by 2030 (AA. VV., 2013: 4).

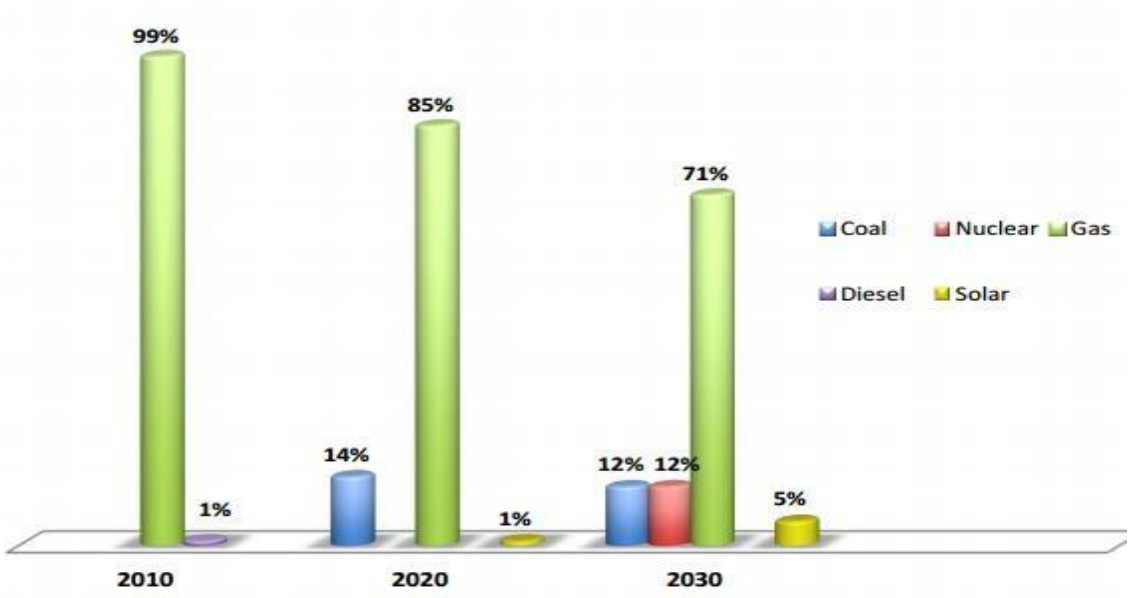

Fig. 47 Dubai's energy diversification from gas, clean coal, nuclear and solar energy (AA. VV., 2013: 4).

DEWA is adopting many projects to achieve this strategy, such as the Sheikh Mohammed Bin Rashid Al Maktoum Solar Park (Fig. 48 and Fig. 49), which has the capacity of 1000 MW, supported by a clean coal project (AA. VV., 2012: 5). This project aims to support an energy diversification strategy, reducing carbon footprint, converting desert west lands into natural resource environment and maintaining earth natural resource by using renewable resources. It consists of solar energy production, managed by the Renewable Academy and Research and Development Centre. The '13 megawatt (MW) solar photovoltaic (PV) power plant' is the first phase of the Dubai landmark Project. The second phase with a capacity of 200 MW is underway Drawing on public-private partnerships and the third phase with capacity of 800 MW.

Mohammad Bin Rashid Al Maktoum Solar Park is expected to generate more than 22 million kilowatt of electricity per year, on average, which is enough to meet the average annual electricity needs of Dubai. The generated electricity will displace more than 15.000 metric tons of CO_2 annually, which is equivalent to remove 1.600 cars from the roads every year or to have 692.303 planted trees (AA. VV., 2014d: 9). With this type of projects using renewable energy, DWEA looks up to reduce the demand of water and energy by 30% by 2030 (AA. VV., 2014d: 12).

Fig. 48 Sheikh Mohammed Bin Rashid Al Maktoum Solar Park in Dubai (AA. VV., 2014d: 2).

Fig. 49 The 13 MW solar photovoltaic in Dubai, the first phase of Sheik Mohammed Bin Rashid solar park (AA. VV., 2014d: 9).

DEWA developed a comprehensive Smart Grid strategy with the aim to connect several renewable energy sources. This Smart Grid is contributing to make Dubai a smart city. The smart grid consists of three initiatives constructed to ensure accessible and non-stop connected water and electricity services that meet daily living requirements of supply, while enabling the monitoring to facilitate smart environment and friendly use of resources. These three initiatives consist of smart applications, which are described below.

The first initiative (Fig. 50), called Shams Dubai initiative aims to integrate renewable energy in form of solar power for housing and building supply. It aims encouraging the owners and households to install the photovoltaic solar panels on the rooftops of their houses, in order to generate electricity. This system will be connected to DEWA's grid, and the produced electricity will be consumed in the buildings. The surplus production of energy will be exported to the DEWA's grid. This scheme encourages the use of solar energy and increases the energy sharing, promoting a green economy for sustainable development (AA. VV., 2013b: 13).

Fig. 50 Scheme of the smart PV on the buildings - Dubai (AA. VV., 2013b: 13).

The second initiative relates to smart applications (Fig. 51). Through smart meters and grids which will be installed in public and private services, is possible to provide automatic and detailed readings (both current and historical) of consumptions. The obtained data through these readings will be available to customers by smart applications, in order to allow them to monitoring their consumptions for a specific period of time, to better understand and manage their bills. Therefore, DEWA has launched actions to install Smart Water and Electricity Meters, which has in a first phase 200.000 meters long, aiming to achieve in a final stage 1.2 million meters of this smart infrastructure (AA. VV., 2013b: 13).

Fig. 51 Scheme of the use of smart applications by smart meters - Dubai (AA. VV., 2013b: 13).

The third initiative is the green charger (Fig. 52): according to this, DEWA commits to establish and management an infrastructure for electrically driven vehicles, to be charged by providing charging station points in several areas in Dubai, with priority to airports, Dubai Municipality, shopping centers, petrol stations, hotels, or car parks. This initiative will enhance the grid efficiency; Therefore, DEWA supports the introduction of electric vehicles in Dubai, in order to decrease the air pollution and to protect the environment against the impact caused by transportation sectors in the Emirate (AA. VV., 2013b: 14). Since 2015, more than 100 charging station points for electric vehicle have been established at various locations in Dubai (Wam, 2016: 2).

Fig. 52 Charging station scheme in Dubai for electric vehicles (AA. VV., 2013b: 14).

Finally, DEWA's core objective is to develop and to maintain water resources and supply, supporting the vision of Dubai Government in order to promote a sustainable development by driving energy and water use efficiency and investing in alternative energy sources. By the previous projects DEWA will contribute to reduce the carbon footprint, and by the solar power system it will reduce 1 million tons of carbon in 2030 (AA. VV., 2012: 7), and the demand for water and energy will reduce by 30% until 2030 (AA. VV., 2013b: 4).

4.2.4. Smart waste management

Nowadays Dubai is witnessing a sharp increase in its population growth due to its development as a business centre in the Middle East region. Consequently, there is as well a highly increasing in the waste production, which made Dubai the highest city in the world in terms of waste production rate. According to the latest municipal statistics the daily production of Dubai's general waste scored 11.500 tons in 2011 which equals 2.9 kg daily production of waste per capita (Sibai, W., 2013).

A small proportion of this waste is recycled, while most of them go to sanitary landfill reservoirs. But Dubai municipality (DM) aims to make Dubai smarter on this domain, putting the population aware of the importance of recycling and reducing the waste, and of the protection of natural

resources and wealth projects. In this sense Dubai's authorities are planning to create new jobs and encourage new investments in this area in particular. For doing that DM has developed and adopted an Integrated Waste Management Master Plan for the Emirate, which provides the roadmap and the required approach to efficiently manage the generated waste. The Waste Management Department (WMD) of DM has the responsibility for management of waste generated in this Emirate. This includes collection, treatment and disposal of the waste.

Waste in Dubai is classified under five main categories namely General Waste; Green/Horticultural Waste; Construction and Demolition Waste; Liquid Waste; and Hazardous Waste.

Waste quantities generated in 2011 in Dubai are presented in Table no. 6. It shows that the main quantity of waste is related with general waste, which consists of Municipal Solid Waste, Domestic Waste, and Institutional Commercial Industrial (Saifaie, A. A., 2013: 4).

Waste Type	Quantity (tones)
General Waste	2,689,808
C & D Waste	6,638,471
Horticultural Waste	175,022
Liquid Waste	154,119

Table 6: Waste quantity generated in Dubai in 2011 (Saifaie, A. A., 2013: 5).

