



Towards the Second Sustainable City in the Middle East: Retransforming Ras El Khaimah Costal City with the Estidama First Model of the Abu Dhabi Master Plan 2030

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Abstract. The new Pearl Rating System (PRS) consists of three rating stages—design, construction and, operation—and is the core of the UAE Estidama program that was introduced under the vision of the Abu Dhabi master plan 2030 "Towards the 1st Sustainable Capital in the Middle East". By monitoring every stage in a building life cycle, the system will guarantee applying all development aspects in a sustainable manner. As one of the fastest-developing countries in the Middle East, and rushing to be one of the best developed countries in the region, having one city as the first sustainable capital is not enough for conserving the heritage, culture, and the unique virgin environment of the Arabian Gulf western shore. A small city such as Ras El Khaimah, with its few resources and richness with desert-hidden treasures, is a good second candidate for the application of the vision of the Abu Dhabi 2030 Estidama program. This paper will present two detailed analytical studies regarding the Abu Dhabi master plan 2030 and Ras El Khaimah's current situation in order to investigate the challenges facing the sustainable development in the city under the Estidama program. The aim is to generate a guideline and provide a set of recommendations that can take care of the development process while applying the Pearl Rating System and the UAE Estidama program. With a population somewhere between 250,000 and 300,000 (2010), Ras El Khaimah has maintained its original Emirati character in a unique manner that manages modern architectural style without distracting from the traditional image of the city. This small, coastal city has good potential along with many challenges due to the lack of natural resources and closed community. The UAE federal government system will face a challenge against the application of the Abu Dhabi Estidama model. However, such cases are proof that sustainability is the most efficient solution for developing traditional communities with their own empty hands.

Keywords. *sustainable development, Abu Dhabi Vision 2030, Ras Al Khaimah, Pearl Rating System (PRS), Estidama*

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1. Introduction

The United Arab Emirates (UAE) is an Arabian country located in the southeast end of the Arabian Gulf and is surrounded by Oman from the northeast, east, and southeast; Saudi Arabia from the south and west; and the gulf waters from the north. It is considered one of the most important countries of the Gulf Countries

Council (GCC), which it joined back in 1981, as the council was established and announced in Abu Dhabi on the 11th of February 1981. The UAE is now leading a regional and international initiative in the field of sustainable development. Taking into consideration that it is only 44 years old, the UAE is one of the first

countries who noticed the need for an immediate environmental enhancement to the communities we are living in. His Highness Shaikh Khalifa Bin Zayed Al Nahyan, President of the United Arab Emirates and Ruler of Abu Dhabi, realized how limited the natural sources that the UAE and the world have, which is why the UAE has already started taking serious actions and steps to protect those resources in a very professional way that does not delay or stop its development plan.

"We cherish our environment because it is an integral part of our country, our history, and our heritage. On land and in the sea, our forefathers lived and survived in this environment. They were able to do so only because they recognized the need to conserve it, to take from it only what they needed to live, and to preserve it for succeeding generations. With God's will, we shall continue to work to protect our environment and our wildlife, as did our forefathers before us. It is a duty, and, if we fail, our children, rightly, will reproach us for squandering an essential part of their inheritance, and of our heritage" said the late His Highness Sheikh Zayed bin Sultan Al Nahyan founder of the UAE.



Figure 1: View of Ras Al Khaimah coast (RAKTDA, 2013)

a. Glimpse of the Past

A quick overview of the UAE's past shows its role and importance through the years. At earlier stages, around 130,000 years ago, there were strong interactions between this land and

the outside world. It was discovered that the Julfar area (currently known as Ras Al Khaimah) was the main export port for copper coming from the Hajar Mountains now located in Oman. It was also the starting point for the Islamic invasion of the Sasanian Iran and the spread of Islam to the whole of Asia back in 637 AD. The recent history of the UAE during the 20th century shows that many countries invaded these parts of the Arabian Peninsula, ending with the British invasion, which ended with the declaration of the independent country of the United Arab Emirates by the late His Highness Sheikh Zayed bin Sultan Al Nahyan, the ruler of Abu Dhabi, on the 2nd of December 1971. The new federal union consisted of Abu Dhabi as the capital of the new country, Dubai as the trade and commercial center, Sharjah, Ajman, Umm Al Quwain, and Al Fujairah where Ras Al Khaimah (RAK) joined the following year. On February 1972, a federal council was created containing only seven emirates after Qatar and Bahrain refused to join the union.



Figure 2: UAE's location and territory map (Abu Dhabi Government, 2013)

b. Shaping UAE's Future

As a natural result of the existing federal system that is applied in the UAE, each emirate has its own rules, regulations, and development plans. Yet, the federal council approved certain approaches that were experienced in certain emirates and generalized them on a federal

level to maintain the unity and integrity of the UAE as a country. The leading emirate in the field of the development plan is Dubai. In 1971, it undertook a huge, rapid development plan that changed the whole image of the city in a matter of a few years. Under the wise leadership of His Highness Shaikh Mohamed Bin Rashed Al Maktoum, the Vice President and Prime Minister of the UAE, ruler of Dubai, the emirate did not deny or ignore the sustainability aspect while applying the emirate's development plan. Thus, as a new growing city, there were no sustainable plans or approaches regarding how to study the existing situation and recommend strategies in the scope of a holistic sustainable package of the development process. As a natural result, the government approved some US and European approaches and programs, such as the LEED program to design and rank buildings, communities, and developments.

