Is the United Arab Emirates Capable to Create a Green and Sustainable Future?

هل دولة الإمارات العربية المتحدة قادرة على خلق مستقبل يعتمد على الاستدامة ؟

By

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Acknowledgement

A research work like this would certainly not have been possible without the support and blessings of my family members, friends, my supervisor and other well wishers. I would like to convey my profound gratitude to Almighty God for providing me with the strength and courage to carry on this work and seek His blessings for my future endeavors. I also thank my supervisor for his counsel and technical guidance, without which it would have been impossible to create this thesis. I dedicate this thesis to my late father who remains the guiding star of my life. .

Abstract

A plethora of research has established that the anthropogenic activity triggered climate changes can elicit catastrophic consequences, jeopardizing the existence of life on earth. For assuaging such a looming peril, international organisations have recommended taking suitable steps so much so that the global mean temperature do not increase beyond 2° C. This can be achieved by intensive endeavours for attenuation of the carbon footprint by undertaking greener and sustainable approaches in diverse sectors of life including energy, water management, lifestyle etc. According to published reports UAE has virtually the highest carbon footprint in the world partially owing to its rapid development over the last few decades. Motivated by the inspirational and enthusiastic leaders, UAE is determined to take necessary measures to go green and sustainable in virtually each and every sector of life and living. The current research intends to evaluate various criteria to elucidate weather UAE is at all capable of a green and sustainable future. Such an assessment involves a detailed evaluation of a number of aspects including, motivation from the leadership, levels of awareness and motivation of the nationals, evaluation of the current achievements and future prospects. We also performed simulation studies for better explication. Overall our studies indicate that, notwithstanding that a plethora of works needs to be done on this arena; UAE definitely looks to be capable of a green and sustainable future.

ملخص

هناك عدد من النشاطات البشرية التي تؤثرسلبا على البيئة بشكل عام والمناخ بشكل خاص , مما يهدد وجود الحياة على الأرض . تم الأخذ بعين الإعتبار لهذه المسألة من قبل المنظمات الدولية, ووضع خطط هادفة من أجل تخفيف الآثار على البيئة والمناخ . تسعى المنظمة جاهدة للحفاظ على متوسط درجة حرارة بحيث لا يتعدى ال 2 درجة سيليزية. و وصولا إلى هذا الهدف يستوجب التوجه نحو الإستدامة في قطاعات متنوعة من الحياة بما في ذلك الطاقة, إدارة المياه, وطريقة الحياة , وتقليل استخدام الطرق التقليدية من أجل تقليل انبعاث الغازات الخضراء.

وفقا لتقرير تم نشره في دولة الإمارات العربية المتحدة يعتبر التطور السريع الذي يشهده االعالم خلال العقود القليلة الماضية هي السبب الأساسي لإنبعاثات الكربون . دولة الإمارات العربية المتحدة عازمة على اتخاذ التدابير اللازمة للتوجه نحو حياة مستديمة خضراء. حيث تسعى حكومة دولة الإمارات وقادتها لرفع مستوى الوعي وحث المواطنين والمقيمين للتوجه نحو الاستدامة, بالإضافة إلى ذلك تحرص الدولة على تقيم المنجزات الحالية ووضع توقعات استراتيجيات مستقبلية لتقليل الأثار على البيئة .

الهدف من المشروع هو تقييم إمكانية دولة الإمارات للتوجه نحو الإستدامة , حيث تم اجراء عدد من الدراسات والحسابات التي تعتمد اعتماد كلي على أرقام وإحصائيات حقيقية للدولة. حيث كانت النتائج تشير إلى ظرورة التوجه السريع نحو الطرق البديلة من أجل تخفيف الآثار على المناخ. وأوضحت الدراسة ان هناك عمل هائل يتوجب على الدولة القيام بها, وجميعنا يؤمن ان دولة الإمارات قادرة ومتمكنه ومستعده للتوجه نحو التغير ونحو الإستدامة.

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CHAPTER I – Introduction

I.1 Green and sustainable future – What and Why?

A plethora of anthropogenic activities have posed severe threats to the global climatic stability jeopardizing human existence. Such activities which have fostered the growth and prosperity of human civilisation for centuries have now become a major threat to this continued opulence. Extensive use of fossil fuels triggering increased emission of green house gases is one amongst many such activities. Such greenhouse gas emission in combination with a plethora of other factors, have induced climate change and global warming. Climate change can trigger catastrophic consequences threatening the very existence of human civilization.

In an effort to assuage such impending hazard, the global conglomerates have settled on a consensus to keep the mean temperature amplification within 2° C. In order to achieve such a target a globally, a collaborative strategy for decreasing the global carbon footprint is warranted. Usage of high carbon energy such as coal, oil or natural gas is therefore being discouraged. Novel strategies entail utilisation of wind energy, solar energy and nuclear energy as energy sources which use minimal or no carbon. This apart generation of alternative low carbon electricity as well as changes in lifestyle patterns can significantly contribute to abrogate this increasing global threat. Therefore shifting towards a more greener and sustainable future is being emphasized (DCCE & UNDP, 2015).Greener economy is believed to lead to superior human welfare, at the same time reducing environmental risks. Such an initiative will diminish carbon emanation and pollution, foster improved energy efficiency as well as resource utilisation, avert biodiversity loss etc.

Like many other gulf countries, UAE faces extreme menace from this looming global danger. The recent economic growth and prosperity of the Emirates have actually had an impact on the climate. A government body has been established in UAE to research on ways to mitigate this threat. Sheikh Mohammed Bin Rashid is a leader that gives high importance to clean technology and green economy and energy. According to him, "We recognize that preserving our energy resources will be one of the greatest challenges in our drive towards sustainable development. This, however, will not materialize unless the different facets of our society adopt energy conservation principles in their core values. The future generations will be the chief beneficiary of our achievements and the best judge of what we accomplish in this field" (DCCE & UNDP, 2015). A thorough elucidation of the science of climate change is the first and foremost requirement to develop mitigating strategies like greener and sustainable alternatives.

I.2 Climate change – An introduction

A significant change in the weather pattern over the landmass, ice sheets and on oceans occurring over decades can be considered as climate change. The statistical properties of the climate system are generally defined by averages, variability and extremes. A change in these parameters at a minimum of 30 years signifies a change in climate. This can occur due to earth processes that are natural like shifts in the sun's radiation, volcanic emissions, slight changes in the atmosphere's content, or shifting patterns of land usage (IPCC, 2013).

Weather is the description of the humidity, wind, rainfall, temperature etc. of the atmosphere over hours to weeks. It is influenced by the oceans, land surfaces and ice sheets, which together with the atmosphere form what is called the 'climate system'(Steffen et al., 2004).Interestingly while weather forecasting can be accomplished about a week in advance it is indeed quite complicated to forecast changes in climate conditions. Temporary vacillations in

climate, like droughts, can be forecasted season to season. Long term significant change in climate however can be calculated only if it is triggered by predictable factors (Steinemann, 2006).

The earth's climate is influenced by solar energy. Part of the sun's radiation is returned to the atmosphere by the clouds, land, ice, water surfaces, aerosols, etc. Ultimately the solar energy absorbed by Earth is returned to space as infrared (heat) radiation. This radiation flow in the atmosphere is an important determinant of the climate (see figure 1).

The solar energy interacts with the climatic components like the land surfaces, oceans, ice sheets etc. Certain atmospheric gases absorb infrared radiation reflected from Earth's

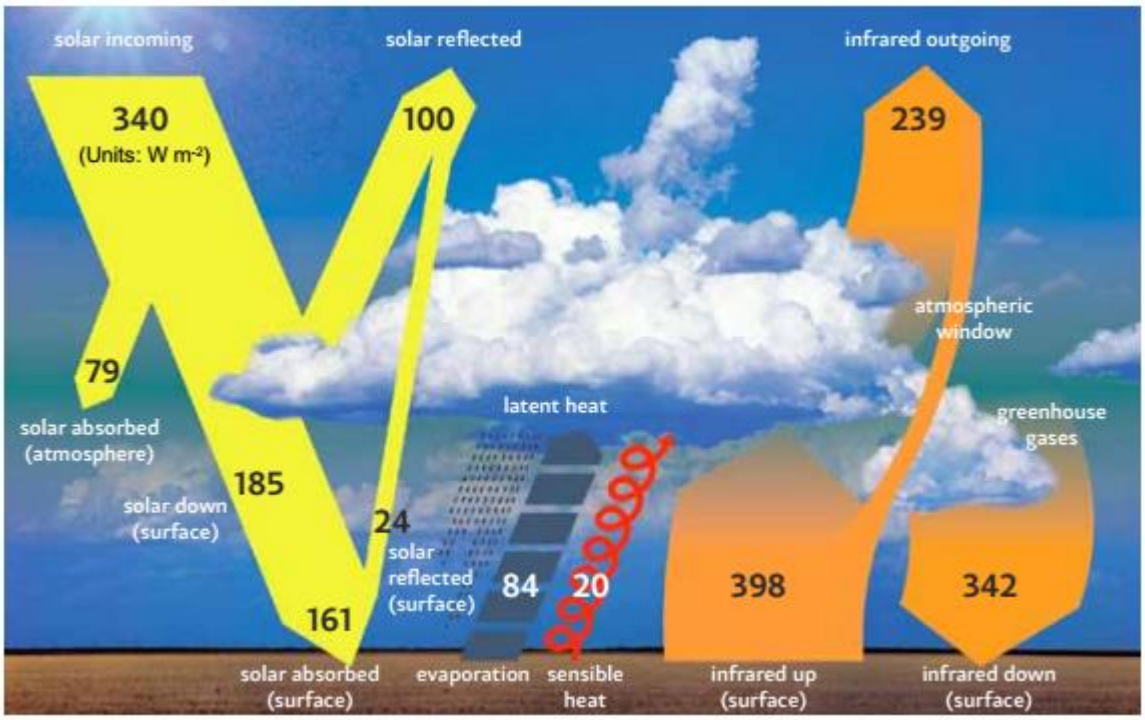

Figure I.1: Entry and dissipation of solar energy from the earth (IPCC, 2013).

surface and re-radiate it in all directions, including back downwards thereby hindering the outward flow of infrared energy from Earth to space. This is known as the ‘greenhouse effect’. These gases like methane, carbon dioxide (CO2), and water vapour interact with the infrared radiation, educing the ‘greenhouse effect’ are the greenhouse gases (Tyndall, 1861). The ‘greenhouse effect’ helps to keep the earth surface warmer and therefore congenial for existence.

Global climatic variations from can be due to natural causes or can also be induced by anthropogenic activities. The natural variations can originate in two ways: from internal fluctuations that exchange energy, water and carbon involving oceans, ice, land and atmosphere and from outside influences on climate system, including the solar energy variations, volcanic eruptions etc.

Human activities can alter the concentrations of natural and chemically manufactured greenhouse gases like CO2, nitrous oxide, methane and halocarbons as well as aerosols, thereby influencing climate change. These gases enhance the natural greenhouse effect and further warm the surface. Additionally the warming that results from increased amounts of long-lived greenhouse gases can be amplified by other processes. Indeed, various climatic factors like atmospheric moisture content, polar ice sheet covering, temperature, amount of long-lived greenhouse gases maintain a close equilibrium. Disturbances of any one of these factor initiate a feedback loop that may amplify the original disturbance.

These feedbacks occur on a wide range of time scales: those involving the atmosphere are typically rapid, while those involving deep oceans and ice sheets are slow and can cause delayed responses. A rapid feedback example is the role of water vapour. Water vapour has been responsible for about fifty percent of the greenhouse effect. Concentrations of water vapour in

the atmosphere are controlled mainly by atmospheric temperatures and winds, in contrast with the concentrations of others which are directly manipulated by anthropogenic activities. The boost in temperature provides a simultaneous boost in water vapour which amplifies the initial warming causing an enhanced greenhouse effect. In this way, human activity leads indirectly to increases in water vapour concentrations. The mechanism of this feedback of water vapour is documented by recent observations. Increased water vapour concentrations have been observed and attributed to warming and this feedback almost doubles the susceptibility of climate to anthropogenic activities (Chung et al., 2014 ; Sherwood, 2010).

The repeated cycles of ice age that is occurring over the last one million years is an example of a slow feedback. It is triggered by Earth's rotational and revolutionary fluctuations, changing the distribution of solar radiation causing temperatures change. This consequently leads to changes in ice sheets and carbon cycling that together amplified the temperature response.

I.3 Patterns and Evidences of Climate Change

Since its formation 4.5 billion years ago, Earth experienced dramatic changes in its climatic conditions a number of times. The principle triggers behind such changes can be attributed to a plethora of phenomenon. These include alterations in the Sun's intensity, volcanic eruptions, changes in configuration of continents and oceans, variations in Earth's orbit, variations in the concentration for atmospheric greenhouse gas, evolution of life and meteorite impacts, etc.

Indeed, millions of years ago the world's average temperature was more when compared to today. Warmer waters were present farther from the equator. The ocean and atmospheric circulation pattern was therefore much different from today. The sea level has been estimated at

120 meters reduced around 20,000 years ago. This was during the coldest period of the ice age on earth. Water was confined in the land in ice sheets. This temperature fluctuation have significantly stabilised over the last 8,000 years albeit being on the warmer end. It is this stability which educed progress in agriculture, permanent settlements and population growth.

Largely these previous changes in global temperature happened very gradually encompassing a period of over ten thousands or millions of years. There are however some records which indicate few abrupt changes at the regional level. For example, during the last ice age, temperatures in the North Atlantic region changed by more than 5°C within a few decades, likely owing to abrupt subsidence of Northern Hemisphere ice sheets or ocean current alterations.

A plethora of research evidence indicates that small but persistent influences trigger global climatic changes. Ice-age for example were commenced by small deviations of Earth's rotation thereby altering seasonal and latitudinal solar energy distribution on Earth. Measurements from climate archives such as ice cores show that changing temperatures triggered changes to other climate factors. During warm periods, the major greenhouse gases were liberated into the atmosphere, and much less sunlight was reflected by the receding ice sheets. These observations confirm that the climate system is sensitive to small disturbances that can be amplified by reinforcing feedback processes. Likewise, the climate system today is sensitive to disturbances from human influences.

Notwithstanding some variations, global climate and sea level can be considered to be stable during the last ice age through the 19th century. From 1850 to 2012 the ambient air temperature at the surface of Earth has increased by 0.8°C on average (Cowtan and Way, 2014).

From around 1850 the temperature progressively increased over the decades. The last decade has been the warmest (see figure I.2). Satellite observations and direct measurements also show warming in the lower atmosphere over the past three decades. In contrast, the stratosphere temperature has decreased over this time. The greatest ocean warming has taken place close to the surface. The top 75 m of the ocean has warmed by an average of 0.11^{o}C each decade between 1971 and 2010 (Etheridge, 1996).

The effect is evident in several global phenomenons. This includes shrinking of mountain glaciers leading to global sea level increase since 1850, reductions of ice for Greenland and West Antarctic since 1990 again contributing to sea-level rise, a significant decrease in the ice over area and a 30 % decrease in the ice thickness of the Arctic Ocean since 1987, increase in the amount of atmospheric moisture since the 1980s, freshwater dilution from increased rainfall. There has also been a reported change in ocean currents due to changes in surface winds, ocean temperature and ocean saltiness. An increasing number of aquatic and terrestrial living beings, are undergoing shifts in their distribution and lifecycles that are consistent with observed temperature changes (IPCC, 2013).

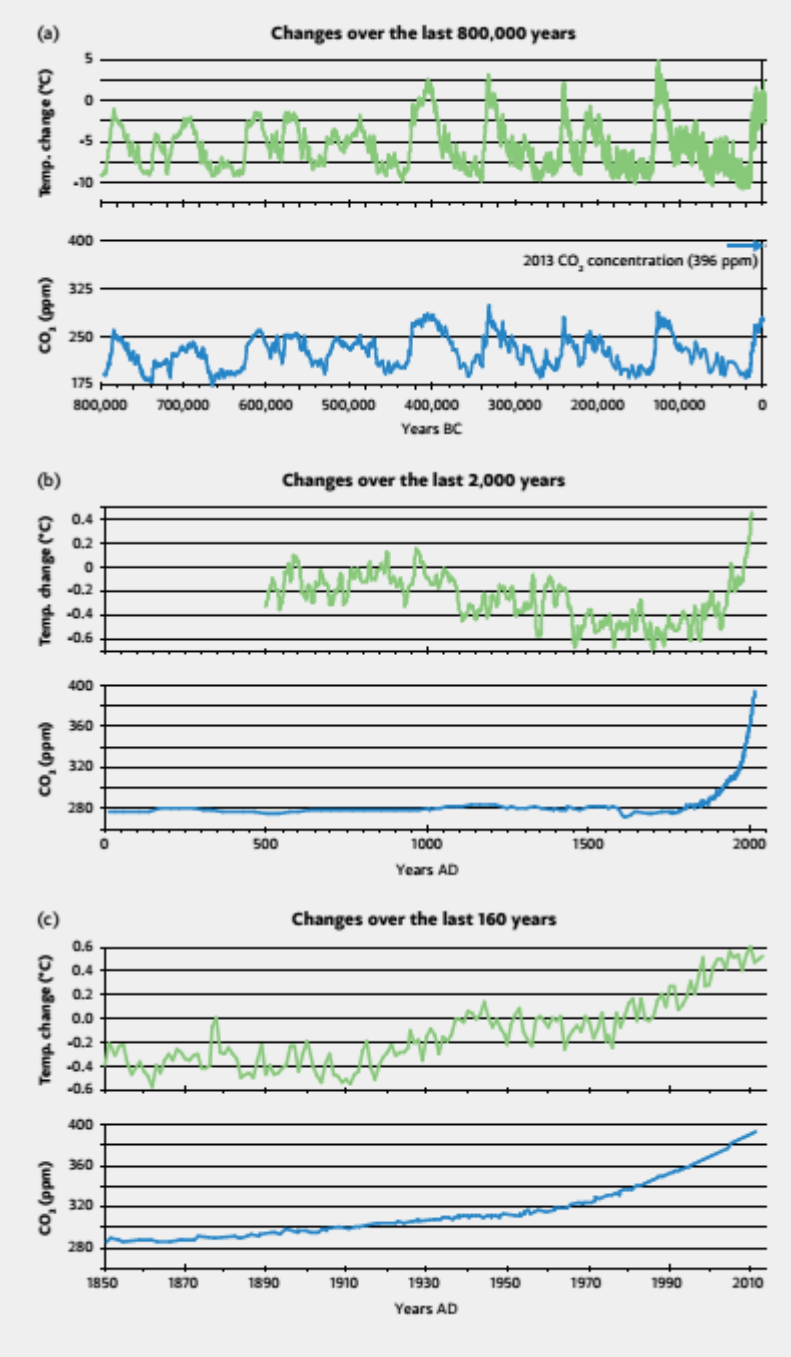

Figure I.2 - the changes from long-term average temperature and average CO2 levels over the last (a) 800,000 years, (b) 2,000 years and (c) 160 years (Etheridge, 1996).

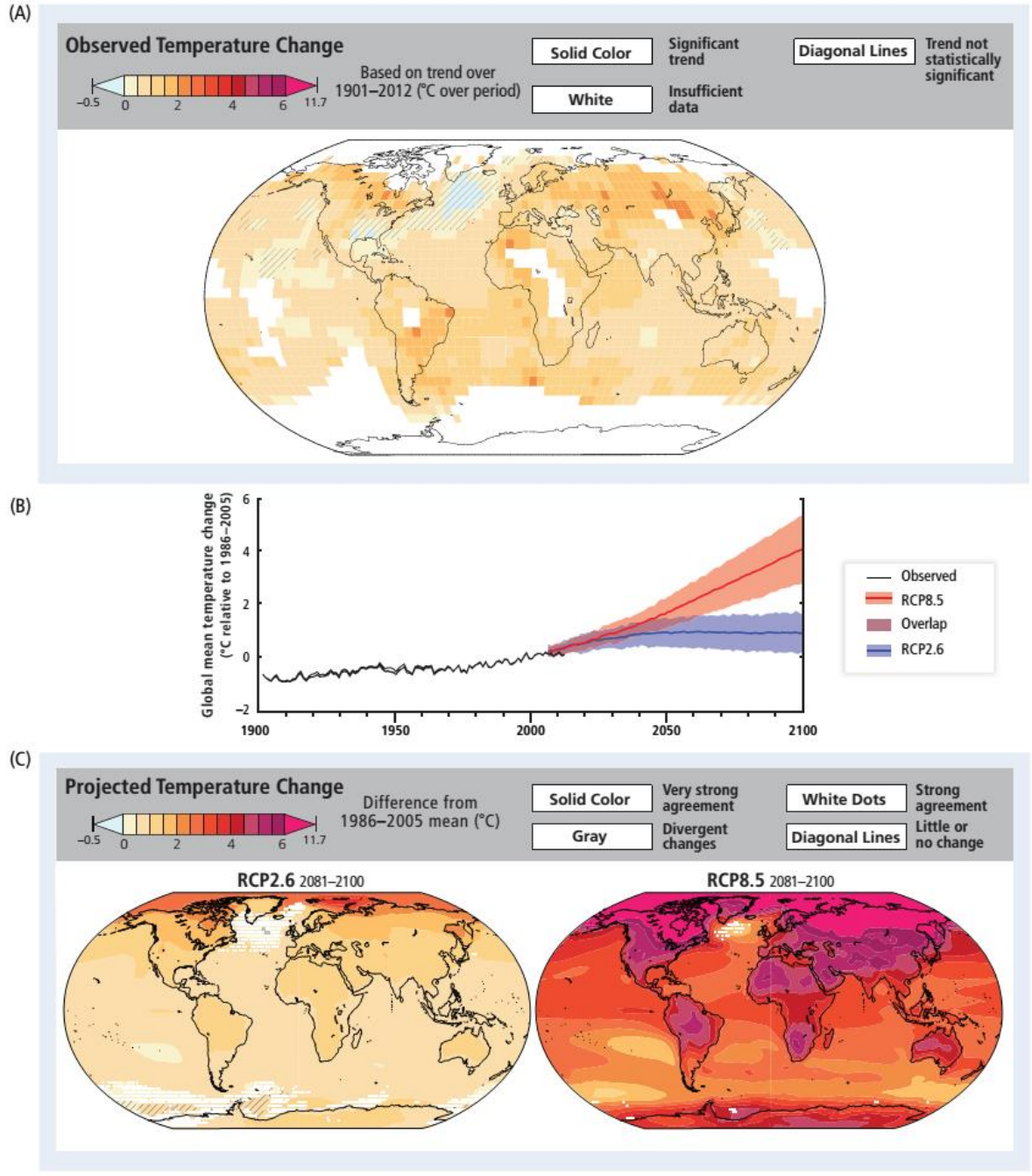

Figure I.3 Recorded and estimated change in annual surface temperature. (IPCC, 2014)

I.4Anthropogenic causes for climate change

A plethora of anthropogenic activities have augmented the concentration of atmospheric gas within the environment. Research data indicate that over the last 200 years the concentration of CO_2, nitrous oxide, and methane have increased. CO_2 release was 280 parts per million (ppm) before 1800. It has now increased to 396 ppm in 2013. Such increase has been attributed to fossil fuel combustion, deforestation, cement manufacture etc. which have disturbed the carbon cycle. The equilibrium between the CO_2 addition and removal from the atmosphere has been destroyed. The rate of addition of CO_2 to the atmosphere is faster than its removal. This has resulted in the acidification of sea due to increased (25% in last 50 years) CO2 absorption by the ocean jeopardizing the water ecosystem.

The leading cause of this increasing CO_2 concentration is the burning of oil products. The increasing use of oil is a direct consequence of Earth's growth in energy use and economic activity in the last two hundred years (Raupach, Canadell, & Quéré, 2008). Interestingly, volcanic emissions contribution to this CO2 increase is only about 1% of current human-induced emissions.

The human-induced drivers to global warming have therefore greatly overridden the natural causes in the past century. These include increases in aerosols, deforestation, increases in greenhouse gases etc. (see fig I.4).

