JAUES

Journal Of Al Azhar University Engineering Sector

Vol. 12, No. 42, January, 2017, 199-211

# TOWARDS SUSTAINABLE URBAN DEVELOPMENT IN ARID REGIONS: MASDAR CITY AS A CASE STUDY

**Mohammed Farouk El-Aby**

Architecture, Deanship of Preparatory Year & Supporting Studies,
University of Dammam, Saudi Arabia

**ABSTRACT**

The United Nations has highlighted the importance of the issues of development and housing policies through endorsing the International Strategy of Sheltering in 1988 [25]. The efforts of the United Nations in the domain of housing, whose concepts have been formulated so as to include Sustainable Cities in the conference of the United Nations: "Rio + 20: The Future We Desire", concerned with sustainable development, and held in Brazil in 2012. Hence, there is stress on partnership bonds among governments, the civil community and the private sector in order to develop cities in which opportunities are availed and everyone gets the chance to attain the basic services, energy, housing and transport in a sustainable manner [27].

The increase in population, however, has led to expansion in establishing new cities so as to fulfill the need for housing and effectively participate in accelerating development. It is also important to reclaim the desert regardless of the harsh environmental circumstance of those regions. Thus, the planners and the decision makers adopt the strategies of sustainable development in order to avoid creating new environmental, economic, social problems. Therefore, it is important to research in the study of experimenting in establishing sustainable cities in the environment of arid areas for the purpose of finding the pros and cons of those experiments and lay the foundation of developing those cities in a sustainable manner. Thus, we have chosen the city of Masdar in Abu Dhabi Emirate as a case study due to the richness of experimenting on that Emirate concerning the shift from investing in the formidable revenues of petro-urbanism, in what is known as petrol communities, to sustainable urban development represented in establishing the city of Masdar as the first sustainable city in the world. Nevertheless, so as to achieve those objectives, the research adopts the analytical descriptive methodology in the study of that strategic shift which is witnessed by Abu Dhabi Emirate. Also, the methodology of the case study is used in analyzing and evaluating the strategies of sustainability in the city of Masdar.

The research includes three principal aspects. The first aspect centers on the study of the environmental, economic, social and political factors which leads to transforming Abu Dhabi Emirate from petro-urbanism to urban sustainability. The second aspect deals with defining the city of Masdar as well as studying and analyzing its system of sustainability. The third and final aspect deals with analyzing the case study according to the three main principles of sustainability: social participation, economic sustainability and environmental sustainability. Thus, the research concludes many results and recommendations, on top of which the importance of providing an integrated system that works on developing cities in arid areas in a sustainable manner.

**Key Words : Sustainable Development, Arid Areas, Desert Cities, Masdar City, United Arab Emirates (UAE)**

## 1- INTRODUCTION

With the participation of the representatives of 176 countries, among which there are 108 of the leaders of those countries in the Earth Summit, the United Nation's conference concerned with the environment and development, in Brazil in 1992 [28], the new term "sustainable Development" has been endorsed; i.e. the fulfillment of the needs of the current generation without lessening the rights of the upcoming generations to living in a standard that is not less than that in which we live. The, e economic, social and environmental dimensions have been determined as three pillar that are complementary and supplementary among each other so as to achieve sustainable development. This has been also confirmed in "Rio + 20: The Future We Desire", the conference of the United Nations, which is concerned with sustainable development, held in Brazil in 2012 [26], which also has stressed the importance of the role of governments in setting plans and policies that guarantee its development in a sustainable manner. There is no doubt that this role has been maximized when it is necessary to develop arid areas. However, the reclamation of desert regions is influenced by the modern western trends of planning and building styles as well as the transportation means, while the conventional systems and techniques of building in traditional desert communities are totally neglected. Therefore, non-sustainable urban communities are formed, which are extremely alien from the urbanization of desert regions.

Hence, there emerges the importance of studying the experiment of Abu Dhabi in its transformation from dependence on petrol as a corner stone for development – along with the adverse impacts on the environment which accompanied that era – to leadership in the establishment of the city of Masdar, amidst the desert of Abu Dhabi Emirate, as the first sustainable city that is free from Carbon emissions and completely dependent on the techniques of renewable energy and recycling. Nevertheless, the study of that case and its evaluation is a frame work for applying the modern techniques of management and urban development in arid areas.