Abu Dhabi started this process later than Dubai. Despite this, it closely mirrored Dubai's steps for achieving this huge development in such a short time. The leadership of Abu Dhabi has established the Abu Dhabi Urban Planning Council (UPC) back in 2005 to design, undertake, and monitor the development procedures of the emirate. The UPC's general mission is to establish procedures, plans, and development regulations that govern Abu Dhabi's physical environment. As a result of this mission, UPC launched the Abu Dhabi Vision 2030 "Towards the 1st Sustainable Capital in the Middle East" to control all development aspects in accordance with the Abu Dhabi economic Vision 2030 that was launched earlier by the Abu Dhabi Council for Economic Development (ADCED) back in 2008.

2. Methodology

As mentioned before, the future of the UAE would be very bright if all the emirates followed the steps of Dubai and Abu Dhabi. Yet Abu Dhabi seems to be a better model, as it undertook its own systems and plans and came up with a unique design for the development process that emphasizes the strengths and opportunities the city has, avoiding the weaknesses, and overcoming the threats that

may delay its sustainable development. Taking the rest of the emirates into consideration, especially RAK, they may not have the same potential and opportunities that Abu Dhabi has, which is why it should follow Abu Dhabi's steps in developing its own unique development plan. The last emirate to join the union seems to have many opportunities in terms of sustainable development, although many challenges may arise along the development way.

This study will analyze the Abu Dhabi model, highlighting the techniques and approaches that can be applied and reflected on RAK. In the study, there will be full details of the current situation of RAK, emphasizing the major challenges and the possible solutions towards the second sustainable city in the UAE and the Middle East.

The methodology used in this study is a comparative analysis between the status of both Abu Dhabi and RAK in all sustainability aspects, including environmental, social, and economic. The proposed analysis will highlight the strengths, weaknesses, opportunities, and threats for both cities and will test some of the practices addressed in Abu Dhabi and how they are relevant to application in RAK.

3. Literature Review

The nature of this study as a comparative analysis between two existing case studies required huge amounts of data and information gathering and analysis in order to address the actual current situation of both Abu Dhabi and RAK. It also required a detailed search to be conducted on previous developments for RAK in order to list all the previously proposed solutions and development plans to avoid any duplication or repetition and to provide feasible relevant solutions to the current problems.

Analyzing the status of the emirate of Abu Dhabi limited most of the data resources in governmental reports and studies. The UPC, which is responsible for the development procedures in Abu Dhabi, has published the development missions, objectives, procedures, rules, regulations, and plans framework on its formal website. These data were used to address the

sustainable development in the city. In terms of RAK, there was very little information on its governmental portals, yet some non-governmental entities took the responsibility of publishing a number of studies and reports addressing the current situation of the emirate and discussing its future developments. The government of RAK later approved these studies as governmental resources and published them on its formal portals.

In addition to the sources mentioned above, research and studies completed by AlGhais (2010), Al Naboodah (2013), Alshemeili (2014), Al-Zubaidi (2007), Bualhamam (2009), Goudie et al. (2000), Pollock-Ellwand (2011), Shayah and Qifeng (2014), and Walters et al. (2006) have been reviewed in order to address the sustainability package in general and how it was applied in a certain place or city around the world. Taking into consideration the unique nature of the UAE makes it very difficult to apply a certain technique or approach within its context unless it was carefully tested and wisely studied. Moreover, several papers and doctoral theses that investigated the same topic and the unique environmental nature of the UAE were studied as useful sources of information.

4. Research Framework

a. Abu Dhabi's Status Brief

The emirate of Abu Dhabi is the capital of the UAE and the largest among of the rest of the emirates in area and population. Located on around 67,340 km² and occupying almost 87% of the total federation area with a population of 2,120,700 people, it controls most of the UAE's oil and natural gas sources, which makes it the strongest economy in the UAE. Despite the fact that all opportunities given to the emirate abundance of natural gas and oil, the visionary leadership of His Highness Shaikh Khalifa Bin Zayed Al Nahyan, the President of the United Arab Emirates and Ruler of Abu Dhabi, ordered the executive council to publish a policy agenda to set the emirate's objectives towards its sustainable development. In 2007, the executive council launched this agenda in accordance with Abu Dhabi's economic vision 2030. The policy

set nine main objectives that will shape the emirate's future:

- 1) A large empowered private sector
- 2) A sustainable knowledge-based economy
- 3) An optimal, transparent regulatory environment
- 4) A continuation of strong and diverse international relationships
- 5) The optimization of the Emirate's resources
- 6) Premium education, healthcare, and infrastructure assets
- 7) Complete international and domestic security
- 8) Maintaining Abu Dhabi's values, culture, and heritage
- 9) A significant and ongoing contribution to the Federation of the UAE

Under these nine objectives, four priorities that conclude the sustainable package aspects were addressed:

- i. Economic development
- ii. Infrastructure development and environmental sustainability
- iii. Social and human resources development
- iv. Optimization of government operations

In order to complete this vision, the UPC chaired by His Highness Sheikh Mohamed Bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Chairman of the Abu Dhabi Executive Council, launched the Estidama program in 2008. Estidama, which means "sustainability" in Arabic, is not just a program or a building rating system, but it is a clear progressive vision for political governments to develop a balanced society based on the four pillars of Estidama: economic, social, environment, and cultural.

