The United Arab Emirates

Initial National Communication to the United Nations Framework Convention on Climate Change

Ministry of Energy
United Arab Emirates

Foreword

On behalf of the government of the United Arab Emirates (UAE), it is my pleasure to present the UAE's "First National Communication" to the Conference of the Parties through the UNFCCC Secretariat in fulfillment of its obligations to the United Nations Framework Convention on Climate Change.

The UAE acceded to the United Nations Frame Work Convention on Climate Change in December 1995 and became an official UNFCCC party in March 1996 with a mandated commitment, as a Non-Annex 1 Party to the Convention, to submit its National Communications.

The National Communication has been prepared by a team of scientists and experts specializing in different disciplines and has been coordinated by the Ministry of Energy.

The UAE, a developing country with an economy highly dependent on oil exports, will be severely impacted by the response measures embraced by developed countries to meet their CO_2 emission reduction targets. Furthermore, the UAE is situated in a pristine dessert climate with scarce rainfall. Consequently, coastal areas, water resources, agriculture, sea level and ecosystems are all highly sensitive to further changes in climate. Long term minor variations in temperature and precipitation could have adverse effects due to the fragile nature of our environment.

The First National Communication has been prepared in accordance with the guide lines provided by the Intergovernmental Panel on Climate Change (IPCC) and reflects the information available at the time of writing this report. However, we intend to utilize this report as a base for the preparation of the UAE's 2nd National Communication, which we hope it will contain more detailed information.

I would like to seize this opportunity to thank H.H Sheikh Hamdan Bin Zayed Al Nahyan, Deputy Prime Minister and chairman of the Abu Dhabi Environmental Agency for his support. I would also like to thank all the parties and individuals who participated in the preparation of this report, and in particular, the Abu Dhabi Environmental Agency for their role in the compilation and preparation of this report.

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AIM	Asia Pacific Integrated Model
BAC	Biosaline Agriculture Center
CCC199	GCM from the Canadian Center for Climate Modeling
CDM	Clean Development Mechanism
CH_4	Methane
CHP	combined heating and cooling
CO	carbon monoxide
CO_2	carbon dioxide
CSI296	GCM from the Commonwealth Scientific and Industrial Research Organization
Dh	dirham
ECH498	GCM from the European Centre/Hamburg
EPA	Environmental Protection Agency of the USA
FNC	Federal National Council
FSC	Federal Supreme Council
GCAA	General Civil Aviation Authority
GCC	Gulf Cooperation Council
GCM	general circulation model
GDP	Gross domestic product
GFDL90	GCM from the Geophysical Fluid Dynamics Laboratory Transient
Gg	billion grams
GWP	global warming potential
Ha	hectare
HAD2TR95	GCM from the Hadley Centre for Climate Prediction and Research
HFC	hydrofluorocarbons
ICBA	International Center for Biosaline Agriculture
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
Kg	kilograms
km	kilometers
km^2	square kilometers
KTOE	thousand tonnes of oil equivalent
LDV	light duty vehicle
LPG	liquid petroleum gas
LUCF	Land-Use Change and Forestry
MAGICC	Model for the Assessment of Greenhouse gas Induced Climate Change
MCH	Maternal and Child Health
mm	millimeters
Mm^3	million cubic meters
MSW	municipal solid waste
N_2O	nitrous oxide
NMVOC	non-methane volatile organic compounds
NO_x	nitrogen oxides
ºC	degrees centigrade
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PFC	perfluourocarbons
ppm	parts per million
PV	photovoltaic
SCENGEN	SCENario GENerator
SF_6	sulfur hexafluoride
SLR	sea level rise

SO_2	sulfur dioxide
SRES	IPCC Special Report on Emission Scenarios
STAPPA/ ALAPCO	State and Territorial Air Pollution Program Administration and Association of Local Air Pollution Control Officials
SUV	sport utility vehicle
TAR	Third Assessment Report
UAE	United Arab Emirates
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VSD	variable speed drive
WHO	World Health Organization

Executive Summary

Located in Southwest Asia on the Arabian Penninsula, the United Arab Emirates (UAE) is a federation of seven Emirates – Abu Dhabi, Dubai, Sharjah, Umm al-Quwain, Ajman, Ras Al Khaimah and, Fujairah - that spans approximately 83,600 square kilometers. This area includes an archipelago that extends over the Arabian Gulf for about 5,900 square kilometers.

The country has an arid climate. Summers are very dry, stretching from April through the month of September, with temperatures rising to about 48 degrees Centigrade in coastal cities – with accompanying humidity levels reaching as high as 90%. In the southern desert regions, temperatures can climb to 50° Centigrade.

Population growth has been quite high, largely due to an ever-increasing expatriate labor force. Indeed, the country's population has grown dramatically from under 300 thousand in 1971 to over 4 million in 2004. Given the combination of a very dry region, rapid economic development, a fast-growing population, and a national policy that strives for agricultural self-sufficiency, water supply is of acute importance in the UAE.

The discovery of oil in 1958 in Abu Dhabi and 1966 in Dubai transformed the economy dramatically, enabling the country to move away from a subsistence economy toward a modern, industrial base. Total estimated oil reserves in the UAE are about 98 billion barrels, or nearly 10 percent of the world's proven oil reserves. The Emirate of Abu Dhabi, has about 94% of the UAE's total reserves.

Coupled with strong government policies for liberalization of the economy, the economy has grown significantly into one of the most open in the Middle East. Income levels per capita today in the UAE are among the highest in the Arab world, as are indicators for public health and literacy.

Although oil has been a driving force behind the UAE economy, economic diversification has been a concerted government strategy since about the mid-1980s. This strategy has led to the development of a number of new service sectors and hubs of non-oil industrial activities. Cities like Dubai, in particular, have emerged as an active international trading center, combined with a large tourism sector and dynamic real estate markets.

The UAE has always recognized the importance of conserving environmental resources, something it has striven to make a cornerstone of its developmental policies for present and future generations. Indeed, during the last three decades of the twentieth century, the UAE has achieved major steps in sustainable development including the establishment of a federal environmental agency, the formulations of a comprehensive national environmental strategy and legislation, and participation in numerous multilateral environmental agreements.

The UAE compiled its first-ever inventory of greenhouse gas emissions for the year 1994. The results of the UAE's national GHG inventory, discussed in detail in Chapter 2, are summarized in the Table below. Net carbon dioxide-equivalent emissions for 1994 amounted to 74, 436 Gg. The main gas emitted is carbon dioxide (60,246 Gg), which constitutes more the 81% of net CO2-equvivalent emissions.

Energy production and consumption is the dominant source of GHG emissions in the UAE. Energy-related CO_2 emissions from fossil fuel production and combustion are 60,246 Gg – about 95% of the CO_2 emission total. The energy sector also

emits the overwhelming share of all other GHGs such as methane and nitrous oxide. When combined with these other emissions, the energy sector accounts for about 95% of the CO_2-equivalent total.

Total GHG emissions in the UAE, 1994 (Gg)

Sector	CO_2-equivalent	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
Energy	70,879	60,246	396	5	162	836	95	18,310
Industrial processes	3,455	3,443	1	0	1	138	6	5
Waste management	2,552	0	108	0	0	0	0	0
Agriculture	1,777	0	48	2	0	0	0	0
Land use change & forestry	-4,227	-4,227	0	0	0	0	0	0
Total	**74,436**	**59,462**	**553**	**7**	**163**	**974**	**101**	**18,315**

Industrial processes account for about 4% of CO_2-equivalent emissions, almost all of it in the form of carbon dioxide. Waste management activities account for about 3% of CO_2-equivalent emissions, virtually all of it in the form of methane. Agricultural production accounts for about 2% of overall CO_2-equivalent emissions.

Finally, land-use change and forestry constitutes a sink of GHGs in the UAE. The amount of carbon dioxide sequestered in green parks exceeds the total emitted from all industrial processes. This fact is indicative of steady increase in the stocked volume of forest resources throughout the country.

The geographic region where the UAE is located will likely experience significant changes in climatic conditions in the coming years. Temperature projections in 2050, though containing significant uncertainty bounds, will be between about 1.6ºC and 2.9ºC warmer than they were over the period 1961-90, and between 2.3ºC and 5.9ºC warmer by 2100. Average annual rainfall in 2050 is projected to be between 20% less or up to 10% more than levels over the period 1961-90, and between 45% less or 22% more by 2100.

In addition to temperature and precipitation changes, the UAE will be affected by sea level rise associated with climate change. Global mean sea level is projected to rise by 9 to 88 cm between 1990 and 2100, with a central value of 48 cm, for the full range of SRES scenarios.

The combination of changes in temperature, precipitation and sea level pose significant risks to the UAE with its already very low levels of soil-water and nutrient reserves, and vulnerable coastal zones. Indeed, the vulnerability and adaptation assessment presented in Chapter 3 reveals many levels at which the UAE is potentially vulnerable. Its coastal zones, water resources, dryland ecosystems, agricultural production, human settlements, public health, and energy infrastructure are all considered to be highly sensitive to climatic changes.

There are a number of measures, technologies and practices that the UAE could consider to not only reduce GHG emissions but also contribute to the country's economic development. It is understood that there is no obligation under the Framework Convention to implement activities for the express purpose of achieving GHG emission reductions.

Nevertheless, the UAE has compiled this initial set of attractive strategies in an effort to demonstrate its solidarity with the international community in tackling the threat of climate change, as well as to inform future policy discussions. Chapter 4 describes a number of such initiatives. These include new appliance standards, high efficiency district cooling systems, rooftop solar photovoltaic systems, more efficient electric motors, solar powered desalinization plants, fuel economy standards for light duty vehicle imports, and landfill gas capture and use for power production are some of the measures that upon review show promise for reducing GHG emissions while promoting economic development.

A national action plan that focuses on climate change issues -- and which builds

on the work already completed in GHG inventory development, vulnerability assessment, and mitigation analysis – is the logical next step for the UAE to continue to address climate change issues. Future action will strive to increase public awareness of the threat of climate change, keep the UAE unique national circumstances clearly in view when formulating policy responses, and seek to identify and evaluate specific adaptation strategies. Such action will necessarily require a strengthening of national capacity at a number of level, as well as the development of stronger data systems and networks.

Chapter 1:

National Circumstances

1. National Circumstances

The United Arab Emirates (UAE) is a nation of dynamic social, economic, and ecological systems where sophisticated modern infrastructure exists side-by-side with desert landscapes and traditional eastern cultural practices. In this chapter, the country's main characteristics are outlined to provide a sense of the overall national context in which climate change challenges are being considered.

1.1 Geography

Located in Southwest Asia between latitudes 22.0° and 26.5° N and between 51° and 56.5° E, the United Arab Emirates (UAE) is a federation of seven Emirates – Abu Dhabi, Dubai, Sharjah, Umm al-Quwain, Ajman, Ras Al Khaimah and, Fujairah - that spans approximately 83,600 square kilometers (see Figure 1-1). This area includes an archipelago that extends over the Arabian Gulf for about 5,900 square kilometers.

Figure 1-1: The United Arab Emirates in regional context

Source: Environment Agency-Abu Dhabi

The UAE shares borders with Qatar to the west, Saudi Arabia to the south and west, and the Sultanate of Oman to the east and south. There are approximately 700 kilometers of coastline - 100 kilometers along the Gulf of Oman and 600 kilometers along the Arabian Gulf.

The UAE can be divided into 3 major ecological areas: coastal areas, mountainous areas, and desert areas. Over four-fifths of the UAE is classified as desert, especially in the western parts of the country.

Along the Arabian Gulf coast there are numerous offshore islands, salt marshes, and coral reefs. Along the Gulf of Oman, there are plains where appreciable rainfall and good groundwater resources have made agriculture possible. Interior regions of the country are characterized by vast stretches of desert interrupted by scattered oases, gravel plains, and the Hajar Mountain range, which reach an altitude of over 1,500 meters and extends along the northeast part of the country to Oman.

Arable land constitutes around 6.5% of the UAE's total land surface (UAE 2nd Report to UNCCD, 2002). Most of the cultivated land lies in four areas: a strip of land along the east coast, Al Ain, the oasis of Dhaid, and the gravel plains in Ras Al Khaimah.

1.2 Climate

The United Arab Emirates has an arid climate that is subject to ocean effects due to its proximity to the Arabian Gulf and the Gulf of Oman. Although generally warm and dry in the winter, coastal weather brings in humidity along with very high temperatures during the summer months. In the proximity of the Al Hajar al Gharbi Mountains, high altitudes lead to generally cooler weather conditions.

Two main seasons characterize the UAE's climate. Winter lasts from November through March, a period when temperatures seldom drop below 6 degrees Centigrade. Summers are very dry, stretching from April through the month of September,

with temperatures rising to about 48 degrees Centigrade in coastal cities – with accompanying humidity levels reaching as high as 90%. In the southern desert regions, temperatures can climb to 50° Centigrade.

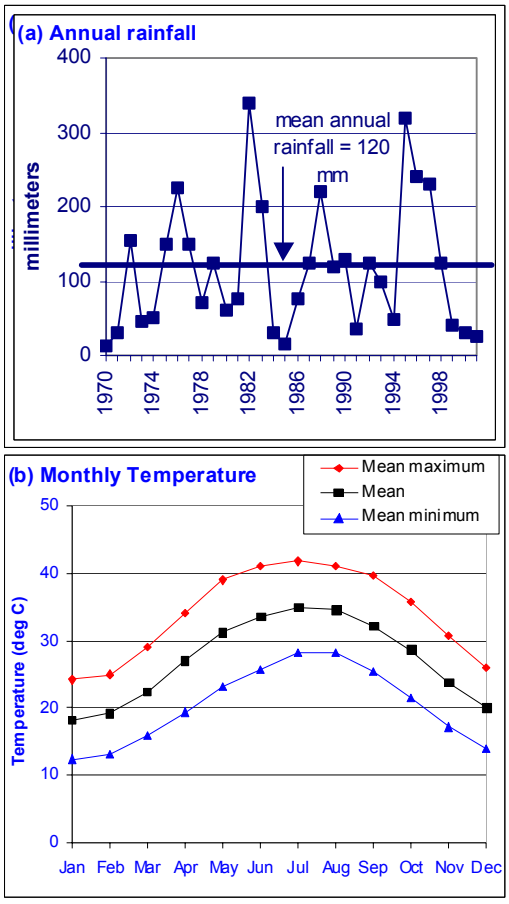
Most of the country is subject to violent dust storms with rainfall being infrequent and irregular. Humidity averages between 50% and 60% in coastal areas, and declines sharply inland where its annual average reaches 45%. Relative humidity is least during the month of May, and increases during winter months. Evaporation rates are typically very high, averaging about 8 mm per day. In desert areas, minimum temperatures can approach zero during the winter months, with large temperature fluctuations during the course of a typical winter day.

A combination of atmospheric depressions and northwesterly winds from the Mediterranean results in much of the rainfall occurring in the winter months, with February and March being the wettest months of the year. While summer rainfall levels are very low in the coastal areas, they are appreciable in the mountainous and southeastern regions, where annual average rainfall ranges between 140 and 200 mm/year.

Average annual rainfall over the period 1970-2001 is about 120 mm per year, with rainfall in the driest years being over 20 times below rainfall levels in the wettest years (see Figure 1-2). Average monthly rainfall patterns fluctuate widely throughout the year, with most of the rainfall occurring between January and April when temperatures are lowest. These rainfall levels, while showing a large range across the Emirates in the winter months (especially the month of March), are uniformly very low across the UAE during the summer months between July and October.

Average temperatures also show significant variation across the country as well as over time. The annual average temperature is about 27° Centigrade over the 1970-2001 period. Average monthly temperatures for the UAE over this period show clear trends (see Figure 1-2b). The range in maximum observed monthly temperatures is highest in the summer months, reaching nearly 6 degrees Centigrade across the UAE. The range in minimum observed monthly temperatures occurs during the winter months, when there is about 11 degrees between the minimum temperatures throughout the country.