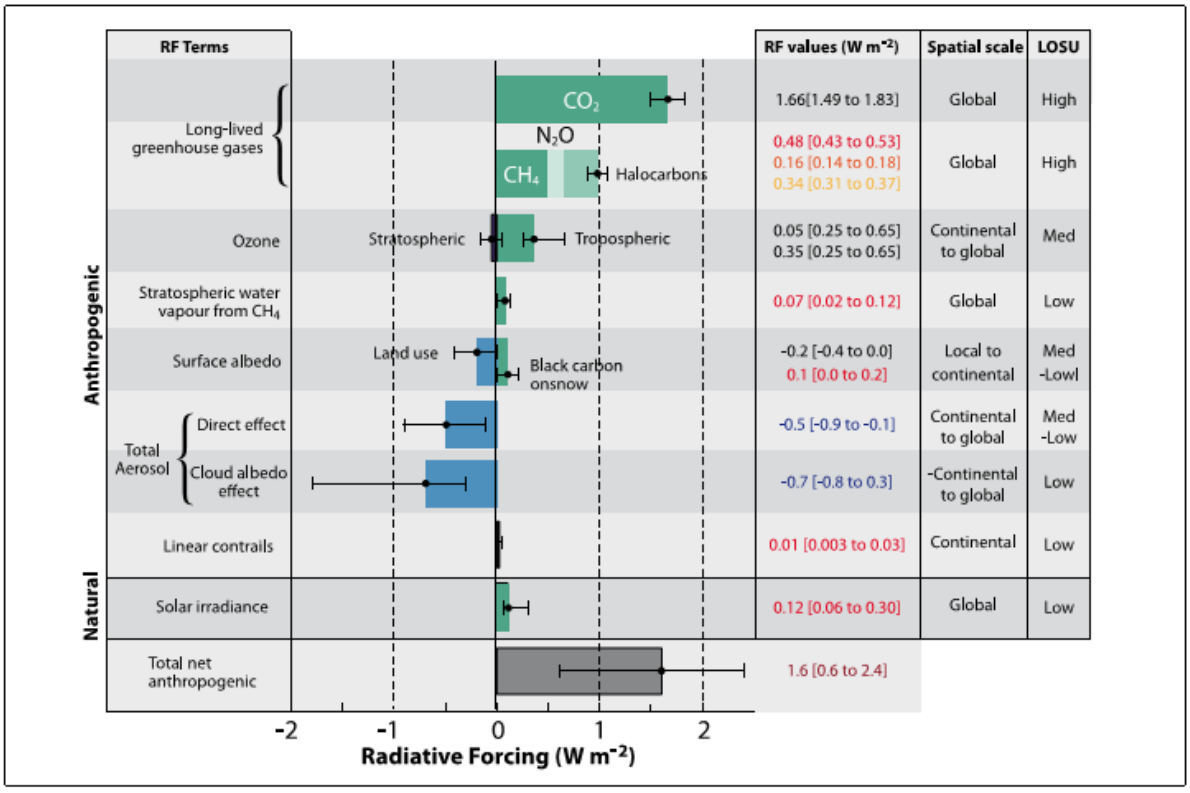

Figure I.4 – Effects of anthropogenic activities to RF values. (IPCC, 2007)

Changes in the concentration of greenhouse gas especially CO_2 has perhaps the maximum contribution in global warming. The effects of natural influences like changes in the brightness of the sun, volcanic eruptions, etc. on the global climate pattern are much smaller in comparison to the anthropogenic effects. Various climate models have been proposed to segregate the anthropogenic from the natural inducers of climate change. These models clearly indicate the dominating roles of human actions in inducing climate change over the past century.

The degree of anthropogenic effect on climate and natural influences can be separately studied for a comparative evaluation. For example, it was envisaged long back that increases in CO_2 would trap more heat near the surface and also make the stratosphere colder. Satellite measurements and other indications have provided strong evidence for the consequences of extra

greenhouse gases, cooling of upper atmosphere has cooled and warming of lower atmosphere. This underscores the hypothesis that the near-surface warming is primarily induced by the increasing concentration of the greenhouse gases rather than natural events.

I.5 Future trends of climate change

As the society continues to rely on the fossil fuel and consequently progressive increase in the emission of CO2, global warming is predicted to simultaneously increase even more jeopardizing the biogeographical equilibrium of the earth. Statistical analysis predicts, with the current trend, then carbon dioxide (CO_2) concentrations will two times the pre-industrial values by 2050, and three times by about 2100. This will result in even more increases in environment water content, heat waves that last longer, less freezing, more reductions in the sea ice, melting of glaciers, changes in rainfall volume, more oceanic warming, and more increases in sea content.

The consequential average warming of is expected to be of 4.5˚C by the year 2100. It might range from 3˚C to 6˚C, triggering catastrophic consequences. The degree of this potential change depends on greenhouse gas emissions and climate feedbacks in the future. Future projections, based on climate models operated across a large number of research centres worldwide, broadly agree on the patterns of global-scale warming, and in the tropics and Southern Ocean. Future changes depend on the emissions pathway, and will be less if emissions are curtailed. At more localised regional scales the models can produce different results: for example, few models predict considerable changes to El Niño or dramatic vegetation changes, and regional projections of precipitation vary between models.

To keep global warming below any specified threshold, there is a corresponding limit on cumulative carbon dioxide emissions. The amount of future global warming is closely related to cumulative CO_2 emissions. So far, humanity has emitted well over half of this quota: between 1870 and 2013 cumulative emissions were 530 billion tonnes. Various strategies have been proposed for amelioration of this impending catastrophe. A greener and sustainable approach is warranted as a possible assuaging approach. Stott (2003) carried out some optimal detection analysis on the reasons for 20th century change in temperature in six different land areas of the Earth. The effects of warming were prominently detected in all the regions.

I.6 Climate change and extreme events

In recent years extreme climatic events have greatly increased endowing substantial economic and environmental disruption. Such extreme climatic events have also been attributed to global warming. Human-actuated environmental change is superimposed on regular variability. In a warming atmosphere, the recurrence of to a great degree cool days is diminished and warm days are expanded. These progressions have as of now been watched. In spite of the fact that these patterns have fluctuated quite between. Other amazing occasions like tropical twisters, there are not yet adequate great quality observational information to put forth definitive expressions about past long haul patterns. Nonetheless, as the atmosphere keeps on warming, heightening of precipitation from tropical typhoons is normal. Late exploratory advances now permit us to start crediting environmental change to an arrangement of fundamental normal and human reasons. For instance, it is currently attainable to gauge the part of human-incited an unnatural weather change to the probabilities of a few sorts of amazing occasions. There is a perceivable human impact in the watched increments in greatly hot days and warmth waves. Over the globe, projections guide comprehensively toward a heightening of the wettest days and

a lessening in the arrival time of the most great occasions, albeit there is much local variety in these patterns. Besides, what we encounter as an one-in-20-year temperature today may turn into a yearly occasion by this century end in a few sections of the globe. Future changes in other compelling climate occasions are less sure. Proof recommends there will be less tropical tornados, however that the most grounded twisters will deliver heavier precipitation than they do as of now.

I.7 Effect of Global Warming on Sea levels

In past warmer climates, sea level was higher than today. Sea level was between 5 metres and 10 metres above current levels around 129,000 to 116,000 years ago. This period coincided with the last interglacial period. The estimated contributions from ocean thermal expansion and a then smaller Greenland Ice Sheet imply a contribution also from Antarctica to this higher sea level. Worldwide, there is a current rise in sea levels. Before the mid-19th century, for a round a couple of hundred years, the changes in sea-level was limited to only a few centimetres per century. A 19cm increase in lea levels from 1900 to 2012 has been recorded. The period from 1920 to 1950 period experienced a similar high rate. This can be attributed to the spreading out of warmed ocean water. Since 1990, there have been further contributions from Greenland ice sheet melting. This increase in ice-sheet discharge is related to increases in ocean temperatures adjacent to and underneath the glacier tongues and floating ice shelves that fringe the coast of Greenland and Antarctica. The sum of storage of water in terrestrial reservoirs and the depletion of ground water have made a small contribution.

It is estimated that the Sea levels will rise even faster in the 21st century than ever before. Even if the greenhouse gas emissions are low, the sea water level is forecasted to rise by 28 to 61 cm in consideration to the mean level over 1986 to 2005 by 2100. And if the emissions are high the rise is predicted to be 52 to 98 cm (see fig I.) (IPCC, 2013).

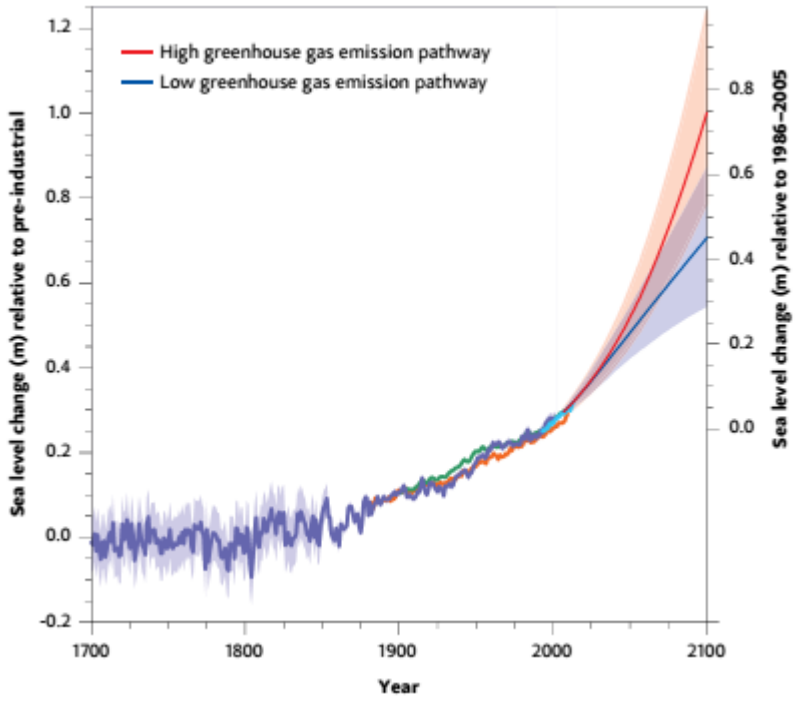

Figure I.5 - Global average sea level change (IPCC, 2013).

Various variables have been considered in charge of such a disturbing increment in ocean levels. Heat extension in seas and loss of icy masses as a result of a dangerous atmospheric devation are likely the most vital elements. Perceptions demonstrate that an expanded release of water from the softening ice in Antarctica is now happening, especially from areas of Antarctic ice. Current models have the capacity to reproduce this increased stream of Antarctic ice sheets. These models bolster the rates of ice sheet misfortune that were utilized to gauge worldwide ocean level increment of 98 cm through 2100. It is anticipated that the ocean levels will endure

to increment in the advancing years. It is however to be borne as a main priority that this system of ocean level ascent is yet to be completely illustrated. Thusly a considerably higher ascent in ocean level than the anticipated worth can't be precluded. In reality, it is convoluted to decisively reproduce the varieties in the Antarctic and Greenland ice sheet release. Kept warming would bring about a practically finish loss of the Greenland ice sheet, bringing about around 7 meters to worldwide normal ocean level ascent.

This would happen over a warming edge evaluated to be between around 1°C and 4°C, of worldwide normal warming in respect to preindustrial temperatures. Current comprehension is inadequate to survey the timing or size of such a multi-century commitment from Antarctica, albeit there is expanding proof that it might as of now have initiated.

Territorial ocean level changes can be distinctive contrasted with normal in light of changes in sea streams, and changes in provincial climatic weight. Notwithstanding atmosphere driven ocean level change, nearby elements can likewise be critical and may overwhelm at a few areas. These incorporate tectonic area developments and subsidence coming about because of the extraction of ground water or hydrocarbons, residue stacking and compaction. Changes in residue supply can influence nearby disintegration/ gradual addition of the coastline. Rising ocean levels actuate a plenty of hindering outcomes on human presence. There is a possibility of more noteworthy seaside surges and expanded disintegration.

I.8 The impacts of changes in atmosphere

Atmosphere movements will propagate both immediate and backhanded effects on social orders and environments. History take the stand concerning emotional breakdown of social orders because of environmental change affected by characteristic or anthropogenic reasons. It (dry spell) may have prompted the decrease of the Maya progress in Mexico, to the loss of the Vikings of Greenland in the 15th century (purportedly attributable to diminishing temperatures). Undoubtedly a few human advancements have been seriously influenced by changes in atmosphere throughout history. Alarmingly, various these atmosphere changes at the provincial level occurred quickly.

Impacts of the anthropogenic environmental change are unmistakably clear in nature around us. It is clear in both the natural and physical world. On the organic world plant and creature species appropriation and consequently their flexibility is extremely influenced. These adjustments thus specifically impacts human exercises including business and recreational fisheries, tourism and so on. With the present pattern these progressions are not anticipated that would get diminished, rather without a doubt they are going to escalate later on. Very much various zones are going to get effected by environmental change and related occasions like ocean level ascent. It will influence common biological system, nourishment security, human wellbeing, framework and so forth. As such it can conceivably destabilize the support of human presence.

Numerous physical and marine environments are helpless against environmental change. Atmosphere warming affects relocation of sea-going and physical life far from worm regions, towards ranges that beforehand were excessively cool. In the natural world occasions that may

look as miniscule may trigger a course of ruin inconvenient results. Environmental change prompted species eradication and in addition new species attack is a high likely occasion which can't be without a doubt anticipated.

Clearly little adjustments, similar to the eradication of a key pollinating animal varieties, may trigger a course of conceivably hurtful effects. Biological systems are specifically influenced both absolutely and contrarily via Carbon dioxide fixations. It enhances the development of numerous physical plants by 'CO2 preparation'. It however causes fermentation of seas and undermines environments. Warmth waves adversely affect human wellbeing in a plenty of ways. It may actuate warmth anxiety, increment in spread of specific ailments like gastroenteritis, and so on. Significantly great occasions additionally have dependable effects on the brain research of the sufferers. Dry spell reasons stress and despondency amongst the agriculturists and pastoralists. Environmental change may have huge negative effects power, transport and different bases. The above discourse suggests that environmental change along or as a team with different anxiety elements effects can move biological communities and social orders into new states with noteworthy adverse results for human welfares.

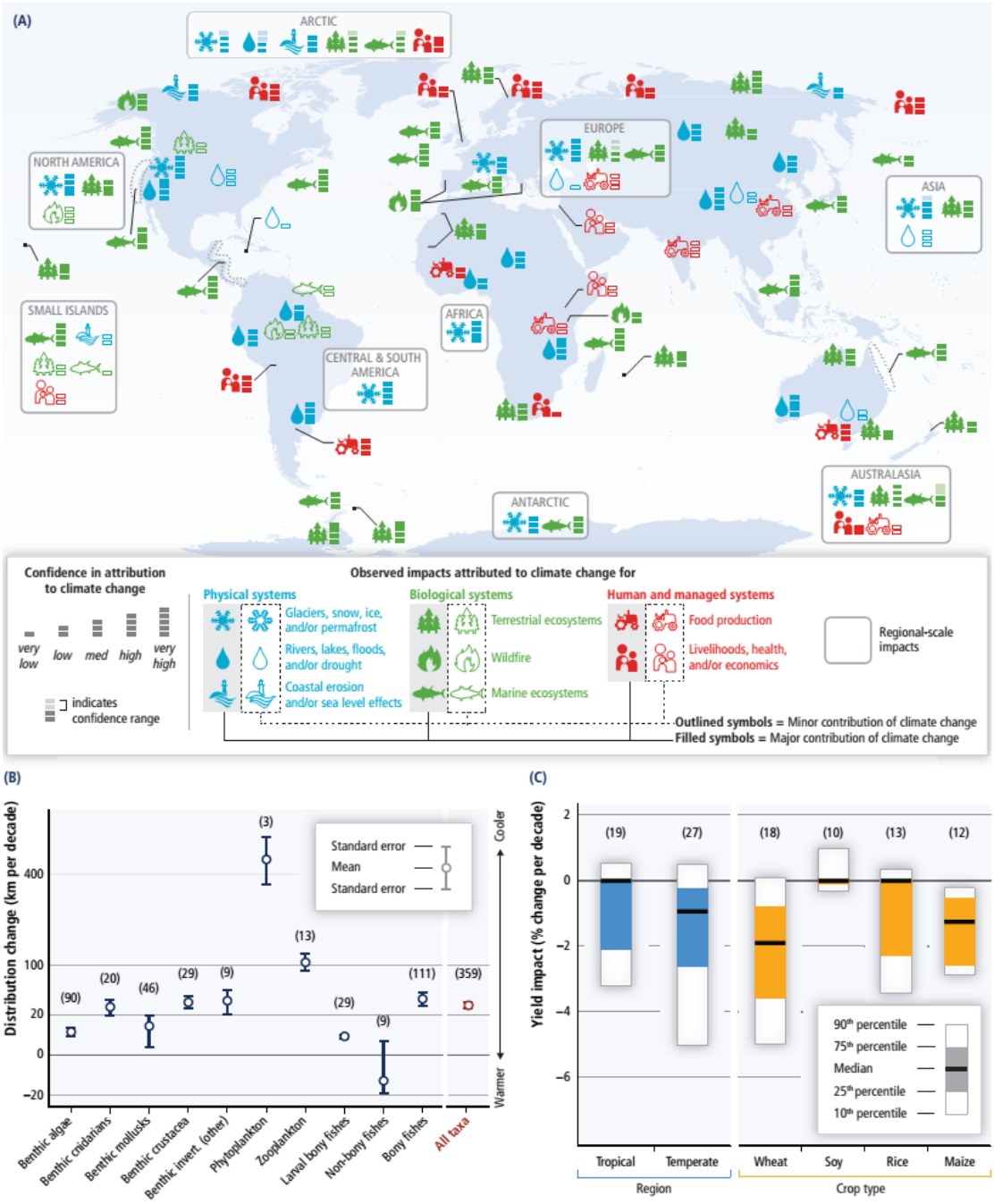

Figure I.6 – Widespread impact of climate change in human civilization

I.9 Uncertainties in predictions and their implications

The entire climate science is based on mathematical predictions. Notwithstanding significant advancements in the climate physics and weather prediction, it can never be 100% accurate. There are several reasons for this. The rate of future global warming will depend on the amount of emissions likely to take place in the future, feedback processes, and natural influences like volcanic eruptions which cannot be predicted. It is also extremely hard to forecast for particular locations, predominantly with respect to precipitation. Regional manifestation of a global trend is increasingly difficult to elucidate and will depend on changes in ocean currents, wind patterns, plants, and soils.

Notwithstanding these predictive limitations, most researchers equivocally confirm global warming is a truth. Inrfact, they agree that post industrial revolution there have been a metamorphic change in the lifestyle of the people which have lead to increased emission of the greenhouse gases which have warming effect that have been observed and calculated and corroborated by scientific analysis. It is also quite certain that continued dependence on fossil fuels would worsen the situation in the future. One aspect however that merits attention is that the future climate change can be greater or lesser than the predicted outcomes.

I.10 Scientific approaches for ameliorative strategy

A number of mitigating strategies are being worked out for amelioration of this catastrophic threat on mankind. The first and foremost strategy is to decrease the volume of green house gases. An effective strategy might also be to sequester carbon dioxide by trapping it

in permanent geological, biological or oceanic reservoirs. Adaptation to climate change would be a natural process of evolution. This might make up for the effects of greenhouse gas emissions.

CO_2 is the overriding contributor to anthropogenic climate change. Despite the fact that the amount of carbon present in the fossil fuel reserves that are accessible to mankind is yet to be definitely estimated, scientists unanimously agree that these carbon reserves in fossil fuel are in any case much larger than the proposed carbon cap needed for achieving the 2^{o}C warming limit. Thus a significant portion of this available fossil fuel reserve. Another approach is to capture and sequester the released CO_2. Similar reduction in Methane, nitrous oxide, halocarbon gases and black-carbon aerosols are also warranted. The importance of abrogating CO2 emission is realised from the fact that the combined contributions of all these gases to global warming is significantly less than CO_2.

The primary mitigation effort must be directed towards generating alternative energy sources with significantly lesser reliance for fossil fuel. Uptake of all of these options is happening now, and multiple studies have shown that they can be expanded effectively.

Recently some other propositions have been forwarded. These proposals involve disposing of CO2 under the Earth or within space outside of Earth's atmosphere. Another alternative approach is to use technological innovations to decrease the amount of sunlight that hits the Earth. For example by generating a stratospheric aerosol layer or placing shields in space. Both these strategies might educe detrimental collateral consequences and are not recommended at the moment.

As our society makes choices about managing the risks and opportunities; there is a vital role for objective scientific information on the consequences of alternative pathways. Choices

also hinge on ethical frameworks and value judgements about the wellbeing of people, economies and the environment.

CHAPTER II Impact of climate change in UAE

The United Arab Emirates (UAE) is located in the Gulf region of the Middle East. Climate change is not a thing of future, it is already happening, and the Arab world have started to experience the effect of such change in terms of higher temperatures, extreme weather events etc. (World Bank, 2010). 2010 was in fact the warmest year in the region in two hundred years. Climate change is set to influence 340 million Arabs about a third of whom are poor and least resilient to such change. According to World Bank, "current and future damage from the region's rapidly changing climate and calls for strong leadership in preparing countries and communities to face the threat" (World Bank news, 2012). In the UAE and other Arab countries such climate change poses grave threat to the already challenging desert ecology. It is predicted to increase water scarcity, reduce agriculture production, effect tourism thereby severely abrogating significant revenue source (World Bank news, 2012).

Majid Al Mansouri, Secretary-General for Environment Agency in Abu Dhabi, have recently commented in an interview that there are several levels by which the UAE are concerned regarding climate change. The UAE has already gone to great lengths and that will become the only extreme option to answer climate change. Even very small long term variations in the temperature and rainfall may have adverse impacts on production activity due to the sensitive nature of the UAE's important natural resources with the interconnection of the global

economic activity. The remedial measure first will require adjusting policies as well as institutional frameworks to improve attitudes. The second is to embrace technological change so that the conditions are favourable to support the ongoing changes (Dougherty, 2009).

II.1 Ecological footprint in UAE

Unprecedented development in the gulf countries in the socio-economic sectors, principally attributable to Oil proceeds, have amplified the carbon footprint of all these countries, with UAE leading. Indeed, UAE have the dubious distinction of the biggest carbon foot prints in the world according to Global Footprint Network report (EWS-WWF, 2015). Ecological footprint measures the total impact of a country on earth. It includes everything that is consumed and used. It "measures each country's environmental impact by calculating its demand from cropland, grazing land, fisheries, forests, carbon uptake land and built-up land, while taking into account the impacts of importing and exporting" (EWS-WWF, 2015). Data indicate that households account for 57% of UAEs total footprint. Indeed, if all other countries had similar ecological footprint, it would have taken 4.5 Earths to sustain civilization. This underscores the alarming depletion of natural resources.

With regard to ecological footprint, UAE is facing with two significant challenges. Firstly, there is a growing demands for energy, with data showing that the primary energy of UAE has amplified by 55.8% between 1997 and 2007. There has been a stupendous 15.3% increase in a year between 2007 and 2008. Secondly, the unparalleled increase of emission of CO2. CO2 emission increased between 33% and 35% between 1997 and 2006. Several developmental activities which include industrial processing, waste management, fossil fuel combustion, etc. have been causally associated with this amplification. Data indicates that 76%

of the Ecological Footprint in UAE is owes to carbon dioxide emissions due to excessive consumption of energy and desalinated water. 78.6 per cent of all emissions in UAE is Carbon dioxide (CO_2), which is therefore the maximum amongst the green house gases emitted in UAE (see fig II1 and fig II.2).