Under each pillar of Estidama, there are principles to address the sustainability package in the community of Abu Dhabi and to ensure the harmony and integrity between these pillars. As the last step to completing the sustainability package for the future development of Abu Dhabi, the UPC published nine design manuals

that any development in the emirate should comply with, starting from private residential

villas up to major community developments and infrastructure design.



Figure 3: Four pillars of Estidama (UPC, 2010)

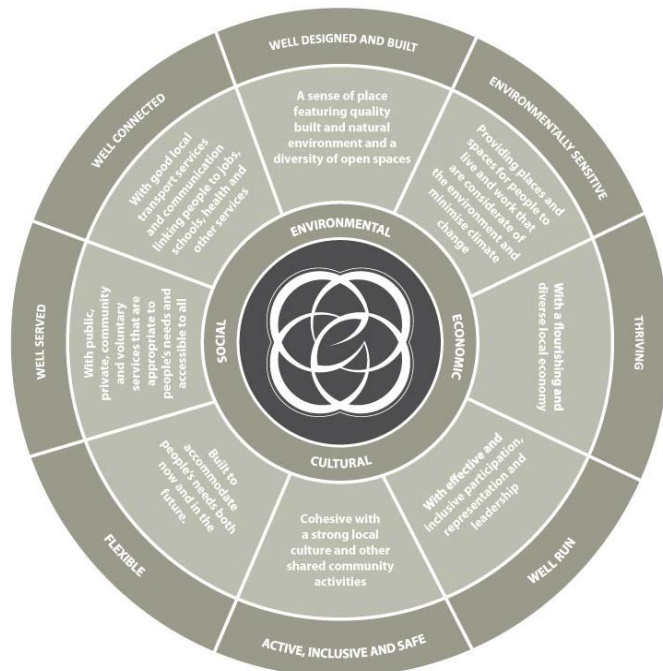


Figure 4: Sustainable communities' eight principles as set by the UPC (UPC, 2010)



Figure 5: Sustainable communities' design manuals published by the UPC (UPC, 2010)

Finally, Estidama is not concerned only with development proposals and designs. The program delivered three rating stages: (1) design ratings to make sure that the proposed design complies with the previously mentioned design manuals, (2) construction ratings to ensure that the proposed building strategies addressed in the design report are being implemented through the construction stage, and (3) operational ratings to monitor a building while it operates and make sure that it is operating as it was designed to.

b. Ras Al Khaimah's Status Brief

Ras Al Khaimah, which means "top of the tent" in Arabic, lies within the northernmost part of the UAE and is located along the gulf very close to the strait of Hurmoz about 65 km away from the Iranian coasts. It is the fourth largest emirate in the country, occupying a matter of area of 247 km² with a population of 263,217 people, and it has a population growth rate of 5.6% per year, according to the National Bureau of Statistics 2010. Its landscape is slightly different than any other emirate in the UAE, as it varies from coastlines and shores that lie along the gulf's rich waters to mountains and hills presented by the Al Hajar mountains that reach heights of 1900 m above sea level to the widely spread desert and its sand dunes. The weather in RAK is slightly cooler than the rest of the UAE, especially in winter times.

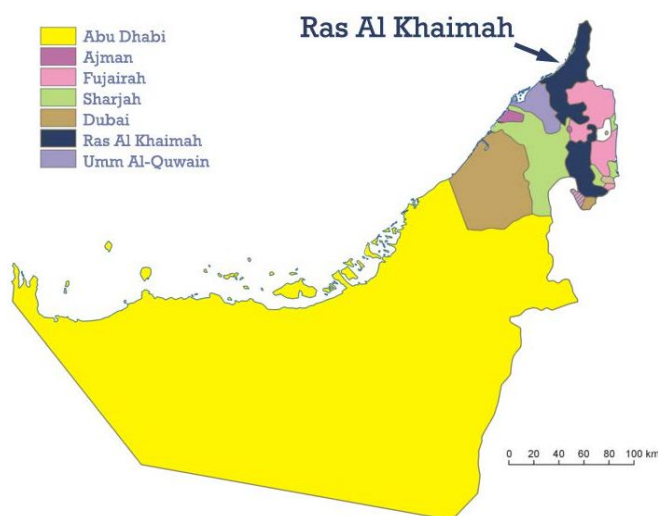


Figure 6: UAE map showing RAK's location (RAKTDA, 2013)