Figure 1-2: (a) Average annual rainfall and (b) monthly temperature patterns



Source for annual rainfall: Al-Assam and Sattar, 2005; Source for monthly temperature: Ministry of Communication, 1996

1.3 Demography

The UAE population growth rate was about 6.8%/year over the period 1994 through 2004. While this growth rate is quite high, it is important to note that it is largely due

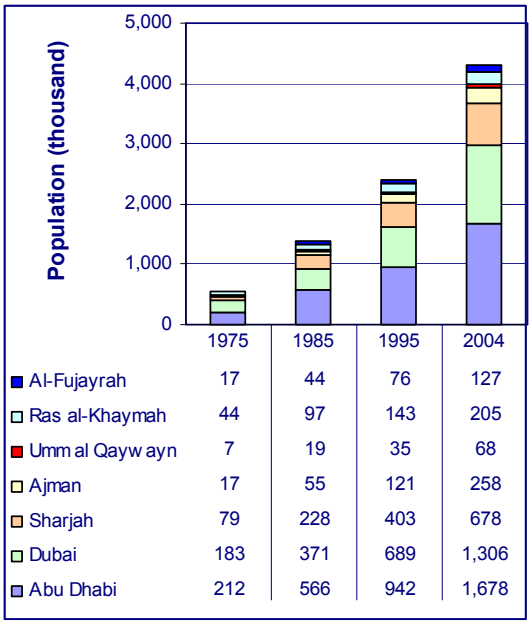
to an ever-increasing expatriate labor force. The natural population growth, a better indicator of how population is growing, actually decreased from about 2.2%/year to 1.3%/year over the period 1994 through 2004.[1]

In 2004, the total population in the UAE was estimated at about 4.32 million, a 6.9% increase from the previous year, and over 15 times the population in 1971 when the population numbered under 287,000. Steady decreases in the infant mortality rate, improvements in life expectancy, and the high influx of expatriates have contributed to making the UAE the second most populated country among the other five Gulf Cooperation Council (GCC) states (i.e., Saudi Arabia, Kuwait, Bahrain, Oman and Qatar). Population is unevenly distributed among the UAE.

The three most populous Emirates - Abu Dhabi, Dubai, and Sharjah - account for roughly 85% percent of total population. The remaining 15% live in *Umm Al Quwain, Ajman, Ras al Khaimah* and *Fujairah*. The overwhelming majority of the population lives in urban areas in coastal zones. The largest city, *Abu Dhabi*, the federal capital, had an estimated population of about 1,678,000 in 2004. *Dubai*, the second largest city and the UAE's main port and commercial center, had a population of about 1,306,000 in that year. The largest inland populations are around *Al Ain* near the eastern border with Oman. Figure 1-3 summarizes population trends by Emirate for several years over the period 1975 through 2004.

The high population growth rate among UAE citizens is most evident in younger age groups, especially those younger than 5 and between 20-44 years in age. The large number of expatriate workers falls within this latter age group. It is noteworthy that those older than 65 are predominantly UAE citizens.

Figure 1-3: UAE Population, 1975-2004



	1975	1985	1995	2004
Al-Fujayrah	17	44	76	127
Ras al-Khaymah	44	97	143	205
Umm al Qayw ayn	7	19	35	68
Ajman	17	55	121	258
Sharjah	79	228	403	678
Dubai	183	371	689	1,306
Abu Dhabi	212	566	942	1,678

Source: Ministry of Economy – Planning Sector

In 2004, there were 2,929,000 males and 1,391,000 females. This is a roughly 2:1 male-female ratio, and has been evident over many years due to the fact that expatriate workers are mostly male. Women have traditionally played an important part in society, enjoying the same legal status, claim to titles, access to education, and right to practice professions as men, all of which are set forth in the federal Constitution. Literacy among the women has risen from about 31% in 1975 to about 84% in 1995, contributing to high levels of women in the workforce. In 1995, the percentage of women working as federal employees was about 44%, with about 65% of all teachers being female.

Over the past three decades the UAE has invested heavily in public education. The UAE guarantees free access to primary through secondary schooling to all citizens, with primary education being compulsory. Steady improvements of the school system, combined with an increase in enrollment

[1] Natural population growth rate represents the percentage increase in a population per year related to births, and is expressed as the difference between the crude birth and crude death rate, divided by the current population. (*Source: Ministry of Health, Preventive Medicine Sector, UAE*)

and the number of adult education centers, have led to a leap from a 24% literacy rate for men in 1970, to the current 79% for men, and 84% for women.

1.4 Governance

Since 1971, when the interim constitution was written, power has been divided between executive, legislative, and judicial branches with legislative and executive powers being separated into federal and emirate jurisdictions. In addition, each emirate has its own local government, consisting of its own ruler, municipalities and departments. Each emirate retains a good deal of political and financial autonomy. The constitution was made permanent in 1996.

At the Executive level of government, the Federal Supreme Council (FSC) is the highest federal authority in the UAE and consists of the seven emirate rulers who elect a president and vice president every five years. As chief of state, the President is commander of the Union Defense Force and chairman of the FSC. The FSC is responsible for policymaking, as well as ratification of federal laws, international treaties and other agreements. Rulers of the emirates make decisions by simple majority vote unless it concerns substantive issues. Substantive issues call for a two-thirds majority (5 of the 7 rulers). The FSC meets four times a year, usually in an informal setting.

The Federal National Council (FNC) is the principal legislative authority. It is composed of 40 members, each of whom serves for a period of two years and is composed of appointed representatives from each of the seven emirates proportional to population. The FNC has both a legislative and supervisory role. Through its various functions, the FNC has an overarching mandate to promote national development in a consultative way that is compatible with traditions. In December of 2005, the Federal Supreme Council announced that half the members of the FNC would be elected.

The Council of Ministers or Cabinet, described in the Constitution as 'the executive authority' for the Federation, includes the usual complement of ministerial portfolios and is headed by a Prime Minister, chosen by the President in consultation with his colleagues on the Supreme Council. The Prime Minister then selects the ministers, who may be drawn from any of the Federation's component emirates, although, naturally, the more populous emirates have generally provided more members of each Cabinet.

1.5 Economy

Prior to the discovery of oil and natural gas, each of the emirates that now constitute the UAE had similar economies – all based upon subsistence fishing, pearl harvesting, herding, rural handcrafts, and some agriculture. Except for the construction of wooden boats and simple handicrafts, there was virtually no industrial activity across the UAE.

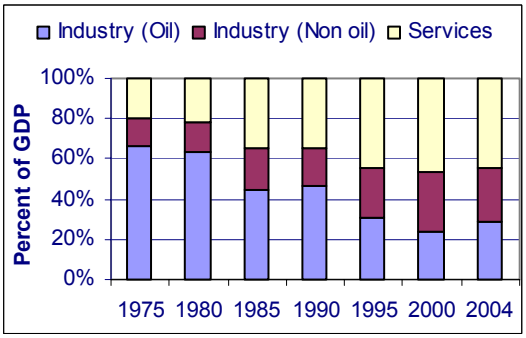
The discovery of oil in 1958 in Abu Dhabi and 1966 in Dubai transformed the economy dramatically, enabling the country to move away from subsistence and toward a modern, industrial base. Coupled with strong government policies for liberalization of the economy, the economy has grown significantly into one of the most open in the Middle East. Income levels per capita today in the UAE are among the highest in the Arab world.

Although oil has been a driving force behind the UAE economy, economic diversification has been a concerted government strategy since about the mid-1980s. This strategy has led to the development of a number of new service sectors and hubs of non-oil industrial activities (see Figure 1-4). Cities like Dubai, in particular, have emerged as an active international trading center,

combined with a large tourism sector and dynamic real estate markets.

Combined with revenues from foreign investments, the diversification of the UAE economy has increased the resilience of the UAE to recurring changes in oil prices. By 2004, the contribution of non-oil economic activity to overall GDP resulted in a share just over 77% (see Table 1-1 for a breakdown by sector). Development of the non-oil sectors continues – it increased by 5.2% in 2003 from the previous year - and reflects a determined government focus to temper adverse impacts associated with oil price volatility.

Figure 1-4: Evolution in the UAE GDP profile



Sources: 2004 and 2006 Statistical Yearbooks

The UAE has also established Free Zones in different Emirates as an additional incentive to promote industrial activities. Companies that are legally involved in industrial production outside UAE and are within a Free Zone can be issued an Industrial license.

Table 1-1: GDP profile, 2004

Non-financial enterprises	**86%**
Oil & gas	29%
Other mining	0%
Agriculture, livestock & fishing	3%
Manufacturing	14%
Water & Electricity	2%
Construction	8%
Trade	10%
Transport, Storage & Communication	7%
Real estate & Business Services	8%
Restaurants & Hotels	2%
Other services	2%
Financial enterprises	
Finance & Insurance	**7%**
Government services	
Government services	**8%**
Total	**100%**

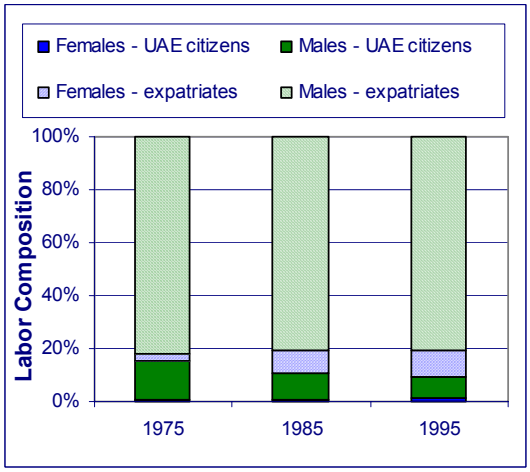
Source: UAE 2006 Yearbook

There are eight free zones in UAE, 3 in Dubai (Jebel Ali and Dubai Airport, and Dubai Technopark), 2 in Sharjah (Al Hamryah and Sharjah Airport), 1 in Fujairah, 1 in Ajman. and 1 in Ras Al Khaymah.

Thus far, there is a general consensus that the performance of these zones has validated the country's liberal economic policies while providing a valuable hedge against the volatility of oil markets.

Economic progress has produced a steady demand for large numbers of skilled and unskilled laborers. Since 1975, the structure of the labor market of the UAE has reflected a heavy dependence on foreign labor and a growing entry of women into the workforce (see Figure 1-5). Of the nearly 1.3 million people in the workforce in 1995, about 90% were people from other countries, and roughly 12% were women.

Figure 1-5: Labor composition



Sources: ElHiraika & Hamed, (2002)

1.6 Environment

The UAE has always recognized the importance of conserving environmental resources, something that is an important foundation to its developmental policies for present and future generations.

During the past three decades of the twentieth Century, the UAE has achieved

major steps in sustainable development covering economic, social and environmental fields. In addition, the UAE has promoted investments and diversified the sources of its national income to reduce its economy's oil dependency and has promoted environmentally friendly industrial growth.

There are a number of efforts that focused on protection of the environment, including:

- Establishment of an Environmental Agency at the federal level, as well as other environmental institutions at the Emirate Level.
- Formulation of the National Environmental Strategy and National Environmental Action plan which was completed in 2000, with the following priorities for future action: water resources, pollution (water, air, waste), marine environment, urbanization, land resource degradation, and biodiversity.
- Development and endorsement of major environmental and sustainable development related laws and regulations. These include Federal Law No. (24) of 1999 "Concerning Protection and Development of the Environment", which is the first comprehensive environmental law in UAE at the federal level.
- Formulation of the National Action Programme and Strategy for Combating Desertification in UAE in 2003.

The UAE is endowed with a variety of important terrestrial, coastal, and marine ecosystems. Much of the terrestrial ecosystems in the UAE consist of rangelands, which are an integral part of the nomadic heritage of its people, and continue to provide important areas for forage, green cover, pasture, water and recreation. Plant and tree species able to survive in the harsh environment conditions have developed a uniquely adapted genetic biodiversity able to withstand high temperatures, extreme drought and elevated levels of soil salinity.

Coastal ecosystems in the UAE have experienced an intensification of anthropogenic activities over the past three decades. These activities mostly include fishing, urbanization, industrial development, oil extraction, port and coastal support facilities, land reclamation, aquaculture and tourism.

Figure 1-6: Typical rangeland in the UAE

Source: Brown, et al., (2003)

The shallow saline lagoons and mudflats are important winter-feeding grounds for millions of Arctic and central Asian migrant shorebirds, including wildfowl, waders, gulls and terns. The sheltered tidal lagoon at Khor Dubai, within Dubai's city limits holds over 50,000 birds at any one time during the winter season and is internationally important for its large migrant flocks of Lesser Sand Plovers and Broad-billed Sandpipers and Greater Flamingo.

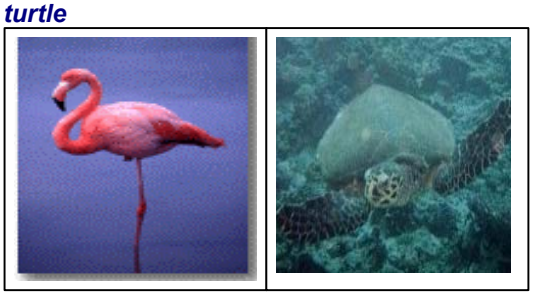
Figure 1-7: Mangrove forest in Umm al Quwain lagoon

Source: Ministry of Agriculture and Fisheries

These shallow coastal waters are also places where mangrove forests thrive.

These forests are important natural vegetation that can enhance biodiversity and provide a moderating localized micro-climate. Since 1985, the UAE has been supporting mangrove research as well as the cultivation of mangrove trees in inter-tidal zones of lagoons and islands as a way of restoring organic matter that can be utilized by bacteria, plankton, shellfish, crabs and various fish species. Moreover, efforts are underway to ensure that future development activities in coastal areas apply an integrated coastal zone management approach.

Figure 1-8 Greater flamingo & green sea turtle



Source: www.datadubai.com/birds.htm; and /...turtles.htm

Marine ecosystems include important coral communities and seagrass beds, as well as numerous offshore islands in the Arabian Gulf that are used as nesting sites for turtles and birds. These islands also have a rich reptile fauna of geckos and lizards. A variety of marine animals are relatively common in UAE waters and include whales, dolphins, dugongs, and sea turtles (hawksbill and green turtles), the latter two being globally important endangered species.

The Dugong Population in the Arabian Gulf is believed to be the second largest in the world after Australia. The Arabian Gulf is considered to contain the most important dugong habitat in the western half of the dugong's range. Four core areas were identified as being the most important areas for dugongs in the Arabian Gulf. One of these areas is between Abu Al Abyad Island, Jabal Dhannah and Bu Tinah shoal in UAE.

In a Survey conducted by the Environment Agency of UAE Waters in the Arabian Gulf in summer 2000 and winter of 2001 (Al Ghais & Das 2001), the population of Dugongs in the survey zone (five zones over 34 transects covering 6,075 km^2 in summer and 6,697 km^2 in winter) was estimated to be 1,861 individuals in summer and 2,185 in winter (UNEP/IUCN, 2002).

To promote the conservation of wildlife, UAE has declared a total of 14 areas - 6 terrestrial and 8 marine with a total area of around 4,406 km^2 – to be protected.

1.7 Water Supply

Given the combination of a very dry region, rapid economic development, a fast-growing population, and a national policy that strives for agricultural self-sufficiency, water supply is of acute importance in the UAE. The Ministry of Agriculture and Fisheries[2] through its departments of Water & Soils department is the national agency responsible for the management of irrigation water, dams and metrological data.

Despite the fact that there are no perennial streams in the country and rainfall produces far less than annual demand for water, the UAE is currently the world's third largest per capita water consumer after the US and Canada. In 2005, the total water consumption in UAE was about 4,180 Mm^3. As illustrated in Figure 1.9, the agricultural sector was the largest consumer (2,508 Mm^3, or 60%), followed by domestic consumption (1,045 Mm^3, or 25%), industrial activities (376 Mm^3, or 9%) and landscaping (251 Mm^3, or 6%).