## 2- Abu Dhabi from the Petro-Urbanism to Urban Sustainability

Since discovering formidable quantities of petrol in the early sixties of the 20$^{th}$ century, along with the following events of independence from the British Reign and the establishment of the United Arab Emirates in 1971, Abu Dhabi Emirate has witnessed one of the fastest processes of civilization in the entire world in the modern era (Figure 1). Moreover, Abu Dhabi Emirate is endowed with 90 percent of the total production of petrol in the UAE (almost equal to 80 percent of the world production). The ruler of Abu Dhabi Emirate, Sheikh Zayied ben Sultan Al Nahyian, who is the founder of the UAE and its first president, has managed to develop the Emirate in less than 30 years, through the massive movement of construction in the fields of housing, infrastructure and services (fig. 2) [9].

Abu Dhabi Emirate has led the urbanism movement in the Arab Gulf area supported by the formidable revenues of petrol in what is known as petrol societies. Further, the three main factors which have shaped its traits are politics; socioeconomics and the environment. Those factors altogether have resulted in petro-urbanism. One the political level, the petrol revenues enabled the Sheikhs from providing prosperity to their people through expanding on allocation of land for housing; health, education and service projects; as well as the infrastructure projects [9].

**Figure 1: Abu Dhabi in the early 70s. Source [24]**

**Figure 2: Abu Dhabi in the early 21$^{st}$ century. Source [23]**

As for the factor of socioeconomics, dependence on the policy of petrol economy has led to a change in the demographic composition of Abu Dhabi City. However, the population has risen from few thousands in the late sixties to more than a million in 2010. Of that population the native Emirati citizens constitute 20 percent, while the immigrants represent nearly 80 percent in a magnificent mixture of people who have come from all over the world. However, the majority of those immigrants have come from India and South East Asia; leading to the necessity of providing separate housing for those groups of immigrants for the sake of preserving the traditions of society. There are laws, nevertheless, which prevent the visitors from ownership, except in few investment projects; hence, it is difficult for the government to convince those groups of immigrants to preserve the environment of land in which they have no share [9].

This should take us to the third factor of petro-urbanism: the environmental one. The radical urban growth, supported by the petrol revenues has led to fatal environmental damages. According to the World Wildlife Fund, the UAE is responsible for the highest carbon emissions in the world, which is five times higher than the global average. It also produces the highest rates of global-warming causing gases from each individual. In addition, the UAE is considered one of the main producers of wastes in the world; each family produces annual wastes that are thirty percent higher than the standard rate decided by Family Development and Cooperation Organization [3]. Also, the decline in the prices of petrol encouraged using private cars while there is no effective system of mass transportation. Further, there is encouragement from the government to expand through the desert so as to provide the maximum space of paid housing triggered by an urgent need from the citizens to own separate houses (villas). Finally, there is the water problem, each individual in Abu Dhabi consumes 550 liters of water daily in 2010 [4]; which is the highest consumption rate in the world. Due to the scarcity of water, it is found that 98 percent of the consumed water is produced through the processes of sea water desalination; i.e. greater consumption of energy along with increasing the salinity of sea water due to restoring the salt resulting from the desalination process to the sea again. It is expected that there will be an increase in population that is estimated to be three times more within the coming 40 years. However, the image of urban development in Abu Dhabi will still be as far away as potential from sustainability [9].

All those previous factors have paved the way before Abu Dhabi so as to take a serious step to realizing sustainable urban development. Those efforts have been crowned in 2009 by the construction of partnership between the government of Abu Dhabi and the World Economic Forum, represented in the Slim Cities Initiative to set a world order for the best practice of sustainable urban planning. In addition to this, Ethisphere Center for Researches has declared Abu Dhabi as one of the best ten future, sustainable cities in the world. Masdar City comes, with no doubt, is on top of the list of the most famous ones among Abu Dhabi's programs of urban sustainability. Furthermore, the government of Abu Dhabi plans to make Masdar City the first sustainable city in the world [29].

Construction in Masdar City has stated in 2008, 17 kilometers away from the center of Abu Dhabi City. Further, Masdar City, lying in the desert of Abu Dhabi has set several ambitious objectives for that project. The objectives include the exclusive dependence on renewable energies and adopting the polities which guarantee that the city becomes free of carbon emissions, work on the recycling of wastes and recycling used water. The city also endorses the principle of "car-free" city with a mass transportation system that connects the city with the center of Abu Dhabi City [22].