The city has many potential opportunities. Looking at the economics of the emirate, one can easily tell that it does not have many sources of income. The emirate has very limited natural resources in terms of natural gas and oil. This is why it depends on Abu Dhabi to supply it with its oil and gas needs. When it comes to natural resources, like any other part of the UAE, RAK does not have any fresh water resources, so it mainly uses the treated gulf water for domestic uses and bottled water for potable uses. This treatment process consumes energy and is very costly. Despite of all of this, the emirate found other sources of income. Its location on top of the UAE very close to the Strait of Hurmoz makes it a very active port for trading between the gulf countries and the world. The free zone area of RAK is one of the fastest-growing free zones in the UAE. Development there is very rapid, and many industries were established to cover the port's and the free zone's needs. Considering the tourism sector, as mentioned before, RAK has a very long coastal line that lies along the gulf shores surrounded by the Al Hajar Mountains, which makes it a unique tourist location, attracting many investments in this field. In addition to its beautiful nature, it has widespread deserts full of sand dunes and a very traditional Bedouin lifestyle that could be used to attract tourists to the emirate. Moreover, the emirate produces most of the UAE's livestock, as this activity is considered an important part of the UAE's heritage.

The natural environment of RAK is very rich, yet the infrastructure of the city is still very primitive, which is the main threat to the unique biodiversity the city has. The lack of clear sustainable development in the city may cause some major losses to the environment.

One of the most important aspects of RAK is its social and cultural life. RAK still presents the traditional Emirati life that locals used to live years ago. Although the government is trying its best to give the city a modern image by applying new and modern building techniques, the locals still prefer to live in their traditional houses and stick to their traditional lifestyle. This aspect of life is very critical, as it may result in a unique and traditional developed city image or it may

cause major delays to the development process as the people refuse the changes formed by the government.

c. Sustainable Development Obstacles in RAK

The sustainable development of RAK is a very complicated process, but it is not impossible. On the contrary, others may see it the perfect time to start such a development process, taking into consideration the potential the city has. To develop a good idea about the development process, an analysis of the main obstacles that may delay this process should be conducted.

i. Environmentally:

The lack of natural resources in the emirate is the main threat to any development that may take place in RAK. The study will investigate the water scarcity and the energy shortage issues. Moreover, the loss of natural biodiversity is more likely to happen since the city has no clear biodiversity enhancement plan or a clear infrastructure strategy.

Lack of Natural Resources

The term “natural resources” in this study addresses the basic resources required for sustainable development, such as water and energy. Water is the main component of life. Throughout ancient civilizations, great empires were built on a source of water. RAK, as a part of the UAE, is located in an arid area of the world. The main characteristics of these areas are severe shortage of natural fresh water resources due to the irregular and limited rainfall, high evaporation rates, and the lack of fresh water resources like rivers and lakes. The annual mean rainfall is around 120 mm and the evaporation rate is 8.2 (UAE State of the Water Report, 2011). General factors that affect water scarcity are also presented in RAK and include population growth, irresponsible use of water resources, water pollution, drought caused by changes in climatic conditions, industrial development, and life standard enhancement. These factors affect the water resource directly and increase the demands on fresh water.

As a natural result of this huge shortage of water, the city depends mainly on the desalina-

tion of gulf water for daily domestic and industrial use and irrigation. The city also depends on bottled water as the main source of potable water. This bottled water comes from natural ground water that has gone through basic treatment procedures, been tested, bottled, then distributed and sold to consumers. The last water source in the emirate is treated wastewater. This source is very limited in RAK, although the government encourages the use of this treated water. Currently, there is no plan to generalize the practice of wastewater treatment, although it is considered the optimum alternative for the use of fresh water for irrigation and industrial uses. Irrigation and industry consume around 60% of the total fresh water demands worldwide. If treated wastewater can replace around 50% of these demands, then huge savings in the fresh water demands will be achieved. In summary, the UAE State of the Water Report 2011 prepared by the Ministry of Environment and Water stated that in 2009, the total UAE renewable fresh water resources is estimated to be 150 MCM/year or less where the fresh water demand was 4.5 BCM in 2009, representing 51% from ground water, 40% from desalinated water, and 9% from treated wastewater.

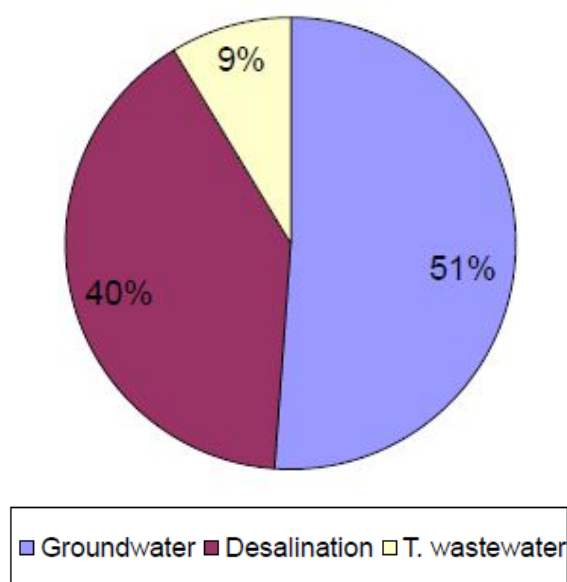


Figure 7: Water resources in the UAE (MOENR, 2015)

Energy is the core of any development plan, as it is the one and only engine to make strategies and practices feasible for implementation. Generally, energy around the world is generated either through renewable or non-renewable sources. Up to present day, the main energy producer has been the non-renewable sources coal, oil, and natural gas. Although global awareness has started to rise lately, there has also been a rapid increase in the demand for coal, oil, and natural gas, which must be monitored. The UAE, as one of the world's fossil fuel producers, is thought to be safe from any shortage that may occur to these natural energy resources. Despite this, the leadership is encouraging the uses of renewable resources available in the region like solar and wind power through very strong strategies and regulations.