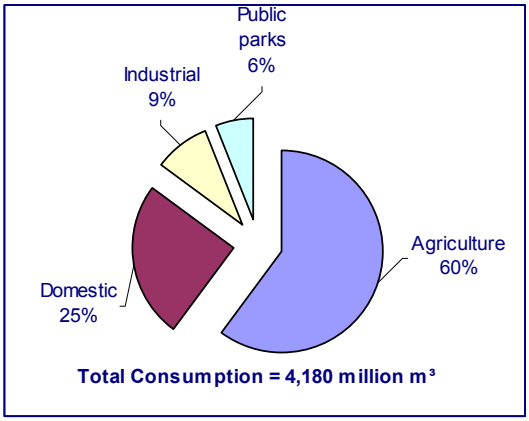
Water supplies to meet growing demands consist of three types: groundwater and two types of unconventional water resources: desalinated water, and treated wastewater.

[2] now called the Ministry of Environment and Water.

The latter two types of water supply have become essential in addressing an ever-growing gap between available natural water and water demand in the UAE.

Groundwater is used solely for meeting domestic water demand in rural areas and for the cultivation of high value crops, including those in the forestry sector. Groundwater is located in four main aquifers (see Figure 1-10) that are recharged annually by about 120 million m^3, equivalent to less than 5% of annual water consumption in the Abu Dhabi Emirate alone.

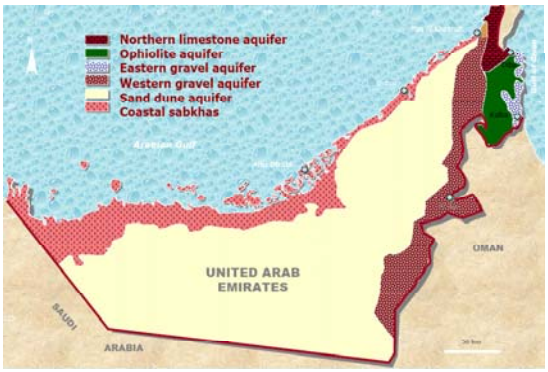
Figure 1-9: UAE water use, 2005



Source: World Bank, 2005

The main aquifer system is the Quaternary aquifer system, comprising alluvial gravels and sand on both sides of the northern Oman Mountains in the eastern region of the country. This aquifer system contains the largest reservoir of fresh groundwater storage in UAE, with total annual extraction equal to about 2,650 Mm^3 (Dawoud, 2005).

Figure 1-10: UAE aquifers



Source: Al-Assam and Sattar, 2005

Consistent overuse of limited groundwater resources has led to a lowering of the water table by more than one meter on average over the last two decades, and has exacerbated saltwater intrusion in the coastal area soils and groundwater. Other conventional water resources include man-made water channels (falajes), and small dams.

In an effort to maximize the capture and use of rainfall, the Ministry of Environment and Water has constructed 113 recharge and storage dams to utilize the estimated 150 million m^3 per year from 15 main catchment areas. The UAE's nine largest recharge dams have a combined capacity to collect 47 Mm^3 of flash flood water a year while the other 104 smaller dams have a combined capacity to collect about 60 Mm^3 of flood water each year.

The traditional *falaj* system is another approach to capture and use rainfall in the UAE. A falaj is a man made channel or tunnel that intercepts the groundwater table through a single or several wells at the foot slopes of high mountains, then it brings water to the surface through a tunnel that has a slope gentler than the natural hydraulic gradient. Of the about 40 operational falajes, most lie in the Eastern Region. According to the Environment Agency of Abu Dhabi, the average annual discharge of falajes is about 31 Mm^3.

Regarding the production of desalinated water, at present there are 22 desalination plants/stations in the UAE, with a total Installed Capacity of about 906 million imperial gallons/day (1,504 Mm^3/Year) (Source: Ministry of Energy-Electricity and Water Sector, 2004). Water desalinization is an efficient process in the UAE with co-production of electricity and the reuse of the exhaust heat produced. Regarding the production of treated wastewater, about 265 Mm^3 was produced in UAE in 2005. This treated wastewater is used exclusively for the irrigation of green parks and

recreational areas (source: Environment Agency-Abu Dhabi, 2005).

While there is currently no national water resource management strategy in place, a variety of water conservation measures are being implemented throughout the UAE, especially in the agricultural sector where plant suitability, crop replacement and drip irrigation techniques are being promoted to save water. Public awareness campaigns are also underway in Emirates such as Abu Dhabi to educate the general public about the importance of water conservation. Finally, a long-term plan for the conservation and development of water resources in a sustainable manner is being prepared and scheduled for completion in 2008.

1.8 Energy

In contrast with the region's limited water resources, the UAE has access to some of the most extensive sources of oil and natural gas in the world. Under the UAE constitution, each emirate controls the exploitation of its hydrocarbon reserves.

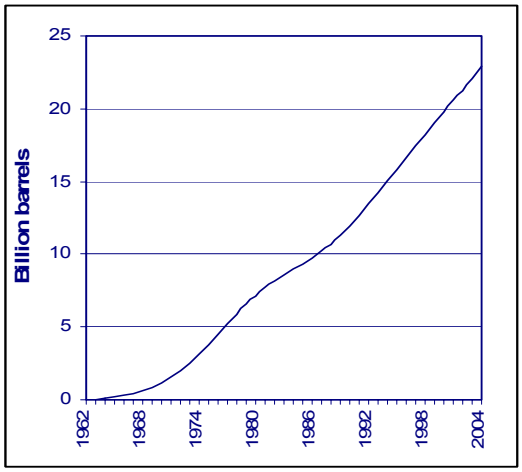
At the federal level, the Ministry of Energy combines the former roles of the Ministry of Petroleum & Minerals and the Ministry of Electricity & Water, in the coordination of oil production activities.

Total estimated oil reserves in the UAE are about 98 billion barrels, or nearly 10 percent of the world's proven oil reserves. The Emirate of Abu Dhabi, has about 94% of the UAE's total reserves, with proven crude oil reserves estimated at 92.2 billion barrels. Dubai has the second-largest reserves in the country with 4 billion barrels, followed by Sharjah with 1.5 billion and Ras al-Khaimah with 100 million barrels.

UAE's oil fields began production in the early 1960s. By the end of 2004, nearly 23 billion barrels had been extracted (see Figure 1-11). Over the past decade, exports have typically accounted for nearly 90% of total oil production. At production at the 2004 OPEC production quota, there are over 100 years left of crude oil reserves available for extraction in the UAE.

The UAE also possesses significant amounts of natural gas. The UAE ranks fifth in the world in terms of the size of its reserves, after Russia, Iran, Saudi Arabia and Qatar. Natural gas is also concentrated in the emirate of Abu Dhabi, which has 196.1 trillion cubic feet, followed by Sharjah with 10.7 trillion cubic feet, Dubai with 4.1 trillion cubic feet and Ras al-Khaimah with 1.2 trillion cubic feet. In response to growing national energy demand, the UAE has begun to encourage the use of natural gas in electricity production and increased investments in the natural gas sector. The UAE also exports significant amounts of liquefied natural gas.

Figure 1-11: UAE Cumulative oil production



Source: UAE 2006 Yearbook

The UAE is a member of the Organization of the Petroleum Exporting Countries (OPEC). Abu Dhabi joined OPEC in 1967, four years before the UAE was formed. The UAE, together with the four other largest oil producers in the organization - Saudi Arabia, Kuwait, Iraq and Iran – are in possession of more than 60% of global oil reserves and currently provide world oil markets with around 16 million barrels per day.

Of the seven emirates in the UAE federation, the Emirate of Abu Dhabi possesses the largest hydrocarbon resources. The leader of the Abu Dhabi emirate, His Highness the late Sheikh Zayed bin Sultan, had the foresight to require oil and gas companies to eliminate flaring as a condition of operation. This was codifed into Law No. (8) issued by the ruler of the Abu Dhabi court, and then issued by an Emiri Decree as far back as July of 1978 - well before the challenge of climate change.

1.9 Transportation

Transport in the UAE has kept pace with the pace of its economic development, with great strides in going from a landscape of desert and sand dunes to an infrastructure consisting of roads, ports, and airports.

As of the end of 2003, about 4,030 km of paved highway have been constructed in the UAE. The principle road connects the key coastal cities, running from Shaam to the northwestern border where the UAE meets with roads to Saudi Arabia and Qatar. Car ownership is about 200 vehicles for every thousand people as of 2003 and in recent years has been growing at the rate of about 2% per year. There are growing efforts in the development of sustainable transportation policies in UAE. One such effort is reflected in the metro project in Dubai, which if scheduled for completion in 2009 (1st phase) and 2012 (2nd phase).

Maritime trade has been a feature of the UAE economy for many centuries and continues to bring trade to the region. Strategically situated on the Arabian Gulf, the UAE is located on the important trade route between Europe and South East Asia. In addition to the 15 commercial ports (including oil terminals), there are also numerous smaller fishing harbors along the UAE coastline. These ports export raw materials, finished goods, and oil; they import goods and raw materials for local industry and consumers. The UAE is ranked among the world's top five locations for ship supplies and bunkering.

Over the last 20 years, the UAE's aviation industry has steadily expanded, improving business and encouraging tourism. Today the UAE has six international airports, which have recorded a 5% increase in aircraft movement from 2002 to 2003, a passenger throughput increase of 11.2%, and cargo traffic exceeding 49.5 million metric tonnes. The General Civil Aviation Authority (GCAA), which has facilitated this boom in the air transport sector, has also developed a strategic plan for 2004 – 2013 that calls for continued economic diversification, expansion of the aircraft fleet, and increased capital expenditure by the GCAA on infrastructure and equipment.

1.10 Public Health

In the earlier stages of the development of public health services, the main challenges were to reduce the disease burden of communicable diseases, treat minor ailments and ensure safe child bearing. The health infrastructure was developed in a manner that gave precedence to preventive and other services including health education, primary health care, maternal and child health care, and school health services. These services were provided and made easily accessible for the entire population including the rural areas. Systematic development and upgrading of secondary and tertiary care services were also undertaken simultaneously.

In subsequent phases, the emphasis has gradually shifted to the provision of preventive services for non-communicable diseases, control of environmental hazards and accidents, and provision of more sophisticated curative care. This shift in policy was warranted by the mounting toll from chronic diseases such as diabetes, hypertension, cancer, coronary heart disease and accidents that were a consequence of the higher standards of

living that accompanied the rapid socioeconomic development in the UAE.

By the year 2004, the UAE had achieved much progress in the field of preventive and curative health services emulating in contemporary international standards. Health status indicators have improved significantly since 1990 as evidence by the following facts:

- Infant Mortality Rate fell from 11.4 per thousand live births in 1990 to 8.71 per thousand in 2004.
- Under-5 mortality rate decreased from 14.4 per 1000 live births in 1990 to 10.58 in 2004.
- Maternal Mortality Rate diminished from 0.3 per thousand live births in 1990 to zero in the year 2004. In fact no maternal deaths have been reported in UAE since 1997.
- Average life expectancy at birth has increased from 70 to 74 years for males and from 72 to 76 for females during the past decade and is now comparable to that of developed nations.

The United Arab Emirates has succeeded in controlling the spread of communicable diseases through various preventive and public health measures, including the Expanded Program of Immunization, which has achieved an overall coverage of 94% of the target population.

The country has been polio free since 1992, measles is in its advanced stages of elimination, and tuberculosis is well controlled. The last case of malaria was reported in 1997 and currently there is a procedure underway to obtain a certification from the WHO that the UAE is free of malaria.

At present UAE has a well-developed healthcare infrastructure consisting of 57 hospitals, 124 primary health centers, 106 Maternal Health Clinics (MCH) clinics, 612 school health clinics, 77 dental clinics, and 713 pharmacies. These are widely and equitably distributed in rural and urban areas. The 36 government hospitals with 6256 beds and 21 private hospitals with 827 beds provide a total of 7,083 beds with a bed population of 2.28 per 1000. The human resource indicators for the year 2000 showed that doctor to population ratio was 2 per thousand, dentist to population ratio 1.1 per thousand and nurses to beds ratio 1.45 per bed.

Public spending, mainly through budgetary allocations, accounts for nearly 80% of healthcare expenditure. Private spending on the other hand, incurred mainly out of pocket and voluntary private insurance, remained an inconspicuous source of health expenditure.

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Chapter 2:

Greenhouse Gas Inventory

2. Greenhouse Gas Inventory

According to the IPCC, human activities in pursuit of development, such as fossil fuel combustion, industrial processing, intensive agriculture, land-use change and forest utilization, and waste management have caused the release of greenhouse gas (GHG) emissions into the atmosphere. These emissions are producing a discernable human influence on the planet's climate. GHG emissions consist of carbon dioxide (CO_2), the major greenhouse gas, as well as a number of other gases known to contribute to the greenhouse effect. These other gases include methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), and carbon monoxide (CO).

Among other commitments, every party to the UNFCCC has an obligation to regularly submit a national inventory of GHG emissions, by source and sink. Such information will assist the international community to systematically quantify all present day and expected anthropogenic emissions, employing comparable methods to assess the global impacts of such emissions. The UAE is committed to this process and has undertaken the task of compiling its first-ever inventory of greenhouse gas emissions for the year 1994. The results of this effort are provided in this chapter.

2.1 Introduction

The preparation of the inventory has been conducted as a consultative process among analysts across several Emirate and federal ministries in the UAE. It is believed that the inventory process not only has created a national GHG profile for the UAE that can be used within the larger global framework, but it can also assist the nation in formulating climate-friendly development goals and strategic mitigation policies.

2.2 Methodology

The Environment Agency of Abu Dhabi has facilitated the preparation of the national GHG inventory in cooperation with the Ministry of Energy and other concerned parties in the UAE. The revised IPCC Guidelines (1996) were used in which GHG emissions are calculated for the source and sink categories identified in the different sectors. There are five major sectors considered in the inventory, namely energy, industrial processes, agriculture, land-use change and forestry, and waste management.

The development of the UAE GHG inventory used the most recent version of the software tool developed by IPCC/OECD/IEA for use in compiling national inventories. The use of the IPCC methodology and the software tool was an important factor as it contributes toward the international goal of standardizing the system for emissions inventory and reporting, by meeting basic requirements of consistency, comparability, completeness, and transparency.

Following the revised IPCC guidelines, carbon dioxide (CO_2) methane (CH_4) and nitrous oxide (NO_2) emissions were examined and quantified using the best available information. Nitric oxides (NO_x), sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOCs), hydro fluorocarbons (HFCs), and carbon monoxide (CO) were also considered. Extensive cross-checks were conducted for accuracy by the national inventory team. The specific methods related to each sector and associated subsectors are discussed in the relevant sections below.

Data Sources, Coverage, & Reliability

Data on emissions-generating or sequestering activities were collected mainly from national sources as much as possible, though secondary sources such as international statistical databases, published research, statistical reports, and related studies were also used as necessary.

Data was often available in formats that suit government planning purposes, but do not necessarily address all the information required when using the IPCC methodology. This highlights a need for the development of reliable databases within each sector, to provide complete and standardized types of information.

Emission factors were based on IPCC default values and conversion coefficients, and adjusted to reflect local conditions, where possible. Locally derived default values were used in the land-use change and forestry, waste management, agriculture and industrial sectors. Where actual data was not available, expert judgment was relied upon.

Treatment of Uncertainty

A major objective of the IPCC methodology is to assist national experts in reducing uncertainties to a reasonable minimum. However, uncertainties are inherent in any estimate of national emissions and can arise from different interpretations of source/sink categories, use of average values (especially default emission factors), and incomplete scientific understanding of the basic GHG emission and sequestration processes. Sector-specific uncertainties encountered by the national inventory team are discussed in the subsections in this chapter.

Assumptions and Justifications

A number of assumptions were made in the application of the IPCC methodology and default emission factors, to the UAE context. Similarly, a number of assumptions have been made in order to justify the use of locally derived values, intended to better represent the explicit local conditions of the UAE.

2.3 Energy Sector Inventory

In the UAE, the primary sources of energy are fossil fuels. Energy supply is characterized by an overwhelming dependence on oil and natural gas. Biomass accounts for less than 0.1% of energy supply. GHGs emitted from the energy sector are mainly CO_2, CH_4, and NO_x. CO is also emitted but to a lesser degree.