Foster and Partners have designed Masdar City. The authorities of Abu Dhabi and World Wildlife Fund according to the principles of One Planet Living (Fig. 3), with a sustainable plan inspired by the famous experiment of BedZed in the South of London (Fig. 4). Moreover, Masdar City is considered an ambitious initiative in the field of environment and sustainability; not only for being a living model of sustainable urban development, but also for being a model for other following cities as stated by its slogan: "*One day, every city will be constructed like this one*." [9].

**Figure 3: Masdar City, Abu Dhabi Emirate. Source [6]**

**Figure 4: BedZed Project. Source [30]**

## 3- Masdar City: an Overview

Masdar City is located in a desert area with a dry and hot climate between Abu Dhabi City and Abu Dhabi International Airport. It is considered the first sustainable environmental city in the world; being free of carbon and wastes, and entirely dependent on renewable energy. Masdar City covers a space of approximately 1460 feddans. Upon its completion, it is planned that it would contain more than 50 thousand people. Moreover, the center of the city is planned in way that it would be free of using cars and include more than 1600 activities; providing about 60 thousand job opportunities [31].

Abu Dhabi Company for future energy leads Masdar City's initiative (Masdar) which is established in 2006 and completely owned by the government of Abu Dhabi. Masdar is considered a project that aims at commercial profitability through leadership in the sector of renewable energy and sustainable techniques, in addition to providing the necessary pillars of confronting challenges in that fledgling sector [5].

The partnership between Abu Dhabi Company for future energy (Masdar) and Massachusetts Institute of Technology - MIT in the United States of America is one of the most important pillars of that city. Such partnership, which has taken place in February 2007, has worked on establishing Masdar Institute as a research university for post-graduate study students. However, Massachusetts Institute of Technology – MIT is responsible for the administrative and academic supervision and activating the common researches in the fields of technology, renewable energy and sustainability[1]

"Masdar" has managed, within a very short period, to make several strategic partnerships with many international companies that work in the field of technology and development such as Siemens Company, Mitsubishi Heavy Industries, General Electric, Schneider Electric, BASF, Bayer Material Science, Swiss Village Association and Korea Technopark Association. In addition to this, there is establishing the headquarters of The International Renewable Energy Agency-IRENA [12]. Also, the actual constructions in Masdar City have started in 2008 and they are expected to be completed in 2020 [31].

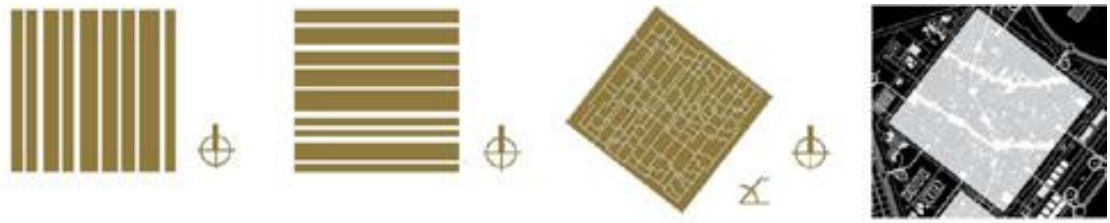
## 4- Sustainability System in Masdar City

The importance of "Masdar" is not restricted to constructing one of the most sustainable cities in the world besides its appealing life style only, but also its ability to achieve that in a high efficiency economic style, through its planning, design and operation using cutting edge, empowering, economic techniques and integrating them into advanced systems capable of shrinking the costs and managing the consumption of materials. The following is a display and analysis of the sustainability system adopted by Masdar City.

### 4.1 Planning, Engineering and Architecture:

The planning of Masdar City is characterized by achieving environmental benefit through inexpensive techniques, such as the alignment of the city direction or the buildings in regard to the sun or the wind. Nevertheless, the city takes the direction of the North East / South West which provides more shades and good ventilation in the buildings (Fig. 5). The second element, regarding efficiency is enhancing the performance of the buildings, such as having

outer covering, effective systems and the provision of smart management for it (Fig. 6). Narrow streets also provide the shading of building to each other and reducing the need for air conditioning (Fig. 7). Moreover, the commercial and entertainment buildings as well as work sites are near one another; allowing more movement on foot [15].