The strategic vision of the Municipality's waste management department is to achieve the excellence throughout an integrated and effective sustainable waste management system and a set of good practices. It aims to convert waste from an environmental problem into an economic resource and thereby to enhance the environmental and health standards of Dubai. In this sense, several projects have been undertaken by DM, such as the following below:

- According to the latest report for the WMD the composition of the waste analysis revealed that 33% is General Waste, including organic waste containing residues of foods, and biodegradable materials. So the municipal works are trying to take advantage of this waste, having a large project in order to convert methane gas into energy, produced by the

decomposition of these materials in landfills. The project that converts methane gas into energy is the first of its kind in the region (Sibai, W., 2013);

- DM also takes advantage by applying a new project which is focused on burning the solid waste and the sludge from treatment plant to generate energy;
- Converting organic waste to compost which is used for agriculture, and landscaping purposes;
- The municipality aims to improve the awareness for the recycling concept and practice, which is without doubt an integral aspect of managing waste, to reduce the carbon footprint and the amount of the waste produced. The waste management department of Dubai has signed a contract with Tadweer Waste Treatment for recycling municipal solid waste, which processes about 4000 tons of waste per day (Saifaie, A. A., 2013: 6);
- The Emirates Recycling is responsible for recycling and recovery construction and demolition waste of the city, having the capacity of recycling 9.5 million tons per year in this domain;
- The municipality of Dubai operates landfills at five different locations in the Emirate. Three of them are focused on general waste, one is for Hazardous Waste Treatment and the other one is for the treatment of medical waste. The latter is fitted with the most advanced pollution control devices, to ensure the environmental protection and sustainability of the process (Saifaie, A. A.,2013: 7);
- DM has announced that it will establish the largest equipment in the Middle East to convert solid waste into energy at a cost of Dh 2 billion in the Warsan District 2. The waste will be burned through a grate furnace to produce electric power and to minimize the waste disposal in landfills. This process of burning the waste will help to get rid of 70% of waste mass, with 90% of the remaining ash to be used for construction operations, as a base for asphalt and basalt of road pavements. It aims to make Dubai the most urban, sustainable and smart city of Arabian world by the year of 2021. Another idea comes in line with the national agenda to reduce the landfill by 75% by 2021, in addition to protect the environment from methane gas emitted by the landfill (AA.VV., 2016c)
- Dubai has Smart Bins waste containers, equipped with intelligent sensors that can measure how full they are in real-time, and which can ensure that they are collected only when full.

Based on the previously referred projects, it seems clear that DM is not only responding to the current demand for efficient and effective waste management, but also for the safeguarding of

economic growth and social development as well, through its integrated approach to a sustainable and innovative waste management system.

4.2.5. Smart healthcare

In the last few decades, changing the environmental conditions and increasing the number of population, have been associated with an increase in the incidence of many chronic lifestyle diseases. So the vision of Dubai smart city will push the government to build additional sophisticated healthcare infrastructures and to adopt smart healthcare initiatives.

The strategy of the Dubai's healthcare authority has been built upon many things. Firstly, it aims to provide the best access to the city's dwellers to the healthcare services. Secondly, the healthcare provision must have the highest quality, according to the needs of the population. Finally, it is trying to ensure the provision of world class health services.

In this sense, the Dubai Healthcare Authority (DHA) is moving towards implementing total IT solutions that will drastically enhance the manner in which healthcare services are delivered and managed. IT integration is understood as the way forward in terms of high quality of the healthcare system. Therefore, it will provide a boost to the healthcare sector and it will ensure that health information is available to both, doctors and patients at their fingertips.

Some of the most important medical projects announced recently by Dubai healthcare authority are the listed in the following explanation. DHA launched a smart healthcare project in 2013 (Dassani, N., Nirwan, D., Hariharan, G., 2015: 16) comprising three main initiatives: smart applications, smart operations and smart hospitals; smart apps involve efficient communication and access to various services to the patients, for instance the SEHHATY application was designed for the convenience of patients, providing them important healthcare information; smart operations are related to all internal operations including administrative work which is paperless.

Smart hospitals are based on ensuring that the patient journey will be enhanced through the use of advanced technology such as touch screens, tablets or other ICT devices. These devices will empower customers by providing them several services and information on their fingertips. An example is the Smart Desk which is a prototype application and device that uses advanced touch-screen technologies to provide excellent experiences to patients.

In 2015 (Dassani, N., Nirwan, D., Hariharan, G., 2015: 17) the DHA had completed the implementation of the previous project by applying a new idea which is called the Electronic Medical Records and a Hospital Information System. It is an environmentally-friendly initiative

that will provide electronic access to the patient's files, containing all necessary details in order to allow the knowledge about the status of the patient health, including the results of any tests, X-rays. It includes as well, the records of doctors' visit to the patients, enabling the doctors to send instructions and medical supplies to other sections of the hospital, such as laboratories and pharmacies. This system interconnects all hospital departments and sections.

DHA by adapting this system will reduce patients waiting times, providing a storage of an accurate patient database. It will also eliminate paper work, which means cleaner data, better safety of information and better quality of health services. This system will give a quicker service, cutting the time needed for procedures by half.

Early of this year 2016 (Chaudhary, S., B., 2016) DHA launched a number of other projects to encourage the collaboration in between the private and public sectors, in order to enhance healthcare services in Dubai. This project is supported by integrating the health system, public and private. Nowadays, there are approximately 2.700 public and private health-care facilities in Dubai, providing a single electronic file for each resident.

In the mid of 2016 (AA. VV., 2016d) DHA initiated a pilot phase of a tele-health project with the development of several electronic applications, which allow patients to enter symptoms into the application and to get an idea about their health situation. This service issues for certain medical conditions, so doctors could provide e-consultations. This could shorten patient's waiting lists in hospitals, increasing patients' satisfaction and improving better diagnoses.

Finally, Dubai has one of the largest healthcare free zone in the world. It is called Dubai Healthcare City which is located in the heart of Dubai Healthcare City (DHCC). It was mandated by the government to meet the demand for high-quality. It is based on a patient-centred healthcare approach, and its main goal is to attract tourists to Dubai for medical services and treatments. Based on the strategy of partnerships, DHCC provides a wide range of services in terms of healthcare, medical education and research, pharmaceuticals, medical equipment, wellness and allied support.

DHA aims to achieve the target of transforming Dubai into the leading city in the Middle East for healthcare tourism.

4.3 Main characteristics and factors of smart Dubai

Several cities around the world have built a transformative culture around the smart concept and Dubai is one of them. It has a unique opportunity to pave the way and make a global impact

in this strategy. So Smart Dubai aims to introduce strategic initiatives and to develop partnerships to contribute to its Smart Economy, Smart Living, Smart Governance, Smart Environment, and Smart People dimensions. These are the main characteristics of smart Dubai.

Moreover, Dubai seeks to distinguish itself as the global leader delivering Smart Economy and Smart Living opportunities for its citizens, by enabling the dimensions of governance, mobility environment and people.

The following sections will illustrate the main projects and plans of the Dubai government to achieve the criteria of smart economy, smart living, smart governance, smart mobility, smart environment and smart people.

4.3.1. Smart Dubai's economy

Dubai has changed dramatically over the last three decades, becoming a major business centre with a more dynamic and diversified economy in the Middle East. Since the beginning of the growth revolution in Dubai in the decade of 1970, the government has a solid performance in pivotal established sectors of the economy such as trade, transport, real estate/construction, tourism or finance. Actually Dubai is focused in diversifying its economic base away from hydrocarbons because the government realized early on, that the access to oil is temporary. Therefore, gradually it is moved the focus towards other sectors where comparative advantages could be found. This is why Dubai's government adopted a strategy based on investing oil revenues on the infrastructures, including airport, ports, or transportations, and diverse industries to prepare Dubai for the post-oil era.

Since the early of 1970 (Al Faris, A., Soto, R., 2016: 16) that Dubai has cultivated an image of business friendly city, putting successive rules consistently, to the open door pro-business philosophy, supported international trade by reducing trade barriers. This strategy started opening Dubai international airport and improving maritime port facilities, with Rashid port deepening on the Dubai creek, followed by dredging Jebel Ali port, to accommodate more and larger ships that could operate in a lower coast way.

These initiatives created a healthy business environment and proved generous trade incentives that attract merchants and businessmen from neighbouring countries. Since the decade of 1990 that Dubai international airport has distributed as one of the world's busiest airports, linking 85 airlines with 130 global destinations (Pervan, S., Al-Ansaari, Y., Xu, J., 2015: 60). While Jebel Ali was reputed to be one of the world's top 10 container ports, connecting the Arabian Gulf with India or Africa.