Energy production and consumption data was obtained from a variety of sources. These included government ministry and department records, particularly Abu Dhabi Crown Prince data (Crown Prince Court, 1999). As this data was highly aggregated, the national inventory team also relied on energy statistics contained in the International Energy Agency's *Beyond 20/20* database (IEA, 2005) which provided sectoral breakdowns of energy use.

Crude oil production during 1994 in the UAE totalled 2,160 thousand barrels per day (107.6 million tonnes of oil equivalent), with exports of 1,930 thousand barrels per day (96.1 million tonnes of oil equivalent). Natural gas production for 1994 totaled 22.5 billion cubic meters (19.3 million tonnes of oil equivalent), of which about 85% was consumed within the UAE and the balance exported. The UAE did not in 1994 – nor does now - allow any oil or gas flaring from its oil and gas operations.

Total energy consumption in 1994 was about 23,468 kTOE. Of this total level of consumption, almost 30% (6,673 kTOE) was consumed in the form of gasoline, diesel, LPG, kerosene, residual oil, and other refined oil products. About 70% (16,447 kTOE) was consumed as natural gas, and less than 0.1% (23 kTOE) was consumed in the form of charcoal.

The transport sector is entirely dependent on petroleum, accounting for about 50% of

total oil product consumption. The electricity sector relies on natural gas for over 96% of its fuel supply, with the balance provided by diesel (3%), residual oil and crude oil (both less than 0.5%). The manufacturing and construction industries also rely heavily on natural gas, with about 85% of total energy consumed coming from this energy source, with the balance provided mostly by residual fuel oil.

GHG emissions in the energy sector are summarized in Table 2-1. A total of 60,246 Gg of carbon dioxide was emitted from energy activities. For methane, a total of 396 Gg was emitted.

Table 2-1: Greenhouse gas emissions, 1994: energy sector (Gg)

	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total Energy	**60,246**	**396**	**5.2**	**162**	**836**	**95**	**18,310**
Fuel Combustion	*60,246*	*5*	*5.2*	*160*	*348*	*22*	*18,293*
Energy Industries	16,991	4	4.0	41	22	0	0
Manufacturing Industries and Construction	24,764	0	0.4	63	96	5	0
Transport	17,683	0	0.7	55	229	16	0
Other Sectors	809	0	0.1	1	0	0	0
Fugitive Emissions from Fuels	*0*	*391*	*0.0*	*2*	*488*	*73*	*17*
Oil	0.00	16	0.0	2	488	73	17
Natural Gas	0.00	200	0.0	0	0	0	0
Venting and Flaring	0.00	174	0.0	0	0	0	0
International Bunkers	*17,885*	*0*	*0.5*	*53*	*222*	*15*	*17*
CO2 Emissions from Biomass	*107*	*0*	*0.0*	*0*	*0*	*0*	*0*

2.4 Industrial Processes Inventory

The contribution of the industrial sector to the UAE's GDP was large – about 60% in 1994 with 35% contributed by the oil & gas activities and the balance from non-oil activities (i.e., manufacturing and mining). This reflects the industrialized nature of a modern, growing economy.

Only a handful of the industrial activities described by the IPCC methodology are practiced in the UAE. These include the production of cement, lime, limestone, ammonia, nitric acid, urea, and aluminium. Greenhouse gas emissions associated with various processes in this sector are primarily CO_2, NMVOC, HFCs, CO, and SO_2. Data used in this assessment was obtained from a secondary source (ERAS, 2005), which relied on official statistical records provided by officials in the Ministry of Economy and Planning, as well as various factories.

For industrial processes, only those GHGs that were emitted from physical and chemical transformation processes were considered in the inventory. Several limitations and uncertainties were encountered in developing the inventory, as outlined below.

- *Cement production*. actual levels in 1994 were estimated from factory capacity and annual operation information, due to the fact that statistical information regarding actual production levels were not available at the time the inventory was developed.
- *Ammonia and aluminium*. Emission factors corresponding to the specific processes used in the UAE were not available. Therefore, an average of various types of processes in use at the time of the development of the inventory available was used as an approximation.

The GHGs emitted from industrial processes are summarized in Table 2-2 for 1994. Not surprisingly, the GHG emitted in the largest quantity is carbon dioxide, with 3,443 Gg emitted. There is only 1 Gg of methane emitted and no nitrous oxide emissions.

The largest share of carbon dioxide emitted in industrial processes in the UAE is associated with the production of clinker – an intermediate product from which cement is made. Cement production accounts for

45% of annual carbon dioxide emissions. The other major sources of carbon dioxide from industrial processes are ammonia and aluminium production, accounting for 25% and 24% of total carbon dioxide emissions, respectively.

Table 2-2: Greenhouse gas emissions, 1994: industrial processes (Gg)

								HFCs		PFCs		SF6	
GHG >>>	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	P	A	P	A	P	A
Total industrial processes	**3,443**	**1**	**0**	**1**	**138**	**6**	**5**	**0.0**	**0.0**	**0.0**	**0.8**	**0.0**	**0.0**
Mineral Products	*1,622*	*0*	*0*	*0*	*0*	*0*	*1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Cement Production	1,562	0	0	0	0	0	1	0.0	0.0	0.0	0.0	0.0	0.0
Lime Production	60	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical Industry (ammonia production)	*860*	*1*	*0*	*0*	*4*	*6*	*0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Metal Production	*961*	*0*	*0*	*1*	*134*	*0*	*4*	*0.0*	*0.0*	*0.0*	*0.8*	*0.0*	*0.0*
Iron and Steel Production	136	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Aluminium Production	825	0	0	1	134	0	4	0.0	0.0	0.0	0.8	0.0	0.0
Other Production	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Production of Halocarbons and Sulphur Hexafluoride	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Consumption of Halocarbons and Sulphur Hexafluoride	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0

P = Potential emissions based on Tier 1 Approach. A = Actual emissions based on Tier 2 Approach. This only applies in sectors where methods exist for both tiers.

2.5 Waste Management Inventory

In the UAE, there are two principal sources of GHG emissions from the waste management sector: municipal landfills and wastewater treatment. Small amounts of nitrous oxide are associated with human sewage.

The decomposition of organic waste in solid waste landfills occurs in a mainly anaerobic (oxygen free) environment, and represents the dominant source of methane (CH_4) emissions from waste management activities. The generation of municipal solid waste (MSW) in the UAE is high, typically greater than 1.5 kg per person per day, comparable to generation rates in industrialized countries. In Dubai, Sharjah, and Abu Dhabi, about 25% of MSW is diverted to compost plants. For the other emirates, there is 100% landfilling of MSW. At present, there is no recovery of methane emitted from solid waste disposal sites in the UAE.

There are two major factors that determine the annual quantities of GHG produced from landfills, namely management practices and the physical characteristics of the landfills. Management practices include type of waste management system such as managed – covered, compacted, leveled, unmanaged which are deep or shallow sites not meeting the requirements of a managed system. Physical characteristics refer to the structural composition of the waste, its moisture content, and the pH of the associated leachate.

The second major source of GHG emissions in the UAE waste management sector is from the treatment of domestic and commercial wastewater, which contributes to methane emissions. Wastewater is treated anaerobically in the UAE, resulting in methane emissions as organic matter is degraded in the process. In Dubai, about 65% of the methane associated with the sludge from the treatment process is recovered and does not escape to the atmosphere.

GHG emissions from industrial liquid wastes and sludge handling were difficult to estimate due very limited or unavailability of data and varied types of disposal within the UAE. Some is discharged directly into anaerobic lagoons in the desert, which are about 4 – 6 meters deep in combination with domestic and commercial liquid waste. Other industrial wastes are treated entirely on-site, while a large quantity is treated entirely off-site at municipal wastewater treatment plants and accounted for in the domestic and commercial estimates.

Increasingly, industrial wastewater is partially treated on-site before recycled or discharged to the sewer and treated at municipal wastewater treatment plants. This is due to trade waste discharge permit for certain quality of wastewater to be achieved prior to sewer discharged or

removed from factories in tankers operated by specialized waste disposal services.

The GHGs emitted from waste management activities are summarized in Table 2-3 for 1994. Of a total of 108.3 Gg of CH_4 emitted, about 95 Gg are from solid waste disposal and the balance 13 from wastewater treatment. Human sewage accounts for 0.2 Gg of nitrous oxide emissions.

Table 2-3: Greenhouse gas emissions, 1994: waste sector (Gg)

	CH_4	N_2O
Total Waste Management	**108.3**	**0.2**
Solid waste disposal	*95.1*	*0.0*
Wastewaster treatment	*13.2*	*0.0*
Human sewage	*0.0*	*0.2*

2.6 Agricultural Sector Inventory

Agriculture is an important sector in the UAE, accounting for about 3% of GDP in 2004 (Ministry of Information and Culture, 2006). The country produces a wide range of crops and has a large animal population of camels, cattle, poultry, sheep and goats. The UAE's agricultural development experience has earned the country international acclaim for turning portions of the desert into highly productive agricultural areas.

GHG emissions in this sector come from several sources, including enteric fermentation, manure management and agricultural soils. From these sources, the key GHGs are CH_4 and N_2O. There is no burning of agricultural residues in the UAE. Data was collected from the Ministry of Agriculture and Fisheries as well as several other sources and assembled in the IPCC Guidelines worksheets.

Enteric fermentation produces methane emissions from the population of cattle, sheep, goats, camel, horses, mules, and poultry. Manure management produces nitrous oxide emissions associated with animal wastes from livestock and poultry manure, bedding and litter, dairy parlor wastewater, feedlot runoff and wasted feed materials. Current regulations prohibit the direct application of raw manure to cropland. Agricultural soils also produce nitrous oxide emissions, based on the physio-chemical characteristics of UAE soils.

Several types of uncertainties were encountered, mostly in the form of the emission factors. The IPCC's default emission factors were used except in the case of enteric fermentation where national experts provided alternative methane enteric fermentation emission factors of 52 and 35 kg/head/yr are used for dairy and non-dairy cattle, respectively, based on the fact that such animals tend to be larger in the UAE than the rest of the region, with about 20% raised on commercial farms where the aim is to maximize meat and milk production.

The GHGs emitted from waste management activities are summarized in Table 2-4 for 1994. Of a total of 48.4 Gg of CH_4 emitted, all of it is from enteric fermentation. A total of 172.3 Gg of nitrous oxide was produced, with about 116.5 due to manure management and 55.9 Gg associated with agricultural soils.

Table 2-4: Greenhouse gas emissions, 1994: agricultural sector (Gg)

GHG>>>	CH_4	N_2O
Total agricultural activities	48.4	172.3
Enteric fermentation	48.4	0.0
Manure management	0.0	116.5
Agricultural soils	0.0	55.9
Field agricultural residue burning	0.0	0.0

2.7 Land Use Change and Forestry Inventory

Planned land-use changes, careful management, and increases in the tree stock have caused trees in the UAE to be a significant sink for the sequestration of GHG emissions.

Data for this component of the inventory was obtained from recent documents and published reports of the Ministry of

Agriculture and Fisheries. In addition, national expert opinion was used to fill data gaps in some tree categories, or to modify and adapt default factors to the UAE's specific circumstances. Data was collected for the 1984 to 1994 period, and converted to suit IPCC guidelines.

The historical background for the carbon sequestration numbers for the land use change and forestry inventory is significant. A little over a quarter century ago, the UAE consisted of towns built of adobe atop a landscape covered with sand with little if any green cover outside of some isolated oases. Today, multi-lane thoroughfares are lined on both sides by shrubs, date palms and other trees, while the major cities boast extensive green park areas.

Also, today farms and forests cover a significant portion of the land, and many of the UAE's islands have been partially greenified. With the proliferation of small farms, incentives given to farmers by the government and the adoption of modern agricultural techniques, substantial change in land use patterns have become evident. Citrus trees are now widely planted, motivated partly by a national desire to become self sufficient in food production in the near future.

Tree planting and greening activities have also been increasingly practiced by homeowners who have been incentivized to green their property by government subsidies of free plants and trees. In public areas, and state-supported green parks are prevalent in cities like Abu Dhabi and Al Ain. Moreover, roads in many parts of the country are now edged by rows of trees, while many islands, to some extent, exhibit coverage with orchards and tree plantations.

There are about 40 million, mostly newly planted palm trees in the UAE, consisting of 37 different species. Progress in the cultivation of palms has increased their number to 20% of all date-palms in the world – leading to the production of over 250,000 tons of dates, making the country one of the largest date producers and processors in the world.

There are also vast areas of newly planted mangrove forests lining the coastline of the UAE. For the past 20 years, new stretches of the UAE coastline have been greened by the salt tolerant mangrove. Today, these patches of greenery have become important habitats for varieties of birds, fish and invertebrates. The Ministry of Agriculture and Fisheries provided the data that was sued as the source for number of trees planted.

In conducting the Land-Use Change and Forestry (LUCF) inventory, two primary sources of uncertainty were encountered. First, total number of trees planted, by type, could only be obtained for the Abu Dhabi emirate. For Dubai, only a total number of trees planted was known. For the other five emirates, no information was available. Secondly, the annual growth rate of urban trees could only be roughly estimated. Best estimates of national experts were used to fill data gaps for particular types of trees.

The total amount of carbon dioxide sequestered from land use change and forestry is summarized in Table 2-5. The roughly 63 million trees planted in the UAE contributed to the sequestration of 4,227 Gg of carbon dioxide in 1994. It is important to note that this level exceeds all of the carbon dioxide emitted from industrial processes in the UAE.

Table 2-5: Greenhouse gas emissions, 1994: land use change and forestry (Gg)

Number of Trees (1000 trees)	63,253
Average annual Growth Rate (kt dm/1000 trees)	0.0364
Carbon Fraction of Dry Matter (%)	50%
Total Carbon Uptake Increment (Gg CO_2)	4,227

2.8 National Summary

The results of the UAE's national GHG inventory are summarized in Table 2-6.[3]

[3] Global warming potentials (GWP) of 23 for methane and 296 for nitrous oxide were used to

Net carbon dioxide-equivalent emissions for 1994 amount 74,436 Gg. The main gas emitted is carbon dioxide (60,246 Gg), which constitutes about 81% of all CO_2–equivalent emissions. This amounted to less than 0.5% of global emissions in that year.

Energy production and consumption is the dominant source of GHG emissions in the UAE. Energy-related CO_2 emissions from fossil fuel combustion are 60,246 Gg – about 95% of the CO_2 emission total. The energy sector also emits the overwhelming share of all other GHGs. When combined with these other emissions, the energy sector accounts for about 95% of the net CO_2-equivalent total.

Industrial processes account for about 4% of CO_2-equivalent emissions, almost all of it in the form of carbon dioxide. Waste management activities account for about 3% of CO_2-equivalent emissions, virtually all of it in the form of methane. Agricultural production accounts for about 2% of overall CO_2-equivalent emissions.

Finally, land-use change and forestry constitutes a sink of GHGs in the UAE. The amount of carbon dioxide sequestered in green parks exceeds the total emitted from all industrial processes. This fact is indicative of steady increase in the stocked volume of forest resources throughout the country.

Table 2-6: Total GHG emissions in the UAE, 1994 (Gg)

Sector	CO_2-equivalent	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
Energy	70,879	60,246	396	5	162	836	95	18,310
Industrial processes	3,455	3,443	1	0	1	138	6	5
Waste management	2,552	0	108	0	0	0	0	0
Agriculture	1,777	0	48	2	0	0	0	0
Land use change & forestry	-4,227	-4,227	0	0	0	0	0	0
Total	**74,436**	**59,462**	**553**	**7**	**163**	**974**	**101**	**18,315**

compute CO_2-equivalent emissions, as per the IPCC.

2.9 Recommendations for Enhancing the Quality of the GHG Inventory

It is important to develop a programme to enhance the accuracy of the UAE's national GHG emissions inventory. A reliable and verifiable greenhouse gas emissions database is a prerequisite for compliance with the Framework Convention, and is vital to the UAE's ability to identify opportunities for mitigating emissions or enhancing its sinks. Based on the experience gained in developing the first national greenhouse gas inventory, there are several efforts that should be carried out, as outlined below.