**North-South orientation of streets allows sunlight penetration of the urban structure with a subsequent increase in cooling loads requirements**

**An East/West alignment also results in an increase in cooling load requirement due to the street exposure of external walls to sunlight.**

**The diagonal grid provides optimal shading**

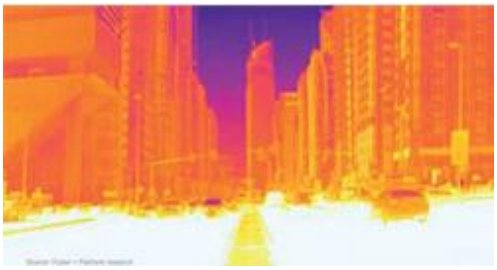
**Northeast/Southwest orientation of the city fabric provides optimal shading**

**Figure 5: Street Orientation in Masdar City. Source [15]**

**Figure 6: The Cover of Housing Buildings in Masdar City. Source [11]**

**Figure 7: Providing Shading in Narrow Streets. Source [7]**

The photos, taking by a thermal photography camera, indicate the difference between the temperature radiated in one of the common streets in the center of Abu Dhabi City and a street in Masdar City. The hot white spots, the yellow ones and the light orange spots in the open street, however, show that the highest temperature is focused on Abu Dhabi Street. In contrast, in Masdar city, the prevalent colors are blue and purple; which indicate that there are decreased temperature degrees. This difference in radiated temperature, reaching 20%, is considered a distinctive accomplishment according to all measures (Fig. 8) [15]. Moreover, using the Tower of Wind in Ma'had Square is a modern formulation of the legacy of wind towers. The tower of wind, as high as 45 m., suck colder air from the higher strata and directs it downwards along with increasing its humidity; i.e. cooling the outer open spaces naturally and a limited use of technology (Fig. 9) [11].



**Center of Abu Dhabi City**

**Center of Masdar City**

**Figure 8: The Thermal Analysis of the Centers of Abu Dhabi and Masdar City. Source [15]**

**Figure 9: The Tower of the Wind in Ma'had Square. Source [15]**

### 4.2 Energy Generation & its Consumption Management:

As for the demand on energy, Masdar City reduces its energy consumption through spreading the best energy-saving, commercially-feasibly international technologies. Moreover, it has set strict instructions on the efficiency of construction in many fields such as thermal isolation, low-energy lighting specifications, glazing percentage (in windows) and enhancing the utilization of natural light, installation of smart equipment, smart gages and building management smart systems, integrated system of distribution management and the system of energy management, on the city level, that controls the electricity load to the extent of the net expansion from the generation facilities to the consumer. As a result of this, the dormitory buildings in the campus of Masdar Institute have managed to reduce the demand of air conditioning with 55% , reduce the consumption of electricity with 51% and reduce the consumption of energy used in heating water with 85% compared to the average level in the UAE [10].

As for energy display, the city is being currently operated now by depending entirely on the renewable energy which is generated in the city. However, with the growth of the city, the situation will change side by side with the existence of an intermediate-term target; necessitating that at least 20% of the energy supplies will come from renewable sources in the site. Otherwise, the rest of the energy will come from external renewable sources. Currently, there are many under execution projects for renewable energy, or these projects are still in their first stages in the UAE. They will provide safe, clean energy sources for the city [10].

In addition to the photoelectric tablets, solar energy is being utilized through hollow pipes that collect the heat of the sun to secure providing hot water to the houses. In addition to this, the condensed sun heat and the heat of the core of the Earth are being measured in order to operate absorption cooling devices with mono or dual effect. These are potential solutions for cooling the air in the city. A station for generating photoelectric solar energy has been already operated in Masdar City with a 10 megawatt capacity. It is considered the biggest of its kind in the Middle East [10].

### 4.3. Water Production and Management:

Masdar City's needs for water are less than half of the normal needs of other similar buildings. In the first stage, the city seeks consuming 180 liters daily for each person. This number is much less than the normal rate of consumption, which is 550 liters daily for each person. The

ultimate objective of the city is decreasing this unit gradually to be 40% less than it has been in the first stage upon the completion of all the facilities. Otherwise, it does not include the necessary water so as to cool the areas, which can multiply the amount of water needed for the city [19].

Aiming to achieve this reduction in consumption, the city uses a variety of techniques and systems that helps in decreasing the use of water. For example, there are the high-quality devices, installations and conveyances; intelligent water gages, which inform the inhabitants with how much water they have consumed and the intelligent gages which detect the cases of leaking in the net. Through the efforts of the city that seeks achieving ambitious aims so as to reduce the consumption of water, additional strategies will be executed; including setting a defining system that encourages the reinforcement of the efficiency of usage [19].