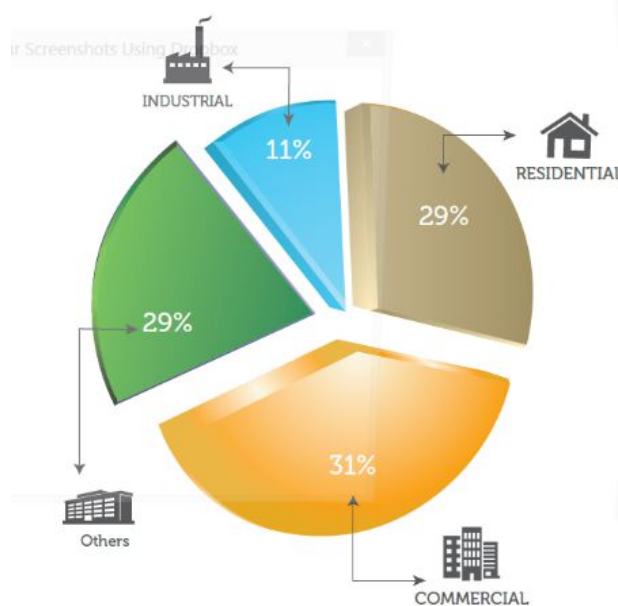


Figure 8: Energy consumers in the UAE (MOENR, 2015)

However, the available fossil fuel sources in the UAE are located mainly in Abu Dhabi. A few more can be found in Dubai and some spots in the northern emirates. On a city scale, RAK does not have any of the energy resources that the UAE has as a country, so it depends mainly on the emirate of Abu Dhabi to supply it with the required demands. The UAE state of energy report 2015 stated that 29% of the energy

generated goes to residential dwellings, 11% to industrial use, 31% for commercial activities, and the last 29% goes to other uses. These other uses include educational, health, and recreational activities and public services. A huge hidden energy consumer is the construction process. Any development plan that will take place will be integrated with wide construction practices that will happen in the emirate in order to bring the proposed plan to life. The construction process consumes huge amounts of energy generated by fossil fuels only, as it is not so feasible to use renewable sources in construction sites.

Loss of Biodiversity

Despite the huge shortage in natural resources that RAK suffers from, it has a unique ecosystem characterized by coastal systems due to its location along the shores of the Arabian Gulf. It is surrounded on the north by the Al Hajar Mountains, and it has widespread deserts and sand dunes. It is critical that this diversity in the ecosystems be conserved and protected, as they should be treated differently. Existing unplanned developments do not have any ecosystem conservation plans or strategies, and this may cause a loss of biodiversity in the emirate. It may be a very slow process, yet it is happening. Major tourist developments on the shores, residential dwellings, and industrial activities near the mountains or in the desert have great impacts on the surrounding environment. These impacts may be minor in the short term, but in a long-term study, huge losses in the environmental systems can be monitored.

The Primitive Infrastructure

Development strategies in RAK are very recent. Years ago, the emirate infrastructure systems were very primitive. New governments developed those systems to cope with the city's demands, but the infrastructure systems are still too primitive to adapt to rapid development and population growth. The urban infrastructure term here is very broad and includes utilities and road networks, educational institutions, health care facilities, and even recreational spaces and public open areas. RAK lacks a comprehensive infrastructure system that addresses the population's demands. Moreover,

the integrity between those networks and systems is almost missing, which is a threat to the city's environmental systems.

ii. Socially:

The social pillar of the sustainability package in RAK is clearly presented and is both a threat and an opportunity. RAK still holds the traditional emirati traditions and lifestyle. Hundreds of years ago, the emirati locals lived in the deserts in tents around water springs. Then development started to take place, and the people moved into more settled houses that used building techniques called the passive designs of today. The locals depended on livestock, fishing, and primitive agricultural techniques for their daily needs. It is also noted that a big number of the emirati people living in Dubai and Abu Dhabi are originally from RAK then moved for better work or educational opportunities.

Lack of Social Awareness

Global awareness of the need for sustainability is growing over time. Although the government of the UAE does its best to increase this awareness among UAE residents, some societies still do not have the required will to pay attention to the environment we are living in. Social awareness in RAK is very weak. People rarely think of sustainability, what it is, and why the government is taking the matter so seriously. Many even think that it is the role of governments to take care of these matters and that there is nothing they can do to help or that the responsibility is not theirs.

Public Acceptance of Development Practices

Public acceptance is very important to the success of any development plan. Governments may set perfect sustainable plans and strategies, but when it comes to implementing these strategies, residents may reject the changes, regulations, or rules to be applied to their normal daily routines. A successful strategy should be trusted and publicly accepted by the people living in the place. RAK, as addressed before, still has the traditional lifestyle of the old emirati. Emiratis who are still in RAK who chose to remain settled in the city and did not move to more developed cities, like Dubai and

Abu Dhabi, may refuse any changes happening or changing their daily routines or lifestyles.