The Ecological Footprint Initiative was launched in the year of 2007 by the Ministry of Environment and Water (MOEW); Abu Dhabi's AGEDI (Abu Dhabi Global Environmental Data Initiative) programme, the Emirates Wildlife Society in association with WWF (EWS-WWF), and the Global Footprint Network (GFN). The primary motive was to elucidate the ecological footprint of the UAE and devise ameliorating measures.

One of the remarkable success of the initiative is the contrivement of a scientific system to determine the effect of changes in the electricity and water sector on Abu Dhabi's carbon dioxide emissions up to the year 2030. According to Dr Mathis Wackernagel, President of the Global Footprint Network, have heaped praise on the initiative.

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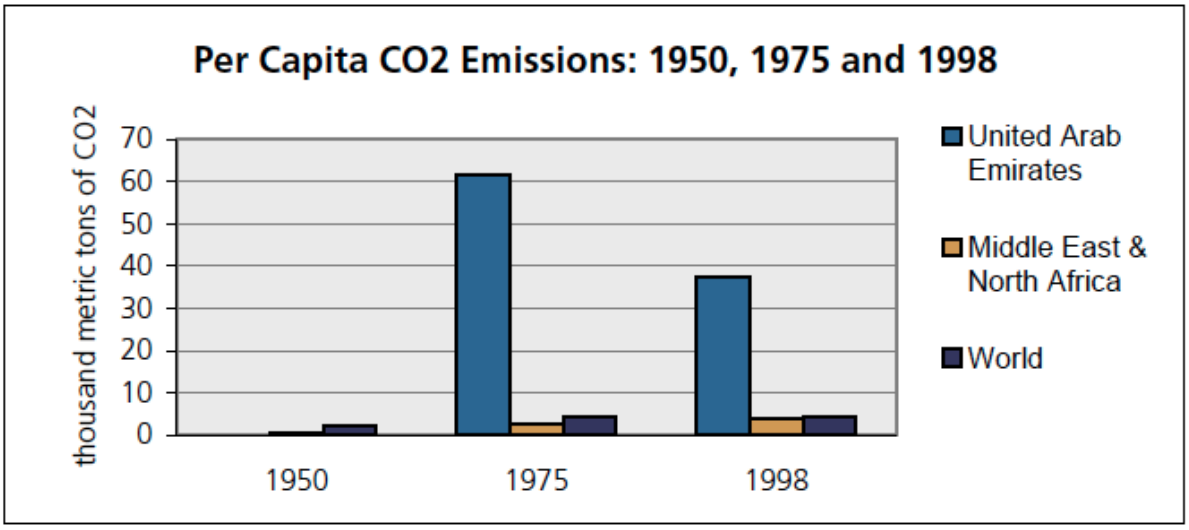

Figure II.1 United Arab Emirates CO_2 emissions per capita: 1950, 1975 and 1998

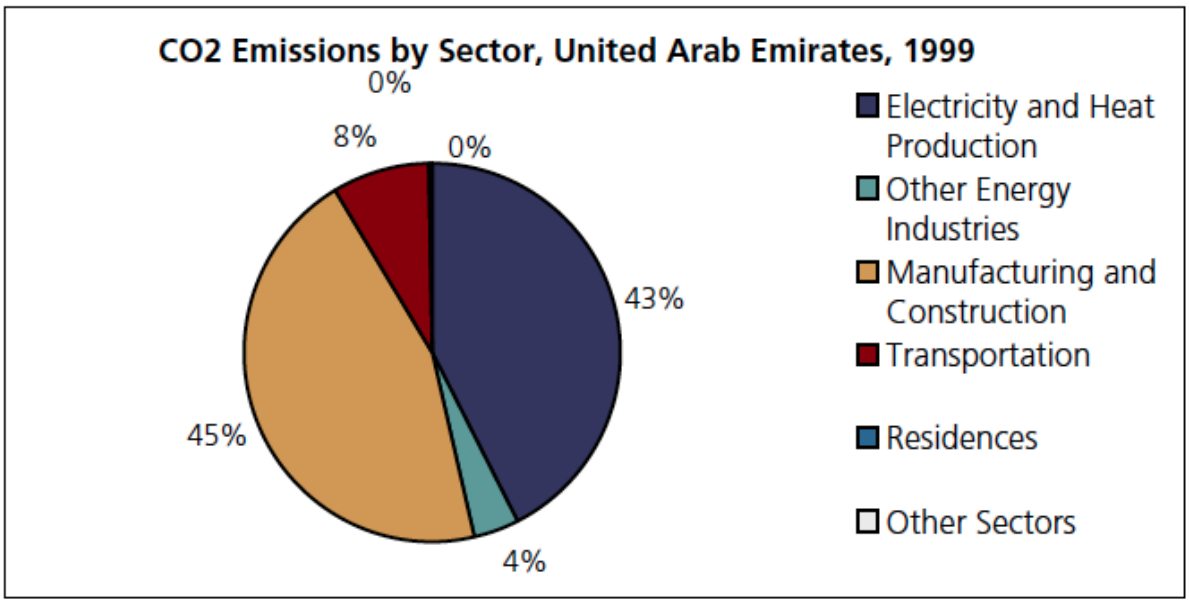

Figure II.2 CO_2 Emissions by Sector, United Arab Emirates, 1999

II.2 Regional Climate Change in UAE

II.2.1 Present climate of UAE

UAE is approximately 83,600 km and has three major ecological regions including the mountains, coasts and deserts. More than eighty percent of the UAE is desert area, more localised towards the western parts. The general climate of UAE is arid to semi-arid. An analysis of the climate of UAE is detailed in figure II.3. UAE has 2 main seasons. November through March is the winter season in the country. The temperature at this time rarely goes below 6 °C. In summers the mean temperatures in the coastal areas is around 48 °C with 90% humidity.

Solar radiation is considerably high in UAE. In May it is around 613 W/m2 and in October it is 546 W/m2. Diffused radiation in July is 273 W/m2. All these data are highest monthly average. An annual north-west wind blow, characterizes the climate of UAE.

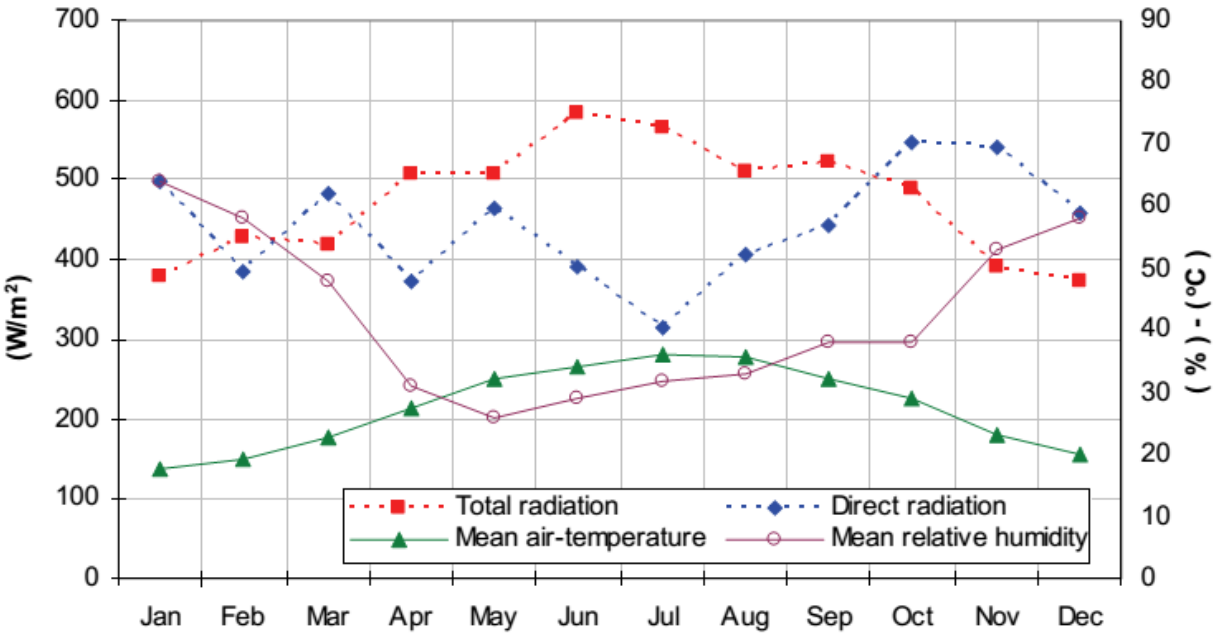

Figure II.3 Analysis of the climate of UAE.

II.2.2 Future predictions on UAE climate

At the regional level, the future temperature changes can be predicted confidently. Forecasting the changes in future precipitation is however more complicated. According to scientific studies, that arctic and equatorial region is predicted to become wetter. The subtropical regions on the other hand might be drier.

Scientists have derived a couple of scenarios based on these projections. Firstly there is a a best case scenario where there is a 10.33% increase in precipitation relative to the baseline

values of 1961-90. The increase of average air temperatures in this scenario is +1.74°C by the year 2050. There is alsoa worst case scenario, where the temperatures is forecasted to increase by 2.67°C with a simustainious decrease in precipitation 21.20%.

GCM outputs data indicate that temperatures increase will be anything between 1.6ºC higher in the month of January and 2.9ºC in 2050 and2.3ºC and 5.9ºC in 2100 compared to 1961-90. The precipitation projections are much more inconsistent.

II.3 Climate Change and Water Management in UAE

II.3.1 Overall Water Status in the Middle East including UAE

Research data indicate that total available natural water in the region is 262.9Bcm. This consists of surface water reserve of 226.5Bcm along with ground water reserve of about 36.3Bcm. 11,874Bcm of ground water is non-renewable (fossil) (Abahussain et al., 2002). More than 75 % of the aqua levels of the Middle East and North Africa region (MENA) are already exploited for human use. Under the circumstances reduction in rainfall in the region severely deplete the usable repertoire of ground water.

The MENA countries located at the Arabian peninsula region is particularly impoverished in terms of water resources. These countries include Kuwait, Yemen, Oman, Bahrain, Saudi Arabia, Qatar, along with UAE. In these countries overall precipitation is already very low and surface and groundwater reserve in most countries is progressively dwindling due to natural as well as anthropogenic causes. Under the circumstances these countries rely on the Gulf water to cater to their needs. This water needs to be extensively desalted before further use and most countries like UAE utilize a highly sophisticated desaltation technique for this purpose. Importantly, the area boosts of over fifty percent of world’s established oil and natural gas

reserves. This induces a highly developed lifestyle which further exececerbates the water demand of the region due to extremely high rate of abstraction. Over and above the impending peril of stress factors are set to worsen the situation by further depleting the available resources.

Few regions of UAE are already experiencing diminutive precipitation along with high evaporation rate due to the arid climatic conditions. The Abu Dhabi region (ADE) for example experienced exceptionally high evaporation rate which amounts to 2-3m per year. The impending climate change and global warming is set to worsen the situation (see fig. II.4).

Notwithstanding this limitation in basic water supply, the region saw rapid population expansion and economic growth. 2008 Reports claim population growth rates have exceeded 8% per annum. The age old practice of procuring groundwater (mostly from shallow wells, traditional Falaj system, hand dug tunnels) no longer exist due to drying up of these systems. An elaborate system of boreholes is now in place as an alternative. Despite the fact that these waters are saline and brackish in nature, they have supported the socioeconomic growth in the area. According to published reports, the landmark GWRP and GWAP, studies separately studied the groundwater reserve in the Abu Dhabi Emirate. Both the studies indicated major shortage of groundwater storage. As per GWRP estimation, at existing consumption rates, it will be depleted within 50 years (see fig II.4).

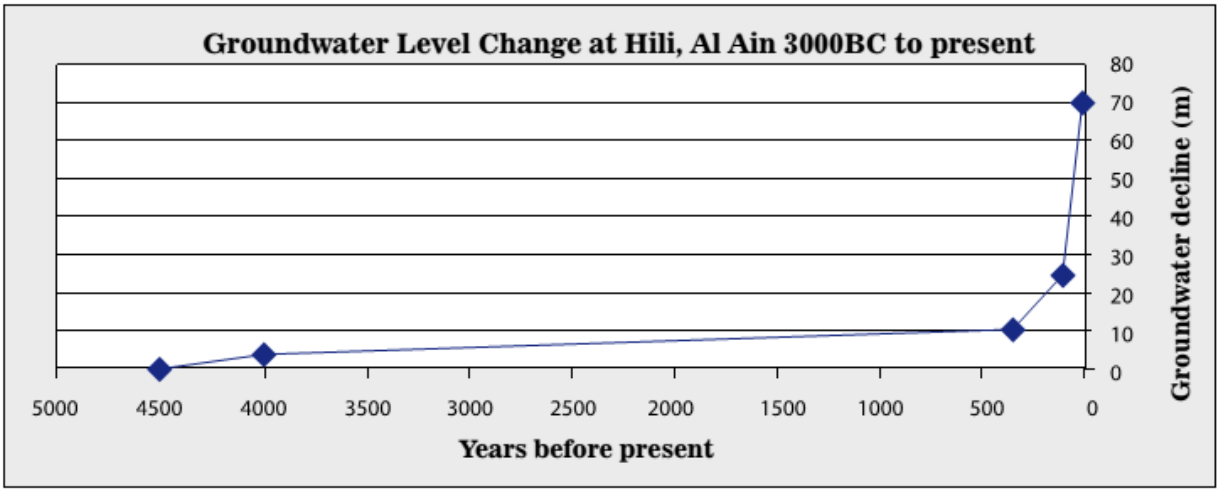

Figure II.4 Groundwater changes over previous 4500- years

II.3.2 Water status and climate change impacts

Under the scenario the changes in climatic conditions, such as rainfall and temperature, can add additional stressors on the already limited rainfall water at the surface as a resource. The potential modifications to the climate are the cause for a very serious concern as well as a careful observation to encourage the best planning (Dougherty, 2009). As detailed in fig II.4 and also explained before, the mean monthly temperatures in UAE in 2050 will be higher than the 1961-90 period, on a month to month comparative basis. For 2100 the progressive increase is estimated to continue. The increases in mean monthly temperature is estimated to be higher evaporation in the region.

Projections of the amount of precipitation indicate greater variations amongst different estimates (see figure II.5). A number of models predict a dryer region with decreasing precipitation, while some others proclaim the possibility of a wetter region with a considerable enhancement in precipitation. Mean monthly precipitation is forecasted to be higher in 2050.

Baseline data is provided by the period 1961-90 (see fig. II.6). Importantly, given that the current rainfall is inadequate the potential for much significance will increase over time (Ragab et al.,2001).

With the predicted rise in temperature and changes in precipitation the demand for water is going to rise even more, superimposing on the existing explosive demand, further threatening an already comatosed system. ADE experiences extreme summer temperatures. Increasing temperature also in winter would induce incrementally larger water use.

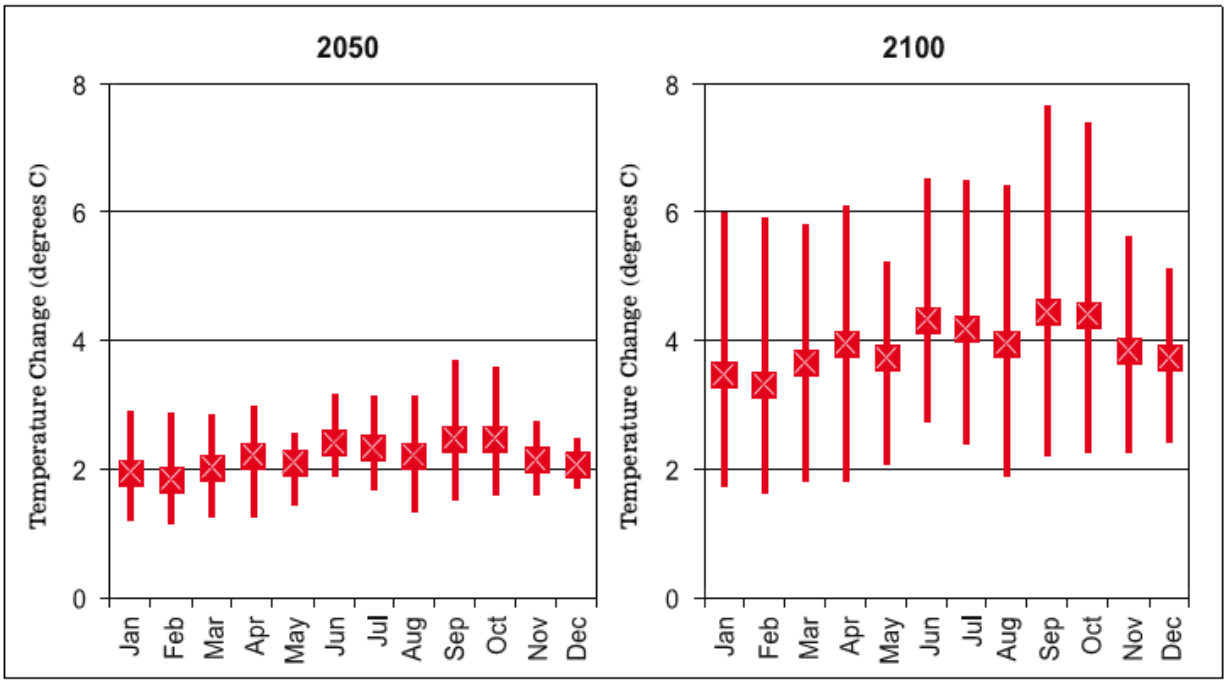

Figure II.5 – Forecasted temperature changes into the future (UAE, 2006)

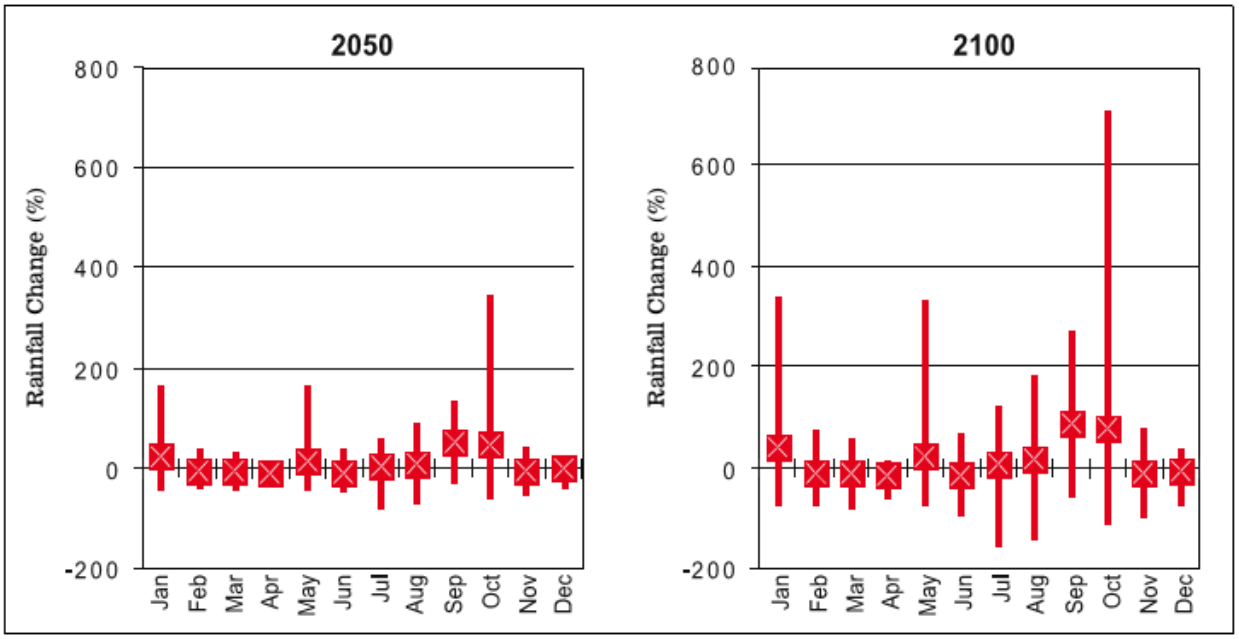

Figure II.6 – Forecasted rainfall changes from 2050 through 2100. (UAE, 2006)

Temperature	**Precipitation**
= +1.74 - 2.67°C (2050)	= -21.20% - 10.33% (2050)
= +3.11 - 4.76 ° C (2100)	= -37.82% - 18.42% (2100)

Table II.1 Summary of GCM Outputs for Abu Dhabi

II.3.3 Quantitative forecast on water management using experimental scenarios

It is impracticable to clearly elucidate the conduit of economic expansion, demographic transformations, patterns and priorities of water usage, etc. throughout UAE over the next thirty to forty years. This calls for utilising standard scenarios to make logical and most practicable the

assumptions that regard the future and investigation into what the circumstances are will equate to the solution for a water supply and need balance (Wilby et al, 2004).

In a landmark study Dougherty et al. (2009) combined these assumptions into a set of scenarios which they named either as optimistic, pessimistic, or the middle of the road. For every Scenario, they made assumptions about the triggers of prospective water demand (see fig. II.7 and II.8). This included inhabitants growth duty, per-capita aqua use, and change in climate. For example probable decrease in agriculture and amenity watering, along with potential sources of water. These are indeed various options for adaptations to climate change. For the purpose of our current research simulation techniques are going to play an extremely pertinent role. Therefore the simulations engineered by Dougherty et al. (2009) and described in great detail in the report on climate change, impacts, adaptation, and vulnerability is discussed. The excerpt below have been taken (with some modifications) from the second part of the report in Abu Dhabi.