All these infrastructures are reasons that are making Dubai a global trade hub, with a strategic location and classified as the biggest re-exporting centre in the Middle East. Dubai's government built the Dubai world trade centre, which is one of the most important points of leading conferences in the world, with a million square feet of diverse and viable areas for exhibitions, along with a range of cafes, restaurants and palm garden. It has a range of annual exhibitions that combine more than 6.000 events, 500.000 visitors and 2.600 media outlets from 150 counties. These exhibitions are great examples of how versatile the business in Dubai is. For example, Gitex is the largest electronic retail exhibition for fans interest, presenting the latest technology innovation and development.

Since the beginning of economic revolution in Dubai that the government aimed to open the door for businessmen and traders all around the world to invest in Dubai by providing some significant cost advantages not generally available internationally such as: no foreign exchange controls, no trade barriers or quotas, competitive import duties (generally 4%), competitive labour costs (the labour force is multi-lingual and skilled), competitive energy costs, competitive real estate costs, competitive financing costs and a high levels of liquidity in financial terms. There is as well no corporate profits or personal income taxes (except for oil companies and branches of foreign banks). These advantages are provided by free zones, that were designed as multi-industry areas, such as the free zone in Jebel Ali (Jafza), established in 1985 (Pacione, M., 2005: 257), which is one of the world's largest business areas. There is a fast growing of free zones in Jafza, which are spreading over an area of 48 km^2. It is home to over 6400 companies, including over 120 of the Fortune Global 500 enterprises (according to Dubai Free zone council). The success of the institutional framework of Jebel Ali led to the subsequent establishment of several new free zones, devoted to rising industries and that give to Dubai a particular characteristic, a business city within the city. This business city as several features such as the following:

- Logistic and industries: as Dubai airport free zone (DAFZ) which is since 1996 (Akhavan, M., 2016: 348) one of the fastest growing premium free zones in the world, located within the boundaries of Dubai International Airport. DAFZ is currently home of over than 1600 companies from diverse sectors, including electronics, construction, aviation, logistics, and other industries. It ranked the Top Free Zone in the World by the Financial Times' Magazine. DAFZ offers attractive packages for Dubai businesses set up, with 100% foreign ownership (the Dubai Free zone council);

- Financial: as Dubai International Financial Centre (DIFC) which is the financial and business hub of the city, connecting the region's emerging markets with the markets of Asia, Americas and Europe. It has been built to encourage economic growth and development in Dubai, by

applying to strong financial and business infrastructures. Nowadays the DIFC's clients base consists of 912 active registered firms including 19 of the world's top 25 banks, 8 of the world's 10 largest insurers, 6 of the top 10 law firms, 11 of the top 20 money managers and 7 of the top 10 consultant companies in the world. It provides an employment for 14.000 employees, 100% foreign ownership, zero per cent tax rate and no restrictions on capital convertibility or profit repatriation;

- Media: as Dubai Media City (DMC) which has rapidly emerged as a global media hub. DMC provides an advanced infrastructure and supportive environment for media related business, to operate globally out of Dubai. Many global media giants and promising entrepreneurial ventures are part of DMC's vibrant community, including CNN, BBC, MBC, Al-Arabia, Showtime and CNBC Arabiya, just to name a few;

- ICT: Dubai Internet City provides a knowledge economy ecosystem, designed to support the business development of information and communications technology companies. It is the Middle East's biggest ICT infrastructure, built inside a free trade zone;

- Healthcare: DHCC aims to provide the demand of healthcare, and a patient-centred healthcare approach. This city is currently comprising two hospitals, over 120 outpatient medical centres and diagnostic laboratories, with over 3.700 licensed professionals occupying 4.1 million square feet in the heart of Dubai;

- Dubai Investments Park is an integrated commercial, industrial and residential community.

The government also took an initiative of fostering strategic industry by developing institutional framework that allows public sector property of companies to be managed in an independent and autonomous manner. It is using private sector regulation and incentives. This scheme was applied firstly with Emirate's airline which has a fast growth of the international air lines, with one of the youngest fleets in sky, more than 400 awards for excellence and the most luxuries travel (Al Faris, A., Soto, R., 2016: 17).

On the other hand, the government of Dubai contemplated about the long term economy. So it has set a new model by investing in a luxury international tourism industry that confirms high quality tourism related to services as shopping malls, beach facilities, restaurants, cafes, and transportation. This strategy is supported by well-articulated activities, including exhibitions, sports, or shopping festivals. Actually in the recent years Dubai has witnessed a huge boom in the constructions sector to meet the increasing of population and absorbing the requirements of

tourists. For example, Dubai mall is listed as one of the biggest shopping mall in the world (Michele, A., 2010: 278).

An iconic example is the Burj Khalifa building (Fig. 53), the tallest structure ever built, 828 meters high, including private residential units, offices, restaurants, and hotels. It includes at the top of the tower, on the 124th floor, an observation platform outdoors to the sky (Acuto, M., 2010: 277).

Fig. 53 Burj Khalifa the tallest structure in the world - Dubai (Acuto, M., 2010: 273).

Also some special artificial islands on the coastline of Dubai such as the palm Jumeirah, the World Islands and the Burj Al Arab are ranking the first place over the past years and probably the next in the top 10 list of most attractive and fascinating artificial islands in the world. Dubai launches many new artificial islands like Jebel Ali Island and Deira.

Within a short period of time, Dubai has become one of the most important destinations for travellers and it is the second largest tourist recipient in the Arab world after Saudi Arabia. This success has supported the growth of other sectors in the economy, as trade, finance and transport. As a result of this strategy Dubai's GDP (Fig. 54) has increased very much (Nassar, A. K., Blackburn, A., Whyatt, D., 2014: 55), referring to retails (27%), transport sector (15%), real estate (14%), manufacturing (13%), banking and finance (13%), and construction (9%).

The next figure shows the recent construction of Dubai's GDP in 2014 (Said, R. R., 2016), so all of these initiatives reduce the contribution of the oil in Dubai's GDP which scored 46% in 1980 while in 2005 was 30% and finally nowadays less than 2.7%(Nassar, A. K., Blackburn, A., Whyatt, D., 2014: 58). With GDP per head about 22,000$ (Pacione, M., 2005: 565).

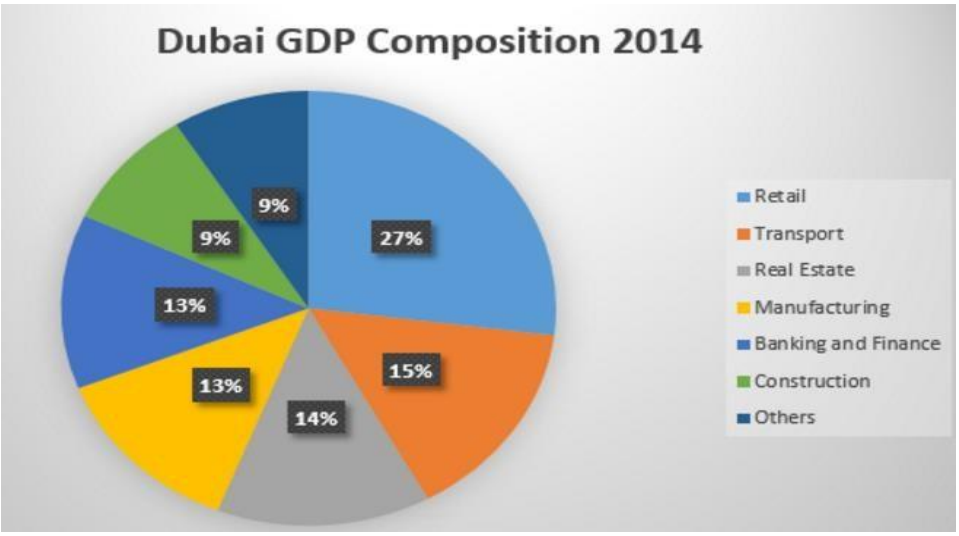

Fig. 54 The construction of Dubai's GDP (Said, R. R., 2016).

The Dubai economic council (DEC) is pushing the wheel of economic innovation by announcing some projects. DEC promotes investment funds to aid Emirate's small and medium-size enterprises, helping the start-ups. It is announcing the objective of launch the Dubai Global Innovation Centre, a joint initiative with Royal Philips, to expedite Dubai's transformation into the world capital of innovation. Projects related with trade and tourism are helping Dubai to become one of the top five fastest growing cities in the world, according to a survey of 300 cities by an American think tank (Everington, J., 2015: 1). Dubai reported the world's lowest unemployment rates on both the domestic and international levels, with an unemployment rate not exceeding 0.3% for last year 2015 (Dubai statistics centre). So Dubai is among other top contemporary cities, establishing its position with the global economy.