Moreover, the processed drainage water is recycled with a percent of 100% in order to be used in irrigating gardens. This has helped in the reduction with a percent of 60% in water consumption per every square meter compared to the usual consumption conditions. This has been achieved through a variety of strategies including the high quality "Economical Irrigation System" and collecting rain water, designing the green areas in a way that reduces the processes of transpiration and water evaporation of plants and using the regional plants and trees which use little water [19].

**4.4 Wastes Management:**

The strategy of managing solid wastes in Masdar City aims at reducing the amount of wastes sent to landfills by recycling, reusing the wastes, turning them into compost and regaining energy from them. The total amount of wastes in the city is expected to reach 22 thousands of tons annually in the first stage. This strategy aims at cropping 50% off the wastes before sending them to the landfills [18].

Solid wastes in Masdar City, however, are classified according to three main categories, which are: recyclable dry wastes like (cans, plastic items, carton paper, paper and others), recyclable wet wastes like (food leftovers and other organic wastes) and wastes that cannot be obviously categorized under the two previous categories like (toothpaste containers, empty containers of food and others). There is a fourth category of wastes that represents a tiny amount compared to the previous categories that includes massive wastes, dangerous wastes and wastes with special nature like batteries. Each of the city buildings has been provided with three containers in order to facilitate the separation of wastes into the three main previously mentioned categories [18].

The Sources Retrieval Center in Masdar City will include facilities that allow more accuracy in separating the recyclable dry wastes before sending them to the local or regional treatment establishments. This center also allows turning the organic wastes into compost to be used in the green areas of the same city. On the other hand, the rest of the wastes (the special and non-recyclable wastes) will be sent to be managed in external sites [18].

**4.4. Planning and Managing Transportation:**

In response to the priorities of the major scheme of Masdar City, that looks forward to making the city a walking- encouraging community, wide options of public and private transportation means will be available to guarantee moving around the city very easily and smoothly. This will be the fruit of the planners' effort of focusing on building a lot of pavements and shady wide paths all over the city. Moreover, the public transportation system with buses, electronic cars and others clean-energy vehicles will assist in providing the transporting service inside the city. In addition, the light trains and Abu Dhabi underground lines will pass through the center of Masdar City to provide the service of internal transportation and to be a link to the center of Abu Dhabi City and its suburbs. Also, most of the private cars will be parked in a

parking lot at the city borders where the public transportation means are linked to the rest of the city parts [17].

In search for sustainable and suitable solutions for the transportation service, Masdar City has taken initiative to adopt the "Personal Rapid Transport", using auto-motion cars and Uno-compartment cars that work using electricity. These cars provide to their users levels of comfort and privacy equal to those of the taxicabs (Fig. 10). Masdar City has also contributed with Mitsubishi for Heavy Industries Company in an experimental project of cars that works with electricity, using the five- door Mitsubishi cars (i-MiEV) and using "The CHAdeMO-certified Rapid Charger" that charges the batteries of this car with 80% in a period of about 30 minutes. The fully-charged car can go for 150 kilometers (Fig. 11) [13].

**Figure 10: "Personal Rapid Transport" Cars. Source [14]**


**Figure 11: Cars "Rapid Charging". Source [13]**

### 4.6 Sustainable Construction Materials:

The quantities of carbon, resulting from the construction work of buildings, are greatly reduced by using environment-friendly construction materials. However, through the process of detailed evaluation of the materials and products include the economic, environmental considerations (including costs and quality) and social aspects; Masdar City participates in reducing the general economic effect of the materials which are used in the city [16].

In addition to the aforementioned, the team of supply chains in the city cooperates with local and international importers to develop more sustainable materials of better performance than the usual ones. This includes the use of slag concrete (industrial wastes) to replace cement; leading to a decrease in the level of carbon emissions, which are caused by the production of traditional concrete [21], besides providing better performance and greater force. Moreover, the recycled aluminum test, developed in cooperation with the city of Masdar, is conducted. It has accomplished high standards of performance that exceed international criteria. The following is a display of some of the examples of using sustainable construction materials in the buildings of Masdar City:

- Using wood that comes from sustainably run forests with the percent of 100%.
- Using recycled aluminum for the outer cases of buildings with the percent of 90%.
- Using environment-friendly concrete that uses slag so as to reduce the environmental impact of carbon with the percent of 30 – 40 %.
- Using water dyes which do not contain volatile organic compounds which harm the health of man.
- Using construction iron bars which are made of recycled steel with the percent of 100%. [16].