In the near-term, the highest priority areas are to strengthen the institutional structure for carrying out future assessments, and to develop a set of emission factors that better represent conditions in the UAE. Specific recommendations are as follows:

- **Institutional strengthening:** It is recommended that a national system be established in order to develop protocols for GHG data collection, monitoring, reporting, and verification associated with future updates to the national inventory. Ongoing capacity building efforts will be needed in methods and tools for ensuring that an inventory updating system – including database development - is both sustainable and of high quality.
- **Improvement of local factors:** Locally developed GHG emission factors should be used in place of the IPCC default values in future updates to the inventory. Studies should be carried out regarding enteric methane production from livestock, as well as emissions of nitrous oxide from organic soils.

In the mid- to longer-term, the highest priority is to address the gaps in the data available. Efforts to improve data availability and quality should be

principally targeted at the following sectors:

- **Energy:** Conduct an assessment of all sources of local data for energy production and consumption across the UAE. Develop a centralized, comprehensive, systematic, and regularly maintained database of energy information for the UAE.
- **Industrial:** Conduct surveys to better represent the production of local industries, and the use of various types of fuels in industrial facilities.
- **Agriculture:** Collect data on nitrogen emissions associated with animal waste management.
- **Waste:** Data needs to be collected regarding the amount of solid waste generated in urban and rural areas.
- **Land Use Change and Forestry:** Conduct an assessment of all tree plantings by tree type across the UAE. Develop a centralized, comprehensive, systematic, and regularly maintained database of tree planting information for the UAE.

2.10 List of References

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Chapter 3:

Vulnerability and Adaptation

3. Vulnerability and Adaptation

According to the IPCC's Third Assessment Report, arid and semi-arid regions of Asia are moderately to highly vulnerable to the effects of climate change. With already very low levels of soil-water and nutrient reserves, the effects of climate change on these regions may be among the first observed on the planet. Indeed, over the coming decades, assuming continued anthropogenic interference with the climate system, there is likely to be rising sea levels, adverse fluctuations in the hydrological cycle, as well as changes in both the level and distribution of rainfall. All of these events pose potential impacts that can seriously affect social, economic, and natural systems whose degree of vulnerability can vary considerably across regions and within countries.

An assessment of vulnerability and adaptation options is a critical component of the UAE's response to the threat of climate change. There are many levels at which the UAE is potentially vulnerable as its coastal zones, water resources, dryland ecosystems, agricultural production, human settlements, public health, and energy infrastructure are all considered to be highly sensitive to climatic changes. These are the focus of this assessment which should both promote a better understanding of the specific issues faced by the UAE with regard to climate change, as well as offer initial guidance regarding the national strategies and priority areas of intervention.

3.1 Projected Climate Change

Arid regions such as the UAE are sensitive to global climatic changes and the effects they produce. In their climate simulations, the IPCC has determined that temperatures in the Arabian Peninsula region could increase by 1ºC to 2ºC by the 2030-2050 time period, while precipitation levels could significantly decline (TAR, 2001; Al Shindagah, 2001).

In assessing the implications of these broad shifts in climatic patterns on the vulnerability of sensitive systems within the UAE, an initial step was to develop a plausible characterization of the range in future climatic change in specific areas within the UAE. This involved bracketing the potential range in long-terms changes in temperature and precipitation through the use of four different GHG emissions scenarios and five general circulation models (GCMs) (see Box 3-1). For the most part, the Asia Pacific Integrated Model (AIM), developed by the National Institute of Environmental Studies in Japan, was the emission model selected.

Using a software tool called MAGICC/SCENGEN, temperature and precipitation outputs for each scenario-GCM combination were generated at the regional level and then scaled to eight cities within the UAE, as follows: Abu Dhabi, Dubai, Sharjah, Al-Ain, Ras al-Khaymah, Khawr Fakkan, Umm al-Qaywayn, and Ajman. The projected change in annual temperature and rainfall shows significant variation across the various GCMs, scenarios considered, and selected cities in the UAE.

Projected Temperature Changes

Annual average temperatures in 2050 are projected to be between about 1.6ºC and 2.9ºC warmer than they were over the period 1961-90, and between 2.3ºC and 5.9ºC warmer by 2100. These trends, illustrated in Figure 3-6, suggest that an already hot climate will become even hotter putting additional stresses on a variety of systems.

Box 3-1 Emission scenarios & GCMs

a) SRES Scenarios and "storylines"

- **A1B:** a future of rapid economic growth, low population growth, and new technologies, with a balance of progress across all technology in the energy system. Future carbon emissions under this scenario are in the mid-range.
- **A2:** a future of self-reliance, preservation of local identities, and slow technological change. Future carbon emissions under this scenario are among the highest.
- **B1:** a future of clean energy and other global solutions to sustainability, low population growth, and low GHG emissions. Future carbon emissions under this scenario are among the lowest.
- **B2:** a future that focuses on environmental protection and social equity at the local and regional levels. Future carbon emissions under this scenario are in the mid-range.

b) Global circulation models

- **CCC199:** Canadian Center for Climate Modeling, Canada
- **CSI296:** Commonwealth Scientific and Industrial Research Organization, Australia
- **ECH498:** European Centre/Hamburg Model 4, Germany
- **GFDL90:** Geophysical Fluid Dynamics Laboratory Transient, USA
- **HAD2TR95:** Hadley Centre for Climate Prediction and Research, Climatic Research Unit, Unified Model 2 Transient, UK

In absolute terms, these projected changes imply that average annual temperatures in the UAE could reach as high as 33ºC by 2100 (see in Figure 3-7). In contrast, the average annual temperature over the period 1961 to 1990 in the UAE was about 27ºC.

Projected Rainfall Changes

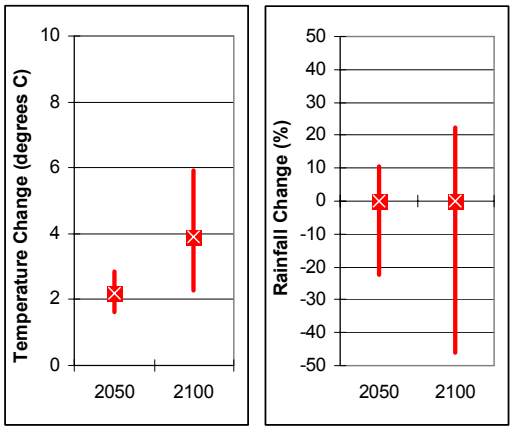
The projected change in annual rainfall is more varied. Rainfall in 2050 is projected to be between 20% less or up to 10% more than levels over the period 1961-90, and between 45% less or 22% more by 2100. These trends, also illustrated in Figure 3-6, suggest the possibility of an increasingly arid region with decreasing precipitation, while also leaving open the possibility that of a wetter region experiencing significant increases in precipitation.

In absolute terms, these projected changes imply that minimum annual rainfall levels in the UAE could remain level at about 0.25 mm/day (see Figure 3-7). Maximum rainfall level could increase slightly from 0.9 mm/day, on average, over the period 1961 to 1990 to about 1.25 mm/day.

Spatial Variability

Not surprisingly, given their proximity to each other coarse resolution of the GCM models, there is very little variation between cities for any of the scenario-GCM combination considered.

Figure 3-1: Maximum and minimum projected change in temperature and rainfall in the UAE



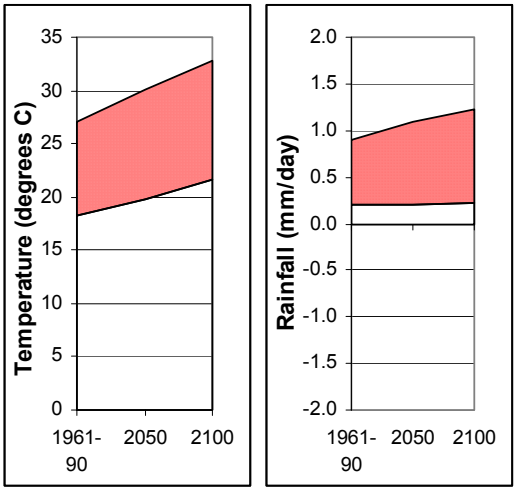
The projected temperature increase varies by less than 0.2ºC across the eight cities in 2050, and by less than 0.3 ºC in 2100. There is a relatively greater difference for precipitation as the projected rainfall varies by 5.3% across the eight cities in 2050, and by 11.0% in 2100.

Sea Level Rise

In addition to temperature and precipitation changes, the UAE will be affected by sea level rise associated with climate change. This poses significant risks for the UAE's investment-intensive coastal zones. Global mean sea level is projected to rise by 9 to 88 cm between 1990 and 2100, with a central value of 48 cm, for the full range of SRES scenarios (Klein *et al.*, 2006).

It is important to note that the this represents a rise in sea-level that is over twice the observed rate over the 20th century. Given the long response time of the global ocean system, sea level will continue to rise for centuries beyond 2100 even with large reductions in global GHG emissions. This emphasizes sea level rise as acutely important for the UAE.

Figure 3-2: Projected annual average in temperature and rainfall range in the UAE



Uncertainty

It should be noted that model outputs are subject to significant levels of uncertainty from a variety of sources including the course nature of the GCM models, inclusion or exclusion of aerosols and drift in the analysis, as well as model sensitivity to the emission scenarios.

3.2 Water Resources

A severe shortage of water resources associated with projected increases in air temperature as well as increases in potential evapotranspiration is likely to be the most significant impact of climate change in arid and semi-arid Asia (TAR, 2001).

In the UAE, groundwater and limited surface water resources play very a important role in a range of natural and economic sectors including agriculture, fisheries, livestock rearing, industry, forestry, as well as the residential sector. Any change in climatic conditions that increase the vulnerability of these already scarce water resources is cause for serious concern.

Current Status

Groundwater generally originates in the eastern region and moves West and North-West towards the Arabian Gulf coast where it discharges into sabkhas and the sea. In some cases the flow processes supporting this recharge takes more than 15,000 years (Abu Dhabi Environment Agency, 2005). Deepwater aquifers are also slow to recharge, as most rely on rainfall recharge from neighboring countries, for example from the Eastern Arabia Aquifer (Federal Research Division of the Library of Congress, 1993).

Groundwater throughout the UAE has been depleted over the past decades through extraction levels that consistently exceed the natural replenishment rate. Water tables have dropped, which has in turn led to the need to halt agricultural production using groundwater in many cases. Currently, most of the groundwater resources available, is brackish or saline (Brook et al., 2005).

In the UAE, rainfall occurs infrequently giving 70 mm to 160 mm as annual average in 9 to 19 days out of a whole year. Rainfall is orographic in nature and not evenly distributed over the area, the Northern Emirates receives more amounts of rain than the rest of the country (Source: Ministry of Communication).

This results in extremely low runoff potential and, in turn, shallow groundwater recharge from runoff. Throughout the country, insufficient rainfall run-off to shallow groundwater is exacerbated by high evaporation rates (a daily average of around 8 mm per day) and high average wind speeds, resulting in approximately 75% of rainwater lost to evaporation and

an additional 10% draining directly to the sea (ERAS, 2005).

Current Impacts and Vulnerability

There are a number of ways in which water resources in the UAE are currently vulnerable. In addition to the over-extraction of groundwater mentioned above, these include an increasing demand for freshwater from the domestic and agricultural sectors, and saltwater intrusion. Both contribute significantly to an acute water stress situation in the country at present. In the face of climate change, the vulnerability of the UAE's will only worsen apart from the implementation of effective adaptation strategies.

Freshwater demand in Abu Dhabi alone, approximately 2.5 billion cubic meters per year, is projected to more than double by 2020 (Ministry of Information and Culture, 2006). Notably, water consumption in Abu Dhabi is increasing at a rate of 5% annually though only 4% of total annual water consumption is renewable (water use is approximately 26 times greater than available renewable freshwater resources).

Future Impacts and Vulnerability

Under a changing climate, the vulnerability of water resources in the UAE will likely worsen. Given climate projections suggesting the future possibility of lower rainfall levels, surface runoff could decrease drastically, further reducing both surface and groundwater availability.

The presence of higher air temperatures associated with climate change would almost certainly increase the potential for more evapotranspiration and, in turn, decrease availability of surface and groundwater fed by run-off. This is important because any loss of freshwater supply will result in the need for additional desalination capacity or an increase in other alternative sources to satisfy demand. Such a circumstance would result in higher costs and additional energy consumption for water provision in the UAE. It could also lead to changes in the efficiency of groundwater pumping; as groundwater tables are lowered, the efficiency of groundwater extraction decreases, increasing the price of groundwater provision and direct changes to the agricultural and industrial sectors of the country.

Moreover, accelerated sea level rise associated with climate change would exacerbate increasing soil and water salinity in some coastal aquifers through direct salt water intrusion. Salinization of soil and water used for irrigation would threaten agricultural and food production in the UAE and, in turn, the stability of these sectors of the economy.

Adaptation Strategies

In response to existing pressures on its water resources, the UAE is embarking on a number of water resource management options. These include planning the construction of more desalination and wastewater treatment plants, restoration of traditional *falaj* systems, the building of recharge dams where there is favorable topography. Dams are only constructed in the northern Emirates because Abu Dhabi topography is not suitable for dams.

Water conservation measures are also underway in order to reduce the vulnerability of water resources throughout the UAE, particularly in the agriculture and amenity planning sectors. Measures under consideration include new irrigation technology that projects can reduce water usage by 80% and other innovative water management designs and technologies (TAR, 2001).

Regarding future climate change, strategies for adaptation in the water resources and hydrology should address both the supply and demand systems in the UAE.

On the supply side, the focus should be on adjusting the operation of existing and planned water supply infrastructure. For instance, while recycling of wastewater is source of water production in the UAE (treated wastewater is used for irrigation of parks and recreational areas), the problem of water quality could be exacerbated by climate change. Low flows and higher water temperatures, predicted for such an arid area as the UAE, tend to deteriorate water quality, complicating the recycling process and reducing recycling efficiency (European Parliament, 1999). Delay and recharge dams must be designed (or re-engineered) to consider the potential for increases in prolonged rainfall events and droughts. Every effort must be made to design or re-engineer supply infrastructure to account for potential increases in temperature, changes in precipitation frequency and magnitude, and increases in humidity and evapotranspiration.

On the demand side, water application practices, particularly in the agricultural, sector (the leading water use in the UAE) should be the focus of climate change adaptation strategies. Reducing the extremely high demand for freshwater in the agricultural sector will make the UAE less vulnerable to the range of potential effects of climate change that remain uncertain. .

Uncertainty in the precise long-term effects of climate change on the meteorological and hydrologic regimes requires that monitoring efforts continue to be improved in the areas of meteorology, hydrology, and climate. Only with consistent monitoring and collection of data in these fields can the relationship between adaptation strategies and water resources be adequately assessed (National Assessment Synthesis Team, 2000).

3.3 Agriculture

The IPCC estimates that by 2050 land degradation in Asia will result in a decrease of approximately 1.8 million km^2 of productive, cultivatable land (TAR, 2001). In Middle Eastern countries specifically, it is projected that a decline in agricultural productivity resulting from soil degradation caused by climate change may exceed 20% (European Parliament, 1999). These broad assessments suggest that the UAE with its strategic emphasis on increasing it s agricultural self-sufficiency in a water-stressed context could be highly vulnerable to future climate change.

Current Status

In the UAE, agriculture is an important sector and any decrease is productivity will have adverse effects on local employment and markets. In 2004, agricultural activities (including livestock and fisheries) in the UAE contributed about 3% of GDP or 10.1 billion Dh at current prices (Ministry of Information and Culture, 2006).