Figure 9: An old photo showing the traditional emirate lifestyle (RAKTDA, 2013)

iii. Economically:

Economics in a city are the engine to address any proposed plans or practices, and they are directly influenced by all threats or weakness that the city may suffer from. For example, the environmental hazards addressed above will require large investments to overcome and limit their impacts. Moreover, the social problems, including public awareness and a sense of responsibility, will consume recognized sums of money if they are to be changed. The economic obstacles are covered at the end of this analysis because they will cover all the threats presented in RAK.

Lack of Natural Resources

The lack of water and energy resources are a huge economic threat. The water demands in the city require big investments, as desalination stations cost a lot to construct, operate, and maintain. Also, extracting the ground water, transferring it, and then treating it costs millions of Dirhams. Taking into account the rapid population growth, the costs required for these procedures gets higher each year. In most cases, the water supply charges fall on the government's shoulders, and although there are consumption charges that are paid by residents in the city, they do not reflect the real costs of supplying fresh domestic water. The situation

for potable water is a different matter, as the responsibility of providing it falls on private sector companies where the investors charge consumers the real value of the fresh water supply costs.

When it comes to energy, the calculations get even more complicated. Energy in RAK is mainly generated from fossil fuels, oil, and natural gas, which the city does not have. The energy costs include two main factors: purchase and generation costs and the annual consumption rates. Purchase and generation costs are set by the global market prices, and the ministry of energy in the UAE calculates the annual consumption rates annually. Besides the main activities (e.g. residential, commercial, industrial) that have a share in the energy consumption, the construction sector and the desalination process consume huge amounts of energy that affect the emirate's budget directly.

The Rapid Unplanned Development

RAK's unique location on the top of the emirate, as it is the last emirate in the north, provided a good opportunity to host a huge free zone area. This may seem to be a good opportunity for the emirate's development, yet it is considered a threat since some unplanned developments have started to take place. These developments are based on some old outdated plans that do not cope with the rapid needs of the city. The main area where a good expansion plan is needed is in industrial activities and their supporting facilities. If unplanned industrial expansion continued, then it would be very difficult to be controlled afterward, and the impact of such activities could be undesirable environmentally, socially, and economically.

5. Sustainability Package Proposal

Achieving successful development is not an easy task, especially when the development is designed to be sustainable. The goals and objectives should be as clear as the concerns and threats. Defining general solutions to the main problem should be highlighted at the beginning of any planning process in order to study these solutions in detail and approve or disapprove them. Abu Dhabi should be taken

into account as an existing model that succeeded in designing a sustainable feasible development plan and started to achieve the benefits of its proposed practices. In a matter of only seven years, starting from the launch of the Estidama program in 2008 until now, major changes in the city's image can be seen. Residents of the city feel the changes applied by the government. It was hard in the beginning to adapt the public to the new rules, regulations, and practices; but in a matter of a few years, the people started coping with the changes and finally realized that they were happening for their own good. Comparing both the cases of RAK and Abu Dhabi, many similarities can be found. RAK does not have the same economic assets that supported Abu Dhabi's vision, but it has other natural assets that can be used as a source of income.

a. Environmentally:

Environment, or the natural surroundings that we live in, is the host of all our resources, including energy, water, air, and earth. Damaging any of these elements means manipulating the natural balance that we live in. That is why the environmental aspect is always the first to be discussed and investigated when it comes to sustainable development. The environmental threats addressed before may seem very serious, yet they have many feasible solutions that were tested and practiced before in other areas like Abu Dhabi. The proposed solutions achieved great results in a matter of a few years. This encourages the reuse of those solutions in RAK.

Resource Substitutes and Savings

Regarding the lack of natural resources, it is easily seen that the water problem will always come first before any other source. The water scarcity issue is a general problem across the UAE. Looking at the consumption rate, we find that 60% of the total yearly consumption goes to industrial, irrigation, and commercial uses. This amount of water can be easily substituted with treated wastewater. Over the past 50 years, several studies investigated the efficiency of wastewater treatment in several areas around the world. Some researchers approved the procedure and rated it as the optimum

solution for the water scarcity problem around the world. Others had some doubts about the efficiency of the treatment process since it is very costly due to the costs of collecting wastewater, construction and operation of treatment plants, water networks from collection patches and to final consumers, and finally, the most important factor, the energy required to operate those treatment facilities. Some groups of researchers were completely against the use of treated water, as it may have very serious health implications on the people who use of it.