4.3.2. Smart living in Dubai

Since the beginning of the development strategy in Dubai, that the first target for the government anchored to make Dubai the happiest city in the world. Nowadays, the government is continuing to strive in order to maintain an exceptional quality of life and a cultural vibrant lifestyle, in a safe and secure environment. It is, as well promoting equal opportunities, maintaining social cohesion and minimizing social exclusion. It is also implementing city for everybody with a high quality, focused on the customer services, providing initiatives to promote excellence in these services, with participation and inclusion of people with disabilities in the community. The main areas are education, healthcare, safety and security, and tourism to get social inclusion.

The standards of a smart living are really hard to be evaluated because they depending on the different cultures, countries and lifestyles. However, is accepted everywhere that education, healthcare, security or tourism aspects, are keywords in a smart way of living. Actually Dubai is not as exception related with these criteria.

Education is the cornerstone of any country's growth and future. That's why the government of Dubai aims to improve and to invest in the education sector. About 35.7 % of 2015's (Dassani, N., Nirwan, D., Hariharan, G., 2015: 25) total budget was allocated to social development including the education sector. So Dubai's Knowledge and Human Development Authority (KHDA) introduced the smart e-Services portal for universities, schools and training institutes to connect directly to KHDA, saving time and paperwork, and improving costumers' satisfaction. For example, for the universities, KHDA is providing online registration for both staff and students certificate attestation, while for the schools and training institutions there is the online payment, alerts on permit expiry, tracking of permit requests, email notifications and separation of services for amendment processes.

Also Dubai launched a new smart learning initiative to connect students, staff and parents in a single e-platform. It creates a new learning environment in schools, by introducing smart classes in all public schools and providing every pupil with a tablet PC enabled by high speed 4G networks. These strategies are making a learning approach motivated by using smart technology (Dassani, N., Nirwan, D., Hariharan, G., 2015: 25).

On the other hand, the education in Dubai is unique in catering to a range of different higher education systems including British, American, French, Indian, Japanese and other national curricula. As well the International Baccalaureate, with 158 of private schools. 57 is the number

of higher education institutions in Dubai. The most important universities are the University of Dubai, the Zayed University and the Al Ghurair University (AA. VV., 2014e: 3).

Dubai has many cities inside the city, like Dubai Academic City which is a foundation for colleges, schools and universities, while the Knowledge Village is a ground that offers accommodation for training to educational institutes. Dubai International Arbitration Centre is a foundation for educational growth and excellence enclosed inside Dubai Academic City (Dubai free zone council). The city anticipates housing and about 40.000 students are attending about 40 institutes. The facilities in this area include a food complex with shopping sites, and the Rixama student accommodation.

Healthcare quality is depending on information mentioned in advance in point 2.3 of Chapter 2. Therefore, Dubai government has invested heavily in healthcare sector, whether infrastructures or healthcare system. DHA provides special initiatives including smart applications, smart operations and smart hospitals and other projects to facilitate an open access to data of patients and quality criteria in healthcare sector. Also Dubai has one of the largest healthcare free zones in the Arabian World, the Dubai Healthcare City (Dassani, N., Nirwan, D., Hariharan, G., 2015: 15).

Safety and security for the citizens are crucial issues in smart Dubai. The city is known as a main destination for tourists and expats in Arabian World, and as an economic centre in the region. So the main goal for the government is to provide the safety and security for inhabitants. Recently the crime rate in Dubai is considerably lower than in most cities throughout the world of similar size. This is the result of many initiatives launched for this area in Dubai, by the police which is the first Arabic Police Force using DNA testing in criminal investigations, implementing paperless, establishing a Human Rights Department, and applying electronic services. In fact, the Dubai Police app is one of the most popular governmental apps across Dubai. This app provides many services that can be accessed on mobile phone, like customers accessing and making payments of fines, applying for a good conduct certificate, reporting traffic violations or crimes, providing a list of pharmacies which are open, and traffic services (Dassani, N., Nirwan, D., Hariharan, G., 2015: 26). SAND-STORM app is a new mobile application that consists of various features such as forecasting sandstorm and fog. Therefore, Dubai Police is one of the first organizations in the world, using Google Glass, allowing officers to identify road users who have outstanding warrants through their car number plates. The use of Google Glass is part of Dubai Police's ambition to develop the smartest police stations in the world by 2018 (Dassani, N., Nirwan, D., Hariharan, G., 2015: 26). In fact, Dubai Police launched the first intelligent robot officer –ROBOCOP (Fig. 55), which is providing all Dubai Police services to the public in six languages, much like a human

policeman. It moves around in public areas such as shopping malls, communicating with the users, and providing them information. Finally, Dubai police has many departments to meet all the necessary requirements rapidly as general department of operation, e-services, traffic, finance, and so on. The UAE including Dubai is ranked as the safest country in the Middle East and the 5th at the world scale (Mustafa, A., 2012: 1).

Fig. 55 the intelligent robot officer of Dubai police (Al Shouk, A., 2015)

Tourism is a target in smart Dubai. Dubai is quite popular among tourists and expats from all over the world. It was the fifth most visited city in the world in 2014 (Dassani, N., Nirwan, D., Hariharan, G., 2015: 23) with about 11 million visitors. The city aims to welcome 20 million tourists annually by 2020 for world Expo-20. The major portion of tourism is formed by the leisure sector, such as luxurious hotels, big shopping malls, and sunshine that attract visitors. So the government of Dubai has established more than 70 shopping centres with various events including Dubai shopping festival, or Dubai summer surprises. The most important shopping mall is Dubai mall & mall.

In Dubai there are 573 hotels and hotel apartments (Mehta, S., Jain, A., Jawale, R., 2014: 530) ranging from luxurious five-star hotels to seven stars like luxury Burj Al Arab, which is one of the

most important features of this Emirate. This legendary hotel is located on an artificial island, and connects to the mainland by a private bridge. As well Atlantis the Palm hotel can be reached through an underwater tunnel.

There are many entertainment places as Dubai sports city which is the first purpose-built sports of the city. It combines several sports such as a multi-purpose outdoor stadium, cricket stadium, multi-purpose indoor arena and a field hockey. Additionally, to sporting facilities, Dubai Sports City provides housing, commercial developments, international schools, world-class medical facilities, hotels and leisure opportunities, such as skydiving free over the artificial deserts of Al Jumeirah palm.

Dubai sustains its cultural heritage in the Dubai Museum and souks (world's oldest market). The Dubai museum is one of the oldest buildings in Dubai and gets lots of visitors every year and lots of foreign people trying to engage in its culture and tradition by visiting souks and dessert safari.

Dubai has the most developed tourism infrastructures of Arabian World. It is one of the best connected cities in the world with air transportation networks reaching out to all continents, mainly thanks to its local carrier Emirates Airlines. Dubai Airport has a smart gate system to shortened immigration waiting time for passengers through electronic identification. It has the Dubai International Airport app allowing checking the status of flights, arrival or departing or the plan of flights of Dubai International Airport. There is an app for applying for online visa. This service has greatly improved since 2010, when Emirates airline launched its online visa system for people from 56 countries who visit the UAE.

The department of tourism and commerce marketing has introduced the e-Permit and the e-Ticketing platforms to support and develop Dubai's events. This Sector-Ticketing is a centralized platform for the sale and distribution of tickets for all events in Dubai. Both platforms speed up and simplify the entire events application, licensing and ticketing process (Dassani, N., Nirwan, D., Hariharan, G., 2015: 23).

4.3.3. Smart governance

One mission and main goal for the government of Dubai in terms of smart city, is to transform the traditional government management to an e-Government platform in order to deliver world-class smart services and infrastructures, by using electric and smart ICT in all public services. The Dubai Smart Government (DSG) is a pioneering initiative that provides a wide array of online services for business and personal needs. It is using the technology arm of Smart Dubai, a city-wide initiative to transform Dubai into the world's smartest city in the Arabian World. It offers

services to government entities and employees through its corporate website. The DSG department manages the official website of Dubai Government, which features more than 1.000 different services for citizens, residents, business and visitors. Dubai won the best Middle East e-Government portal in 2005 (Milakovich, M., 2012: 203) by providing 300 online services.

In 2011 (Holzer, M., Manoharan, A., 2012: 58) Dubai ranked 15th in top 20 cities in the world by applying e-Government. In fact, Dubai realized that e-Government will provide smart services for all citizens and then the services will achieve the innovation, promoting quality of the life.