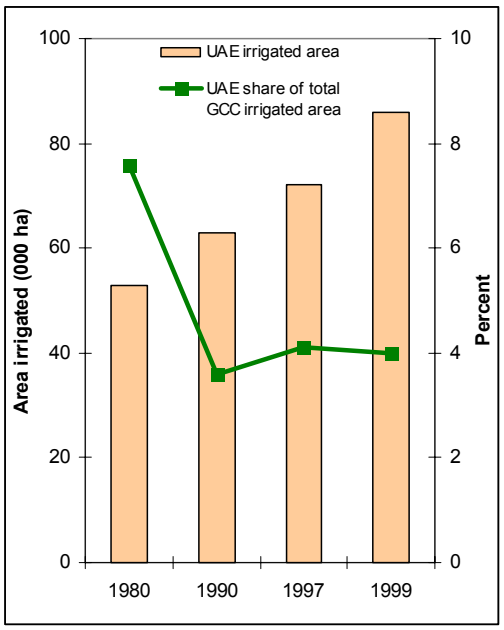
Indeed, once a nation of subsistence farming, the UAE is now an agricultural exporter and its production capacity in some sectors approaches domestic demand (Al-Abed and Hellyer, 2001). A consistent focus on increasing agricultural self-sufficiency has driven the UAE to cultivate around 600,000 hectares of its land area, including 337,000 hectares (ha) of man-made forests (Ministry of Agriculture and Fisheries Annual Report, 2002).

Such agricultural development in the UAE would not have been possible without modern irrigation and desalination technologies, which have played a central role in agricultural activities (European Parliament, 1999). As in most of the Gulf Corporation Council (GCC) countries of the Arabian Peninsula, irrigated area has increased significantly since 1980 (see Figure 3-3). Traditional livestock rearing of sheep, goats, and camels continues in several regions of the country.

Current Impacts and Vulnerability

The vulnerability of agricultural land is of growing concern in the UAE. At present, high velocity winds, sand invasion, extreme temperature and drought years threaten agricultural activities (Kahn, 1983). Current forms of land degradation in the UAE include reduced litter production, decrease in organic matter production, lower productivity, reduced stability of soils, less permeability, diminished microbial activity, slower geobiogene turnover, and lower fertility of soil (Al Shindagah, 2001).

Figure 3-3: Irrigated Area in the UAE



Source: Recreated from ICBA, 2003

Inadequate drainage and excessive irrigation evaporation have led to an increase in total dissolved solutes in soils (Khan, 1983). Indeed, groundwater samples at various sites throughout the UAE have shown soluble salt concentration exceeding 10,000-20,000 ppm while the acceptable threshold for irrigated water is around 500 to 1,000 ppm (Watershedss, 2006 and ICBA, 2003).

The effect of this situation on land productivity has been wide spread and there are reports that a quarter of the land in the UAE is now saline (ICAB, 2003**).** Moreover, crops subject to saline condition experience a high level of osmotic stress which cause reactions that leads to reduced yield or in some cases, total crop failure (European Parliament, 1999). Figure 3-4 illustrates the effects of salinization on agricultural land at al Ruwayyah in the Dubai Emirate.

Overgrazing of livestock herds also contributes to current vulnerability of land resources. Over recent years, the number of camels has increased from about 148,000 in 1994 to around 220,000 in 2000 and the population of goats and sheep has increased by about 50% over this period (Ministry of Agriculture and Fisheries). This renders land more susceptible to degradation from water and wind erosion of topsoil (Pazira and Sadeghzadeh, 2000).

Moreover, the livestock industry (producing meat, milk, and related dairy products) is subject to no formal control by the government (Al-Abed and Hellyer, 2001). The livestock industry also depends heavily on the production of fodder, a highly water-intensive process that has contributed to salinity problems, and had led to an increasing amount of fodder demand met by imports (Brown et al., 2003).

Figure 3-4: Salt-Encrusted Plots in Dubai

Source: ICBA, 2003

Future Impacts and Vulnerability

With climate change, land resources are likely to become even more vulnerable. Less rainfall could lead to lower productivity of dry and ultimately lower organic matter content in soils. High intensity rainfall has the potential to

desalinize, cause increased runoff or lead to salinization depending upon localized soil conditions.

Some of the largest projected temperature increases in temperature are for the regions of Ras al Khaymah and Abu Dhabi (see Volume II). Abu Dhabi is at the center of the agricultural sector of the UAE producing a majority of the country's vegetables including tomatoes, cabbage, eggplant, squash, cauliflower, mangos and citrus plants. An increase in temperature, particularly in this more productive region, may have a significant affect on heat sensitive vegetable crops such as tomatoes, cabbage, eggplant, squash, cauliflower, and citrus plants in the UAE.

It is also possible that climate change may produce adverse impacts on farm profitability, crop prices, supply and demand, trade networks, as well as lead to previously unobserved climate-soil interactions that are impossible to predict at present (European Parliament, 1999).

Adaptation Strategies

Various measures that are essentially early adaptation methods are already being aggressively pursued in response to agricultural vulnerability in the UAE. A shift in crop types through intensive agriculture in greenhouses has been suggested by the IPCC as part of potential adaptation strategies for the agricultural sector (IPCC, 1997).

The study of salt-tolerant crops is central to adaptation measures in countries with semi-arid and arid climates. The Biosaline Agriculture Center (BAC) was established in the UAE to promote the use of saline water in sustainable agriculture throughout the Islamic World. The initial focus of the group has been in the GCC countries, as their freshwater resources per person are less than 3% of the global average (ICBA, 2000). The BAC is devoted to the study of salt-tolerant plants and the development of production systems that can be useful to farmers and landscape managers (see Figure 3-5).

Increasing water use efficiency is on of the focuses of much effort by the Ministry of Agriculture and Fisheries of the UAE as well as other groups. The Arab Peninsula Regional Program, for instance, conducts research programs on on-farm water management as well as water-use efficiency in forage production (Arabian Peninsula Research Program). All efforts to increase water-use efficiency, particularly in the agricultural sector, where water consumption is extremely high, help to reduce vulnerability by reducing dependence on alternative, more vulnerable sources of freshwater supply and decreasing the over extraction of scarce water resources.

The continued development and pursuit of adaptation initiatives will be essential in order to address the threats posed by climate change. Those measures discussed previously for water resources are central to effective adaptation in the agricultural sector. Increased monitoring and assessment of groundwater resources is integral to sustaining productivity, as is the pursuit of alternative forms of fresh water resources.

Figure 3-5: Crop Research in the UAE

Source: ICBA, 2003

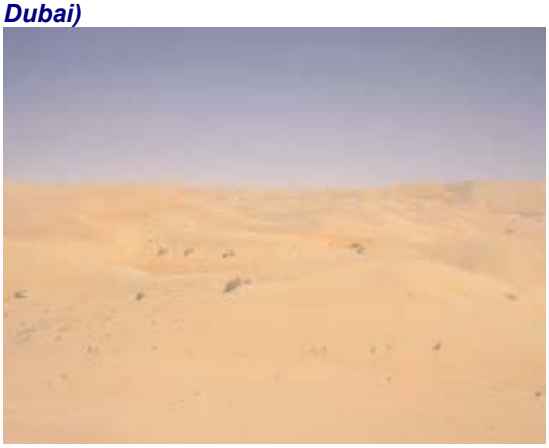
3.4 Dryland Ecosystems

The UAE, like other countries in semi-arid, arid, and hyper-arid Asia, is characterized by several different dryland ecosystems. Hyper-arid regions consist of various types of desert, arid regions encompass shrub and rangelands along coastal areas. The remaining areas are arid to sub-humid highland areas the contain woodlands and rangelands. Each of these land areas function as vital natural ecosystems home to a variety of unique flora and fauna, and/or important rangelands for livestock grazing.

Current Status

Desert areas are a dominant feature of the UAE landscape. Fully four-fifths of the land area is classified as hyper-arid desert regions. Include on the broad classification of desert are several subsystems including sandsheets, gravel deserts, saline flats, and other subsystems. Figure 3-6 illustrates a typical dune landscape in a hyper-arid zone near Dubai.

Figure 3-6: Typical dune landscape (near Dubai)



Source: Al-Abed and Hellyer, 2001

In addition to deserts, woodlands and shrubland ecosystems can also be found in throughout coastal and highland regions (see Figure 3-7). In contrast to desert regions and their hyper-arid climate, highland areas in the UAE are closely linked to the climatic regime in that the formation of fog and dew are critical to their maintenance (Al Abed and Hellyer, 2001).

Figure 3-7 Shrubland and woodland landscape near Khawr Fakkān

Source: Al-Abed and Hellyer, 2001

Flora and fauna in fog and highland regions are also unique to and within Arabia and are of high conservation value, as are some of the rare mammals living in these regions, which include populations of Arabian leopard, Gordon's wildcat, Arabian tahr and ibex (Al Abed and Hellyer, 2001).

Current Impacts and Vulnerability

Deserts in the UAE serve as important ecosystems for traditional grazing by domestic animals. As a result of changes in nomadic practices, these regions have shown vulnerability to chronic overgrazing. It has been argued that future trends in human and livestock practices may have more impact on desert systems than will climate change (Al Shindagah, 2001). IPCC models predict that climate change has the potential to affect dryland ecosystems indirectly through parallel changes in land-use and population pressures (Al Shindagah, 2001; TAR, 2001).

Future Impacts and Vulnerability

The distribution of the various dryland systems could change significantly under a changed climate regime. Projected decreases in soil moisture in the region could lead subhumid areas to become semi-arid and semi-arid land to become arid.

Though increased aridity would tend to reduce population pressure on drylands, the IPCC notes that resistance to degradation and resilience following degradation would decrease as aridity increases (TAR, 2001). This decrease in resistance and resilience suggests that the vulnerability of the desert ecosystems to climate change could increase significantly.

Adaptation Strategies

Coping with future climate change will require effective adaptation in dryland areas. Throughout the UAE, significant effort has been expended toward afforestation and the construction of green areas. Such green tracts provide shade and evaporative cooling effects, as well as some degree of protection from sandstorms for cities in the UAE (Salloum, 2001).

Adaptation efforts could include continuing such efforts, with a significant focus on the more efficient use of water for tree and plant production. While green areas provide an invaluable service to dryland ecosystems and protection of the inhabited areas which they border, it is important to manage their development in a manner integrated with water resources management, to ensure sustainable water use,

In shrubland and woodland areas, adaptation efforts could be focused on the restoration and rehabilitation of impacted ecosystems. For example, ex-situ conservation can be successful in some cases, particularly in breeding the Arabian leopard and Arabian Tahr (Al-Abed and Hellyer, 2001). Identifying peripheral species of interest and protecting their habit will likely enhance planned adaptation for natural ecosystems (TAR, 2001).

Finally, it may be that relative to other sectoral or ecosystems in the UAE, adaptation in deserts may not be highly prioritized. These hyper-arid regions of the UAE – covering over 80% of the total land area of the country - are possibly more resistant to climate change since they are already surviving extreme environmental conditions.

3.5 Public Health

There are various adverse health impacts of climate change that are expected throughout Asia. These include thermal stress and air pollution-related diseases, diseases related to higher UV-B exposure, and infectious diseases related to the hygienic circumstances of water (TAR, 2001).

Current Status

While each of these effects is relevant to the UAE, the nation faces these threats from a strong public health baseline. State-of-the art health care services and sanitation infrastructure have drastically increased, leading to effective control of infectious diseases such as malaria, measles, poliomyelitis and other childhood diseases that were once prevalent in the country (Ministry of Information and Culture, 2006; Kronfol, 1999).

Current Impacts and Vulnerability

The health infrastructure in the UAE has given increasing emphasis to preventive and other healthcare services including health education, primary health care, maternal and child health care, and school health services. The increasing emphasis on these services reflects a marked change within the UAE from vulnerability to infectious diseases (e.g., malaria, cholera) to vulnerability to non-communicable diseases, environmental hazards, and chronic health concerns. This shift directly correlates with the mounting toll from illnesses such as diabetes, hypertension, cancer, coronary heart disease, a consequence of the higher standards of living that accompanied the socioeconomic development in the UAE

that have been evident in the country over the past several decades.

Figure 3-8: Modern health care services have dramatically increased

Source: UAE Statistical Yearbook, 2006

Future Impacts and Vulnerability

While clear links between climate change and human health have not yet been established through research, several potential effects of climate change on the population of the UAE are clear. An increase in temperatures, particularly in an area with already extreme temperatures, could increase the risks associated with heat-related illnesses.

Prolonged periods of high temperature increase the production of smog and the dispersal of allergens, both linked to respiratory symptoms (IPCC, 2000; Kronfol, 1999). Moreover, conditions related to urban and rural smog may increase with climate change as a result of periods of high temperature, changes in green house gas emissions, circulation and other factors affecting regional air quality in the UAE.

Thermal stresses and weather disasters (both probable in the UAE under future climate change) have been shown through epidemiological studies and health data to cause serious illness and death (Epstein, 1999). Thermal stresses typically affect individuals on either end of the age spectrum. While the geriatric population of the UAE is relatively low, the pediatric population (0-14 years) of the UAE represents about 34% of the population (Kronfol, 1999).

Secondary effects including changes in water quantity and quality, changes in agricultural systems and changes in social structure may also place public health in the UAE at risk. Parched agricultural lands, which appear to be a certainty in the already water-stressed agricultural areas of the UAE, attract aphids, locusts, and virus-bearing white flies (Haines et al., 2000; Epstein, 1999).

Changes in temperature, precipitation, and humidity are all potentially linked to changes in the transmission of vector-borne infectious diseases. While infectious diseases are under continuous surveillance in UAE due to a well-developed programme for control of infectious diseases, the incidence of infectious disease among humans (or livestock) may be affected by increased extreme precipitation events coupled with increased temperature. Disproportionate warming at night is projected under climate change, as cloud cover is expected to increase. This change would be unhealthy for humans and might also provide a more optimal environment for disease-breeding insects.

Rodents could also pose a threat under increased ambient temperature scenarios, as droughts suppress their predators, increasing the possibility of rodents as vectors of infectious disease (Haines et al., 2000). Incidence of disease among livestock or the human population or pests can affect trade, travel, and tourism and their associated contributions to the UAE. Economy.

It has been hypothesized that cholera distribution depends in part on *Vibrio*

cholerae attaching itself to marine plankton. Because algal blooms occur with increases in sea surface temperature, it is possible they may contribute to cholera epidemics under future climatic scenarios in the UAE (Haines et al., 2000).

Finally, El Niño events have been shown to increase death and disease rates through direct injuries or through incidents of infectious diseases resulting from damage to infrastructure, potable water supplies, and agriculture (Epstein, 1999). While the effects of the ENSO on climate in the UAE are uncertain, there may nevertheless be significant effects on public health in the UAE, as has been experienced in other regions.

Adaptation Strategies

Efforts to adapt in the public health sector should be focused in several areas in the UAE. Control programs for infectious diseases, designed to coordinate intervention methods such as vaccination, vector control, health education and chemoprophylaxis have already been implemented for thirty-six infectious diseases (Ministry of Information and Culture, 2006). The last incidence of malaria was recorded in the UAE in 1997 and the Ministry of Health is currently finalizing the procedure to declare the country free of Malaria through WHO. These programs and similar efforts are integral adaptation measures that need to be sustained.

Another potential adaptation measure is the establishment of monitoring systems. Tracking of water quality, water treatment efficiency, and soil quality is central to adaptation in the public health sector. Monitoring of algal blooms should also be a focus of adaptation efforts, for improved understanding of their development, distribution and effects on marine biota and, in turn, the human population. Finally, monitoring of ENSO events will also play a central role in adaptation in the UAE. As more is learned about he system's relationship with meteorology and hydrology in the UAE, this information must be considered in designing future public health programs as well as infrastructure related to water, solid waste, and wastewater.

3.6 Human Settlements

Residents of the UAE live mostly in urban settlements. The majority of the population is concentrated in the two main coastal cities of Dubai and Abu Dhabi, which account for about 60% of the population (Ministry of Information and Culture, 2006). Settlements – and the energy, water, transport and other infrastructure that supports them – have varying degrees of vulnerability to climate and are generally evolving more quickly than the natural environment (TAR, 2001).

Current Impacts and Vulnerability

If the current rates of expansion and labor demand continue, the population of the UAE may possibly double in the next 10 to 15 years (Ministry of Information and Culture, 2006). Among other things, these growth rates will require the provision of additional water resources, agricultural production and public health systems, sectors which are already highly vulnerable to the effects of climate change. In addition, various other infrastructural elements that accompany areas of human settlement may be vulnerable to the effects of increased temperature and changes in precipitation in a number of ways.