Among all the scientific discussions, the Estidama vision addressed a very feasible solution that can be applied in RAK. The plan was to encourage the use of treated wastewater in industrial, landscape irrigation, and toilet flushing in commercial and industrial buildings. It will not be used for any residential or agricultural uses to avoid any health risks. Regarding efficiency of the process, the strategy was to set a new regulation that investors in new developed industrial areas should have their own treatment plant inside their plots. The case is not general; it specified that if an industry's daily fresh water consumption exceeds a certain level, then this facility should have its own treatment plant to treat the water before discharging it into the wastewater network. This will ensure that the wastewater is of a certain quality before it reaches the main governmental treatment stations. Certain industrial activities are required to have their own treatment networks, such as food and pharmaceutical industries, which consume huge amounts of fresh water and produce high

quantities of wastewater. Simple treatment processes can be implemented onsite, and small tanks and pumps can redirect this treated water to be used again in the same facility for landscape irrigation and toilet flushing. Other pre-treated wastewater is collected for a final treatment process, which is handled by the government, to generate water for landscape irrigation, golf courses, and public toilet flushing in the whole emirate. These practices have resulted in huge savings in daily water consumption. This strategy is still very new, and hopefully more savings will be achieved in time. This practice was very successful in achieving many benefits, including fresh water savings in consumption rates, reducing the charges of water networks, reducing the construction costs of huge treatment plants, and reducing the yearly utility bills for investors. If RAK can adopt such practices, there will be great savings, as it depends mainly on industrial activities as a source of income. The industrial sector consumes huge amounts of the emirates' share of fresh water, which can be saved or at least reduced by substituting it with onsite treated wastewater. Another strategy that is applied now in Abu Dhabi, which was delivered also with the PRS system, is controlling water fixtures' and appliances' flow rates. The UPC publishes a list of the allowable flow rates to be used in any new project that is being constructed in Abu Dhabi. This practice helps to achieve water savings in water consumption on a smaller individual scale, which will be welcomed by the public because these savings will be reflected on their monthly utility bills.

Fixture of Fixture Fitting	Percentage Reduction
Bathroom Taps, private	6 liters/min at 417.7 kPa
Bathroom Taps, public	1.9 liters/min at 417.7 kPa
Shower Head	9.5 liters/min at 551.6 kPa
Kitchen Sink Faucet	6 liters/min at 417.7 kPa
Bidets	6 liters/min
Urinal	0.5 liters/flushing cycle
Toilets (Dual Flush)	6/4 liters/flushing cycle (full/low)

Figure 10: The approved water fixture flow rates by the UPC (UPC, 2010)

Regarding the lack of energy sources, fossil fuels can also be substituted by natural renewable resources like solar and wind power. The emirate is very rich with both sources. Generating power from solar panels is a very old technique that can be carried out on both an individual and governmental scale, yet it has not been generalized. On the governmental side, one can see small solar panels attached to the public light poles, traffic signals and signage, and commercial signs in both Dubai and Abu Dhabi. Again, this is an easy practice that can be generalized in RAK. On a personal scale, the emirate market is very rich with simple PV panels and solar systems that can be added to the small residents' villas to provide domestic use of energy. In addition, solar lights are widely used, and they need no wiring, connection or source of power. All they need is a sunny atmosphere, as they charge their batteries all day long and use this power to provide lighting in the evening time. Other practices should address the issue of energy saving not only find other sources for generation it. The UAE is well known for hot weather all year long. Like every other emirate in the UAE, RAK consumes most of its generated energy for cooling systems. Those systems cannot be substituted by any other cooling techniques, yet they can be designed to be energy efficient. Lowering the cooling electrical loads requires good architectural design, limited glazing areas, selection of materials with a certain UV, providing good insulation, and assuring the airtightness in the building. All these factors can be listed under the passive design techniques that lower the heat gain in a building and are highly recommended by the PRS. The system also addresses certain approved materials with certain U-values to be used. Moreover, conditioning equipment was also accurately specified, including types, cooling capacity, power consumption and technical specifications. The PRS approved two ways of calculating the electrical cooling demands in a building: the perspective method and the energy modelling method.

Natural Systems Enhancement & Protection

The loss in the biodiversity in RAK is very slow, meaning that it can be controlled with simple

practices. Referring to the PRS system, it did not deny such an important aspect. The natural system protection strategy should address the different ecosystems that exist in the emirate including marine, desert, fertile land, and mountains. The main part of this strategy is the government's responsibility. Any master plan that addresses sustainable development should be supported by a natural system analysis study to locate the different ecosystems in the emirate. The environmental analysis study should clearly state which activity is best suited for each ecosystem and what the exact practice is that should be implemented to protect that ecosystem in a certain location. The Estidama vision developed a comprehensive land use master plan covered by Abu Dhabi's territory and proposed a certain location of the different natural ecosystems in compliance with the proposed land use required to address the sustainable image of the city. Thus, individual practices should also take place along with the governmental plans. It is possible to find some precious plants and species apart from the defined ones that should be protected in other areas. This is why some protection of simple practices are imperative for individuals.

A Comprehensive Integrated Infrastructure

The responsibility for this falls on the government's shoulder. An integrated infrastructure is very complicated to design and construct. Abu Dhabi designed the basic infrastructure in phases. Phase one was updating the existing network to cope with the population growth and to comply with the Estidama vision. Phase two was expanding roads and utility networks to reach and serve new developed areas. The final phase is constructing new networks for the new cities that will be constructed according to master plan Abu Dhabi vision 2030. In order to achieve this integration in RAK, a full master plan should be designed first, and the design of the infrastructure networks should come next in order to address the design proposed in the master plan. RAK can adopt such a practice only if a general master plan is designed for the emirate's future planning.

b. Socially:

The social aspect of sustainable development is different from place to place and people to people. The social practices applied in Abu Dhabi can still be applied in RAK but with caution. Social sustainability addresses the even distribution of physical human assets, human rights, social justice, the need to preserve cultural and environmental heritage, promotion of education and creativity, and finally, achieving harmony between citizens and other residents in the emirate.