Dubai is classified as one of the cities which have the highest number of mobile phone subscribers. The e-Government's development strategy aims to regulate and facilitate government transactions through simplified applications on smart phones and tablet devices. As a result, the public services are accessible to residents by using their smartphones. The m-Gov. will focus on any government services delivered solutions, provided via mobile phone using any of the below means:

- Smart phone Applications (mainly mobile operation system, Android, Blackberry OS, and Windows Phone);
- Mobile Web solutions;
- SMS (short message service) solutions.

The best M-Government Service Award will be based on the following domains: health, education, environment, social affairs, safety and security, tourism, trade and economy, transportation and infrastructures.

The government in Dubai launched the Happiness Meter initiative which will send daily reports to decision-makers enabling them to understand which government services that are being provided to customers are or are not pleased them. It measures the satisfaction and happiness of people, considering the Dubai government services through a smart application. So the Happiness Meter will contribute to make Dubai the first city, measuring the happiness of its nationals and visitors on a proactive daily basis.

Finally, one of the most important apps is Dubai now which puts a multiple government services in the palm of a hand. It allows the citizens to pay most of their bills and fees, to plan and track their travels around Dubai, to plan their child vaccination, to find out school ratings, to find local prayer times and mosques, to get a specialist doctor or clinic, to track flight arrivals and departures, or to find a 24 hours' pharmacy.

4.3.4. Smart environment

The government of Dubai realized that a smart city depends on securing its natural resources and requirements, and on ensuring its sustainability. Thus, the government tries to control and reduce the contamination in terms of pollution, by imposing many laws and regulations such the federal law 24 from 1999 (Clayson, N., King, A., Lynch, L., 2015) for the Protection and Development of the Environment. The key principles behind this law can be summarized as the following below:

- To protect and conserve the quality and natural balance of the environment;
- To control all forms of pollution avoiding harmful results from economic, agricultural and industrial domains;
- To protect society and the health of human beings;
- To apply for the concept of the polluter pays, meaning that the person who pollutes will be liable for clean-up costs and subject to any other penalties permitted by law.

So based on that, all the business sectors operating in Dubai should be aware of the various environmental laws and regulations that are compulsory in this territory.

On the other hand, the Environmental Protection and Safety Section (EPSS) of the Dubai government began the air quality monitoring by the dissemination of knowledge to the citizens as the major part of its network and its motto is that the prevention is better than costly rehabilitation. This shows its dedication to cleaning up Dubai's environment. EPSS is working to help decreasing the link between Dubai and air pollution.

Also the main target for the government is providing green urban planning by many green space areas such as Safa Park with different kinds of trees, bushes and lakes. Creek Park is located in the old city, on the shores of Dubai creek. Zaabeel Park is one of the largest parks in Dubai and there are still other parks like Al Rashidiya Park, or Satwa Park. In addition to this, Dubai has the world's largest natural flower garden, featuring with millions of flowers planted with a special organization, called Miracle Garden (Fig. 56 and Fig. 57).

Fig. 56 Miracle garden in Dubai with different kinds of flowers (MIRACLE GARDEN DUBAI).

Fig. 57 the organization in Miracle garden in Dubai (MIRACLE GARDEN DUBAI).

But smart environment doesn't mean only pollution reductions or increasing the green area. It is as well related with saving the natural resources and trying to generate new resources from winds, sun, waves or from the waste management. Dubai is applying these strategies by generating energy from the use of solar panels in Mohammed bin Rashid Al Maktoum Solar Park projects. It is using turbines to generate energy in many skyscrapers, launched the world's first moving building, the Dynamic Tower skyscraper (Fig. 58), which will be ready in a couple of years. The power for this building will be supplied by horizontal wind turbines installed between the

floors. Also photovoltaic solar panels will be installed on the roof of each rotating floor. On the other side Dubai has generated energy from the waste by exploiting the gases emitted to produce environmentally friendly alternative energy.

Fig. 58 The Dynamic tower – Dubai (Pedersen, D., 2008).

4.3.5. Smart people

To have smart people is one of the most important requirements of smart cities. In this field, the government of Dubai facilitates transferring information and knowledge among its citizens by using ICT. The government not only provides a wide broadband of internet but also makes the access to the internet easily and safety to the environment, by creating more than 5.000 hotspots to offer free Wi-Fi at 100 locations in Dubai (Dassani, N., Nirwan, D., Hariharan, G., 2015: 12).

Also it is inserting Solar Smart Palms to empower Dubai's public places, converting solar power into energy. This is helping the users to recharge their phones, tablets and laptops, enjoying free Wi-Fi. The first Smart Palm of Dubai is Zabeel Park, while the second in Al Jumeirah Beach (Fig. 59) near to the Burj Al Arab hotel.

Fig. 59 The solar smart palm in Jumeirah Beach- Dubai (Balbo, L., 2015).

One of the most important things in this domain is the creation by the government of Dubai of free zones for information technology, called Dubai Internet City. It aims to promote entrepreneurship and technical innovation in Dubai. This city enables ICT enterprises to operate locally, regionally and globally from Dubai. It includes international companies such as Microsoft, Canon, Google, or Dell (Pacione, M., 2005: 262).

It seems clearly over the past decades, that Dubai has experienced a deep transformation towards a smart approach. 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 its government, which is adopting the unique smart city approach by focus on applying smart infrastructures, whether physical or digital, with an efficient management for water, energy, good conditions for the healthcare, mobility and housing quality, available to all citizens. This approach could be considered as a perfect management to get new resources of energy, providing the best ITS ever and without forgetting a wide application of ICT infrastructures, with good communications, where intelligence and information flow rapidly. Regarding to the previously referred projects, which have been done in Dubai, they were contributing to achieve the main requirements of the smart city concept, which are smart economy, smart people, smart living, smart environment, smart government and smart mobility. Dubai is nowadays a smart city, not only by doing that, but also by implementing the concept of sustainability including its three pillars.

The economic sustainability by diversification of economy, including the diversification of income sources, investments in the non-oil sectors such as banking and finance, real estates, transportation, manufacturing, and expansion in trade infrastructure. This is decreasing the share of oil revenues in the composition of the Dubai's GDP to less than 2.7% (Nassar, A. K., Blackburn, A., Whyatt, D., 2014: 58)

The environmental sustainability by reducing the pollution levels and the CO_2 rates in the atmosphere, by encouraging the use of public transportation and electric vehicles, or by getting energy from the sunlight using solar panels.

Finally, the pillar of social sustainability is important in smart Dubai, by providing high quality of living and lifestyle for all citizens, providing public service with the best efficiency for all residents. So Dubai's government is not only thinking about the needs of present era but it is also putting an attention for the future generation needs. The following figures illustrate the development process with a short period (Fig. 60 and Fig. 61).

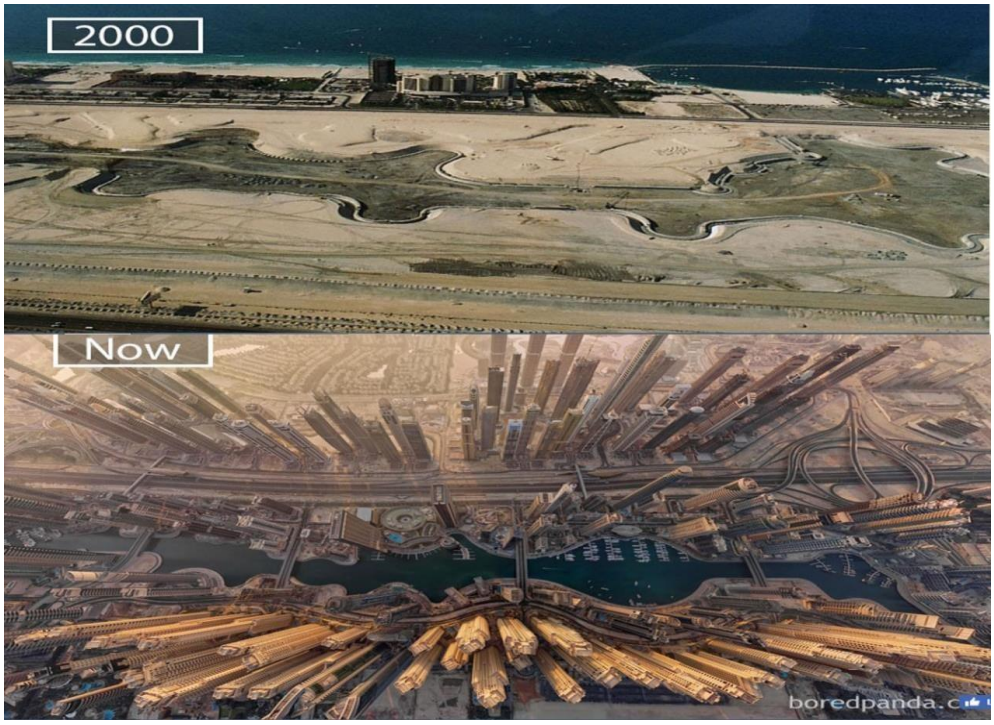

Fig. 60 Developed process in the urbanism of Marine Dubai (deMilked).