Provision of infrastructure including solid waste, wastewater, transportation, housing, etc. may also be complicated by increases in ambient temperature and precipitation. The range in per capita waste varies widely in the UAE between 0.6 kg/day in rural areas of Abu Dhabi to 2.6 kg/day in Dubai, one of the highest in the world. Infrastructure for solid waste and wastewater treatment is designed with consideration for regional ambient temperature, humidity, and rainfall

parameters. Changes in these parameters could have significant and widespread effects of the efficiency of these systems (and consequentially on associated elements of public health).

Future Impacts and Vulnerability

Population centers in the UAE could be affected by climate change in two basic ways. They could be affected directly through changes that occur in public health and various types of urban infrastructure. They could also be affected indirectly through impacts on the environment, natural resources, and local industries such as oil production, tourism or agriculture. These effects themselves could also lead to a number of related changes such as redistribution of population, altered trade patterns, and land use changes.

While urban areas in the UAE have some built-in capacity to endure the consequences of environmental vulnerability, climate change will result in some changes for which settlements are not yet adequately prepared. Sea-level rise will increase the risk of inundation of coastal settlements and associated infrastructure. In addition, an increased probability of extreme weather events could also jeopardize some of the institutional systems that have been built up over recent years. In urban areas, legislation and administration relating to infrastructure, including buildings, land use, waste management and transportation, all have integral environmental facets and may need to be updated to ensure they are compatible with the threats posed by climate change.

Adaptation Strategies

Adapting to environmental hazards has been at the core of management and governance of human settlements throughout the history in the UAE. To cope with future climate change, attention should be focused on a range of activities including, planning processes to reduce sensitivity to climate change, designing resilience and flexibility into transport and water supply infrastructure, and management of urban settlements in a climate-resilient manner. By necessity, these activities should be integrated into ongoing activities related to land-use planning, environmental assessment, and information and education.

Finally, adaptation strategies should also include actions aimed to ensure the provision of and improvement in infrastructure and services through site and infrastructure planning and design (e.g. building codes which promote health and safety).

3.7 Energy

The UAE is concerned about two types of vulnerability regarding its energy infrastructure and resources. On the one hand, electric power, desalination and oil & gas infrastructure are integral to meeting human and industrial needs in the country and are vulnerable to a variety of stresses imposed by a changing climate.

On the other hand, the UAE considers itself economically vulnerable to the impact of response measures that Annex B countries adopt to reduce their emissions in accordance with targets specified in the Kyoto Protocol. Both types of vulnerability pose serious issues related to the country's industrial productivity and economic development as a whole.

Current Impacts and Vulnerability

Projected increases in air temperatures could produce adverse impacts on the operation of electric power and desalination facilities in the UAE. This could occur through efficiency losses and forced reductions in power output.

Power plants and desalinization infrastructure have been designed for specific climatic conditions including ambient and seawater temperature prevalent in the UAE. Increases in

ambient temperature by the 1.6ºC and 2.9ºC that have been projected for UAE cities would likely exceed the plant design limits. This would increase fugitive emissions in some of the older, non-gas-fired power plants and introduce steam and condenser efficiency losses of about 3% (ERAS Ltd.). The effect of higher temperatures on new gas-fired turbines would also likely adversely affect power output by about 2%. Adaptation strategies should focus upon increasing the efficiency of energy use, as well as changes in plant designs to accommodate higher heat tolerances.

Future Impacts and Vulnerability

Over 80% of the oil produced in the UAE is exported, compared with about 20% for natural gas. A reduction in the demand of oil in Annex B countries will adversely affect the UAE, depending on the future costs of production and the extent to which the economy remains reliant on oil export revenues.

The economic vulnerability of oil exporting countries like the UAE is explicitly addressed by the Convention. In Articles 4.8(h), 4.9 and 4.10, the Convention calls for the Parties to consider funding and other types of actions that can offset the impacts of response measures on countries whose economies are highly dependent on oil export income.

The IPCC has reviewed a number of studies of the potential effects of greenhouse gas mitigation measures in industrialized countries on the global oil market. Citing a study by Pershing (2000), they summarize results from a number of macroeconomic modeling analyses of the impacts in 2010 of implementing the Kyoto Protocol (see Table 3-1).

Each of the modeling efforts assumes that Kyoto Protocol GHG reduction targets are achieved by imposing a carbon tax or auctioned emission permits with revenues recycled through lump-sum payments to consumers. No ancillary benefits, such as reductions in local air pollution damages, are taken into account in the results. Each of the studies concludes there will be adverse economic impacts on oil-exporting countries. The use of the Kyoto Protocol's flexibility mechanisms (i.e., greenhouse gas emissions trading) will reduce but not eliminate the economic impact on oil producers.

Modeling tool	Without "global trading"	With "global trading"
G-Cubed	-25% oil revenue	-7% oil revenue
GREEN	-3% real income	not available
GTEM	0.2% GDP loss	not available
MS-MRT	1.39% welfare loss	0.36% welfare loss
OPEC	-17% revenue	-8% revenue
CLIMOX	not available	not available
Note: G-Cubed and OPEC analyses focus on OPEC countries only; GREEN analysis focuses on some oil exporting countries; GTEM focuses on Mexico and Indonesia; MS-MRT focuses on OPEC and Mexico; CLIMOX focuses on West Asian and North African oil exporters.		

Source: Table 9.4 of TAR

Table 3-1: Impacts on oil-producing countries from implementation of the Kyoto Protocol

There are several measures that could be implemented in countries facing Kyoto targets that could lessen the economic impact on oil-exporting countries, as outlined below (TAR, 2001)

- Removal of oil subsidies
- Energy tax restructuring relative to carbon content
- Increased use of natural gas

When coupled with the implementation of international trading, each of these falls well within the intent of the Convention language for taking into consideration measures to assist countries that are vulnerable to the implementation of response measures. Further analysis is needed to better understand the full range of options that could be considered to mitigate the adverse economic

implications from the implementation of the Kyoto Protocol.

3.8 Coastal Zones

Coastal areas of the UAE consist of two distinct sections, separated in the northeast by the Musandam Peninsula in Oman. The larger of the two sections stretches from the Qatar peninsula east to Oman and is located in the southern portion of the Arabian Gulf. The smaller, eastern-most coast, an area known as the Al Batinah coast, extends along the Gulf of Oman from the Musandam peninsula.

The Arabian Gulf coast of the UAE extends from the Qatar peninsula northeast to Ras al Khaimah and is characterized by coastal embayments, barrier island-lagoons, spit-lagoons, and coastal sabkha subsystems (Alsharhan and El-Sammak, 2004). Eight of the nine major cities in the UAE are located along these coastal areas, representing some 85% of the population.

Current Impacts and Vulnerability

There are a variety of current, wave, and tidal actions that affect the various coastal subsystems in the UAE.

The embayment subsystem located along the western coast of the UAE in the Emirate of Abu Dhabi (i.e., where the coast sits in the lee of the Qatar peninsula) is protected from the full effects of waves and currents. The shores of the western embayment subsystem are wide intertidal flats and narrow beaches, backed by sabkhas up to 3 km wide, while the western portion of the embayment coast is characterized by a long storm beach (Alsharhan and El-Sammak, 2004).

The Great Pearl Bank and associated islands are located along the coast of the Abu Dhabi emirate, leading to the formation of East-west trending lagoons along the Abu Dhabi shores. The eastern portion of the Arabian Gulf coast directly faces the length of the gulf and is impacted by wave action, resulting in the development of long-shore spit systems.

The spit-lagoon systems, consisting of linear coastlines with beaches backed by either costal sabkhas or coastal dunes, are common throughout both the Arabian and Gulf of Oman coasts of the UAE (Alsharhan and El-Sammak, 2004). The Al Batinah coast of the UAE is characterized by high-relief mountains and valleys, though in the south, tidal and marine erosion has generated a wide lagoonal coastal plain with low topographic relief (Alsharhan and El-Sammak, 2004).

Of particular importance throughout the UAE coastline are coastal Sabkha systems, evaporitic tidal flats consisting of fine-grained, largely wind-blown sediments and prone to periodic inundation. Common throughout arid shallow-shelf environments, they have been studied extensively in the past as they are believed to have played an important role in the formation oil (Al-Farraj, 2005). Coastal Sabkhas extending inland along this coastal area are inundated during storm high tides.

Future Impacts and Vulnerability

The IPCC estimates that the range for global average sea-level rise (SLR) could be about 10-90 cm by 2100, based on a range of IPCC SRES scenarios and a range of climate models. Potential impacts on the UAE could include inundation, erosion, and flooding from this rise in sea level. These are particularly important due to the concentration of population, infrastructure, and industry in coastal zones. Moreover, the vulnerability of its natural ecosystems is also of particular concern as coastal areas in the UAE are characterized by intricate ecologies of coastal sabkhas, mangrove wetlands, and other areas which provide habitat for a wide variety of flora and fauna.

Sea level rise may have several interrelated effects on coastal sabkha areas. Flooding could serve to remobilize the fine sediments, increasing coastal turbidity and, in turn, affecting coral reefs, sea grass, and other marine biota. In addition to an increase in turbidity, the inundation of coastal sabkhas could create an extremely shallow sea along the coast. This, more shallow, body of water would be susceptible to strong heating and cooling and may exhibit associated density changes due to evaporation. Other potential impacts from sea level rise include increased turbidity, density, and salinization which could prove detrimental to sea grass, coral, and mangrove growth and, in turn, marine mammals and fish stocks.

UAE coastal zones are home to extensive mangrove areas, which may also be adversely impacted by sea level rise. The growth of mangrove forests is dependent on depth and other water characteristics including salinity. Historical studies on the development of mangroves under sea-level rise indicate that high islands and continental coastlines will be more prepared to cope with rising sea-level than the low, carbonate coastlines characteristic of the UAE (Kimberlyn, 1999).

Marine mammals including dugong and turtles depend heavily on sea grasses growing along the coasts of the UAE. Potential increases in turbidity, water density, temperature, and salinity caused by sea level rise and other climate change phenomena may all negatively impact sea grass growth in the UAE coastal zones and, in turn, may compromise local marine mammal populations and fish stocks.

Reef-building corals persist in the Arabian Gulf, despite the fact that it is one of the most stressful environments in the world (Purkis and Riegl, 2005). Coral along the UAE coast has already been affected by temperature-related bleaching (Riegl, 2003, Purkis and Riegl, 2005). In addition to increases in water temperature, increased turbidity may also negatively impact coral assemblages.

Figure 3-9: Seagrass & coral reef in the UAE

a) Dense Seagrass Meadow

b) Coral Reef with dead coral covering some living species

Source: Wijsman and Riegl, 2001

Adaptation Strategies

Climate change is but one of many interacting stresses in UAE's coastal zones. Controlling non-climatic stresses posed by coastal development plans is also important as the vulnerability of these areas to climate change is not only determined by the degree of climate change but also by prevailing social, economic and environmental conditions, as well as existing management practices. Reducing vulnerability to the impacts of climate change may well include actions that are directed at improving such conditions and management practices.

For example, in the National Environmental Strategy for the marine environment of the UAE, there is a recognition that there is an urgent need for data collection in order to determine

baseline environmental quality and to provide the necessary information for decision-making in coastal areas (Federal Environment Agency, 2002). Activities associated with the marine environment strategy include; conservation, awareness, regulatory and economic policy; fisheries management; and a national oil spill contingency plan.

Taking into account uncertainties associated with vulnerability in the coastal zone sector, the Third Annual Report suggests that the most promising policy options for adaptation to climate change are those that offer benefits regardless of the progression of climate change. Those current initiatives related to the UAE include breeding of new crop varieties and species (heat-tolerant, low-water-use crops), promotion of efficiency of irrigation and water use in dissemination of conservation management practices. Those strategies which provide a benefit to existing vulnerabilities should be focused upon, as the natural and social systems of the UAE are currently exposed in a variety of ways.

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Chapter 4:

Greenhouse Gas Mitigation

4. Greenhouse Gas Mitigation

This chapter provides an overview of some initiatives that would be attractive in the UAE to reduce or sequester greenhouse gas emissions. Given the importance for the UAE to continue to pursue its economic development priorities, it is expected that greenhouse gas emissions will increase despite ongoing efforts at both the emirate and federal levels to promote sustainable development, such as environmental education/awareness, wildlife protection, and water resource management.

The measures discussed in this chapter focus on the potential of certain technologies and practices to not only reduce GHG emissions but also contribute to the country's economic development by making life better for all its inhabitants. They represent an initial scooping effort into possible future activities for the reduction of greenhouse gases. It is clear that to implement the measures laid out in this chapter would involve significant new coordination around a number of institutional, regulatory, legislative and financial initiatives. This is something the UAE is committed to exploring within the framework of further feasibility assessments and international support and cooperation.

4.1 Introduction

The UAE's ratification of the UNFCCC commits it to submit National Communications on national programs and measures to respond to climate change. One of the responses that the UAE can make is to identify a set of appropriate options that can reduce its emissions of greenhouse gases. This chapter summarizes a national-level examination of a set of mitigation options across the UAE economy.

The UAE understands that it can reduce its greenhouse gas emissions over the next decades while its economy continues to grow. This can be achieved through a set of policies and measures that are targeted within and across sectors – residential and commercial buildings, industrial facilities, transportation, and power generation. These measures would have the effect of increasing energy efficiency, accelerating the adoption of renewable energy, reducing air pollution, reducing waste, shifting to less carbon-intensive fuels, and pressing ahead with its green park plantations. Many of these initiatives would save more money that the cost of implement and long-term operation. At the same time, many of these initiatives would also have the effect of opening up new employment and market creation opportunities.

The UAE further understands that it is not obliged under the Framework Convention to implement activities for the express purpose of achieving GHG emission reductions. Moreover, any emissions reductions that would result in the UAE would be very small compared to the magnitude of emission reductions needed for stabilizing the global climate. Nevertheless, the UAE has compiled this initial set of attractive strategies in an effort to demonstrate its solidarity with the international community in tackling the threat of climate change, and its strong commitment to contribute to the process.

The rest of this chapter identifies GHG mitigation options that could be considered. As a general matter, each of the strategies discussed are consistent with three key guiding principles, as follows:

- They are broadly consistent with the UAE's development objectives;

- They would be replicable using the financial and technical resources available;
- They represent validated approaches and technologies that have shown success in other countries; and
- They would be amenable to evaluation and comparison using UAE-specific objective criteria.

Finally, these mitigation strategies represent potential future investment opportunities under the Clean Development Mechanism (CDM). Parallel activities would also need to be considered to support the implementation process such as regulatory reform, public outreach, and strengthening of the national CDM office.

4.2 Buildings Sector

Carbon emissions associated with meeting electricity demand in residential and commercial buildings accounts for a significant portion of national GHG emissions. Based on the results of the national inventory, these sectors are responsible for about 28% of all energy-related greenhouse gas emissions in the UAE in 1994, and about 25% of all carbon dioxide emitted.

A number of measures are appropriate for the UAE to consider reducing these emission levels. These include new building codes, new appliance standards, use of high efficiency products, implementation of district cooling, and greater use of solar energy technologies.

Building codes

In the UAE the dominant energy demand in the buildings sector is to meet a quite large space cooling need, as well as lighting needs. Building energy codes would require all new residential and commercial buildings to be built to a minimum level of energy efficiency that is cost-effective and technically feasible. "Good practice" residential and commercial energy codes, as exemplified by the International Energy Conservation Code could be introduced in the UAE to encourage energy conservation through efficiency in envelope design, mechanical systems, lighting systems, and the use of new materials and techniques. International literature suggest that the impact of these changes, would be about a 20 percent energy savings in cooling in buildings in new homes and commercial buildings.

New Appliance Standards

The international track record for electricity efficiency standards is impressive. These standards have had the effect of removing the most inefficient models from the market, while still leaving consumers with a diversity of products.