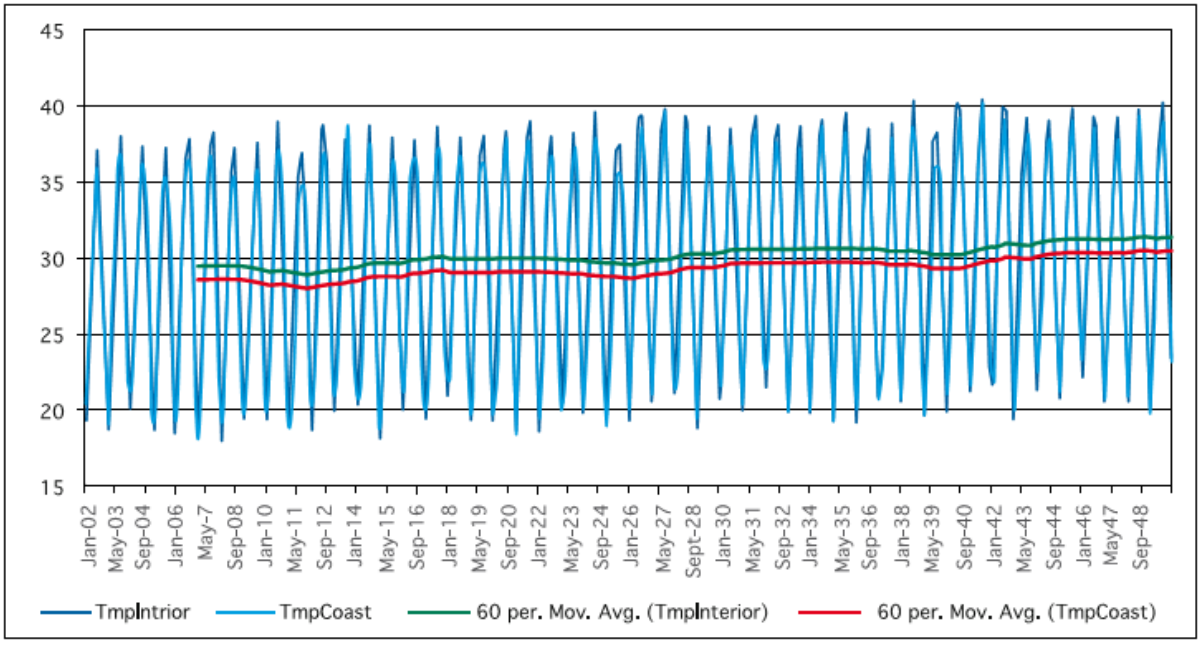

Figure II.7 temperature for the Middle-of-the-Road (MOR)

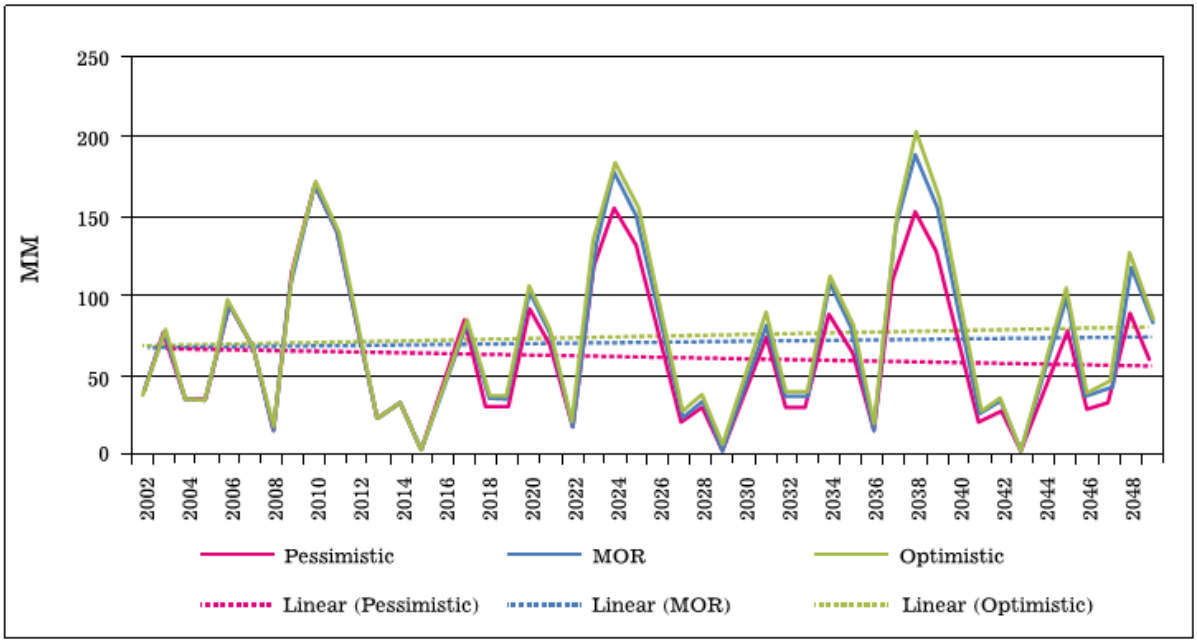

Figure II.8 graphs trends for all Scenarios

Utilizing Optimistic, Pessimistic, and Middle-of the-Road suspicions about future atmosphere and also water interest and populace development, the specialists added to three exceptional Scenarios. The idealistic situation anticipated lower populace development rates, enhanced every capita request, and moderate environmental change. The negative situation anticipated additionally warming and compelling environmental change, high populace, not as effective every capita-use diminishments. The Middle of the street situation anticipated common development rates with "expected" or normal atmosphere projection.

Likewise, the researchers have created and run five different Scenarios which level off of the three gauge Scenarios, making suppositions about future adjustments to decrease water interest (see fig II.9). The drivers of the scenarios include assumptions about population developement, every capita interest, and environmental change, and an arrangement of

adjustment choices. For the Optimistic Scenario, the scientists have expected that a high populace development rate of 8% every annum proceeds until 2015, with the rate diminishing to 4% through 2025 and afterward to 2% for the rest of the study period. This situation expect that protection projects are fruitful and every capita water interest for household, modern, and greenery enclosure watering is lessened to 800 l/top/day by 2010 and afterward to 700 l/c/day by 2012 as per expressed strategy objects, with this interest rate proceeding to the end of the research period. It is to be noticed that this is a remarkable every capita rate.

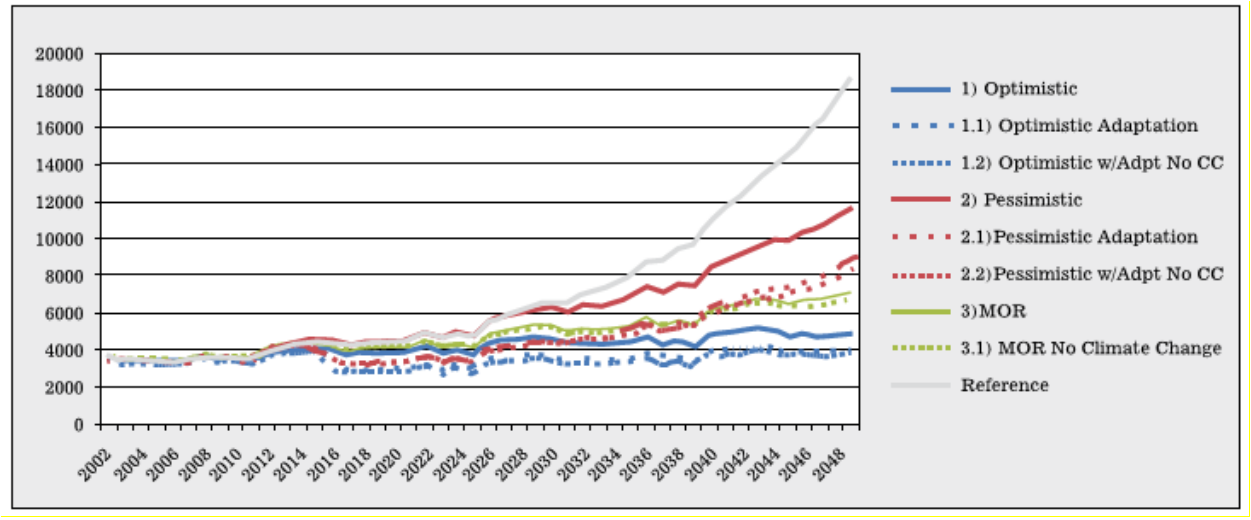

Figure II.9 - Total yearly water estimates for the nine scenarios.

II.4 Climate Change and Health of Humans

Researchers are beginning to realise that climate change is has the potential to impact the health of humans on Earth (McGeehin and Mirabelli, 2001). Various expected environmental change results will have inconvenient intimations for human wellbeing. For sure, climatic changes will have expanded immediate and roundabout danger to human wellbeing through distinctive pathways and instruments. WHO appraisals trait more than 150,000 passing with 5

million "disability–adjusted life years" (DALYs) because of illnesses influenced by the changing atmosphere in the most recent three decades (Patz et al., 2005). The wellbeing impacts can be direct created by compelling climate occasions like surges, tempests, and warmth waves, or aberrant, for example, changes in the scopes of illness vectors (e.g., mosquitoes), water-borne pathogens, water quality, air quality, and nourishment accessibility and quality. Also, the real wellbeing effects will rely on upon the nearby ecological conditions, financial circumstances, and the scope of embraced social, institutional, innovative, and behavioural measures.

The constrained examination led in UAE and other Arab nations has demonstrated that environmental change assumes an essential part in the spread of vector-borne irresistible infections, for example, jungle fever and schistosomiasis. It likewise influences the regular convergences of a few allergens in the air, bringing on hypersensitive responses and pneumonic illnesses and declines the general wellbeing effect of warmth waves. Warmth waves are anticipated to end up more exceptional, incessant, and delayed because of environmental change. Various studies in the locale have taken a gander at warmth related death rates, and have reliably discovered a critical relationship in the middle of temperature and mortality.

The relationship between irresistible maladies – which internationally execute somewhere around 14 and 17 million individuals every year – and climatic conditions has been examined broadly. Jungle fever, for occurrence, which taints around 3 million individuals in the Arab district every year, may turn out to be more pervasive as higher temperatures decrease the sickness' brooding period, spread the scope of jungle fever bearing mosquitoes, and expand mosquito plenitude. Ocean level ascent and beachfront flooding may affect sustenance security and lead to ailing health and hunger, and diminished precipitation and expanded temperatures may irritate water lack, expanding its negative effect on human health.

Husain and Chaudhary (2008) directed a Case Study of the Gulf Countries to comprehend the Human Health Risk Assessment because of Global Warming. IPCC has distinguished an arrangement of future emanation situations taking into account nursery gas (GHG) and vaporized discharges for the 21stcentury in their Special Report on Emissions Scenarios (SRES). The situations are in view of unequivocal presumptions about their main thrusts with respect to demographic nature, foreseen financial and innovative progressions in future in light of anticipated vitality utilization and populace development rates. To create conceivable foreseen situations for future expectations with respect to atmosphere changes, discriminating presumption of no-lessening in discharges was made by the exploration bunch. A few conceivable situations characterized by the IPCC were viewed as and the two doubtlessly and broadly utilized situations were considered for their study as takes after:

i) A-2, otherwise called "divided world situation", speaks to a world with unchecked populace development, impressive uniqueness in every capita salary, self-reliance and nearby personalities with territorial based innovative headway.

ii) B-2, otherwise called "nearby supportability situation", accept a world with unchecked populace development, unassuming temperate development, slower however assorted innovative improvement, accentuating conceivable provincial based arrangements of financial concerns.

Vital month to month time arrangement information for temperature, precipitation and mugginess by the three worldwide atmosphere models was recovered for the two situations taking into account the Third Assessment Report (TAR) from the United Nation's Intergovernmental Panel on Climate Change (IPCC) information circulation focus. At that point

utilizing a PC system (coded in C++) the exploration gathering recovered information for the scope and longitude directions incorporating Yemen, Oman, United Arab Emirates, Qatar and Bahrain. The direction runs in which the majority of the nations falsehood reach out from longitude 41.25°E to 61.875°E and scope 9.2779°N to 27.8334°N in the worldwide information.

These models are Hadley Centre Climate Prediction and Research Model(HADCM3), Canadian center for Climate Modeling and Analysis(CCMa), National Center for Atmospheric Research(NCAR). The research highlights were, that

> "there will be significant increase in the disease incidence and affected population size while taking into account the rapid population growth rates, posing major challenge for the health services and national financial resources.... It is thus emphasized that the adverse impact of climate change on human health in above Gulf countries necessitates emission reduction, well planned housing and health-care infrastructures for future. Improved intervention programs capable of reducing population's vulnerability towards direct and indirect adverse impacts should be initiated. Measures should also be taken to improve social and behavioral adaptation at individual, community and national levels with regards to the basic improvements in social structure and minimization of inequalities within population groups. Adapting necessary mitigative strategies can give health benefits in short term, but developing effective system of regionally based targeted public health intervention strategies is imperative for minimizing the climate related health–risks" (Husain and Chaudhary, 2008).

II.5 Climate Change and Infrastructure in UAE

Environmental change is relied upon to altogether influence foundation over the Arab world including UAE. Transportation base is for the most part helpless against anticipated increments in the force and recurrence of hot days, storm exercises, and ocean level ascent. Foundation in the waterfront zones of UAE is especially powerless against conceivable tempest surges. Unwavering quality of water supply frameworks will be affected by reducing new water supplies and higher normal temperatures. Wastewater systems are especially helpless against

unreasonable precipitation occasions. Vitality era will be hampered by higher surrounding temperatures which will decrease the proficiency and limit of gas turbines, and diminish the cooling effectiveness of warm plants. Vitality conveyance and transmission frameworks will be more inclined to disappointment as great climate occasions turn out to be more successive.

Various studies have investigated the Effect of Global Warming on the UAE Built Environment. The expanding discharge of CO2 and its commitment to an unnatural weather change has turn into a developing sympathy toward building industry and regulation bodies in the UAE. There are two reasons: firstly, CO2is the fundamental by-result of the era from fossil powers of vitality. Structures constitute one of the significant customers of vitality. In this way they are likewise the essential supporter to increasing the environmental CO2. Another vital thought is that the building operations is additionally potentially to be especially affected by a worldwide temperature alteration.

Plainly, by utilizing none renewable fossil fills, structures add to the CO2 emanations prompting warming the globe. In turns, an Earth-wide temperature boost impacts the vitality consumptionof structures prompting build the creation of CO2emissions. A paper by Radhi (2009) talks about issues identified with the potential effect of a dangerous atmospheric devation on aerating and cooling vitality use in the hot atmosphere of the United Arab Emirates. Al-Ain city was decided for this study. Reproduction studies and vitality examination were utilized to explore the vitality utilization of structures and the best measures to adapt to this effect under distinctive atmosphere situations. The paper concentrates on private structures and presumes that an Earth-wide temperature boost is liable to build the vitality utilized for cooling structures by 23.5% if Al-Ain city warms by 5.9 °C. The net CO2 emanations could increment at around 5.4% throughout the following couple of decades. The reproduction results demonstrate that the

vitality outline measures, for example, warm protection and warm mass are imperative to adapt to an unnatural weather change, while window range and coating framework are valuable and touchy to environmental change, though the shading gadgets are direct as a building CO2 discharges saver and heartless to a dangerous atmospheric devation.

II.6 Climate Change, Agriculture, and Food.

Farming generation and nourishment security are firmly connected to the accessibility of water. Environmental change is relied upon to influence sustenance security through its effect on agribusiness and nourishment generation frameworks. At the worldwide level, total horticultural yield potential will be minimal influenced by environmental change, with huge varieties between locales. As per the IPCC 2007, by the 2080s, agrarian potential could increment by 8% in created nations, essentially as an aftereffect of longer developing seasons, while in the creating scene it could fall by 9%, with sub-Saharan Africa and Latin America anticipated to experience the best misfortunes. The lion's share of Arab nations including UAE are considered among the world's most water rare, and in numerous spots interest for water as of now surpasses supply. Higher temperatures and less precipitation make the whole district more bone-dry. These progressions will have a progression of impacts, especially on farming, vitality and nourishment security. The primary environmental change chances in the Middle East locale will generally be connected to long haul drying up and dry season connected with climatic variability. Water anxiety is of enormous significance, and abatements in water accessibility may have extreme effects on sustenance security. A few projections demonstrate that under moderate increments in temperature, water stream will be to a great extent affected. Horticultural yields, particularly in downpour encouraged regions, are required to change all the more broadly over the long haul and to meet to a fundamentally lower longer-term normal.

II.7 Climate Change and dryland ecosystem

Dryland ecosystem is one more area set to be significantly impacted by the climate change and global warming. A plethora of studies have tried to elucidate the effect. Some of the studies have been conducted at the molecular and cellular level. Sala and Chapin’s (2000)

simulation models estimate the change of biodiversity for one hundred years, envisage that grasslands, savannahs, and Mediterranean ecosystems will be most affected.

II.8 Public Perception of Climate Change

A conducted a pan-Arab survey was conducted by AFED across Arab countries including UAE, in order to understand, the climate related awareness of among the Arab community, their acuity of the need to take action, and enthusiasm to individually contribute to the efforts of climate change alleviation and various adaptation measures. 98% of the participants agreed that the climate is changing, and 89% thought that this was due to human activities. 51% alleged that derisory government interventions to ameliorate the problem. 84% Arabians understood that climate change posed a grave challenge to their countries. Over 94% of the participants proclaimed that their countries would profit from joining in global action to mitigate climate change. Encouragingly, 93% vowed to participate in personal action to reduce their contribution to the problem.

When the participants were quizzed to select sectors where climate change will have a major impact in their countries, it was important to note that not even a single respondent said there would be no effect at all. The common opinion at the regional level prioritized health, drinking water and food, followed by coastal areas. Participants were also asked to select the three most important methods to alleviate the causes and to adapt to the effects of climate change. Changing consumption patterns, mainly reducing the use of energy, was the main measure chosen, followed by education and awareness. Ratifying and implementing international treaties came third.

The respondents to the AFED survey showed a clear yearning for their governments to participate and cooperate in order to achieve collective mitigating measures to the global threat. Most importantly, the Arab public seems ready to accept and be part of concrete national and regional action to deal with climate change. The sceptical attitudes which prevailed among some groups on the facts and causes of climate change, either denying it entirely or limiting it to natural causes, are receding.

II.9 Adaptation and Mitigation – Initiatives by UAE

UAE will confront expanding temperatures as well as, all the more essentially, additionally interruption of the hydrological cycle, bringing about less and more whimsical precipitation that will irritate significantly further the effectively basic condition of water lack and troubles with water designation among distinctive improvement exercises. Most poor inhabitants of provincial regions will endure and will oblige a scope of adapting systems to help them adjust to environmental change. Systems will incorporate differentiating generation frameworks into higher quality and more proficient water use alternatives. Enhanced water use proficiency can be acknowledged by taking after supplementary watering system procedures, receiving and adjusting existing water gathering systems, conjunctive utilization of surface and groundwater, overhauling watering system hones on the homestead level and on the conveyance side, and improvement of products tolerant to saltiness and warmth stress. Water quality ought to additionally be kept up at larger amounts by averting sullying through ocean water interruption.

Relief of the reasons for environmental change incorporates less and proficient utilization of fossil fuel, more generation of renewable vitality and more development of ranger service and green territories. A percentage of the conceivable measures incorporate, utilization of sunlight

based and wind vitality as a substitute to warm and steam force plants, decrease of the outflows of methane gas by lessening rice development and animals compost, advancement of the Clean Development Mechanism (CDM) which empowers creating nations to acquire specialized and money related backing from mechanical nations and to raise the limit of people to diminish nursery gas discharges, end of all wellsprings of sponsorships on the costs of fossil fuel, use of carbon charges on exercises that outcome in the outflow of nursery gasses utilizing the "Polluter Pays" standard, masterminding national mindfulness crusades on the effect of atmosphere changes focusing on school and college understudies, and the overall population and so forth.

II.9.1 Renewable Energy

The UAE needs a large portion of the most boundless renewable vitality assets, with no potential for hydroelectric force or tidal power and generally little biomass. Nonetheless, it has satisfactory daylight. Abu Dhabi has set a renewable vitality target which it hopes to meet to a great extent through sun based force, and 2010 has seen work start on one of the world's biggest concentrating sun powered force plants. The UAE is additionally creating geothermal cooling at Masdar City.

II.9.2 Peaceful Nuclear Power

As indicated by the service of outside issues, UAE sees tranquil atomic vitality as a huge donor to take care of expanding future power demand and as a component of its method for the general decrease in carbon outflows. With its about zero carbon foot shaped impression and high accessibility component, it supplements the UAE's other renewable and low carbon vitality sources, for example, sun powered and clean fossil fuel force plants. A sizeable atomic vitality part is being produced in the UAE which comprises of four atomic force reactors and the related framework, the first of which is planned for business operation in 2017.

II.9.3 The MASDAR activity

Waste and auto free-city in Abu Dhabi, named MASDAR city. The city is wanted to host 40,000 inhabitants and get another 50,000 day by day suburbanites. It is imagined to be a free zone clean-tech bunch home to around 1,500 visionary organizations and exploration focuses. The MASDAR Institute of Science and Technology is the first to go to the city. Autos are banned inside of the city; travel is proficient by means of open mass travel and individual quick travel frameworks, with street and rail lines associating suburbanites to different areas outside the city. The city is walled, to keep out the hot desert wind. The absence of autos has took into account limited, shaded roads that will likewise enhance air dissemination and lessen interest for aerating and cooling. The city is arranged upper east to minimize the measure of direct daylight on structures' sides and windows. Sun oriented boards and sun based gatherers on rooftops and somewhere else create power to meet a large portion of the city's power needs. Water is given through a sun oriented fueled desalination plant. Arranging inside of the city and yields developed outside the city will is watered with dark water and treated waste water created by the city. As of late, MASDAR City was chosen to host the recently settled International Renewable Energy Agency (IRENA);this is a development accomplishment for Abu Dhabi and marks the first occasion when that an Arab city plays host to the central station of a global association.

II.9.4 Carbon Capture and Storage (clean fossil fills) venture

Carbon catch and capacity (CCS) is a method for relieving environmental change by catching carbon dioxide (CO2) from vast point sources, for example, force plants and putting away it securely underground as opposed to discharging it into the air. The potential effect of CCS is immense. The Intergovernmental Panel on Climate Change says CCS could contribute somewhere around 10% and 55% of the total overall carbon moderation exertion throughout the

following 90 years. Innovation for catching of CO2 is now industrially accessible for vast CO2 emitters, for example, force plants. Capacity of CO2, then again is a moderately untried idea. UAE is adding to a noteworthy CCS venture.

ADNOC and Masdar are working together to develop the CO2 Capture, Transportation & Injection components. Masdar responsible to provide technology & project support for the CO2 Capture, Compression and Pipeline facilities. The technical overview of the process will entail CO2 capture form source, CO2 compression and dehydration, CO2 transportation, and CO2 injection in Rumaitha and and Bab fields (see figure II.11).

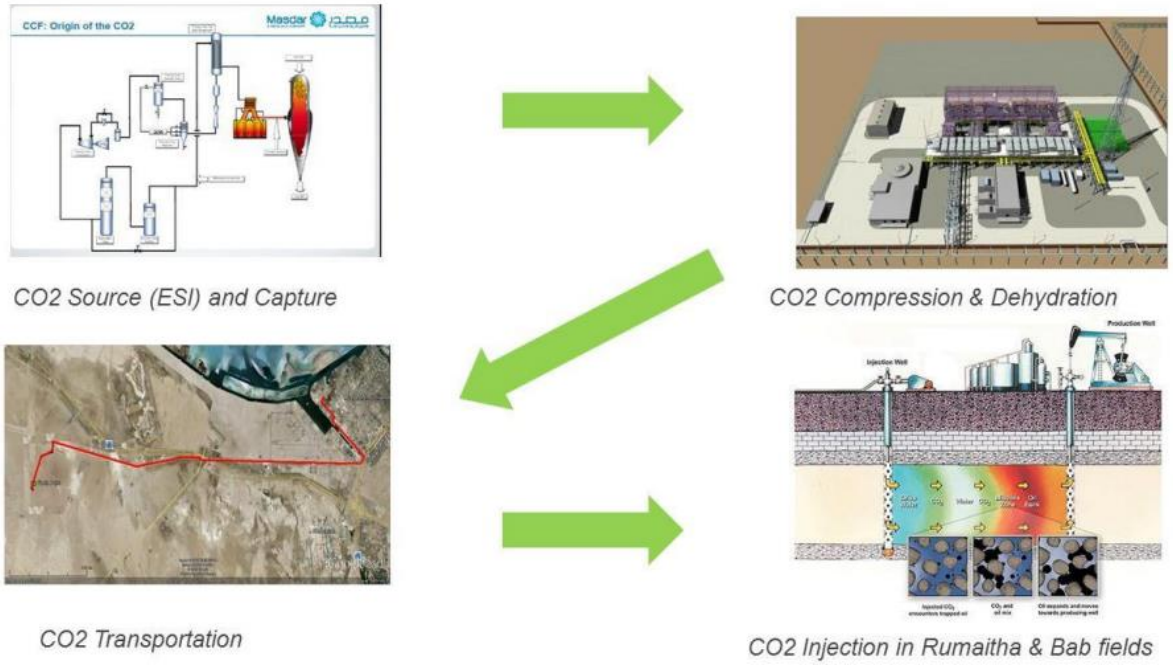

Figure II.11 - Carbon Capture and Storage methodology

II.9.5 Building design

Dubai Electricity and Water Authority developed a new mandatory guideline for Green Building Requirements. Dubai has established a Dubai Carbon Center of Excellence that works with the government on Clean Development Mechanism. UAE homes and businesses to harness own solar power by Installing rooftop solar panels

II.9.6 Transport

Globally different modes of transportations are the fastest-growing sources of emissions worldwide. Sustainable transportation initiatives include declaration of 1 November as Public Transport Day , Car Free Day, Dubai Sustainable Transport Award, Public Bikes, Etihad Rail, Dubai Metro, Dubai Tram, Abu Dhabi Metro etc.

Chapter III Research Design, Results and Discussions

III.1 Research Methodology

The decision of the most suitable exploration system which addresses this examination inquiry is in reality precarious. The chose research approach must be helpful as far as handling the exploration variables (Ismail 2005). As a possible decision from previous exploration works managed comparative subjects and examination issues; recreation, coherent contention with writing audit, interpretive, and quantitative research strategies appear to be proper to answer the examination question. Coherent contention system for exploration depends on a wide status of information and arranges an answer for open dubious subjects. As indicated by Groat and Wang (2002), sensible contention examination is situated - up for calculated structure assembled with nuts and bolts and effective procedures to manage a contention.