Fig. 61 Dubai between 2005 and 2017 (deMilked).

Chapter 5. Conclusions

The very first conclusion of this dissertation is that the analysis of Dubai as a case study, is a complex process, based on the lack of scientific bibliographic references, comparing with other cities or regions of the globe. However, there was an effort, which was always present, of keeping the research on the track, based on scientific references, even though they were not focused on the chosen case study, neither on the Arabian culture framework. Therefore, there was the need of transferring the collected knowledge coming from other cities and scientific surroundings, to the case of Dubai, with its own features and its particular cultural and territorial environment.

As this research has shown, there is no doubt that nowadays cities are creating different challenges because they are considered a fertile place for emerging problems, such as carrying more than half of total world population, consuming 70% of global energy production, emitting three quarters of GHG especially CO_2 all over the world, and generating a huge amount of waste.

In social terms, and depending on these reasons, countries have a huge number of young people facing unemployment, energy and water uses are rising and causing scarcity of resources. In this sense, new concepts are emerging regarding cities, in order to address all of the previous challenges in the best way. Thus, smart city is a concept that is given an opportunity to solve these different challenges, based on strategies such as to provide an eco-friendly approach for the climate change with their effects, to create processes to reaching the efficient management for all the natural resources, or to increase the quality of life for its inhabitants. Vienna in Austria and Barcelona in Spain were two presented examples, where the conclusion is that these strategies are producing their benefits.

Depending on the definitions of smart city that were mentioned in point 2.2 of Chapter 2, is possible to conclude that a smart city approach means further using of ICT in all the aspect of the life and city services. As well ICT are crucial in order to do the right use of data that are coming from different sources, like sensors, social networks and statistics, to achieve high performance in terms of mobility, people and society, to promote more efficiency of governance and public administration, environment and economic performances, or to provide a high quality in general terms of the life for inhabitants. Also the concept of smart city already holds the potential to address aspects of the sustainability challenge in social, environment and economic realms, such as it was shown in point 2.4. of the same chapter.

At the same time, there is the conclusion that the underlying areas of development for a smart and sustainable city, despite cultural or territorial environments, include several aspects, such as the following:

- Focussing on natural resources, reducing the consumption of energy, finding new renewable resources from waste management or others (sunlight, wind, or tides);
- Reducing the transportation problems as congestion, traffic jams, painful accidents and so on.

To beyond these aspects, there is a set of several other requirements which should potentially be achieved in a smart city, and which have been pointed out in a detailed way, in point 2.5 of Chapter 2. They include smart people, smart living, smart economy, smart environment, smart mobility and finally smart government.

Along to the Chapter 3 there is an overview about the Arab nation in terms of urbanization and territorial transformation process. It's clear as a conclusion that the Arab world stretches across more than 14 million square kilometres, with 22 countries, in two main areas al Mashreq and al Maghreb. As this chapter wanted to show, al Mashreq is comprising the Persian Gulf and the Levant area with 12 countries, all of them with a great diversity in terms of territory, GDP or levels of development.

From point 3.2.1 is possible to conclude that Levant area has 4 countries, including the largest in terms of area and population, which is Syria while the smallest is Lebanon. However, the latter has achieved the highest percentage in terms of urbanization, use of internet and GDP of this Arabian region. Regarding the Persian Gulf, Saudi Arabia is the richest country, having the biggest area, and the highest GDP among the others in this region. The smallest in territorial terms is Bahrain, and Qatar is the one where there is the highest percentage of population using ICT including internet among the entire Arab world.

Depending on the analysis presented on point 3.3.3 there is the conclusion that al Maghreb, with its 12 countries, has Algeria as the largest in territorial terms, while in terms of population Egypt is on the top of the list among the entirely Arab world. In summary, according to the all previous information it becomes clear that the largest country in the middle east and north Africa is Algeria followed by Saudi Arabia which has the highest GDP. In terms of population Egypt is the biggest, having on the other side of the list, Comoros with the lowest number.

Regarding the case study of Dubai, the main conclusion is the rapid urbanization process of this city, which was, in the early seventies of the 20th century, little more than a small settlement in

the middle of the desert. As Chapter 4 has intended to show, this city is a pioneer example of a smart city in the Arab world. Dubai has experienced a deep transformation towards a smart approach, turning a place, which was not much more than a strip of desert, into a bustling metropolis and one of the world's most modern cities. This transformation was possible throughout the vision of its governments, which were adopting strategies in order to achieve a smart city approach, by focussing on applying smart infrastructures, whether physical or digital, with an efficient management for water, energy, good conditions for the healthcare, mobility and housing quality, available to all citizens. This approach could be considered as a good management example to get new resources of energy, providing the best ITS ever, and without forget a wide application of ICT infrastructures, with good communications, where intelligence and information flow rapidly, such as it was shown in point 4.2 of the same chapter. All of these projects were contributing, step by step, to achieve the smartness concept for Dubai as well the sustainability with its three pillars, the social realm including a high quality of life for citizens also providing a wide range of services, the environmental realm with a concern of saving the natural resources (fuel, water, or energy), discovering new renewable energy sources, and the economic realm including diversification, dealing with flexibility in terms of economic shocks, like falling oil prices.

In a word, this dissertation shows that Dubai is a successful smart city, an example not only in the Arabian world but also on a global scale, which is a result of a long-term strategy, of improving the standards of life, having as a key word the use of ICT, available for the citizens.

Bibliography

Bibliographic references

1. AA. VV., United Nations Commission on Science and Technology for Development: “Issues Paper on Smart Cities and Infrastructure”, in Science and Technology for Development Budapest, Hungary, January (2016) a.

2. AA. VV., “ARAB CULTURAL AWARENESS: 58 FACTSHEETS”, in Office of the deputy chief of staff for intelligence army training and doctrine command FT. LEAVENWORTH, KANSAS, January (2006).

3. AA. VV., “Smart cities Preliminary Report 2014”, in Information technology, © ISO 2015, published in Switzerland, (2015) b.

4. AA. VV., “Solar Energy in Dubai, Mohammed Bin Rashid Al Maktoum Solar Park”, Dubai Govt. DSCE-DEWA, Initiatives & Key, (2012).

   http://www.mesia.com/wp-content/uploads/2012/11/10.15-Fatima-Al-Shamsi-DEWA.pdf

5. AA.VV., “Dubai Health Authority launches pilot phase of the telehealth project”, Emirate news agency, Wam, Dubai 17th January (2016)d.

6. AA.VV., “The World Urbanization Prospects”, United Nations, ISBN 978-92-1-151517-6, New York (2014)a.

7. AA.VV., “World Commission on Environment and Development: Our common future”, Oxford University Press, UK, 4 August (1987).

8. AA.VV., “Cities and aging, Global City Indicators Facility, Cities and Ageing”, University of Toronto, Toronto (2013)a.

9. AA.VV., Ministry of Urban Development Government of India: “Smart Cities Mission Statement & Guidelines”, India: government of India Ministry of Urban Development, June (2015)a.

10. AA.VV., The Smart Cities project team, in the IEC Market Strategy: "Orchestrating infrastructure for sustainable Smart Cities”, Switzerland, International Electro technical Commission IEC (2014)c.

11. Acuto, Michele, “High-rise Dubai urban entrepreneurialism and the technology of symbolic power”, School of Regulation, Justice and Diplomacy, Australian National University, Australia. Cities Research Cluster, National University of Singapore, Elsevier, 12 January (2010).

12. Akhavan, Mina, “Development dynamics of port-cities interface in the Arab Middle, Eastern world - The case of Dubai global hub port-city”, Volume 60, Part A, February 2016, Pages 343–352, © 2016 Elsevier, Milano (2016).

13. Al faris, Abdulrazak, Soto, Raimundo, “The economy of Dubai”, Oxford, UK, Dubai Economy Council (2016).

14. Alawadi, Khaled, “Rethinking Dubai’s Urbanism: Generating sustainable form-based urban design strategies for an integrated neighbourhood”, Abu Dhabi, United Arab Emirates, © 2016 Elsevier, 16 October (2016).

15. Albino, Vito, Berardi, Umberto, and Dangelico, Rosa Maria, “Smart Cities: Definitions, Dimensions, Performance, and Initiatives”, in Journal of Urban Technology, Volume 22, 2015 - Issue 1, Pages 3-21, Toronto, Canada (2015).