## 5- Case Study Evaluation

It is necessary, so as to evaluate the ability of Masdar City to achieve sustainable urban development, to set a frame work that centers on the study of the extent of City's achievement of the principles of sustainability. Those principles could differ from a reference to another;

however, they focus on three basic rules: social participation, economic sustainability and environmental sustainability. In spite of that division, those principles are interrelated and connected to the economic dimension in a way or another. Hence, the following is an evaluation of the extent of Masdar City's sustainability according to each principle separately and in a way that enables us to connect each principle to the other two.

**5.1 Social Participation:**

In spite of the intention of providing good life style to the residents of Masdar City through the diversification of local economy and applying the principle of environmental sustainability, social participation in the stage of planning the city is overlooked. This can be justified through the lack of other sustainable urban communities in the nearby area, from the experience of whose citizens one can benefit; due to the modernity of such idea in the level of UAE in particular and the countries of the GCC in general. However, it is important to hold meetings with the local resident so as to provide the chance to raise and discuss their needs and the profitable activities which are appealing to them; in an attempt to support their acceptance to live in the city and guarantee the compatibility of the suggested development to the life style in the society. It is expected that the local community participation would face many challenges such as the provision of the will and ability to participate in discussions related to the concepts of sustainability. Those challenge can be overcome by providing the necessary education and raising the awareness of the local residents concerning the benefits which result from applying the concepts of sustainability; in addition to informing them in regard to the basic principles of those concept. Thus, they can participate in discussions effectively [20].

Moreover, "allocation" constitutes of the social problems confronted by the UAE; especially in what concerns providing job opportunities for the unemployed citizens in the private sector. It necessitates the provision of an appropriate level of education along with mastering the English language. However, this is considered the basic barrier before allocating jobs in the level of both the governmental and the private sector. There is no doubt that the solution to this problem helps in achieving national sustainability on both its general and social levels. Here, we can refer to the role of Masdar Institute in providing a partial solution to this problem. It provides good education for the stage of post grade studies. Nevertheless, overcoming this problem requires providing good education starting from the skills of literacy until university education [20].

**5.2 Economic Sustainability:**

The development strategy in Masdar City centers on the diversification of the local, economic activities through providing new industries that are related to sustainability and the techniques of alternative energy. However, its role is restricted, currently, to participation in developing researches without actually taking part in the process of manufacturing. Masdar Institute, also works on providing good education for the youth through post-graduate study programs; hence, enabling them to get their share of the jobs which are provided by the sectors of renewable energies and sustainability techniques, which are characterized by rapid growth in Masdar City [20].

The City of Masdar provides many competitive financial privileges. However, the companies which choose this city to be the headquarters of its work enjoy exemption from taxes and custom tariffs on imports in addition to the freedom of capital rotation. The free zone of Masdar City represents a breakthrough towards Abu Zhabi Market and UAE, in general, which is considered one of the fastest growing, booming economies in the world. It will also

provide, for its tenants, the chance of benefiting from the advanced scientific researches conducted by Masdar Institute for Science and Technology [2].
Masdar City witnesses continuous growth and mobilization. It has received Siemens Company in January 2014, which has become one of the biggest tenants in the city with a work team of more than 1000 employees (Fig. 12). Moreover, more than 40 thousand square meters of office spaces are added in order to host more than 130 companies including small, medium and large international companies [2].

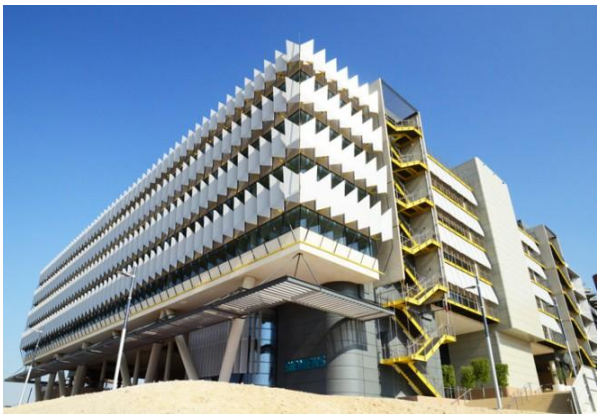


**Figure 12: Siemens Company Building in Masdar City. Source [8]**

**Figure 13: Internal Lobby in Siemens Company. Source [8]**

### 5.3 Environmental Sustainability:

Masdar City has been able to realize the model of sustainable urban development; especially in the frame work of reducing the rates of carbon emissions and working to provide alternative energy sources as discussed earlier. Nonetheless, it is held accountable for the individual's water consumption there; especially with its limited water resources in addition to the increase in the demand on water as a result of urban growth and the expansion in the plots of green areas which need massive amounts of water during the process of irrigation. Moreover, Masdar City is also ibale accountable for its adoption of the policy of presenting the model of the sustainable city only without providing effective solutions to transform the rest of UAE to sustainable cities as well. However, the construction of new cities takes many years; whereas transforming the existing cities to green cities definitely takes less time and guarantees that the current as well as the upcoming generations would enjoy the chance of living in sustainable cities [20].
From here one can say that Masdar City targets finding solutions and strategies for using alternative energy. Also, it can dedicate its efforts to the other environmental issues which support the sustainability system in the city.