For the purpose of this dissertation, logical argument might play a pivotal role. The methodology will entail a detailed evaluation of various greener alternatives, in terms of performance, cost benefit analysis, mass participation, technical feasibility, monthly and annual performance, and long term environmental and economic impact. The methodology of simulation research contributes to composite research prospects. Unlike other studies, the overall objective of this study is such that it is difficult to obtain concluding data by undertaking simulations only. More significant insights can rather be obtained by studying and logically appraising the government policies towards green and sustainable future. Interviews with the stakeholders and the policy makers in this regard are also expected to generate valuable insights. The influence of geographical and socio-economic attributes on these strategies will be studied. An attempt will also be made to enumerate various sectoral initiatives that have already been taken towards a green economy. An evaluation and future status of these initiatives will also be explored.

Following a greener lifestyle warrants reclusion of many lifestyle practices and choises of today and acceptance of new biodegradable and reusable product in every sector of life – “right from what you eat to what you wear”. Needless to mention, customer awareness and behaviour is extremely important and motivating factor, which will drive this metamorphic change. Customer choice on the other hand will be based on awareness, knowledge, education, as well as affordability and convenience of the novel products. Importantly, environmental awareness alone might not be motivating enough to sustain this enthusiasm for a long time for all kinds of consumers, price and convenience are also an important issues. Elucidating the convenience and cost benefit of such changes in lifestyle is therefore an important objective in our present study.

Through simulations we wanted to evaluate the potential effects of green and sustainable development on the future growth of UAE. Indeed, such kind of data lays the foundational motivation for instigating this metamorphic transition. Appropriate scenarios as depicted below were chosen for the purpose of the simulation. Data generated closely parallel other similar studies conducted.

III.2 Results and Discussions

Our simulation study specifically aimed at building a macro-economic model for the UAE with different scenarios. The control scenario selected for the study was growth and development without considering greener alternatives termed as “usual scenario”. The experimental scenarios were different green economy scenarios. The idea was to estimate the potential impact of the changes from green technology and policy interventions. In order to accommodate the time restrictions of our study, we developed a short term model. The interventional scenarios were, moderate deployment of green technologies in the sector of water , electricity and sustainable lifestyle, and aggressive approach. Our results indicate a significant higher GDP for both the moderate and aggressive scenarios compared to the control scenario. However the GDP of both moderate and aggressive scenario did not differ significantly. This might be due to the short term study duration.

The results of our study corroborates with another study conducted for short, medium and long-term (until 2050) time periods. There were five scenarios in this study – business as usual scenario, Green Growth scenario which mandates moderate, mandatory operation of green technologies, behavioural change and economic diversification, Green Growth Plus scenario which calls for aggressive, mandatory deployment of green technologies, behavioural change

and economic diversification, Carbon Pricing scenario, which can be explained by market-based approach that envisages a carbon price being applied across the UAE and Cost Reflective Pricing which is a market-based approach that envisages a movement of domestic energy pricing towards international market prices over a five-year period.

With an assumption of average annual investment of 1.0-1.9% of GDP in diverse green measures until 2030, the modelling of the four green economy scenarios projected GDP in 2030 would be 4.0-5.5% higher than GDP forecasted under the control scenario. This would result from reduced domestic consumption of oil by 7-10% per year, natural gas by 7-20% and electricity by 11-15% through 2030 (resulting in avoided imports or enabled exports of freed-up hydrocarbons from demand-side savings and supply diversification), and increased local production over the period driven by growth in innovation leading to increased exports. By 2030 as the economic benefits will flow down to the population. All four Green Economy scenarios would also bring significant potential reductions in the carbon intensity of the UAE economy, with estimates ranging from 18% to 25% of cumulative emissions between 2013-30 (see fig III.1 and III.2).

Even though it has to be clearly noted that these potential Green Economy benefits are highly hypothetical, both these studies strongly suggest that the best approach is for the environment to be properly managed. A green pathway for the UAE rather offers additional economic growth, based on successful industrial diversification that makes the economy more resilient and sustainable in that it creates economic and social added value from resource efficiency and clean technologies that reduce negative environmental impact.

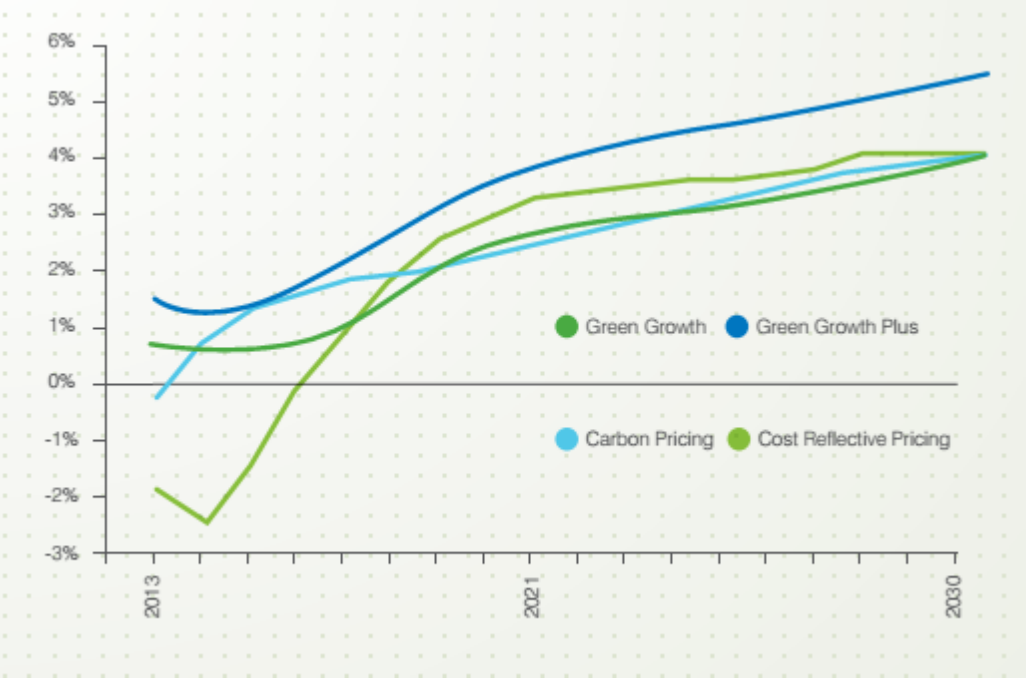

Fig III.1 : Potential changes in GDP under 4 Green Economy scenarios in comparison to BAU scenario

Scenarios	Capital expenditure required till 2030	Average investment required till 2030 (% GDP)	GDP in 2030	Jobs in 2030	Export boost in 2030	Domestic oil consumption (average annual % 2013-30)	Domestic gas consumption (average annual % 2013-30)	Electricity demand (average annual % 2013-30)	GHG emissions (cumulative % 2013-30)
"Green Growth"	AED 673.1 billion	1.6%	+4.0%	+160,000 (+2.2%)	+AED 34 billion	-7%	-13%	-11%	-20%
"Green Growth Plus"	AED 724.8 billion	1.9%	+5.5%	+165,000 (+2.3%)	+AED 47 billion	-10%	-17%	-15%	-25%
"Carbon Pricing"	AED 455.5 billion	1.0%	+4.1%	+139,000 (+1.9%)	+AED 24 billion	-10%	-20%	-14%	-18%
"Cost Reflective Pricing"	AED 437.3 billion	1.0%	+4.1%	+161,000 (+2.2%)	+AED 24 billion	-9%	-7%	-13%	-21%

Fig. III.2 : Potential sustainability benefits under 4 Green Economy scenarios in comparison to BAU scenario.

Our initial study methodology relied on studying the interviews of the political authorities of UAE. Such detailed interview delineates their approach towards this transformation.

According to Vice President and Prime minister of the United Arab Emirates, His Highness Sheikh Mohammed bin Rashid Al Maktoum “We recognize that preserving our energy resources will be one of the greatest challenges in our drive towards sustainable development. This, however, will not materialize unless the different facets of our society adopt energy conservation principles in their core values. The future generations will be the chief beneficiary of our achievements and the best judge of what we accomplish in this field.” (DCCE, 2015)

According to His Highness, Sheikh Ahmed bin Rashid Al Maktoum, Chairman of Dubai supreme council of energy, “There is little doubt that the world is at a crossroad. It’s evident that a change of thinking is required to meet the needs of the burgeoning world population without causing irreparable damage to the planet. As a responsible global nation, the UAE is committed to developing and implementing innovative solutions to protect and sustain the environment and guide the way for the sake of future generations. There has been much progress to date in the move towards a green economy, where economic growth and environmental responsibility are given equal importance in the development of a sustainable future. Indeed, the green economy is an engine of growth, providing opportunities for the private and public sector. Dubai aspires to be at the forefront of the green revolution, providing a role model to the world in energy and efficiency corresponding to the goals of the UAE Vision 2021. To this end, under the guidance of His Highness Sheikh Mohammed bin Rashid Al Maktoum, VicePresident and Prime Minister of the UAE, and Ruler of Dubai, the Dubai Integrated Energy Strategy 2030 (DIES) was developed, to set the strategic direction in securing sustainable supply of energy and enhancing demand efficiency, with the goal of reducing energy consumption in Dubai by thirty percent by 2030 and diversifying energy sources. Naturally, creating a green economy is not a simple process, but new, energy-efficient technologies and continual research and development are

driving a shift in the UAE's ever-growing economy, towards sustainable energy and stable economic growth, in balance with a focus on the environment. In establishing guidelines and frameworks, a clear path is emerging as Dubai also enhances its capabilities as a smart city, with technology playing a crucial role in sustainable development." (DCCE, 2015).

While Ban-Ki-Moon, the United Nations Secretary-General lavishly praised the efforts of UAE government, and stated that **"**We have a moral and political responsibility to advance sustainable development.I am pleased to see governments stepping up as never before. Companies see the investment potential in a green economy. And environmental activists are helping to foster green growth" (DCCE, 2015).Interviews of Mohammed Al Gergawi, minister of cabinet affairs in the federal government revealed that, **"**The Smart Dubai initiative is anchored in the vision of His Highness Sheikh Mohammed bin Rashid Al Maktoum, to make Dubai the happiest city on earth. Sheikh Mohammed's vision for the city is clear: in Dubai, we think of technology innovation as a building block towards creating happiness. We believe sustainability of the environment is vital to everyday quality of life. Indeed, a smart environment is one of the six pillars of the Smart Dubai strategy,along with smart living, mobility, economy, society and governance. Using smart technology,we enable city departments and the private sector to optimise resources, invest in renewable sources, monitor progress, and share data — all towards the aim of greater sustainability. Dubai has a strong track record of supporting innovation to reduce our collective impact on the environment across all industries and segments, actively contributing to a Green Economy. Initiatives within the blueprint include sustainable building practices in the construction industry, electric vehicles for public and private transport, smart meters to optimise energy consumption, and connected grids for renewable energy integration. As part of Smart Dubai, we are implementing progressive environmental

technologies across the fabric of the city, we establish Dubai as the global leader in innovation for a sustainable environment and a benchmark for the world's emerging economies.We invite all public entities and private sector innovators to partner with us on our quest to make Dubai the happiest city on Earth." (DCCE, 2015).

According to minister of environment and Water, His Excellency Dr. Rashid Bin Fahad,

"In March 2014, the UAE government hosted the first Global Conference on the Partnership for Action on Green Economy (PAGE) with United Nations agencies. The fact that more than 650 participants from 66 countries were present showed that the shift towards an inclusive Green Economy is no longer a luxury preserved for wealthy countries but has now become imperative to all. There was a clear sense of urgency to change the current development model and pursue a low-carbon, socially inclusive and resource-efficient model that improves human well-being and values natural capital. The UAE has come a long way in the past few years to meet the challenges of energy and climate change within the framework of the UAE Vision 2021. In January 2012, Sheikh Al Maktoum launched the UAE Green Growth Strategy as a long-term national initiative under the slogan "A Green Economy for Sustainable Development". Initiatives for building an inclusive green economy have been and will be conducted in six major areas. Through its implementation, the Green Growth Strategy will help accelerate and scale up ongoing efforts by the different federal ministries, local governmental departments and the private sector in such areas. It will enforce relevant policies already in place and encourage national champions among industry and citizens to find and implement even more innovative solutions. At the same time, a clear national leadership and government coordination are essential to guide a faster transformation into

a green economy. Through the establishment of a cross-cutting policy framework, the Strategy will also help make a clear articulation on the country's green technology potential and needs, prioritize green business and industries as new growth engines and conduct a strategic assessment in every economic policy decision-making. We therefore highly appreciate Dubai's early adoption of the Green Economy Approach and its firm commitment to realizing it. We would like to congratulate the publication of the Dubai State of Green Economy Report, which is an indication of Dubai's strong leadership, and look forward to working together to spread best practices across the UAE. The PAGE partners have agreed to have another biennial conference in six years' time, simultaneously with the Dubai Expo 2020. We sincerely hope that at that time the UAE will be able to show the world the advancement of its knowledge, innovation and creativity to guide all countries towards a promising, sustainable future." (DCCE, 2015)

According to His Excellency, Saeed Mohammed Al Tayer, MD and CEO of DEWA, "The United Arab Emirates is the first country in the Middle East and North Africa (MENA) region to commit to a green economy strategy, and Dubai is leading the region in green infrastructure investment from renewable energy and green building to public transport and green technologies." At Dubai Electricity and Water Authority (DEWA), we take pride in our achievements, which demonstrate our commitment to achieving the vision and directives of HH Al Maktoum to strengthen the pillars of our green economy, the maintenance of sustainable development, and the future of the emirate. DEWA has been at the forefront in championing a greener world through its concerted focus on promoting renewable energy and the rational use of energy and water.Also, these achievements exemplify our commitment to fulfil the UAE Vision 2021, the UAE Green Development Strategy and the Green Economy for Sustainable Development initiative announced by His Highness to maintain sustainable development so that

it supports long-term economic growth. The World Green Economy Summit (WGES) organised this year was an initiative of DEWA, under the leadership of the Supreme Council of Energy, which confirms Dubai's transition to a green and low-carbon economy across all strategic economic sectors. Dubai is also home to the first global multi-stakeholder collaboration initiative. "We will continue our efforts by adopting policies and initiatives that spur sustainable development and position Dubai firmly as one of the global cities that are leading the transition to a green economy." (DCCE, 2015)

Her excellency, Helen Clark, administrator, United Nations Development program, on the occasion of the rst World Green Economy Summit, Dubai, April 22 2014 commented that, "The [Green Economy] Summit bringstogether key people from around the world,public and private sector, civil society,international development community, indialogue on how can we work together toadvance sustainable development throughgreen economy, innovation and entrepreneurship across sectors. Overall aim: To drive and inuence the global transition to a green economy, which is so urgently needed in today's reality of ecosystem degradation, including in our climate (...)"(DCCE, 2015)

Our detailed survey indicate that many consumer brands have already started to design their products and services in a more environment friendly way. Acknowledging the fact that consumer opinion provides the largest impetus for such a change , we conducted an extensive survey in Dubai on the opinion of the citizens towards green and sustainable lifestyle. An wooping 80 % of the participants voted for green and sustainable future. Our results are closely parallel to earlier reports published by Bayt.com, which "showed that 72.5 percent of respondents considered going green as something very important to their lifestyle, with 80

percent also stating that environmental issues and conservation of natural resources concerned them to a large extent."

The importance of embracing a greener and sustainable lifestyle by UAE is well documented in the aforesaid discussions. An important consideration however is whether the socio-economic and political scenario in UAE is conducive to such metamorphic changes. Indeed a plethora of factors might act as the determinant factor for such transformation. These might include the geography of the region, environmental challenges, socio-economic landscape, mass participation, etc. The initial part of our research therefore focussed on understanding these factors with respect to their role in triggering green transformations.

Much of the geographical aspects of UAE that have been published in the literature have already been reviewed in the previous chapters. Our extensive research on the socio-economic landscape of UAE revealed that UAEs nominal gross domestic product (GDP) has grown 27 times since 1975 totalling USD 402 billion in 2013, indicating the economy of the country have prospered since then. Building on the endowment of considerable oil and gas reserves, the UAE's economy has prospered. Currently it stands just next to Saudi Arabia in terms of economic growth in the Arab world. The high pace of growth over the past years has been largely supported by the revenues from oil and gas, which have been systematically reinvested in economic diversification in preparation for the approaching post-oil era.

Since the Federation was established, the UAE's seven emirates have forged a single identify while maintaining a large degree of control over their internal affairs, each having its own separate institutions of government. The Constitution granted the federal authorities explicit powers over such areas as foreign affairs, security and defence, education, public health and

communications services. The federal government system includes the Federal Supreme Council, the Council of Ministers (the Cabinet), the Federal National Council (a partly elected parliamentary body), and an independent judiciary overseen by the Federal Supreme Court. The Federal Supreme Council comprises the rulers of the seven emirates and has both legislative and executive powers.

The City of Abu Dhabi was officially made the permanent capital of the Federation in 1996. Following his succession in November 2004 as Ruler of Abu Dhabi, His Highness Sheikh Khalifa bin Zayed Al Nahyan has served as the UAE President. His Highness Sheikh Mohammed bin Rashid Al Maktoum, new Ruler of Dubai, was elected as Vice-President and appointed Prime Minister in early 2006. The UAE is a member of the UN and the League of Arab States as well as the Cooperation Council for the Arab States of the Gulf (GCC), a regional political and economic union consisting of six member countries: Kuwait, Bahrain, Oman, Saudi Arabia along with UAE.

The UAE's natural water sources are limited to groundwater and the country is resorting to desalinated water to meet the rapidly increasing requirement. In the UAE, desalinated water has been produced using excess heat from electricity generation but has also caused impact on the marine environment from discharging highly concentrated brine to the Arabian Gulf, etc. Marine life also faces a number of other threats such as over-fishing and habitat loss.

Marine species including fish and coral are also increasingly affected by climate change. Keeping the ambient air quality within required standards has been a major challenges to the environment authorities in the country, as it is largely affected by human activities, the emissions from fuel combustion for energy, water and transport, and industrial activities. The UAE's per-

capita waste generation is also among the highest in the world, the majority of which (77% of solid municipal waste) ends up in landfills due to lack of separation schemes across the country.

These pressures have motivated the government to take effective policy actions and to build scenarios and coordinated strategies to reduce any significant impact and to protect biodiversity and ecosystems.

Following the recent multiple global crises in food, water, energy, climate and the financial system, it is increasingly recognised that the conventional paradigm based on a trade-off between economic development and environmental sustainability – "grow first, clean up later" – requires revision towards a model which is able to tackle both outcomes together. Conventional economic development and growth strategies have encouraged rapid accumulation of physical, financial and human capital, but at the expense of excessive, often irreversible, depletion and degradation of natural capital. This pattern of development has had detrimental impacts on the well-being of current generations and presents tremendous risks and challenges for the future. The recent crises could be all considered to be linked with the misallocation of capital – overflow of money into property, conventional energy and structured financial assets, as well as lack of investment in clean energy and energy efficiency, sustainable agriculture, sustainable transport and protection of biodiversity and natural resources.

There is now substantial evidence that there is not necessarily a trade-off between "green" and "growth" but that the promotion of the green economy has the potential to become a new engine of growth, a net generator of high-quality jobs and a vital strategy to eliminate persistent poverty. However, new enabling conditions are required to shift both public and private investment towards green development promotion. It is necessary to consider ecological

resources, such as safe drinking water, clean air and a stable climate, not as free goods but as real resources that provide added value to productive activities and that therefore need to be utilised sustainably. The government needs to implement policies that enable this shift in investment by addressing market failure created by externalities or imperfect information, introducing market-based incentives, installing appropriate regulatory frameworks, implementing sustainable public procurement, reducing or eliminating perverse subsidies, and supporting innovation and entrepreneurship.

Over the last five years, the emerging concepts of Green Growth or Green Economy have been taken up by many countries in the world. Under the Republic of Korea's leadership, 30 member states and four candidate states of the Organisation for Economic Cooperation and Development (OECD) signed a Declaration on Green Growth in June 2009. At the United Nations, the concept of Green Economy was proposed to foster transformed policy development of the nation, cooperation between the nations and backing for sustainable development. In 2012, more than one ninety nations along with UAE unanimously approved at the UN Rio+20 Summit to consider Green Economy as a valuable tool for achieving sustainable development.

Green Economy may be a new expression but the concept has been deeply embedded in the UAE's societal development thinking ever since the country's establishment. The UAE's development for the last four decades owes a great debt of gratitude to the perseverance, wisdom and forward vision of its founding father, the former president, His Highness the late Sheikh Zayed bin Sultan Al Nahyan. He made great efforts to carefully preserve the limited existing resources while improving the harsh desert environment. He charted the future development path of the UAE in the early years of the country's establishment. In 2005, the late Sheikh Zayed was recognised as a Champion of the Earth by the United Nations Environment Programme (UNEP).

The UAE continues to aim for improvement in its development path. To chart the next stage of the nation's journey and present its united ambition and determination, the UAE Vision 2021was launched in February 2010, being inspired by the principles of the founding fathers and guided by the National Work Programme launched by His Highness Sheikh Khalifa bin Zayed Al Nahyan, the President of the UAE.

The UAE Vision 2021summary statement reads, "In a strong and safe union, knowledgeable and innovative Emiratis will confidently build a competitive and resilient economy. They will thrive as a cohesive society bonded to its identity, and enjoy the highest standards of living within a nurturing and sustainable environment." (DCCE, 2015). At the local level, each emirate also sets its own medium to long-term strategic goals for development, most of which reflect the commitment to elements of the Green Economy. An analysis of individual vision statements at this point will provide valuable insights on the focus area of government action with respect to green and sustainable future.

An analysis of Abu Dhabi Vision 2030 reveals that their principle focus area consists of the Economic Vision and the Urban Planning Vision, supplemented by Visions for each region in the emirate and the maritime area. The core commitment is to build a sustainable and diversified, high value-added economy and to filter all planning decisions through environmental, social and economic criteria. Dubai Integrated Energy Strategy 2030, aims to drive energy diversification and decarbonisation and ensure sustainable supply and efficient use of energy. Dubai Plan 2021 is to ensure sustainable and systematic developments of the emirate throughout sectors, "a smart and sustainable city" is firmly placed among the six core themes of the plan unveiled in December 2014. Ajman 2021 Vision was launched in February 2014. Its principle objective is to create a happy society through an active economic movement

contributing in building a Green Economy and enhancing sustainable development, aiming to achieving prosperity in the various fields.

Given the current pace of increasing environmental impacts and carbon emissions together with the prospective growth in population and demand for energy and resources, it is evident that the UAE's ambition for further economic growth and high-quality lifestyles and the targets set by the Vision 2021and emirate-level strategies will not be met by simply continuing the current development path. Therefore the only way to manage both its economic aspiration and natural heritage is through a greatly accelerated effort to decouple environmental impact from economic growth by putting sustainable development at the heart of the UAE's development in the coming decades. In fact, it has been found that making a transition to a greener economy will bring significant opportunities and advantages for the country as demonstrated in our scenario studies. Utilising renewable energy sources can help reduce the country's dependence on fossil fuel and lower carbon emissions, while allowing it to reserve more crude oil for export thus generating extra trade revenues. Cleaner transport and cooling system mean less pollution and better health. Low-carbon agriculture with innovative technologies will be both more productive in terms of labour, energy and water, and more climate-resilient. Energy efficiency can help reduce production cost, while low-carbon technologies and new green products and services can open up new sources of growth and jobs and help economic diversification.

Retaining abundant capital reserves and significant returns from local and foreign investment, the UAE is now in a good position to change the course of national development and prepare for a shift of capital investment towards perpetual assets including human capital,

innovative capacity and technological leadership that will enable the Green Economy within the next few decades.