16. Bakıcı, Tuba Almirall, Esteve Wareham, Jonathan, “A Smart City Initiative: The Case of Barcelona”, in Journal of the Knowledge Economy, Volume 4, 2: 135–148 2, no. 1 (2012).

17. Barrionuevo, Juan M., Berrone, Pascual, Ricart, Joan E., “Smart city sustainable progress”, in smart city, Center for Globalization and Strategy, Cities in Motion Strategies, innovation, social cohesion, IESE insight, Issue 14, third QUARTER (2012).

18. Basiago, A. D., “Economic, social and environmental sustainability in development theory and urban planning practice”, USA Boston: Kluwer Academic Publishers (1999).

19. Batagan, Lorena, “Indicators for Economic and Social Development of Future Smart City”, in Journal of Applied Quantitative Methods, Vol. 6, No. 3,P 27, Bucharest, Romania, November 3 (2011).

20. Cretu, Liviu Gabriel, “Smart Cities Design using Event-driven Paradigm and Semantic Web”, in Informatica Economica, 2012, vol. 16, issue 4, pages 57-67,Norton & Company, Romania (2012)

21. Dassani, Neeraj, Nirwan, Dnyanesh, Hariharan, Gopalakrishna, “Dubai a new paradigm for smart cities”, in KPMG international, UAE (2015).

22. Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., and Meijers, E., "Smart cities Ranking of European medium sized cities", Centre of Regional Science, Vienna (2007).

23. Giffinger, Rudolf, Haindl, Gudrun, "Smart Cities Ranking: an Effective Instrument for the Positioning of Cities?" Centre of Regional Science, Vienna, Austria (2009).

24. Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., and Williams, P., "Foundations for Smarter Cities", IBM J. RES. & DEV. VOL. 54 NO. 4 PAPER 1 JULY/AUGUST 2010 (2010).

25. Harrison, Colin, Donnelly, Ian Abbott, "A THEORY OF SMART CITIES", IBM Corporation, 1 New Meadow Road, Armonk, NY 10504, USA (2011).

26. Hessel, Volker, "Smart Mobility –A tool to achieve sustainable cities", München, Siemens AG, February 12th (2015).

27. Höjer, Mattias, Wangel, Josefin, "Smart Sustainable Cities (Definition and Challenges)", Series Advances in Intelligent Systems and Computing, 310: 333-349 Stockholm, Sweden, Royal Institute of Technology (2014).

28. Holzer, Marc, Manoharan, Aroon, "Digital Governance in Municipalities Worldwide (2011-12)", National Center for Public Performance, ISBN: 978-0-942942-26-2, United States of America (2012).

29. Huwart, Jean Yves, Verdier, Loïc, "Economic Globalization: Origins and consequences", in Organization for Economic Cooperation and Development, OECD Publishing, ISBN: 9789264111899, Pages156, April (2013).

30. Jacobs, Jane, "The Economy of Cities", Vintage books, Random House, New York, USA (1970).

31. Komninos, Nicos, "Intelligent cities: Variable geometries of spatial intelligence", Intelligent Buildings Integration, London, July (2011).

32. Kourtit, K., Nijkamp, P., Arribas, D., "Smart Cities in Perspective – A Comparative European Study by Means of Self-organizing Maps", in Innovation: The European Journal of Social Science Research, Pages 229-246, 19 April, (2012).

33. Lazaroiua, George Cristian, Roscia, Mariacristina, "Definition methodology for the smart cities model", Volume 47, Issue1, Pages 326–332, Asia-Pacific Forum on Renewable Energy 2011, November (2012).

34. Lombardi, Patrizia, Giordano, Silvia, Farouh, Hend, Yousef, Wael, "Modelling the Smart City Performance", in Innovation: The European Journal of Social Science Research, 25, 2: 137-149 (2012).

35. Marchal, Virginie, Dellink, Rob, Vuuren, Detlef Van, Clapp, Christa, Château, Jean, Lanzi, Eliza, Magné, Bertrand, Vliet, Jasper Van, "OECD Environmental Outlook to 2050 Climate Change Chapter", in The Consequences of Inaction ISBN 978-92-64-122161 © OECD 2012

36. Marsal, Maria-Lulisa, Colomer, Joan, Meléndez, Joaquim, "Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart Cities initiative", in Technological Forecasting and Social Change 90, ISSN-e 1873-5509, Vol. 90, 2: 611-622 (2014).

37. Mehta, Shreyans, Jain, Anshul, Jawale, Rahul, "Impact of Tourism on Retail Shopping in Dubai", International Journal of Trade, Economics and Finance, Vol. 5, No. 6: pages 428 December (2014).

38. Milakovich, Michael E., "Digital Governance: New Technologies for Improving Public Service and Participation", in Political Science, © Routledge Taylor & Finance Group, 351 pages, New York (2012).

39. Nassar, Ahmed K., Blackburn, G. Alan, Whyatt, J. Duncan, "Developing the desert: The pace and process of urban growth in Dubai", in Computers, Environment and Urban Systems, Volume 45, May 2014, Pages 50–62, Lancaster, UK 11 February (2014).

40. Pacione, Michael, "City profile Dubai", in Cities, Vol. 22, No. 3, p. 255–265, 2005, Elsevier, Scotland, 23 May (2005).

41. Townsend, Anthony M., "Smart Cities – big data, civic hackers and the quest for a new utopia", in Technology, New York: by W. W. Norton & Company, Norton (2013).

42. Virtudes, A., "'Good' governance principles in spatial planning at local scale", in JOURNAL PROCEDIA ENGINEERING, 161: 1710-1714 (2016) DOI: 10.1016/j.proeng.2016.08.650

43. 45. Washburn, Doug, Sindhu, Usman, "Helping CIOs Understand "Smart City" Initiatives", Cambridge University, February (2010).

44. Zygiaris, Sotiris, "Smart City Reference Model: Assisting Planners to Conceptualize the Building of Smart city innovation ecosystem", in Journal of the Knowledge Economy, vol. 4, 2: 217-231 (2012).

45. Hsich, H. N., Chen, C. C., Chou, C. Y., Chen, Y. Y., "The Evaluating Indices and Promoting Strategies of Intelligent City in Taiwan", in Proc. Multimedia Technology, DOI: 10.1109/ICMT.2011.6003158, Publisher: IEEE July 26–28 (2011),

Websites

1. AA. VV. European Parliament: "Mapping Smart Cities in the EU" Published in: Mapping Smart Cities in the EU / Catriona Manville et al. (Brussels: European Parliament, Directorate-General for Internal Policies, Policy Department A: Economic and Scientific Policy, Jan. 2014), Pages 200, Manuscript completed in January 2014© European Union, (2014) b.

http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdF

2. AA. VV., "THE WORLD FACTBOOK", in Central intelligent agency website, United Nation of America (2016) f.

https://www.cia.gov/library/publications/resources/the-world-factbook/

3. AA. VV., "Smart monitoring on Dubai roads with new technologies", ALkaleej Time TRANSPORT, staff reporter/Dubai, March 27 (2016) b.

http://www.khaleejtimes.com/nation/transport/smart-monitoring-on-dubai-roads-with-new-technologies

4. AA. VV., "Arab world geography and Arab countries", Dubai website, Jan 4 (2014)d.

https://where-is-dubai.com/arab-world-overview-arab-world-geography-arab-countries/

5. AA. VV., "Dubai Private Education Landscape 2013/2014", Knowledge and Human Development Authority, Dubai, UAE (2014) e.

https://www.khda.gov.ae/CMS/WebParts/TextEditor/Documents/LandscapePEEnglish.pdf

6. AA. VV., “Dubai Water & Electricity Authority DEWA”, Under the Umbrella of Dubai Supreme Council of Energy, Dubai Govt, DSCE-DEWA, Initiatives & Key, © DEWA, Dubai (2013) b.

http://www.kallman-dev.com/shows/wetex_2015/pdfs/DEWA-USA%20%20presentation%2026072014.pdf

7. AA. VV., “PHASE 1 Mohammed bin Rashid Al Maktoum Solar Park 13 MWdc PV Plant”, Dubai Govt. DSCE-DEWA, Initiatives & Key, DEWA Generation Division (2014) d.

http://frog4webservices.com/french-side-events-2015/presentation/PV%20Solar%20introduction%20of%20DEWA%20GD%20to%20External%20Visitors.pdf

8. AA. VV., “POPULATION - TOTAL IN MIDDLE EAST AND NORTH AFRICA”, TRADING ECONOMICS, website (2016) e.

http://www.tradingeconomics.com/middle-east-and-north-africa/population-total-wb-data.html