Raising the Awareness of the Public

Education is the key for any developed and successful nation. A good educational system produces aware, educated generations that benefit their societies and communities. RAK, as a part of the UAE, follows the federal education system that is designed for the whole country. Despite this, there is still a lot to be done to raise public awareness of the importance of sustainability. Some people think that it is the government's responsibility to take care of these matters. However, this is wrong. There is a lot that must be done on an individual scale, and each resident in this society should have his or her share of responsibility. These ideas and concepts can be easily corrected through national campaigns that address the public directly. Training seminars and workshops for all development stakeholders make the process much easier to accept by the public. Also, social campaigns to schools, universities, and other educational institutions will help raise awareness. Finally, some commercial campaigns can be undertaken, such as road signs and media advertisements.

Governmental Legislations

Rejection of change is a natural human behavior. The public in a certain society will initially reject any changes to their lifestyle. This is where the government should interfere to help the public make the necessary changes. The government should issue design manuals to control the developments proposed to take place in the emirate as well as new rules, regulations, and building codes that delivers the goals of the development plan. It should also

host workshops for residents, investors, consultants, and contractors to introduce the development objectives and how all the stakeholders should work together to achieve it. In the case of Abu Dhabi, the UPC launched nine design manuals to control any building activity that takes place in the city. Moreover, the Abu Dhabi municipality generalized the use of the international building codes (architectural, structural, plumbing, mechanical, electrical) and the firefighting code and made them mandatory codes.

c. Economically:

Economics is the motive for any development, and sources of income in a city are always limited to the private and public sectors, as they are the soul of any development strategy. A successful development plan is the one that attracts investors from around the world to invest in a particular city. The private sector can be directly responsible for many projects that shape a city's future in all fields, including education, health, tourism, commercials, and recreation. Yet the government is largely responsible for development projects.

Securing Resources: Water and Energy

Securing natural resources through the solutions proposed above costs a lot. The solutions suggested that individuals should undertake are: using certain water fixtures and appliances with lower flow rates, adding extra meters to monitor the exact water consumption, using certain materials that have predefined values and were approved by the local municipalities, using solar panels and lights, and installing certain conditioning equipment. All these practices will certainly raise a building's initial cost by 20% to 30%. However, looking only at the short-term is a very limited perspective. Over the long term, the yearly utility bills will be reduced by 15% to 20%. These savings are considered to be more valuable to the economy than the initial increase in cost.

On a wider scale, and in addition to the practices mentioned above, investors are required to undertake more costly practices like adopting onsite water treatment plants. However, the government should introduce

more incentives to keep investors interested in the emirate's market. The practices that involve more commitment from the private sector should be handled with special precautions since the last thing the government wants to see is investors moving out of their market.

Expanding the Industrial Sector (Free Zone)

The location potential in RAK should be used wisely. The industrial activities that support the free zone should be expanded and encouraged. RAK already has many huge industries, varying from light and mixed-use industries to heavy industries like cement, ceramics, and reinforcing steel. The products of these industries are sold within the UAE, and some of them are being imported to other GCC and Arab countries. Such investments shape the core of RAK's income and employment opportunities, so they should receive more attention and support from the government.

Expanding the Tourism Sector

Along with the biodiversity that the city has, the unique integration of the shores, deserts, and mountains creates an amazing environment for tourism activities. The city already has some resorts in some exquisite locations, yet this sector still has a lot to be done. The desert and the Bedouin lifestyle should be used in a more advanced way. RAK can be a tourist attraction if a better strategy is implemented soon.

6. Conclusion

The outcome of the analyses from both studies proves that sustainable development is very likely to happen in RAK. It also proves that Abu Dhabi is a very successful model for the GCC

city. The solutions addressed were all tested and practiced before, and they showed great results. The right step now is to prepare more detailed studies addressing each pillar of the sustainable development package separately i.e., strengths, weaknesses, opportunities, and threats. Accordingly, solutions that are more detailed should be proposed. A final comprehensive strategy should address all problems and their solutions in RAK. At that time, the emirate will be ready to translate these strategies into a land use master plan that delivers the image of a sustainable community.

The PRS as a rating system controls the design process for villas, buildings, and communities through design reports that should be prepared by local consultants and approved by the UPC. No building permit is to be issued without the UPC's approval. Site visits should be planned to ensure that construction is going smoothly and that all approved materials and practices are being implemented. Another report should be prepared at the end of the construction process, confirming that the building complies with the PRS. Again, the UPC should approve this construction report, as the building completion certificate will not be issued without this approval. Finally, the PRS monitors the building while it operates in order to confirm that it is operating as it is designed to be. The process in RAK will be much easier than in Abu Dhabi and Dubai since it has already two successful models to follow. Abu Dhabi's model is more likely to be implemented in RAK, as it was specially developed for the UAE as a whole country. The federal government is now considering generalizing the PRS system for the UAE as a whole instead of wasting more time and money developing new models.

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