In November 2013, the UAE won the bid to host the World Expo in Dubai in 2020, marking the first country in Middle East and North Africa (MENA) region to arrange such an international expo. The UAE would like to make this forthcoming event the greatest opportunity to bring innovative ideas and promising solutions together and to truly realise a global collaboration for sustainable living. Dubai Expo 2020 will be designed around the three themes: Sustainability, Opportunity and Mobility.

The Expo should serve as a powerful springboard to realise a positive and sustainable idea for the future, while celebrating the country's Golden Jubilee. From 20 October 2020 to 10 April 2021 with an estimated 25 million visitors, the UAE strongly believes that the country will be able to show the world the advances it has made in its knowledge, innovation and creativity, and will be able to help guide all countries towards a promising, sustainable future.

Building upon the UAE Vision 2021and influenced by international initiatives for Green Economy, His Highness Sheikh Mohammed bin Rashid Al Maktoum, unveiled the slogan "A Green Economy for Sustainable Development" in Jan 2012. This strategy primarily aims to provide existing national and emirate-level strategies and plans with a clear, unified umbrella for guiding the course of development towards a Green Economy. Under this overarching strategy, six focus areas were presented.

In Green Investment sector, the probable actions can be develop government policies to encourage Green Economy investments, Facilitate the production, import and export and re-export of products and green technologies, Capacity building and preparation of local Emiratis

and create employment opportunities for them in all fields related to Green Economy. In the focus area of Green City the action plans were the development of urban planning policies aimed to preserve the environment, Raise the efficiency of household and buildings from environmental perspectives, Encourage sustainable transport, Develop policies to improve indoor air quality for cities. In the focus area of climate change the strategy was to develop the execution process of the UAE Green Growth Strategy has been carefully chalked out. The idea is to build on existing policies and strategies to help deliver goals of the UAE Vision 2021and enable emirate-level strategies and plans. It is stakeholder-driven by applying extensive and continuous stakeholder consultation and engagement process across sectors at the federal and local level. The implementation strategy is also build on past and ongoing UAE and international studies and qualitative and quantitative research. It is also cross-sectorally integrated and spans across all sectors of the UAE economy.

With such enthusiastic participation from the national leaders a clear, holistic direction for the country's long-term development has been chalked out. The next phase of our study highlighted below, are selected public and private-sector efforts undertaken for enabling Green Economy. This review entails a detailed study on various sectors including Oil and Gas, Water, Electricity, Industry; Transport, Waste Management, Agriculture etc. Indeed our main focus of this thesis is water, electricity and lifestyle. While water and electricity have been dealt with separately, lifestyle is a very broad theme. A plethora of socio-economic as well as political entities help to determine the lifestyle of the citizens. Therefore it is important to consider all these different factors which include Oil, Industry; Buildings, Transport, Waste Management agriculture etc. for proper elucidation of the research problem. Such detailed discussion will be followed by an assessment of the success and opportunities of UAE in these sectors as

determined by different established evaluation models. Therefore the next phase of our study aimed at determining the public and private-sector efforts for realising Green Economy, which has been recently implemented.

The UAE's electricity sector has been dominated by natural gas-powered utilities. In 2012, the total installed capacity of electricity generation was 27.2 gigawatts (GW) (UAE Ministry of Energy, 2013). Sharp increase in population , developing economy, and climate have heightened the requirement for electricity and water. According to Business Monitor International, owing to a probable average annual increase in power consumption of 5.6%, a steep increase in power demand in the country is expected over the period 2012-21.

To circumvent this problem of rising demand, a sustainable approach is mandated. UAE is increasingly focusing on coming up with a balanced energy mix. Both Abu Dhabi and Dubai have set ambitious targets for increasing renewable energy generation. Masdar was established in 2006 to conduct strategic investment in research and innovation of renewable energy technologies and sustainable city projects. Abu Dhabi is also the host of International Renewable Energy Agency (IRENA) since 2009, which is the first inter-governmental organisation setting headquarters in the Middle East (IRENA, 2009).

To date, the Abu Dhabi government has set a target that by 2020 at least 7% of power generation capacity should be renewable energy. The Government of Dubai established the Dubai Supreme Council of Energy (DSCE) in 2009 which oversees all aspects of energy in the emirate and developed the Dubai Integrated Energy Strategy 2030 to drive energy decarbonisation and ensure efficient use of energy. The emirate sets plans to generate at least 5% of its power from renewable energy by 2030, as well as 12% from clean coal and 12% from

nuclear power, as part of the policy to use alternative energy sources (In 2015 January, Dubai proclaimed a revision of its targets for the share of renewable energy in the total energy mix to 7% by 2020 and 15% by 2030). The UAE has initiated a civil nuclear energy programme under International Atomic Energy Agency (IAEA) and the construction of the first nuclear power plants started in 2013 (Adamantiades and Kessides, 2009).

The UAE has only limited natural water resources at its disposal and has employed thermal desalination as the dominant technology. Today, most of the country's portable water (or 42% of the total water requirement) comes from some 70 major desalination plants, which account for around 14% of the world's total production of desalinated water. In 2012, the UAE had an installed desalination and groundwater capacity of 7.2 million cubic metres (m3) per day which has expanded by as much as 35.8% since 2008.

However, UAE is focussing on increasing capacity, efficacy as well as conservation. Indeed in UAE, one of the most exigent facet of sustainable development is this energy-water nexus. His Highness General Sheikh Mohamed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces, emphasised the importance of water security to the country by stating in 2011 that "water is more important than oil for the UAE" (Emirates 24/7, 2011).

Despite its abundant hydrocarbon deposits, the UAE is aiming of becoming a global focal point of renewable energy research and industry as part of contributions towards the diversification of its economy and energy mix as well as reducing carbon footprint. Most notable in this direction are the ongoing development of a few high-profile solar power plants which are among the largest in the world. In March 2013, Masdar commenced the operation of Shams 1, a

100-megawatt (MW) concentrated solar power (CSP) plant near the city of Madinat Zayed in the Western Region of Abu Dhabi. Working together with Total and Abengoa Solar with a total project cost of USD 600 million, this is one of the largest CSP plants in the world. CSP generates electricity from the heat of the sun rather than sunlight as used by solar photovoltaic (PV) technology. Spread over an area of 2.5 km², 768 parabolic troughs that consist of 258,000 mirrors concentrate the heat from the sun into oil-filled central tubes.

The collected heat in turn is used to produce steam, which powers a turbine and generates electricity. The plant relies on some natural gas, which helps boost its efficiency during the day and allows it to produce electricity at night. It produces enough energy to power 20,000 homes and displaces approximately 175,000 tonnes of CO2 annually. The Emirate of Dubai announced in January 2012 that a 1-GW Mohammed bin Rashid Al Maktoum Solar Park would be built in phases and completed by 2030 n Seih Al Dahal, around 50 km south of Dubai city, to meet its renewable energy supply target. This mega-project is undertaken by DSCE and managed and operated by DEWA, as one of the biggest renewable energy projects in the MENA region with an expected total cost of AED 12 billion (USD 3.3 billion). The first phase, a 13-MW solar plant with advanced thin-film PV modules, was built at a cost of AED 120 million (USD 32.7 million) and was inaugurated on 22 October 2013 to mark World Energy Day. This plant can be responsible for the reduction of approximately 15,000 tonnes of CO2annually. The second phase of the project covers the construction of a 100-MW installation expected to be completed by 2017.

Contrary to the conventional notion of meeting the rising energy demand by increasing energy generation and import, demand-side management (DSM) focuses on reducing and optimising energy consumption as an additional option to meet network demand, particularly

that at peak time, at the lowest cost. DSM activities generally comprise a portfolio of policies and programmes for improving energy efficiency and demand response. Some countries started putting an obligation on utilities to deliver a certain quantity of energy savings.

As the Emirate of Dubai set a target of 30% reduction in energy demand by 2030 as a key objective of the Dubai Integrated Energy Strategy 2030, DEWA has developed a DSM roadmap and action plan over the short, medium and long term to 2030. These include 8 DSM programmes and 24 initiatives covering all the potential saving areas, and include cost-benefit analysis, implementation and financing mechanisms, and measurement and verification methodology.

At the core of this demand-side approach is the introduction of smart meters that can provide more precise information about energy use and ensure faster responses to changing supply and demand through automatic reconnections. Smart meters also facilitate the installation of renewable energy in residential, commercial and industrial sectors as the feedback of the generated excess electricity to the power grid has officially been permitted by the resolution issued in December 2014 (The National, 2014d).

DEWA has started a five-year plan to replace conventional meters and will install 200,000 smart meters all over Dubai by the end of 2015 (DEWA, 2014), State of Green Economy Report 2015, DCCE, Dubai, pp.59-60.. ADWEA also launched a DSM programme defining a holistic energy efficiency strategy that ensures a shift towards the development of a smart grid that will support the future needs of the society. It has completed an implementation roadmap for the programme and has already made significant progress in rolling out advanced metering infrastructure (AMI) over 400,000 of the existing 680,000 consumer points in the

municipalities of Abu Dhabi and Al Ain. AMI remotely collects consumption data via smart meters, which is validated and transferred through data management systems to its customer billing system. The Abu Dhabi government-led taskforce on cooling is analysing the benefits of DSM interventions, leveraging detailed metering and customer data enabled by AMI.

In order to realise energy efficiency and savings for which DSM programmes aim, the understanding and collaboration from people is essential. Abu Dhabi's Regulation and Supervision Bureau (RSB), the water, wastewater and electricity sector's independent regulatory body, launched Waterwise and Powerwise initiatives in 2013. They aim to empower wise attitudes and behaviours of consumers by helping them understand how they can save water and electricity and why it is important to do so based on the collection and sharing of reliable data and a comprehensive knowledge base. In addition to various awareness raising campaigns, RSB introduced a new utility bill that shows the actual cost of supplying water and electricity to customers as well as the government's subsidy. It also advises the level of usage with green and red symbols – red warns that consumption is above the level of average households (RSB, 2014).

In Dubai, since June 2013 DEWA has included in the utility bill a statement of CO2 emissions equivalent to customers' electricity consumption to raise awareness over the impact of climate change. Responding to the findings of the Living Planet Report 2006compiled by the Worldwide Fund for Nature (WWF) that the UAE recorded the world's highest Ecological Footprint. In many countries, standards and labelling have been considered as one of powerful policy tools to help consumers to make better choices and be environmentally more responsible. One of the major tasks of the Emirates Authority for Standardization and Metrology (ESMA) has been to set authoritative national efficiency standards adapted to local climatic conditions, and to

provide information to consumers through eco-labelling of products. A mandatory water and energy efficiency rating and labelling system is being gradually introduced on domestic electrical appliances and water fixtures to help consumers make intelligent choices. Those electrical appliances for sale must have a label showing how much electricity they consume in a year, together with a five-star rating to show how energy-efficient they are. The first product category undergone this scheme in 2011 was household air conditioning units, followed by washing machines and dryers and household refrigerators in 2013 and storage water heaters in 2014. This initiative is expected to save the government's subsidies of AED 400 million (USD 109 million) a year by 2016 from energy savings on air conditioners alone (McGinley, 2013). According to the published reports, "The UAE has introduced a mandatory new energy rating system on all domestic appliances to help consumers decide which are the most energy efficient, a move they claim could save up to AED400m ($108m) a year by 2016 on air conditioning units alone. As part of the initiative by the Emirates Standardisation and Metrology Authority (ESMA), all domestic goods for sale must have a label showing how much electricity the appliance uses in a year, plus a star rating to show how energy efficient it is, the WAM news agency said" (McGinley, 2013).

As part of the UAE Ecological Footprint Initiative, a partnership project between EWS-WWF, EAD, ESMA and MoEW, the UAE Lighting Standard was introduced in December 2013 to prevent low-quality incandescent light bulbs from entering the market and to ensure the advancement of energy-efficient light bulbs such as compact fluorescent lamps (CFLs) and LED lamps. However, both the Emirates of Dubai and Sharjah introduced in 2008 a slab tariff system for water and electricity consumption in residential, industrial and commercial customers, under

which as consumers use more power, the unit of power becomes more costly (Khaleej Times, 2008; Abdullah, 2008).

Fuel surcharge is added according to usage (per imperial gallon and per kWh) and shown separately in monthly bills (DEWA, 2014). In November 2014, Abu Dhabi's RSB announced new utility tariffs to be applied from 1 January 2015. For water, tariffs for expatriates living in a flat will increase from AED 2.20 (USD 0.60) per 1,000 litres to AED 5.95 (USD 1.62) for those using up to 700 litres per day. For those using more than this volume, a cost reflective tariff will be applied. The electricity tariffs for expatriates living in a flat or a villa will also rise from AED 0.15 (USD 0.04) per kWh to AED 0.21 (USD 0.06) for those with a daily consumption of up to 20 kWh and a cost reflective tariff will be applied for those using more (The National, 2014a).FEWA already introduced a slab tariff to the customers in the Northern Emirates (Shahbandari, 2014).

Meanwhile, the Federal Authority for Nuclear Regulation (FANR) was established in September 2009, in accordance with the Federal Law Concerning the Peaceful Uses of Nuclear Energy, to regulate the nuclear sector in line with international treaties, such as the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and best practices. In July 2012, FANR granted a construction licence to ENEC for two of the four advanced pressurised water reactors, which are scheduled to start supplying electricity in 2017.

UAE is aiming for zero flaring of natural gas. The flaring of natural gas as a by-product of oil production wastes resources and contributes to severe air pollution and GHG emissions. Globally, the World Bank estimates that approximately 140 billion cubic metres (bcm) of natural gas is flared each year, equivalent to about 30% of the European Union's annual gas

consumption, resulting in CO2 emissions of about 350 million tonnes a year (World Bank, 2014).

To date, the UAE has succeeded in radically reducing flaring since 1990s and its policy is shifting from minimal flaring to zero-tolerance of flaring. The ADNOC group aims to eliminate routine flaring and by 2013 had reduced flaring by 76.4% compared to 1995 levels. Within the ADNOC group, an offshore exploration and production (E&P) company has already achieved zero flaring at its Zakum oilfields for the first time. Onshore, an ADNOC gas E&P company developed a flare management strategy for its Shah Gas Development Project, with the aim of minimising flaring from well-testing and clean-up operations (ADNOC, 2013)

The Abu Dhabi Future Energy Company (Masdar) has accumulated knowledge on formulating policies and projects to reduce flaring and has been serving as a partner of the World Bank's Global Gas Flaring Reduction Partnership since 2009. To share its advanced experiences of flaring reduction, Abu Dhabi has been hosting the annual Flare Management and Reduction Summit since 2012.

Mature oil reservoirs where the oil does not easily flow out have been applying enhanced oil recovery (EOR) methods that inject natural gas contained in the reservoirs to add pressure and boost output. As local demand for natural gas is surging, using CO2as an alternative by applying carbon capture and storage (CCS) technologies could potentially provide a win-win solution that helps slow down the pace of climate change while meeting the increasing demand for oil. In 2012, an ADNOC E&P company completed a two-year pilot project that involved injecting 60 tonnes per day of CO2into its Al Rumaitha oilfield. ADNOC set up a joint venture with Masdar in 2013 to implement CCS projects by which 800,000 tonnes a year of CO2emitted

from Emirates Steel's plant in Mussafah will be piped 50 km to the Rumaitha field in 2016 and later to Bab, its largest onshore oilfield. It is estimated that if CCS technologies are applied for EOR on all Abu Dhabi's onshore oilfields, 7 billion barrels will be added to crude production, equivalent to 7% of the UAE's total proven reserves. The additional cost of applying this technology is estimated around USD 20 per barrel and considered to be viable (Oxford Business Group, 2013 ; Saadi, 2014 ; Barakat, 2012)

The International Energy Agency (IEA) estimates as many as 3,000 CCS projects are needed by 2050 to the Netherlands (TAQA, 2014)

This is one of the first projects worldwide to realise an integrated chain of CO2capture, transport and storage on a large scale. The ROAD project aims to demonstrate the technical and economic feasibility of CCS, and the knowledge and experience acquired can be instrumental in the commercial introduction of CCS in the near future (ROAD, 2014).

Another pertinent objective is promoting cleaner fuels for vehicles. Natural gas is a viable cleaner alternative fuel to gasoline as it produces fewer emissions and the running cost of vehicles is around 30% less. In the Emirate of Dubai, Emirates Gas (EMGAS), an ENOC subsidiary, started an initiative to popularise compressed natural gas (CNG) as an automotive fuel as early as 2006. A pilot project was conducted with Dubai's Roads and Transport Authority (RTA) that converted diesel-operated wooden abras (water taxis) running on the Dubai Creek to operate on CNG. Transguard and the Dubai Electricity and Water Authority (DEWA) among others (UNDP, 2014)

In the Emirate of Abu Dhabi, more than 3,000 public transport vehicles have been adapted to run on CNG to date. ADNOC's gas processing and fuel distribution subsidiaries are

leading the way to expand the use of CNG for vehicles by investing in the infrastructure to ensure that there are enough filling stations to support additional demand for such vehicles. The first phase of the Natural Gas for Vehicles (NGV) Project involves the installation of CNG pumps at 16 stations in Abu Dhabi and Al Ain as well as the Emirate of Sharjah, with capacity to fill 10,000 vehicles per day. ADNOC's fuel distribution subsidiary is also carrying out the conversion of petrol-operated vehicles to run on both petrol and CNG, with the facility to switch over to either fuel by simply touching a button located on the dashboard. Nine conversion centres are planned with a retrofitting capacity of 20,000 vehicles per year.

In July 2014, the UAE became the first country in the Middle East to make the use of "green diesel" in all commercial diesel vehicles mandatory. The new Cabinet decree and the updated guidelines from the Emirates Authority for Standardisation and Metrology (ESMA) requires replacement of the current diesel fuel that contains 500 parts per million (ppm) of sulphur with diesel fuel that contains only 10 ppm similar to Euro 5 standards. This reduction in sulphur levels will significantly reduce particulate matters (PM) and pollutants and contribute to cleaner and healthier environment (Emirates 24/7, 2014).

ENOC introduced the first "green service station" in The Greens neighbourhood in Dubai. This station applies a variety of state-of-the-art technologies and features including devices to contain petrol fumes released by the pump, new waste segregation systems that provides colour-coded bins, use of furniture made from recycled materials, and a centralised vacuum system.

Improving local environment by in-house recycling has been a major focus area under this theme. Sharjah Cement Factory, which was established in 1977 at 25 km east of Sharjah

city, now has a total annual capacity of 2.2 million tonnes for clinker production and 4.27 million tonnes for cement grinding. The factory has recently installed three sewage treatment units that handle about 300 m3 of domestic water daily used in workers' camps, offices and a canteen (the cement plant itself does not use much water as most is evaporated or recycled back into the production process). In addition to the benefit of avoiding groundwater contamination from wastewater seepage, the treated water has been used to create a green belt on the southern boundary of the factory along the Sharjah-Al Dhaid highway where about 200 palm trees have been planted.

Dubai Aluminium (Dubal) and Emirates Aluminium (Emal), which were merged into Emirates Global Aluminium (EGA) in 2013, introduced a co-generation and combined cycle configuration in their power stations, achieving 46-48% thermal efficiency. Dubal's greenhouse gas (GHG) intensity in production was reduced by 12% in five years. Dubal also introduced a waste heat-based absorption chiller, which can reduce 60% of electricity required for cooling (Al Awadhi, 2014).

In the cement industry, alkali dust is generated during the pyro-processing in the rotary kiln. This is considered as a hazardous material but many cement plants dump it in solid waste disposal yards, causing soil degradation. The factory has managed to fully recycle alkali waste through controlled feeding into a cement mill, without affecting the quality of product. It is also currently installing a waste heat recovery (WHR) power plant to effectively utilise waste gases from two kiln lines. With the expected completion in early 2015, the WHR plant will reduce dependence on local grid power and reduce thermal load on the environment as gases will be vented out at much lower temperature.

A business park dedicated to green industry EnPark, a member of Tecom Investments, is a free zone business park dedicated to facilitating and fostering the growth of alternative energy and environment EnPark dedicated to green businesses in Dubai businesses. Located a short driving distance from the centre of Dubai, EnPark caters to companies and organisations operating in energy efficiency, renewable energy, green building and waste management sectors by providing a costeffective business environment and raising the profiles of potential investment opportunities. Besides providing a full range of sustainably designed real estate products, it also offers regulatory and legislative support to its licensees and strives to provide a platform to facilitate public-private partnerships, identify business opportunities and share experiences of operations, products and services with industry peers. To date, more than 50 organisations from cleantech start-ups to large energy multinationals operate under EnPark's licenses (Abdulaziz, 2014).

UAE is also taking pertinent steps for shifting to local cleantech manufacturing. The UAE is not only a big importer of clean energy technologies. Microsol International was set up in the Fujairah Free Zone on the east coast of thex country in 2003 by Indian entrepreneurs with extensive experience in the solar PV industry. The company specialises in manufacturing of crystalline silicon (c-Si) solar cells and its products are highly competitive in the market while providing green jobs to more than 200 employees. Customers comprise leading solar energy players across the world including Germany, Italy, Portugal, Spain, Czech Republic and India. The company's expansion plans include setting up of further cell, module and wafer manufacturing capacities in India and the UAE to achieve an integrated capacity of 500 megawatt peak (MWp). In March 2012, Microsol bought Germany-based Solon Group, which is specialised in design and construction of solar farms as well as tracker and mounting structures.

This will allow Microsol to become a vertically integrated player which can provide turnkey solutions from rooftop installation to large-scale solar parks, while ensuring low-cost but German-quality production.12 3

Beloved animals have also been turned into sustainable products. The camel was and still has been a fundamental part of life in the UAE. The value derived from the practical use of this beloved animal has recently been rediscovered. It provides a source of meat and milk, and increasingly a source of leather material. The Government of Abu Dhabi established Al Khaznah Tannery in 2006 next to the dunes on the Abu Dhabi-Al Ain truck road as one of the most advanced leather processing plants in the world. The plant transforms locally sourced camel hides and skins, alongside those of cows, goats and sheep, into premium quality leathers for a wide range of applications including shoes, bags, interior and fashion design, automotive, aviation and yachting.

The plant is not only technically advanced but also among the first in the world to apply the most advanced environmentally sound production processes in the industry that has been seen as highly polluting. Most tanning processes use chromium salts, which become toxic and carcinogenic if products are incinerated. Al Khaznah manages to totally stay away from chromium and other metals and its products are biodegradable within several months if they are composted. The tanning process is also very water-intensive but the plant is treating and reusing up to 80% of the water, resulting in using less than one tenth of water used in conventional tanneries. Leveraging these competitive advantages, the company aims to break into export markets, including reputable fashion houses in Europe (Al Khaznah Tannery, 2014 ;General Holding Corporation, 2014 ; Ali, 2012 ; Denman, 2012).

In the sector of Buildings, Construction & Real Estate Sustainable cities are being developed. Abu Dhabi's Masdar City project is seeking to provide a commercially viable eco-city model that delivers the highest quality living and working environment with the lowest possible ecological footprint (Barnard, 2014; Deulgaonkar,2014; Saseendran, 2014). In November 2014, the Dubai Government's Land Department and UNEP launched the Centre for Resource Efficient and Sustainable Cities for the Arab Region (UNEP, 2014 ; MoPW, 2010; Masdar, 2014).

The UAE is a leader in adopting district cooling systems (DCS) as the preferred alternative to conventional air conditioning. In general, DCS consume 50% less energy than the conventional systems. A number of district cooling utility companies have emerged and more than one in ten residents now use the systems (Empower, 2014; Tabreed, 2014).

In 2010, the UAE Green Building Guidelineswere developed for new projects to be carried out by the Ministry of Public Work (MoPW). Dubai introduced green building regulations containing 79 specifications, which is now mandatory for all developments. Abu Dhabi introduced the five-level Estidama Pearl Rating System. It is mandatory for all new buildings to obtain a one-pearl rating, while all government buildings and residential villas must obtain two pearls (Al Abbar, 2014; Construction Week Online, 2014).