9. AA.VV., “Dubai cuts carbon emissions by 8.100 tonnes”, in GULF NEWS/ENVIRONMENT, Website, April 24 (2016)g.

http://gulfnews.com/news/uae/environment/rta-cuts-carbon-emissions-by-8-100-tonnes-1.1810547

10. AA.VV., “Dubai’s Dh2bn plant to convert solid waste into energy”, in Emirate news agency Wam, Emirates 24/7 NEWS, Website, 21 June (2016)c.

http://www.emirates247.com/news/emirates/dubai-s-dh2bn-plant-to-convert-solid-waste-into-energy-2016-06-21-1.633573

11. Al Shouk, Ali, “Dubai Police reveal their robot enforcer”, in 7 DAYS UAE Website, June 7 (2015).

https://7days.ae/dubai-police-reveal-their-robot-enforcer

12. Alhadeff, Iakovos, “Pan-Arabism VS Pan-Islamism”, May 21, 2016.

https://iakal.wordpress.com/2016/05/21/pan-arabism-vs-pan-islamism/

13. Ancheta, Justine, “Ten Reasons Why Barcelona is a Smart City”, in Villa Web website, 26 February (2014).

http://www.vilaweb.cat/noticia/4175829/20140226/ten-reasons-why-barcelona-is-smart-city.html

14. Architizer Website: “7 Intelligent Buildings That Prove Digitally Driven Design Works”, Architizer (2016).

http://architizer.com/blog/7-intelligent-buildings-that-prove-digitally-driven-design-works/

15. ASBU Official Partnership program, Tunisia (2016).

http://www.asbu.net/cc/brochure_official_partner.pdf

16. Ashton, Kevin, “That 'Internet of Things' Thing”, in RFID Journal, June 22 (2009).

http://www.rfidjournal.com/articles/view?4986

17. Badam, Ramola Talwar, “Dubai bicycle master plan will link communities with beaches, parks and malls”, in The National UAE/business website, May 22 (2015).

http://www.thenational.ae/uae/tourism/dubai-bicycle-masterplan-will-link-communities-with-beaches-parks-and-malls

18. Balbo, Laurie, “Suntan around these badass solar palm trees in Dubai!”, in greenprofhet.com, November 1 (2015).

http://www.greenprophet.com/2008/09/wind-powered-building-in-motion/

19. Beaumont, Stephanie, “TOP 10 SMART CITIES IN THE WORLD” website, October 12 (2015).

https://www.linkedin.com/pulse/top-10-smart-cities-world-stephanie-beaumont

20. Best M-Government Service Award, UAE website (2016).

https://www.mgov-award.ae/en/page/about

21. Chaudhary, Suchitra, Bajpai, “Integrated health record system launched”, in GULF NEWS, February 21 (2016).

http://gulfnews.com/news/uae/health/integrated-health-record-system-launched-1.1676908

22. Clayson, Nick, King, Adrian, Lynch, Louisa, "10 things to know about sustainability in the UAE", NOTORN ROSE FULLBRITHT Website, March (2015).

http://www.nortonrosefulbright.com/knowledge/publications/125011/10-things-to-know-about-sustainability-in-the-uae#section4

23. Colman, Tim, "Dubai Roads and Transport Authority Smart investment for long-term gain", July 22, (2015).

http://industry-me.com/features/transport/dubai-roads-and-transport-authority-smart-investment-for-long-term-gain/

24. Deangelis, Stephen, "A Thought Probe Series on Tomorrow's Population, Big Data, and Personalized Predictive Analytics: Part 1, Getting Started", in Business magazine website, 26 April 2013.

http://en.paperblog.com/a-thought-probe-series-on-tomorrow-s-population-big-data-and-personalized-predictive-analytics-part-1-getting-started-510001/

25. deMilked, website: "15 Before-And-After Pics of The Iconic Cities Around The World".

http://www.demilked.com/iconic-cities-evolution-before-after/

26. Dubai as it used to be, website: "John Harris Dubai's Master Planner 1960s-70s", Len Chapman 2016.

http://www.dubaiasitusedtobe.com/pagesnew/JohnHarrisMasterPlanner.shtm

27. Dubai Free Zone Council.com., 2016 Dubai Free Zone Council

http://www.dfzc.ae/dubai-freezones/education/dubai-international-academic-city-diac.html

28. Dubai statistics center website, 2015, Government of Dubai.

https://www.dsc.gov.ae/en-us

29. Emirate news agency Wam, "Dubai Green Mobility initiative, Dubai Supreme Council of Energy to increase hybrid and electric vehicle use by 2020", July 23, (2016)a.

http://www.emirates247.com/news/emirates/dubai-green-mobility-initiative-2016-07- 23-1.636558

30. Everington, John, "Dubai enters top five ranked fastest growing economies", The National Business, website January 22, 2015.

http://www.thenational.ae/business/economy/dubai-enters-top-five-ranked-fastest-growing-economies

31. IDA Singapore, "iN2015 Master plan" (2012) http://www.ida.gov.sg/~/media/Files/Infocomm%20Landscape/iN2015/Reports/realisingthevisionin2015.pdf.

32. Jacotine, Sarah, "ANALYSIS: How the UAE is trying to reduce road deaths", Arabian supply chain.com, August, 12, (2014).

http://www.arabiansupplychain.com/article-10248-analysis-how-the-uae-is-trying-to-reduce-road-deaths/

33. Mcqueeney, Kerry, "Dubai before the boom: Staggering pictures show how emirate went from desert backwater to the Manhattan of the Middle East in just 50 years", in Mail online News, website 15 May (2012).

http://www.dailymail.co.uk/news/article-2144613/Pictures-Dubai-1960s-1970s-city-fishing-settlement.html

34. MIRACLE GARDEN DUBAI, Website © 2014-2016 MIRACLE GARDEN DUBAI. POWERED BY SME.

http://www.miraclegardendubai.net/

35. Mustafa, Awad, "UAE ranks 5th in world for order and security", The National UAE website, November 29 (2012).

http://www.thenational.ae/news/uae-news/politics/uae-ranks-5th-in-world-for-order-and-security

36. Pedersen, Daniel, "Dubai's Wind Powered Rotating Skyscraper is Building in Motion", greenprofhet.com, September 18 (2008).

http://www.greenprophet.com/2008/09/wind-powered-building-in-motion/

37. Said, Radwa Radwan, "UAE Economic Diversification Record", Trades research & advisory, website, June 14 (2016).

http://trendsinstitution.org/uae-economic-diversification-record/

38. Saifaie, Abdulmajeed, Abdulaziz, "Waste Management in Dubai", in waste management , A Magazine for the Environmental Center for Arab Towns, 4 January (2013).

http://en.envirocitiesmag.com/articles/pdf/waste_management_eng_art1.pdf

39. Saseendran, Sajila, "Dubai launches green building rating system", GULF NEWS, Environment website. July 12 (2016).

http://gulfnews.com/news/uae/environment/dubai-launches-green-building-rating-system-1.1861227

40. Sequeira, Jerusha, "Dubai approves 15 km metro expansion for Expo 2020", April 12 (2015).

http://meconstructionnews.com/

41. Sherry, Zameer, "Dubai on the Fast-Track to Develop Smart Transportation", Driverless electric cars will soon hit UAE roads, April 15 (2014).

http://gulfbusiness.com/dubai-fast-track-develop-smart-transportation/

42. Sibai, Wajih, "Integrated strategy for waste management in Dubai until 2030", الإمارات اليوم newspaper, 01 September (2013).

http://www.emaratalyoum.com/local-section/other/2013-09-01-1.602509

43. THE Dubai World Trade Centre.com (2016).

http://www.dwtc.com/ar/events/pages/dwtc-events1009-434

44. The Guardian website "Percentage of global population living in cities, by continent", The Guardian website, Guardian News (2016) g.

https://www.theguardian.com/news/datablog/2009/aug/18/percentage-population-living-cities

45. UNEP (United Nations Environment Program), Website: UNEP Environmental, Social and Economic Sustainability Framework (ESES).

http://www.unep.org/about/eses/Home-UNEPESES/tabid/794697/language/en-US/Default.aspx

46. Vienna now & forever website.

https://www.wien.info/en/sightseeing/green-vienna

47. Wam, Emirates news agency “25% of Dubai’s transport trips will be 'driverless' by 2030”, April 25 (2016)b.

http://www.emirates247.com/news/government/25-of-dubai-s-transport-trips-will-be-driverless-by-2030-mohammed-2016-04-25-1.628315