## 7- Conclusions and Recommendations

The study concludes that it is important to provide an integrated system that works to develop cities in arid areas in a sustainable manner as one of the pillars of overcoming the harsh environmental circumstance to which those cities are exposed; taking into consideration the active social participation and the triggering economic dimension of development, besides benefiting from the environmental resources in arid regions so as to develop energy-saving, environment-friendly urban communities which guarantee the right of the upcoming generations to a safe and healthy living. The study also indicates the importance of adopting the principles of sustainability as a solution for the issues of energy and development in the countries of the Gulf Cooperation Council (GCC), as an alternative for dependence on petrol, as the case in Masdar City, on which the study works in order to analyze the pros and cons in its application of the principles of sustainability. This makes it an example for the practical application of those principles in arid areas and a case study, through which we can come out with a number of recommendations to present to the decision makers so as to help them achieve sustainable development in arid areas environment in the following aspects:

- The importance of setting governmental, strategic plans which target the establishment of new urban cities and develop the existing cities in a sustainable manner and with an active social participation through all the stages of planning, execution and management.
- Support of scientific research in the fields of renewable energy and sustainability techniques.
- Encouragement of cooperation with international research institutes in the frame work of supporting the industries related to renewable energy.
- Enhancement of the governmental support for the companies of fledgling techniques which are related to sustainability techniques and renewable energy.
- Work to enhance the environmental awareness of the citizens for the purpose of enabling them to actively and socially participate.
- The importance of using natural resources in arid areas such as the sun and sand in a sustainable manner.
- Work to adopt the policies of economy, recycling and reuse of natural resources.
- The preparation of economic and environmental studies so as to avail them for investment in the fields of sustainable urban development.

Sustainable development is still an objective to the fulfillment of which different countries work with the framework of their efforts aiming at improving the citizen's life standards whose life style, in return, constitute the cornerstone of the success, or failure, of sustainable urban development system. However, its success depends on the faith and conviction of the citizen and the decision maker, on equal footing, concerning its importance for them and for the upcoming generations after them.

## REFERENCES


[1] A. Alusi, R. G. Eccles, A. C. Edmondson, and T. Zuzul, "*Sustainable Cities: Oxymoron or the Shape of the Future?*", Harvard Business School Organizational Behavior Unit Working Paper *No. 11-062* , USA, 2011, pp. 1-26.

[2] AMEinfo.com, "*Masdar City to showcase its attractive investment and free zone opportunities at WETEX 2014*", available at: http://www.ameinfo.com/blog/education-&-childcare/mubadala/adfec/masdar-city-showcase-attractive-investment-free-zone-opportunities-wetex-2014/ (accessed 20 April 2016).

[3] C. M. Davidson, "*The United Arab Emirates: prospects for political reforms*", Brown Journal of World Affairs, Vol. 14, No. 2, Brown University, USA, 2009, pp. 117-127.

[4] C. Stanton, "*UAE's fresh water supply drying up*", The National, UAE, 2010.

[5] D. Reiche, "*Renewable Energy Policies in the Gulf countries: A case study of the carbon-neutral ''Masdar City'' in Abu Dhabi*", Journal of Energy Policy, Vol. 38, Elsevier, Amsterdam, 2010, pp. 378-382.

[6] Foster + Partners, "*Masdar Development*", available at: http://www.fosterandpartners.com/projects/masdar-development/ (accessed 7 April 2016).

[7] Green Prophet, "*First pics of Foster + Partners futuristic incubator building at Masdar City*", available at: http://www.greenprophet.com/2014/01/first-pics-of-foster-partners-futuristic-incubator-building-at-masdar-city/ (accessed 15 April 2016).

[8] Green Prophet, "*Siemens opens Middle East's greenest office building at Masdar City (PHOTOS)*", available at: http://www.greenprophet.com/2014/01/siemens-inaugurated-the-middle-easts-greenest-office-building-at-masdar-city/ (accessed 25 April 2016).