Various modern public transport modes have been introduced. For the last few years, the UAE has been making large-scale investment in introducing various advanced public transport modes to ease road congestion and provide people with low-cost, convenient alternatives. Dubai Metro, which was inaugurated in September 2009 on the 52-km Red Line with 10 stations, has revolutionised the way both residents and tourists move around the city. Guinness World

Records acknowledged it as the world's longest fully automated metro network. The 23-km Green Line was added in 2011 and 47 stations, including 10 underground, are currently operational. The number of daily passengers has jumped from 60,000 in 2009 to about 500,000 in 2014 (Kannan, 2014).

RTA estimates that Dubai Metro helps reduce CO2 emissions by over 645 tonnes per day thanks to the reduction of vehicles from road and the resulting reduced congestion (Shahbandari, 2014b). The authority plans to launch three more metro lines by 2030, as well as an extension of the Red Line to the Expo 2020 site, covering 421 km with 197 stations (Kannan, 2014b). Built on the success of Dubai Metro, Dubai Tram has been launched in November 2014 as the first tramway outside Europe powered by ground-based electric supply system. The first phase of the project has 11 stations and 11 seven-car trams which runs 10.6 km along Al Sufouh Road from Dubai Marina to Burj Al Arab. The second phase will add 4 km of track, six stations and 14 trams. RTA expects that about 27,000 people will use it every day by 2015 and the passenger number will rise to 66,000 by 2020 (Kannan, 2014b).

Abu Dhabi also began work on the design of a 131 km-long metro system. The first phase of the metro is expected to run 18 km from north to south of Abu Dhabi Island, supplemented by two light railways or tram lines linking with surrounding islands (. Barnard and Neuhof, 2013).Furthermore, the development of a 1,200-km national railway network for passengers and freight is underway since the establishment of Etihad Rail in June 2009. It will link the principal centres of population and industry, as well as to form a vital part of the wider 2,000-km GCC railway network linking the UAE with Saudi Arabia, Qatar, Oman, Bahrain and Kuwait. The project will be implemented in three stages and the first phase of 200 km freight services will be operational in the near future between Shah, Habshan and Ruwais in the Western

Region of Abu Dhabi. The second stage will provide a 630-km network for both passengers and freight between Musaffah, Khalifa Port in Abu Dhabi and Jebel Ali in Dubai, as well as extension to the Saudi and Omani borders. The freight trains will travel at 120 km per hour and the passenger trains will run at up to 200 km per hour (Gazzar, 2014).

Converting conventional transport clean and green - More conventional transport modes familiar to UAE inhabitants such as buses and taxis also started their upgrade to a greener and cleaner fuel. RTA introduced the first "green bus" fuelled by biodiesel in 2012 as a pilot project and is now converting a total of 118 Mercedes buses to be powered by biodiesel by the end of 2014. All internal lighting is powered by solar energy and retreated tyres are applied, whilst the material used for seats and flooring is also eco-friendly. It is estimated that green buses will emit 33% less CO2 compared to the conventional buses. RTA aims to make its entire fleet green buses by the time of Expo 2020 (Shahbandari, 2014a).

Professor Bassam Abu-Hijleh at the British University in Dubai estimated that replacing the entire fleet of taxis in Dubai could save AED 104 million (USD 28 million) of fuel cost annually, while more than 109,000 tonnes of CO2emissions could be reduced. Following the successful piloting, Dubai Taxi Corporation introduced 20 Toyota Camry hybrid taxi units in September 2013. Those units display a slogan and the "Hybrid Taxi" green logo on both doors to distinguish them from the conventional taxis (Libo-on, 2013)

Cars Taxi introduced first two hybrid taxis in Dubai in 2012 and now plans to operate 100 hybrid vehicles across the country by the end of 2014. It estimates that even though each Camry hybrid car costs AED 30,000-40,000 (USD 8,200-10,900) more than the normal Camry, it can save more than AED 50,000 (USD 13,600) in fuel costs for driving every 700,000 km. The

company which owns 6,000 vehicles aims to operate an all-hybrid taxi service eventually (Al Taher, 2014 ; Ruiz, 2014).

Making bicycles viable for mobility and sporting Cycling is rapidly becoming popular among health-conscious UAE residents as an option for commuting as well as sport and leisure, but the absence of dedicated lanes and purpose-built tracks in the country has led to the risk of more accidents on busy roads. To respond to the rising popularity and to promote healthy and greener lifestyles, RTA developed the Dubai Bicycle Master Plan that aims at providing 850 km of strategic developments across the globe (Gulf News, 2013). Abu Dhabi opened the 16-km Al Wathba Cycle Track in September 2013 to cater for sportive riders, whereas the Corniche seafront and the Formula One race track Yas Marine Circuit, which is open every Tuesday for cyclists and athletes, have drawn many enthusiasts (Sankar, 2014).

Further to the expansion of bicycle tracks, a European-style bike-sharing scheme was launched in Dubai in February 2013. This novel service has been rolled out by a German company Nextbike which operates in 30 cities in Germany and several other countries. Over 100 bicycles have been installed at the docking stations in Downtown Dubai and Dubai Marina areas where tourists congregate. Abu Dhabi has also started a similar scheme between Al Raha Beach and Yas Island with 10 stations in December 2014. Sponsored by Abu Dhabi Commercial Bank (ADCB), bicycles are free for the first 30 minutes. If the bike is not docked after 30 minutes, users will be charged AED 15 (USD 4.1) for a one-day pass (Al Wasmi, 2014). The Sharjah Investment and Development Authority (Shurooq) also introduced the system in early 2014, with an intention to eventually cover all touristic areas of Sharjah city (Libo-on, 2014).

To cope with the ever-rising traffic volume and road congestion, the Salik (the Arabic word for open or clear) toll collection system was launched in July 2007. Vehicle owners passing Salik gates need to purchase a Salik tag and attach it to the windshield in advance. Each time a vehicle passes under one of the six Salik gates, the toll of AED 4 (USD 1.1) is deducted from the vehicle owner's prepaid Salik account (RTA, About Salikwebpage, 2014; Haine, 2012).

In October 2013, RTA announced the legality of car-pooling in the emirate to increase vehicle occupancy rates and help mitigate congestion. Drivers and potential passengers can register their details on the Sharekni ("share with me" in Arabic) online system www.sharekni.ae for free, which helps them find those commuting in the same direction. On the other hand, anyone using car-pooling for picking up random strangers or for profit motives is fined. In January 2014, DoT launched a new park-and-ride service in Abu Dhabi city as part of its efforts to provide convenient, sustainable integrated transportation services. Under this scheme, shuttle bus services from the city's outskirts to different central locations are provided. In the first phase, the services are free to and from Zayed Sports City, from 6 am to 8:30 pm on weekdays, where 600 free parking lots are provided. The buses are equipped with free Wi-Fi and run every 15 minutes during peak hours and every half an hour at other times. The daily pass for this free service covers the driver and up to three passengers, who are also allowed unlimited bus trips inside Abu Dhabi Island (Emirates 24/7, 2014). DoT also allocated 500 parking permits in the Central Business District to encourage neighbouring offices to provide park-and-ride services for employees (DoT, 2014).

UAE also seeks to contribute to greener air transport. As the UAE has one of the fastest-growing aviation industries in the world, it recognises the urgent need to find the best way to contribute to significant cuts in the aviation industry's carbon footprint. In January 2014, Etihad

Airways, Boeing, Takreer (ADNOC subsidiary), Total and the Masdar Institute of Science and Technology announced a new collaborative initiative BIOjet Abu Dhabi: Flight Path to Sustainabilityto support a sustainable aviation biofuel industry in the UAE. This will engage a broad range of stakeholders to develop a comprehensive framework for a UAE biofuel supply chain, including research and development and expanded investment in feedstock production and refining capability in the country and globally.

The day before this announcement, Etihad Airways made a 45-minute demonstration flight in a Boeing 777 powered partly by UAE-produced biofuel, which was partially converted from plants by Total and refined into jet fuel by Takreer. The UAE has become among a handful of countries that have produced and flown on their own aviation biofuel, which is estimated to reduce carbon emissions by at least 50% compared to fossil fuel over its lifecycle (Masdar Institute, 2014).

Emirates Airline is making efforts to improve eco-efficiency of fleets and operations as the company tracks environmental performance and publishes an environmental report annually. With an average fleet age of only 6.2 years versus the global fleet average of 11.7 years, Emirates' fuel efficiency results in the 2013-14 fiscal year were 14.5% better than the International Air Transport Association (IATA) members' average. The total fuel efficiency for all passenger and freighter flights improved by 0.5% since the last fiscal year, dropping to 0.309 litres per tonne-kilometre. Similarly, carbon emissions dropped to 0.764 kilogrammes (kg) of CO2 per tonne-kilometre, improving efficiency by 0.4% (Emirates Group, 2014).

The Abu Dhabi International Airport achieved in November 2011 the 'Mapping Level' of the Airport Carbon Accreditation, a carbon management standard for the airport industry, making it

the first “carbon-accredited airport” in the AsiaPacific. The Abu Dhabi Airports Company (ADAC) initiated its application to the programme by mapping emission sources within the direct operational boundaries of the airport as defined by the GHG Protocol, calculating the annual carbon emissions, compiling a carbon footprint report and verifying it independently. The airport footprint forms the baseline measure to which future activities and targets will be aligned (ADAC, 2011).

Building on its CSR policy, safety policy and environmental management plan, Dubai Airports also began in 2013 to establish its carbon emission baseline which will set the foundation for environmental priorities and action plans to demonstrate its commitment to limiting both Dubai International and Dubai World Central Airports’ carbon footprint while supporting the growth of the aviation sector and the broader UAE economy (Dubai Airports, 2014). Due to the high level of population growth and economic activities, the quantities of wastes in the UAE have increased in an unprecedented pace in the last decade. The total amount of solid waste collected in the country has reached more than 26 million tonnes in 2012. Most of the waste ends up in municipal landfills or dump sites, where organic waste generates a large amount of methane which is a potent greenhouse gas. Little of the waste is incinerated at the moment; the rate of municipal waste recycling has been rapidly rising but still relatively low.

Among various waste types, the public concern over the use of non-biodegradable plastic bags became prominent, as the deaths of camels and sea turtles in the UAE after consuming plastic bags were highlighted by the media. According to EAD, around half of camel deaths in the UAE were considered attributable to plastic bags they had eaten assuming them to be food (Kader,2012). The MoEW’s survey found that 11.6 billion plastic bags were used annually in the

country, of which 53.3% were non-biodegradable, and plastic bags and other plastic material consisted of 10.9% of the total household waste.

As a response, MoEW launched the UAE Free of Plastic Bags initiative in October 2009. This campaign aimed to cut down the quantity of non-biodegradablebags in a gradual step towards the final prohibition and replacement with biodegradable plastic and other longlasting, reusable bags. The initiative was rolled out in four phases, including awareness raising and alternatives finding, and the ministry finally issued a decree banning the use of nonbiodegradable plastic bags by the end of 2012. Manufacturers and suppliers of plastic bags now have to register their biodegradable products in accordance with the Emirates Conformity Assessment System (ECAS). The requirements and conditions listed in the UAE standard specifications (5009:2009) have to be met by the manufacturers (MoEW, 2014; Khaleej Times, 2011; WAM, 2012).

Since its formation 4.5 billion years ago, Earth experienced dramatic changes in its climatic conditions a number of times. The principle triggers behind such changes can be attributed to a plethora of phenomenon. These include alterations in the Sun's intensity, volcanic eruptions, changes in configuration of continents and oceans, variations in Earth's orbit, variations in the concentration for atmospheric greenhouse gas, evolution of life and meteorite impacts, etc.

Indeed, millions of years ago the world's average temperature was more when compared to today. Warmer waters were present farther from the equator. The ocean and atmospheric circulation pattern was therefore much different from today. Every 100,000 years or so, over the past million years there have been fluctuations of globally averaged surface temperature by around 5˚C or so. The sea level has been estimated at 120 meters reduced around 20,000 years ago. This was during the coldest period of the ice age on earth. Water was confined in the land in

ice sheets. This temperature fluctuation have significantly stabilised over the last 8,000 years albeit being on the warmer end. It is this stability which educed progress in agriculture, permanent settlements and population growth.

Largely these previous changes in global temperature happened very gradually encompassing a period of over ten thousands or millions of years. There are however some records which indicate few abrupt changes at the regional level. For example, during the last ice age, temperatures in the North Atlantic region changed by more than 5°C within a few decades, likely owing to abrupt subsidence of Northern Hemisphere ice sheets or ocean current alterations.

A plethora of research evidence indicates that small but persistent influences trigger global climatic changes. Ice-age for example were commenced by small deviations of Earth's rotation thereby altering seasonal and latitudinal solar energy distribution on Earth. Measurements from climate archives such as ice cores show that changing temperatures triggered changes to other climate factors such as the concentration of carbon dioxide (CO_2), amplifying the initial disturbances. During warm periods, the major greenhouse gases were liberated into the atmosphere, and much less sunlight was reflected by the receding ice sheets. These observations confirm that the climate system is sensitive to small disturbances that can be amplified by reinforcing feedback processes. Likewise, the climate system today is sensitive to disturbances from human influences.

Notwithstanding some variations, global climate and sea level can be considered to be stable during the last ice age through the 19th century. From 1850 to 2012 the ambient air temperature at the surface of Earth has increased by 0.8°C on average (Cowtan and Way, 2014). From around 1850 the temperature progressively increased over the decades. The last decade has

been the warmest (see figure I.2). Satellite observations and direct measurements also show warming in the lower atmosphere over the past three decades. In contrast, the stratosphere temperature has decreased over this time. The greatest ocean warming has taken place close to the surface. The top 75 m of the ocean has warmed by an average of 0.11^{o}C each decade between 1971 and 2010 (Etheridge, 1996).

The effect is evident in several global phenomenons. This includes shrinking of mountain glaciers leading to global sea level increase since 1850, reductions of ice for Greenland and West Antarctic since 1990 again contributing to sea-level rise, a significant decrease in the ice over area and a 30 % decrease in the ice thickness of the Arctic Ocean since 1987, increase in the amount of atmospheric moisture since the 1980s, freshwater dilution from increased rainfall. There has also been a reported change in ocean currents due to changes in surface winds, ocean temperature and ocean saltiness. An increasing number of aquatic and terrestrial living beings, are undergoing shifts in their distribution and lifecycles that are consistent with observed temperature changes (IPCC, 2013).

Although the water produced after wastewater is treated is not fit for drinking, it is well suited to irrigation or use in district cooling systems and other industrial processes, where non-potable water can be utilised. Since recovering usable non-potable water from municipal wastewater cost only a fraction of the costs for desalination, wastewater treatment operations can be considered as an added source of water supply. Lowering desalinated water demand would also reduce energy consumption and the associated carbon emissions from the desalination process (Tuxford, 2013). The UAE aggressively started using wastewater for irrigation and the proportion of treated wastewater in total water use has reached 14% in 2013 (see 3-2-3). In the Emirate of Abu Dhabi, 60% of the 284 million m3 of sewage generated each year is currently

treated and reused. The remaining 40% is being discharged into the sea, affecting the environment and wasting the precious resource. In a new environmental plan from EAD announced in January 2014, Abu Dhabi aims to treat and reuse all of its wastewater to irrigate farms and parks by 2018. The main challenge is to efficiently link the supply and demand for treated wastewater as it cannot be stored under the prevailing climate (Leijen, 2012). A technical committee comprised of the utilities and regulators proposed an investigation into where new infrastructure is required and the cost and benefit associated with such infrastructure.

The possibility of turning waste into future energy sources has been explored. In the last few years, waste-to-energy is becoming an attractive option to the UAE as one of the best ways to manage the increasing amount of waste and a few projects are already ongoing. Al Qusais landfill site is one of the largest municipal waste collection sites in Dubai, receiving about 5,000 tonnes daily in the 3.5-km2 site. A project for extracting landfill gas was commissioned by Dubai Municipality in January 2012 and officially launched in July 2013. It was designed, constructed and implemented by an eco-venture Green Energy Solutions & Sustainability, with horizontal and vertical gas wells being drilled some 22 metres deep into the waste to extract gas.The network of 22-km underground pipes and twelve collection chambers collects a total of 6,000 m3 of gas per hour, most of which is currently burned in a flare. Even though this results in the release of CO2, the project has an overall environmental benefit since it prevents the release of methane (CH4), which is 25 times more potent to cause global warming than CO2. Therefore this has been registered as the UAE's first project under the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC), as reducing the emission by approximately 250,000t CO2e annually. To date, some

of the landfill gas recovered has also been used to generate 1 MW of electricity that can cover the landfill operation's energy needs.

The amount of gas recovered by this project would be enough to power a 12-MW engine. Dubai Municipality has pledged to generate 20 MW of power from landfill gas by 2020 (Todorova, 2014; WAM, 2013). Meanwhile, Emirates Gas is also setting up an advanced facility to compress methane from sewage and landfill sites in Dubai to be used as an alternative fuel for vehicles Neutral Fuels, a Dubai-based venture, struck a deal in 2011 with McDonald's, the world's largest fast-food chain, to convert the cooking oil used in all 80 of its UAE outlets into biodiesel at a factory located in the outskirts of the city. The waste oil collected from McDonald's kitchens is heated and chemicals are added, which turn into a fuel that can power specially adapted lorries. Under the agreement, McDonald's collect 22,000 litres of cooking oil a month in the UAE, and the biofuel now powers all of its UAE fleet without extra cost (Bitar, 2011).

Neutral Fuels had their eye on the McDonald's waste oil since it does not contain too much animal fat, water or particles and its quality and quantity are highly predictable. TAQA and Tadweer plan to build one of the world's largest waste-to-energy facilities at the Industrial City Abu Dhabi (ICAD) at an estimated cost of AED 3.1 billion (USD 840 million). The plant will receive approximately one million tonnes of municipal solid waste a year and convert it into 100 MW of alternative power, enough to power more than 20,000 households. It is expected to begin operations in 2016-17. As a pilot to this major project, they are developing a waste-to-energy demonstration facility on Delma Island, 32 km offshore the Western Region of Abu Dhabi, where waste is currently shipped to landfills in the mainland. Bee'ah in Sharjah also plans to build a similar facility near the emirate's main landfill site (Todorova, 2014; Todorova, 2013).

Waste collection is a both labour and energy-intensive process, involving hundreds of trucks and workers busily loading waste along pick-up routes. Aldar Properties, Abu Dhabi's leading property developer, has recently introduce an automated vacuum waste management system on Yas Island, the city's major leisure and entertainment destination. The system consists of 5.3 km of pipes that can suck 40 tonnes of waste every day from Yas Marina Circuit, which hosts Formula One Grand Prix races, Ferrari World, seven hotels and Yas Marina. Domestic waste can be deposited by hand at one of the 43 inlet points, which provide separate chutes for recyclable and non-recyclable materials. The vacuum created by motors whisks away waste to the central collection station through underground pipes at the speed of up to 75 km per hour. The collected waste is then compressed and transported to an off-site waste facility where it is further sorted for recycling or disposed of in the landfill. Even though this final part requires trucks, this new system saves up to 90% of truck journey times, greatly reduces emissions and provides a hygienic environment.

Since the majority of the UAE population are expatriates who live in the UAE for a short period of time, the country is an ideal place to buy and sell second-hand goods instead of opting for new items every time they need to acquire. Dubizzle.com is the leading free classifieds website launched by an entrepreneurial duo Sim Whatley and JC Butler in 2005 from a shared bedsit with little investment. It has been promoting the concept of "disrupting consumer exploitation" which means a service that allows a more sustainable way of living through trading secondhand goods. On this website, registered sellers can post the list of unwanted items – from cars and furniture to toys and books – with photos, specifications and asking prices. Potential buyers visiting the website can directly contact the sellers and some items could be sold within minutes. Within eight years of the launch, the website has seen extraordinary growth with 3.5

million unique visitors every month, and is now the largest local site, after Google and Facebook. It has become firmly ingrained in the UAE's day-to-day life. The company is expanding into the region and the website is now also available in Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia and Tunisia, employing over 150 people in total (Judge,2013).

Lack of tillable land, high heat, locust swarms, and limited water supplies are the primary barriers to agriculture. The renewable water available in the UAE are the lowest around the world. Against this backdrop, MoEW launched the UAE Water Conservation Strategyin 2010, which introduces an integrated approach to meeting future water demand through both investments in new water infrastructure and efficiency improvements to the existing water supplies. The ministry has focused on both water-efficient farming practices and sustainable development of water resources, including the development of dams and the appropriate maintenance of springs and streams.

Lack of arable land, intense heat, periodic locust swarms and limited water supplies are the main obstacles to agriculture. The renewable water resources in the UAE are among the lowest in the world. Against this backdrop, MoEW launched the UAE Water Conservation Strategyin 2010, which introduces an integrated approach to meeting future water demand through both investments in new water infrastructure and efficiency improvements to the existing water supplies. The ministry has focused on both water-efficient farming practices and sustainable development of water resources, including the development of dams and the appropriate maintenance of springs and streams.

Fisheries in the UAE are artisanal in nature while they still retain a significant heritage value and are an important part of social fabric of coastal villages. Fishermen's cooperatives in each emirate assist in marketing the catch. Demersal stocks and commercial catch rates have fallen sharply over the past decades. MoEW has introduced restrictions to control fishing activities and to regulate the size of capture. There are also initiatives to develop a series of artificial reefs to increase fish abundance, while investment in aquaculture has taken off to supplement supply (FAO, 2015). The country is also dedicated to the objectives of the U.N. Convention to Combat Desertification (UNCCD) and aims to continue improvements to the protections of sensitive habitats and underground water reservoirs, and to monitor desert land usage by integrated sustainable land management practices. The UAE National Strategy to combat deserts has been updated in 2014 in harmony with the UNCCD 10-year strategic plan.

Planted forests have provided a number of benefits to the desert country: providing greenery and amenities; combating desertification; protecting cities from sandstorms; providing natural sanctuaries for breeding animals; and protecting farmland and rangeland. Substantial investments in developing forestry in agricultural and rangeland areas and green spaces in urban areas have been made in the last few decades. Most forest plantations are established in fenced-off areas, while drip irrigation from groundwater, treated sewage effluent or desalinated water is used over the entire life of trees. It is estimated that each tree receives between 18-30 litres (l) of water per day, leading to an annual consumption of 2,135 m3 per hectare (ha) (FAO, 2008)

The UAE has earned the status of being one of the regional leaders in terms of the conservation of its environment and wildlife as well as associated scientific research. The protection of the terrestrial and marine environment is guaranteed by federal legislation and often supplemented by emirate-level decrees. To implement the UN Convention on Biological

Diversity (CBD), the UAE National Biodiversity Strategy and Action Planwas developed in 2014. It aims to ensure fragile ecosystems conservation with a special attention to endangered species, and to prevent the introduction of alien species. MoEW issued a resolution in 2014 which limits the use of some fishing tools and forbids the targeting of shark species protected under the UN Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES). The country has committed to the objectives of the U.N. Convention to combat Deserts (UNCCD) and aims to continue improvements to the protections of sensitive habitats and underground water reservoirs, and to monitor deserts using incorporated sustainable land management practices. The UAE National Strategy to Combat Desertificationhas been updated in 2014 in harmony with the UNCCD 10-year strategic plan.

A plethora of modern technologies are introduced in the traditional sector. Most UAE farmers rely on groundwater to irrigate their crops but the amount and quality of the country's groundwater reserves has been steadily declining after years of exploitation. MoEW has therefore given priority to increasing use of hydroponic technology, which relies on nutrient-rich water to grow plants with use of little or no soil. To date, there are 87 commercial farms using this technology. As lack of knowledge and experience is identified as a significant barrier to spreading this modern farming method, the ministry has started a series of lectures and field sessions around the country to educate farmers and their workers on correct use of such systems, in addition to providing financial support . (Todorova, 2014; Rowlins, 2014).