[9] L. Crot, "*Planning for Sustainability in Non-democratic Polities: The Case of Masdar City*", Urban Studies Journal Ltd, Vol. 50, No. 13, SAGE Publications, USA, 2013, pp. 2809-2825.

[10] Masdar City, "*Energy Management*", available at: http://masdarcity.ae/en/60/sustainability-and-the-city/energy-management (accessed 15 April 2016).

[11] Masdar City, "*Exploring the Masdar Institute Campus*", available at: http://masdarcity.ae/userfiles/files/brochures/exploring_masdar_institute.pdf (accessed 15 April 2016).

[12] Masdar City – Free Zone, "*Question and Answer*", available at: http://www.masdarcityfreezone.com/en/question-answer (accessed 10 April 2016).

[13] Masdar City, "*Masdar City Installs First Rabid Charger in Middle East*", available at: http://masdarcity.ae/en/75/resource-centre/press-releases/?view=details&id=102 (accessed 17 April 2016).
[14] Masdar City, "*Personal Rapid Transit System*", available at: http://masdarcity.ae/userfiles/images/gallery/built-env/Image-showing-the-Personal-Rapid-Transit-System-at-Masdar-City1.jpg (accessed 17 April 2016).
[15] Masdar City, "*Planning and Design*", available at: http://masdarcity.ae/en/59/sustainability-and-the-city/planing-and-design (accessed 10 April 2016).
[16] Masdar City, "*Supply Chain*", available at: http://masdarcity.ae/en/63/sustainability-and-the-city/supply-chain/ (accessed 15 April 2016).
[17] Masdar City, "*Transportation*", available at: http://masdarcity.ae/en/62/sustainability-and-the-city/transportation/ (accessed 15 April 2016).
[18] Masdar City, "*Waste Management*", available at: http://masdarcity.ae/en/98/waste-management/ (accessed 15 April 2016).
[19] Masdar City, "*Water Management*", available at: http://masdarcity.ae/en/61/sustainability-and-the-city/water/ (accessed 15 April 2016).
[20] M. Baydoun, "*Using innovation research to achieve sustainability in urban developments: The case of Masdar*", International Journal of Technology Management & Sustainable Development, Vol. 12, No. 1, Intellect Limited, UK, 2013, pp. 3-14.
[21] M. Bishwapati, N. Lyngdoh, and T. Challam, "*Masdar City: a zero carbon, zero waste myth*", Current Science, Vol. 102, No. 1, Indian Academy of Sciences, India, 2012, pp. 12-21.
[22] N. O. Madichie, "*IRENA – Masdar City (UAE) – Exemplars of Innovation into Emerging Markets*", Foresight: The International Journal of Applied Forecasting, Vol. 13, No. 6, Emerald Group Publishing Limited, United Kingdom, 2011, pp. 34-47.
[23] The Big Project, available at: http://www.bigprojectme.com/wp-content/uploads/2012/01/Abu-Dhabi.jpg (accessed 5 April 2016).
[24] The Professional Pilots Rumor Network, available at: http://www.pprune.org/aviation-history-nostalgia/374714-raf-sharjah-20.html (accessed 5 April 2016).
[25] United Nations, "*Global Strategy for Shelter to the Year 2000*", available at: www.un.org/documents/ga/res/43/a43r181.htm (accessed 10 May 2016).
[26] United Nations, "*Rio+20: United Nations Conference on Environment and Development*", available at: http://www.un.org/en/sustainablefuture/index.shtml (accessed 8 May 2016).
[27] United Nations, "*Sustainable Cities*", available at: http://www.un.org/en/sustainablefuture/cities.asp (accessed 10 May 2016).
[28] United Nations, "*United Nations Conference on Environment and Development*", available at: http://www.un.org/geninfo/bp/enviro.html (accessed 8 May 2016).
[29] W. Arnold, "*Abu Dhabi to develop urban planning code*", *The National*, UAE, 2009.
[30] Wikipedia, "*BedZED*", available at: http://en.wikipedia.org/wiki/BedZED (accessed 7 April 2016).
[31] Z. Dan, M. Kung, B. Whiteford, and A. B. Ebersole, "*Analysis of Sustainable Materials Used in Eco-villages: Review of Progress in BedZED and Masdar City*", *Journal of Wuhan University of Technology-Mater. Sci. Ed, Vol. 27, No. 5, Springer*, Germany, 2012, pp. 1004-1007.