In the last few years, demand for organic food has rapidly risen among healthconscious consumers in the UAE. The country's organic market is valued at AED 367-550 million (USD 100-150 million) per year. However, the number of domestic organic farms is limited and most organic (as well as non-organic) foodstuff inevitably comes from abroad. Winning the trust of

consumers for claims made by producers is key to the successful dissemination of organic products, thereby encouraging local farmers to convert their practices. ESMA hence introduced an organic food certification scheme in February 2012 that is applied both domestic and imported foodstuff. The certification comes with a logo by which consumers can easily distinguish organic products from conventional ones. About half of the existing organic farms have already been certified and others are under process (Masudi, 2012).

Among the UAE's pioneering organic farms, one of the most distinguished is the 35-ha farm in Bani Yas, on the outskirts of Abu Dhabi city. There, around 75 men and women with autism and Downs Syndrome are making a living by growing organic vegetables under an initiative by the Zayed Higher Organisation for Humanitarian Care and Special Needs (ZHO). They grow, pick and pack five tonnes of vegetables (including cucumbers, cherry tomatoes and eggplants) every week and earn AED 2,500 (USD 680) per month. The farm also produces cheese from goats. In April 2013, Lulu Hypermarket signed a memorandum of understanding with ZHO under which Lulu would buy their agricultural produce. A similar deal has also been struck with Carrefour and the Abu Dhabi Cooperative Society (Kumar, 2013). Promoting local produce Farms across Abu Dhabi grow some 42 varieties of vegetables and fruits, with cucumbers and potatoes accounting for the bulk of the produce. About 14,000 farmers work with the Abu Dhabi Farmer Services Center (ADFSC) across the emirate and around 1,000 of them supply their produce to the centre. The ADFSC brands the locally sourced produce as 'Local Harvest' and markets it through 15 ADFSC Souq outlets, besides prominent retail chains. ADFSC is also rolling out "farmers' markets" around Abu Dhabi city where shoppers can purchase fresh products from the local farmers directly. Farmers can be observed when providing

fresh dates, fruits, vegetables, honey, and living birds to customers directly at those markets (Kader,2013).

In Dubai, a private business Ripe Farm Shop opened in 2011 where a mixture of seasonal vegetables are sold in boxes. Rapid expansion and popular demand has meant that the company now runs a weekly food and craft market in Dubai and Sharjah, as well as offering an online ordering and home delivery service (Shardlow,2012). In November 2014, a weekly market also opened on Saadiyat Island in Abu Dhabi, and has drawn an enthusiastic response from residents (Sankar, 2014).

To encourage sustainable seafood choices among consumers in the UAE, EWSWWF launched the Choose Wisely awareness campaign in 2009. As part of this campaign, the conservation group introduced a fish labelling scheme carrying red, orange or green tags depending on whether they are over-fished, rare or sustainably available in the country. The classification is based on scientific assessments carried out by fisheries experts at EAD. The heavily over-fished species where customers are urged to think twice before buying include the country's most popular fish such as hammour and shaari. Several supermarket chains such as Lulu Hypermarket, Choithrams and Spar participate in this scheme, while some local restaurants have started indicating the sustainability of fish on their menu (Dhal, 2010). As an alternative to the rapidly depleting local fish stock, the application of aquaculture has been gaining momentum in the last few years. The world's largest aquaculture farm (56,000 m2) was opened by Emirates AquaTech Caviar.

Farm in November 2013, utilising leading fish breeding technologies that allow for a financially viable, eco-friendly fish farming. Based in an industrial part of Abu Dhabi, the farm

produces premium caviar and sturgeon meat. With the maximum volume to 35 tonnes of caviar production and 700 tonnes of the sturgeon fish meat cuts annually, it could meet 10% of the world's Caspian caviar demand eventually. By supplying premium caviar all year round, the business is aiming to play a vital role in encouraging the protections of globally threatened sturgeon (Emirate AquaTech Cavier Farm, 2013; Al Bustani, 2014).

EAD is currently formulating an aquaculture development plan in collaboration with stakeholders. Hammour, cobia, qabit (gold-lined sea bream), yellowfin tuna and abalone, which are in high demand in the UAE market but whose stocks are seriously declining due to over-fishing, have been identified as priority species to promote farming in Abu Dhabi (Kader, 2014).

The Arabian Gulf has a rich and long tradition in natural pearls but the invention and introduction of cultured pearls by the Japanese in the 1920s killed off the trade that had been the lifeblood of the UAE for millennia. The RAK Pearls project aims to revive the pearling industry in the UAE by creating a unique attraction in the Emirate of Ras Al Khaimah. Established in 2005 as an EmiratiJapanese partnership, the project includes a tourist site dedicated to pearling, with a museum that combines education, experience and entertainment. It not only promotes tourism in the emirate but reinstates the pearling culture to the region which was once known for the most valued pearls in the world.

The RAK Pearls farm is located in a mangrove ecosystem and is culturing pearls using local Pinctada Radiata oysters. The establishing of a pearl farm in a sensitive ecosystem has put this zone under protection from rapid industrial development (Sustainable Pearls Project, UAE, 2015). The farm operates with almost 30 lines of beds and 200,000 shellfish. Some 40,000 implanted oysters are harvested each year with an 80% success rate. Only 5-10% of the pearls

are of the highest quality with rare lustre and colouring, which have been sold to exclusive clients, jewellers and royalty. In June 2013, some 5,000 pearls were sold at auction at the Dubai Pearl Exchange, the first trade of UAE pearls after several decades (Doran, 2013).

An energy service company (ESCO) arranges initial financing of energy-efficient equipment, subject to a guaranteed level of energy saving, and the owners can repay the cost of the equipment from the captured revenue streams. Dubai established in July 2013 a "Super ESCO", Etihad Energy Services Company to help jump-start local ESCOs, with a target of retrofitting over 30,000 existing buildings.

The Emirates Green Building Council (EGBC) has been the national operator of the internationally recognised Green Key labelling scheme since 2013. As of June 2014, 24 UAE hotels have been awarded this certification. Abu Dhabi plans to give all hotels in the emirate a green rating along with the existing star ranking.

Thanks to decades of intensive conservation work, Sir Bani Yas Island in Abu Dhabi's Al Gharbia region is now home to 68 bird species, about 13,000 free-roaming animals and several million plants, which are being appreciated by visitors. The Mangrove Natural Reserve of Kalba on the east coast is also scheduled to be developed as an eco-tourism destination by 2017.

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Our final phase of the study include an evaluation of the success and opportunities of UAE in these sectors. Various established assessment models have been developing for such an evaluation. Indeed a proper estimation of success and challenges will provide pertinent insights on whether UAE is at all capable of developing a green and sustainable future.

In order to guide the formulation of policy instruments as well as voluntary activities to the right course, it is critical to establish a set of indicators that will provide an effective compass for the monitoring and assessment of the progress, and that will help identify potential opportunities and risks. A framework of the UAE Green Economy Indicators was developed in a way to integrate environmental considerations into the conventional input-productivity-output economics model. This is intended to help policy makers and industry understand the dynamics of the economy-environment nexus. The Indicators are structured into the four categories -- Inputs, Efficiency, Outputs and Policies (See Figure III.3):

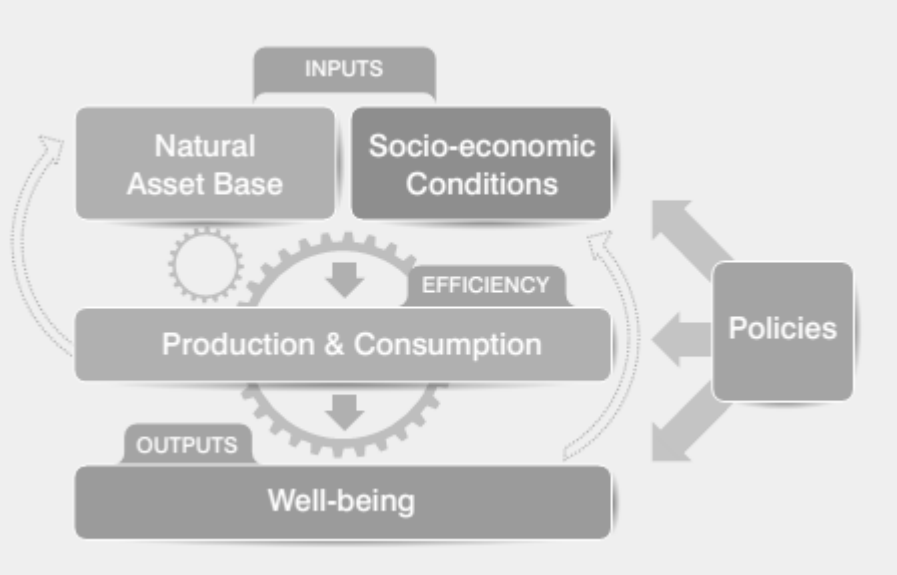

Figure III.3: Framework of the UAE Green Economy Indicators

Based on this framework, 30 performance indicators were defined, which originate from the recommendations from inter-governmental organisations and the input during the consultation process for developing the implementation plan of the Green Growth Strategy. Relevant National Key Performance Indicators (KPIs), which were developed to measure the fulfilment of the UAE Vision 2021, are also adopted as part of the indicator set. The 30 indicators were classified and coded according to the five groups (Figure ii):Inputs I: Natural asset base (N)Inputs II: Socio-economic conditions (C)Efficiency: Production and consumption (E)Outputs: Well-being (W)Policies(P)

The current UAE performance reviewed according to the Green Economy Indicators is summarised as below: Natural resource base: The UAE is blessed with the world's seventh largest oil and gas reserves which have transformed the desert country into one of the most advanced nations with high standards of living. Oil and gas have acted as the driving force of the UAE economy as the sector still provides around onethird of the total GDP. On the other hand,

land and soil resources suitable for agriculture are limited and subject to irrigation. Forest areas have increased by 30% between 1990 and 2012 owing to an extensive afforestation programme. Fish stocks in both the Arabian Gulf and the Gulf of Oman have recorded an alarming rate of decline (more than halved between 2002-11), while various natural and anthropogenic factors have caused the loss of biodiversity. The availability of freshwater (mostly groundwater) is one of the lowest in the world. The government enforces strategies and regulatory measures to protect those indispensable natural resources.

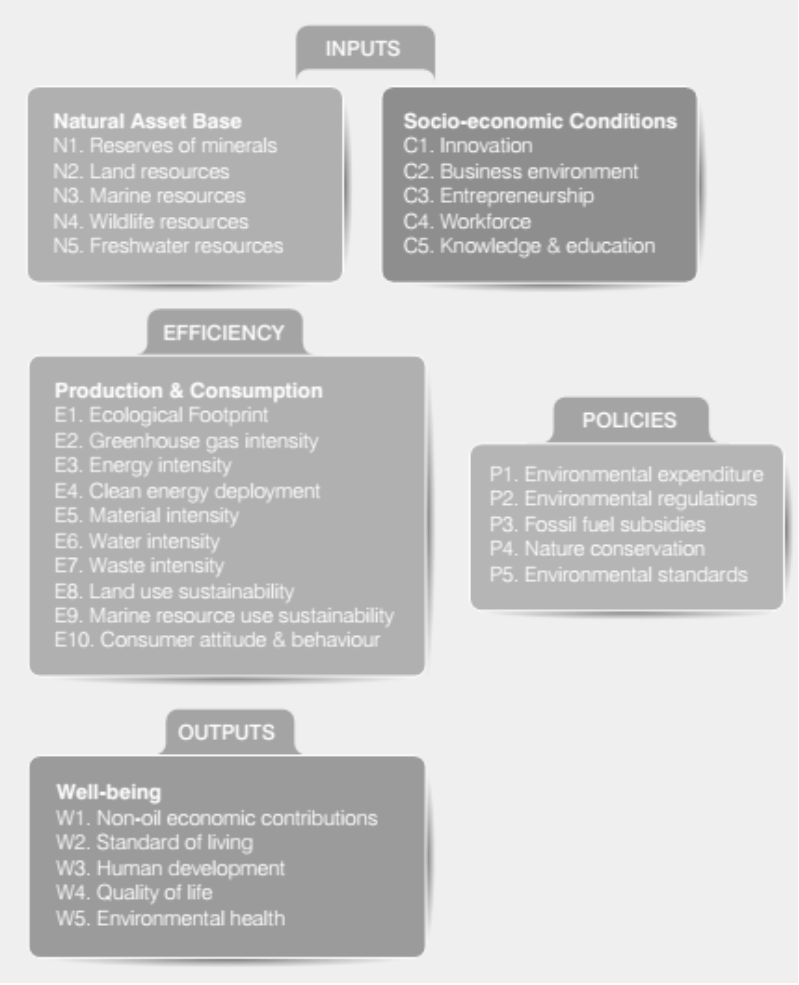

Figure III 4: List of the UAE Green Economy Indicators

Socio-economic conditions: The UAE was ranked 36th in the latest Global Innovation Index and has kept the leading position among the GCC countries. However, the country's R&D spending (0.49% of the total GDP) lags far behind the Organisation for Economic Cooperation and Development (OECD) member countries' average of 2.47%. The country's competitiveness in the global market is also perceived as quite high together with its business-friendly environment and improving entrepreneurship ecosystems. The UAE was ranked 12th in the Global Competitiveness Index 2014-15, 22nd in the 2015 East of Doing Business Index, and 20th in the 2015 Global Entrepreneurship and Development Index.

The country's working population is growing at a record pace, reaching around 6.25 million in 2012, 67.9% of the total population, while women's participation in the labour market is rapidly increasing (46.6% in 2012). The proportion of pupils who reached Grade 5 has risen from 95.0% in 1990 to 97.4% in 2010, having achieved near universal education at the first cycle. The number of graduates from the country's higher education institutions has been rapidly rising (over 19,000 in 2011-12), while there are also a large number of graduates from foreign universities.

Various variables have been considered in charge of such a disturbing increment in ocean levels. Heat extension in seas and loss of icy masses as a result of a dangerous atmospheric devation are likely the most vital elements. Perceptions demonstrate that an expanded release of water from the softening ice in Antarctica is now happening, especially from areas of Antarctic ice. Current models have the capacity to reproduce this increased stream of Antarctic ice sheets. These models bolster the rates of ice sheet misfortune that were utilized to gauge worldwide ocean level increment of 98 cm through 2100. It is anticipated that the ocean levels will endure to increment in the advancing years. It is however to be borne as a main priority that this system

of ocean level ascent is yet to be completely illustrated. Thusly a considerably higher ascent in ocean level than the anticipated worth can't be precluded. In reality, it is convoluted to decisively reproduce the varieties in the Antarctic and Greenland ice sheet release. Kept warming would bring about a practically finish loss of the Greenland ice sheet, bringing about around 7 meters to worldwide normal ocean level ascent.

This would happen over a warming edge evaluated to be between around 1°C and 4°C, of worldwide normal warming in respect to preindustrial temperatures. Current comprehension is inadequate to survey the timing or size of such a multi-century commitment from Antarctica, albeit there is expanding proof that it might as of now have initiated.

Territorial ocean level changes can be distinctive contrasted with normal in light of changes in sea streams, and changes in provincial climatic weight. Notwithstanding atmosphere driven ocean level change, nearby elements can likewise be critical and may overwhelm at a few areas. These incorporate tectonic area developments and subsidence coming about because of the extraction of ground water or hydrocarbons, residue stacking and compaction. Changes in residue supply can influence nearby disintegration/ gradual addition of the coastline. Rising ocean levels actuate a plenty of hindering outcomes on human presence. There is a possibility of more noteworthy seaside surges and expanded disintegration.

Production and consumption: The UAE’s per-capita Ecological Footprint was estimated as the 3rd largest (7.75 global hectares) in the world in the Living Planet Report 2014, after Kuwait and Qatar. The country’s total GHG emissions have increased from 74 million tCO2e in 1994 to 173 million tCO2e in 2012. Since 2007, the country’s annual electricity consumption has increased by more than 8% per annum, exceeding 100 TWh in 2012. The total use of steel has been steady since the sharp drop at the time of the financial crisis. Despite the lack of freshwater

resources, the per-capita intensity of water use has been among the world's highest as the daily consumption of water for domestic (household and commercial) purposes was recorded 353 litres per capita in 2013. The daily municipal waste generation was 1.82 kg per capita in 2014. Meanwhile, agricultural production in terms of weight has fallen to one-tenth of previous levels, and the area of cultivated land had been more than halved by 2012 since the peak in 2002 as the government aimed to reduce the cultivation of fodder crops which consume a large amount of water. The quantity of fish catches in the UAE keeps declining since the peak recorded in 1999, falling to less than two-thirds of the peak amount by 2012.

The positive news is that the relative decoupling of consumption from population and economic growth has started being observed in some areas. The GHG emissions per capita have declined by over 50% between 2005 (38.8 tCO2e) and 2012 (18.8 tCO2e), and emissions per GDP have also decreased by nearly a quarter during the same period (from 422 gCO2e/USD to 324 gCO2e/USD). The carbon intensity of electricity production has also been steadily improving as CO2emissions per kWh was 600 grammes in 2011, 34% decrease from the peak recorded at 913 grammes in 2004. Furthermore, the UAE has shown its ambition and leadership in advancing renewable energy technologies with the development of large-scale projects (138.5 MW capacity by 2013).Although the UAE's per-capita steel use was the world's highest until the crisis, it had dropped to the 5th position by 2013 (756.8 kg/capita/year) despite the rapid market recovery which resulted in many large-scale developments. The level of per-capita waste generation has been declining overall after the financial crisis and the relative decoupling of municipal water use from economic growth is also seemingly being realised. Meanwhile, the value-added by agricultural production is rapidly rising (USD 926.9/ha in 2012) due to the shift of cultivation from fodders to vegetables and fruits.

The government supports the dissemination of organic farming practices (4,446 ha by April 2014) and stimulates the recovery of fish stocks. Over 300,000 fingerlings were released and 3,600 coral reef colonies were farmed in 2013, while 15,000 mangrove trees were planted in 2012. It is also observed that environmental awareness and behaviour among residents have been rapidly improving in the last few years. As an overall index of those improvements, the UAE's Ecological Footprint shows a decline since 2010.

Well-being: The UAE's share of revenues from non-oil sectors has increased from 57% of the total GDP in 2001 to 67% in 2013, helping mitigate the impact from the fluctuation of oil revenues. The share of non-oil export in total export has also risen from 17.5% in 2001 to 28.5% in 2013. The gross national income (GNI) per capita, which indicates average personal income, was recorded at USD 58,090 in 2012. This was the 11th highest in the world though the level has been declining since 2004. The UAE's Human Development Index value has improved by nearly 30% from 0.640 in 1980 to 0.827 in 2013, positioning the country at 40th in the world, one of the "very high human development" group. The country was also ranked 14th, the highest in the Arab world in the World Happiness Report 2013, showing the positive trend in both perceived happiness and quality of life for inhabitants. The UAE's Environmental Performance Index results have shown a dramatic upturn from the 152th out of 163 countries benchmarked in 2010 (Score: 40.7) to 77th in 2012 (50.91) and 25th out of 178 countries in 2014 (72.91).

Policies: Since the issuance of the Federal Law No. 24 of 1999 as the fundamental law of environmental protection, laws, executive orders and ministerial decrees regulating specific environmental issues such as biodiversity, air quality and water conservation have been gradually promulgated. MoEW is making efforts to further develop regulations in emerging areas as its budget is steadily increasing. The designation of nature reserves started in 1995 and

the total number of terrestrial and marine protected areas has reached 35 by 2014. In addition to the conventional “command-and-control” policies, a market-based approach has started being introduced to encourage greener behaviour among industry and consumers. Local authorities are pursuing a utility tariff reform to encourage rational use of water and electricity and reduce fossil fuel subsidies. Eco-labelling and certification criteria have been established for air conditioning units, washing machines, refrigerators, light bulbs and water fixtures as well as organic food. Overall, the UAE has faced severe constraints in non-oil resources and a rapid rise in the consumption of energy, water and materials as well as in waste generation and GHG emissions. However, various different types of initiatives to overcome these issues have been initiated by both the public and private sector in recent years. The relative decoupling of consumption from population and economic growth has started being observed in some areas, while even higher quality of life is being enjoyed by people. The collected performance data should serve as a baseline for monitoring annual changes and analysing the interaction between different factors so as to better judge whether the country is on the right course towards a Green Economy and to plan effective Green Economy policies and initiatives. As elucidated by the above discussions, UAE does seem to be advancing in the proper direction for generating a green and sustainable future.

III.3 Summary of Findings

As stated before the UAE's due to rapid economic development, the country is facing serious environmental challenges that arise from the very high pace of population growth, the increase in the demand for energy and water, and the fast-paced urban development. On a per capita basis, the UAE's energy, water and carbon footprints are amongst the highest in the world as the hot and dry climate requires a high amount of energy and import of many goods which cannot be produced in the country. Meanwhile, there is an ever-increasing need for continued stewardship of limited natural resources. The importance of embracing a greener and sustainable lifestyle by UAE is well documented in the aforesaid discussions. An important consideration however is whether the socio-economic and political scenario in UAE is conducive to such metamorphic changes. Indeed a plethora of factors might act as the determinant factor for such transformation. These might include the geography of the region, environmental challenges, socio-economic landscape, mass participation, etc. The initial part of our research therefore focussed on understanding these factors with respect to their role in triggering green transformations.

Chapter IV Conclusion

A plethora of research has established that the anthropogenic activity triggered climate changes can elicit catastrophic consequences, jeopardizing the existence of life on earth. For assuaging such a looming peril, international organisations have recommended taking suitable steps so much so that the global mean temperature do not increase beyond 2° C. This can be achieved by intensive endeavours for attenuation of the carbon footprint by undertaking greener and sustainable approaches in diverse sectors of life including energy, water management, lifestyle etc. According to published reports UAE has virtually the highest carbon footprint in the world partially owing to its rapid development over the last few decades. Motivated by the inspirational and enthusiastic leaders, UAE is determined to take necessary measures to go green and sustainable in virtually each and every sector of life and living. The current research intends to evaluate various criteria to elucidate weather UAE is at all capable of a green and sustainable future. Such an assessment involves a detailed evaluation of a number of aspects including, motivation from the leadership, levels of awareness and motivation of the nationals, evaluation of the current achievements and future prospects. We also performed simulation studies for better explication. Overall our studies indicate that, notwithstanding that a plethora of works needs to be done on this arena; UAE definitely looks to be capable of a green and sustainable future.

Recommendations for Future Studies

Future studies can expand upon this research in a variety of ways. First, UAE continues to attract attention regarding how it can become water neutral as a community. Future research must target the UAE to encourage implementing policy that will help the area become water neutral. Secondly, future studies can develop new alternatives to educate the public to the

dangers of current policies on ecological sustainability. As the research suggests, the current trends show that the UAE is on a path that is simply not sustainable. It is possible to reverse these trends, but this will include educating the public to the concerns while also providing insights into how the public can do their part to reverse these difficult trends.

In closing, The UAE is currently in a position to embrace massive systematic changes to thwart the ever-present danger of global warming and threats to the water supply. The vast array of research suggests that remaining on this path will eventually lead to irreversible consequences for the people in UAE. However, there is still time to reverse these trends and allow the UAE to become a green country. There are many feasible options that have been outlined in this research study. First, stakeholders must join together and begin making policy changes that decrease the amount of hydrocarbons released in to the environment. Most notably is carbon dioxide; however, methane is also a major concern. Secondly, the country must implement policy changes that govern the amount of water that is currently consumed by the public. Effective management would essentially create a country with a significantly decreased water consumption volume. By eliminating wasteful practices the UAE can drastically improve its water consumption profile. The limitations of this study include new technologies that can help the country become more sustainable and green. Of course, any future advances in technologies that can easily remedy the issues with carbon dioxide, pollution, and water consumption are unforeseen and cannot be included in the discussion at this time. Nonetheless, it is very possible for the country to embrace a green and sustainable future, but this will require major policy changes and public support to execute such an aggressive plan successfully.

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