In the UAE, new efficiency standards could be considered for several key appliances and equipment types. These include commercial air conditioning systems, commercial refrigerators, exit signs, traffic lights, fixtures, ice-makers, standby power consumption for consumer electronics, and distribution transformers. These are all measures that can be taken in the near term, based on technologies that are currently available in the UAE and cost-effective. Studies suggest that the impact of these changes, would be about a 8 percent of annual electricity consumption would be saved over time due to such standards (Kubo et al, 2001).

District Cooling

Cogeneration is a super-efficient means of co-producing two energy-intensive products that are usually produced separately – heat and power (STAPPA/ALAPCO, 1999). The technical and economical value of cogeneration has been widely demonstrated, and some European countries rely heavily on CHP for producing power and providing heat to industries, businesses, and households.

The thermal energy produced in co-generation can also be used to provide cooling in a district cooling scheme.

In recent years, the UAE has begun to consider the implementation of a district cooling system in the Dubai Emirate. While the time and complexity involved in developing the piping networks, especially in the multi-user scheme in Dubai, make district cooling a capital intensive option for reducing greenhouse gas emissions, these systems offer the opportunity to dramatically reduce space cooling loads by capturing the efficiencies on the cogeneration process.

Significant reductions in energy and GHG emissions can be achieved from the improved efficiency of fuel use. Moreover, advances in technologies such as combustion turbines, steam turbines, reciprocating engines, fuel cells, and heat-recovery equipment have decreased the cost and improved the performance of district cooling systems.

Solar Energy Applications

Solar energy applications are becoming increasingly common in the UAE. The abundant sunshine in the UAE, as well as the increasing competitiveness of solar energy systems – photovoltaic and solar hot water systems – suggest that these technologies could be poised to take off in the UAE.

Solar thermal collectors could be used to generate hot water in homes, hotels and factories. In the process, they could save hundreds of million of dirhams annually in in electricity costs while reducing GHG emissions. Solar photovoltaics (PV) convert sunlight directly into direct current electricity. They could be combined with roof tiles or other parts of building structures to supplement grid-supplied power, reduce energy costs, and provide emergency back-up power – all this while simultaeously reducing significant amounts of GHG emissions (Geller, 2003).

Currently, a large apartment building in Bur Dubai is the first building in the Middle East to use solar power to cool a building by day, cutting electric utility bills significantly. The typical period to recover the capital costs for solar energy systems is up to about five years. After this point, it is more economical to use solar power than grid connection systems.

4.3 Transport Sector

Another element of a mitigation plan for the UAE would be is to reduce carbon emissions from its transport sector, which is responsible for about one-tenth of all carbon dioxide emissions from energy use activities.

The overwhelming majority of GHG emissions from transport are associated with the light duty vehicle (LDV) fleet comprised of cars and light duty trucks. Heavy-duty trucks and buses account less than 5% of the total number of on-road vehicles.

The major initiatives that would contribute to the reduction of greenhouse emissions from transport are improved efficiency for the light duty vehicle fleet and measures to reduce road travel.

Fuel Economy Standards for LDV Imports

Today's cars in the UAE comprise both high and low efficiency vehicles that are imported from Japanese, European and North American manufacturers. The average fuel economy of the new light duty vehicle fleet is governed by fuel economy standards set in those countries. Average fleet efficiencies have tended to decrease in the UAE as the trend toward greater imports of gas-guzzling sport utility vehicles (SUVs) which account for nearly a significant percentage of new vehicle sales, and brings down the overall fuel economy of the light duty vehicle fleet.

A fuel economy standard for light duty vehicles, by ensure that all new vehicles

meet some agreed-upon efficiency standard, could help to reduce greenhouse gas emissions from the transport sector (Energy Innovations, 1997). Such a standard would require all imports of cars and light trucks to meet a minimum level of fuel economy that is cost-effective and technically feasible. Depending on the strength of the standard, the increase in vehicle fuel economy could save significant amounts of gasoline and diesel fuel over time, leading directly to reduced GHG emissions.

Reduction in Road Travel

The amount of travel in cars and light duty trucks continues to grow in the UAE due to increasing population and economic development. Between 1994 and 2004, the annual rate of growth in registered cars and light trucks vehicles has increased substantially. The overall efficiency of the passenger transportation system can be significantly improved through measures that contain the growth in vehicle miles traveled through land-use and infrastructure investments.

One such investment is a metro system that can simultaneously relieve urban congestion and reduce GHG emissions from cars. Currently, the Emirate of Dubai has identified the need for an urban rail transit system to supply additional transportation capacity to relieve growing traffic, and support the city's continuing development. The Dubai Urban Rail Transit, or Metro, will be the first such system on the Arabian Peninsula.

4.4 Industrial Sector

Carbon emissions associated with meeting electricity demand in industrial activities accounts for a significant portion of national GHG emissions. Based on the results of the national inventory, these sectors accounted for about 57% of all energy-related greenhouse gas emissions in the UAE in 1994, and about 54% of all carbon dioxide emitted in the country.

Energy Efficient Motors

In the UAE, perhaps the most strategic measure for reducing GHG emissions from the industrial sector are high efficiency motors. It is expected that many factories in the UAE could cut energy consumption 25 percent or more with good payback through a combination of energy-saving strategies for industrial motors. Motors convert electrical energy to mechanical energy, powering fans, pumps, elevators, escalators, conveyor belts and industrial machines; they typically consume nearly a large percentage of the electricity used in industrial applications in the UAE.

Opportunities for efficiency improvements are significant. Motors that are oversized lose efficiency when operating at loads below their rated capacity. Reducing motor size can reduce energy costs by one-third with a payback period of eighteen months. Even with the low electricity costs in the UAE, the annual cost of energy to power a motor is considerably greater than the capital cost of the motor itself as typical motors can use up to four to five times their cost in electricity each year.

High-efficiency motors could reduce energy use by one-quarter to one-half. Potential improvements include re-sizing motors to meet demand and replacing inefficient motors with premium high-efficiency motors. Another key energy-saving strategy for the UAE could be to install variable speed drives (VSDs) on pump and fan motors that have variable loads.

Also, computer-controlled VSDs can often significantly improve control of manufacturing processes, thereby boosting productivity. Compressed air systems—widely used for cleaning, running machine tools, running looms, mixing and moving product around on conveyor belts—can also be made 25 percent to 50 percent more efficient, with much of the savings

coming just from fixing leaks (STAPPA/ALAPCO, 1999).

4.5 Electric Supply

The UAE has seen soaring demand for electric power – about 15% per year, coupled with volatile swings in peak loads and increasing demands for desalinated water. In 1994, total emissions of carbon dioxide were nearly 20,000 Gg, or about 35% of total carbon dioxide emissions from energy activities.

The UAE is taking part in a plan to build a regional power grid throughout the countries of the Gulf Cooperation Council (GCC). The first phase of the plan would link Saudi Arabia, Kuwait, Bahrain and Qatar; the UAE and Oman would join the grid in the second phase of the plan. The plan is based on the assumption that each country will have its own unified power grid, and the UAE is doing its part by connecting all the power stations along its western coast with the central region.

Solar Powered Desalination

For the electric supply sector in the UAE, making greater use of its abundant solar energy resources would be an attractive GHG mitigation option. To this end, a project is already underway to build a solar-powered plant that will desalinate sea water and provide electricity. The complex, the first of its kind among Gulf countries, will take about four years to complete, and likely provide valuable lessons for how to use solar energy across the region. The project is the result of coordinated efforts to create innovative investments in the electric supply sector by tapping new technologies.

4.6 Forestry

Planned land-use changes, careful management, and increases in the tree stock have caused trees in the UAE to be a significant sink for the sequestration of GHG emissions. The amount of carbon sequestered by the countries green parks and man-made oases is significant. In 1994, total carbon dioxide sequestered by these plantations totaled over 4,200 Gg of carbon dioxide. This represents about 7% of carbon dioxide emissions from the energy sector, or more than all the carbon dioxide emitted from industrial processes in the UAE.

Farms and forests now cover a significant portion of the land, and many UAE islands have been partially greenified. Given the fact that most of these activities have taken place recently; the young plantations are at an optimal carbon sequestration potential, and will be so for years to come.

In the UAE, expansion of green parks is both a strategic measure for sequestering GHG emissions and part of a deeply engrained national greenification vision, first promoted by the country's founder, Sheikh Zayed bin Sultan Al Nahyan. Tree planting and greening activities has been actively encouraged in every part of the country. Currently, incentives are given to farmers by the government to adopt modern agricultural techniques and to plant citrus trees. These could be continued. Moreover, homeowners are urged to beautify their surroundings by government gifts of free plants and trees, and state-supported parks adorn cities like Abu Dhabi and Al Ain. Roads in many parts of the country are now edged by rows of trees, while islands like Sir Bani Yas are now, to some extent, covered with orchards and tree plantations.

4.7 Waste Sector

The last element of a mitigation plan for the UAE would be is to reduce carbon emissions from its waste sector. This is a small emitting sector, which is responsible for less than 5% of all carbon dioxide emissions in the country.

The overwhelming majority of GHG emissions from waste are associated with methane leaks from the disposal of solid

waste at municipal landfills. One potential measure that could be considered in the UAE to reduce its greenhouse emissions in this sector is landfill methane capture for electric generation (EPA, 1998).

Landfill methane is created as a natural byproduct of decomposing organic matter, such as food and paper, disposed of in UAE landfills. The gas consists of about 50 percent methane (CH_4), the primary component of natural gas, about 50 percent carbon dioxide (CO_2), and a trace amount of non-methane organic compounds. Reducing emissions by capturing landfill methane and using it as an energy source could yield substantial energy, economic, and environmental benefits for the UAE.

Under this option, no degradable organics would be removed from the waste stream reaching a landfill, thus increasing the economic incentive for the installation of CH_4 gas recovery systems since the total amount of methane that can be produced would be available for recovery and energy production. The feasibility of this option in the UAE depends on the quantity of captured gas, equipment for gas cleaning, and expected rate and period of power generation. All of these issues would need to be addressed in a pre-feasibility study.

Another potential measure that could be considered in the UAE to reduce its greenhouse emissions in this sector is the introduction of an integrated waste management system that includes recycling, composting, landfilling (EPA, 1998). Under this option, a large part of degradable organic materials are removed from the waste stream used for composting thus reducing the economic incentive for the installation of gas recovery systems since the amount of methane that can be produced would be reduced and could not cover the cost of gas recovery. This would be an interim approach until such time as landfill gas recovery systems were in place To date, this is a favored option by the some local governments, having already been introduced at some locations.

4.8 Challenges & Follow-Up

The review of potential mitigation options for the UAE has helped to clarify areas where resources may be necessary to develop an actual mitigation assessment. Such an assessment would involve inter-ministerial links for information sharing and institutional capacity strengthening. If pursued, the various GHG-reducing measures presented in this chapter will likely require training in a number of different areas, such as:

- Residential, commercial and industrial energy audits,
- Preparation of procurement specifications for the importation of high efficiency appliances and equipment.
- The computerized modeling of energy flows in buildings and factories,
- Cost-benefit analysis of energy efficiency measures, plans, and programs,
- The efficient operation and maintenance of building energy systems, including building energy control systems,
- The specification and installation of energy-efficient appliances and equipment.
- institutional capacity strengthening for the identification and assessment of potential mitigation measures and policies across all sectors.
- Building public awareness on common measures to reduce greenhouse gas emissions.

Finally, this brief review shows that the UAE is already undertaking measures that promote GHG reductions, and has identified numerous other initiatives that could be implemented. Relying on national strategies for greenhouse gas reductions,

and being opportunistic regarding the flexibility mechanisms of the Kyoto Protocol, the UAE could enjoy net economic savings will also making a contribution to a reduction in global GHG emissions.

While implementing this set of initiatives would be an ambitious undertaking, it represents an important component under consideration in the national strategy on climate change. It would build on the strong technological and institutional foundation in the UAE and would help stimulate innovation while positioning the UAE as a responsible regional leader in meeting the global challenge of climate change.

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Chapter 5:

National Action Plan

5. National Action Plan

This chapter provides an overview of the initial formulation of a national-level strategy for raising awareness and building capacity concerning climate change issues. Such a strategy is essential for moving toward a better understanding of both the potential impacts on the UAE from a changed climate, as well as the inherent challenges and opportunities that climate change poses to sustaining the country's economic achievements over the past decades.

5.1 The UAE and Climate Change

As the previous chapters have clearly shown, the UAE is a country of strong economic growth, with a modern and well-functioning infrastructure, and a small level of greenhouse gas emissions relative to global emissions. Moreover, far from being solely dependant on its significant oil and gas resources, the country has already made enormous strides in the diversification of its economy.

Today, the productive output of country's many new service sectors is larger than that of the entire oil and gas industry. Yet, these achievements have taken place in the context of a fragile natural resource base and acute water supply needs. And, in the face of the additional risks posed by a changing climate – both natural and economic risks – a national action plan is considered to be not merely an option, but an essential task for charting a path to continued economic and social prosperity.

The United Nations Framework Convention on Climate Change (UNFCCC) obliged developed nations to reduce levels of their GHG emissions. As a non-Annex 1 country, the UAE is not obliged to meet a GHG emission reduction target. However, under the general commitments of the UNFCCC -- based upon the principal of common but differentiated responsibilities -- all nations, including the UAE, are encouraged to undertake actions that limit the growth in GHG emissions, and which are consistent with sustainable development.

Indeed, an action plan that focuses on climate change issues -- and which builds on the work already completed in GHG inventory development, vulnerability assessment, and GHG mitigation analysis – is the logical next step for the UAE Underlying such a plan are the following premises:

- *Awareness and capacity-building.* The plan involves a wide range of the people living in the UAE. Building awareness among the public at large will help ensure that actions are as informed and widespread as possible. The plan also address the need to strengthen local institutions to meet future technical challenges related to climate change;
- *UAE's unique circumstances.* The plan recognizes that there are a number of economic, geographic, meteorological, environmental, cultural, and other considerations that distinguish the UAE from other countries. These will inform the choice of measures and strategies; and
- *Specific strategies.* The plan recognizes that there are many potential areas of focus for adaptation and GHG mitigation measures. The outline of specific, investment technologies or strategies is of most value to the formulation of a plan.

This is the basic framework underlying a National Action Plan to implement the

UNFCCC. The next subsection highlights the various goals of the plan relative to potential challenges and opportunities of climate change.

5.2 Challenges and Opportunities

As has been discussed earlier in this National Communication, the UAE faces significant challenges related to adapting climate change and continuing its economic development in the face of potentially large scale, future global reductions in oil and gas use. With this as the point of departure, the Action Plan seeks to meet three distinct goals.

First, it seeks to outline a plan to strengthen the capacity of local institutions and networks to better understand the implications of climate change on economic development policy. This is of fundamental importance to the UAE as actions taken in Annex 1 countries to mitigate greenhouse emissions will likely have significant economic implications on the pace and direction of economic development within the country. Understanding how to effectively and collaboratively engage the international community around Articles 4.8(h), 4.9 and 4.10 of the Convention will be important in identifying win-win strategies.

Second, the plan seeks to outline a strategy to strengthen the capacity of local institutions to identify, assess, and integrate actions to adapt to climate change within the national and emirate-level development planning contexts. The framework for adaptation to climate variability, while ongoing and widespread, will need to be expanded to address the greater risks associated with climate change.

Finally, the plan seeks to scope out a strategy to strengthen the capacity of local institutions to identify and analyze measures that can achieve greenhouse gas reductions. This is an essential part of the plan as the identification of attractive investment opportunities within the Clean Development Mechanism (CDM) framework. Given a modern economy and mature financial networks, these opportunities are considered to be significant.

The UAE has already taken a number of important steps to promote sustainable development. Yet, these actions would need to be complemented by additional, specific actions to address climate change to account for the greater risks posed to natural and economic systems. Moreover, the Plan needs to be very much in line with sustainable development priorities such as enhancement of water supplies, sustainable management of natural resources, protection of sensitive ecosystems, and continued diversification of the economy.

5.3 Outline of a National Action Plan

The following points summarize a plan of action in keeping with the framework and goals described above. They represent a set of recommendations for broad actions on key areas that have been identified through the process of preparing this National Communications.

Strengthen the Executive Committee

The climate change Executive Committee is charged with the responsibility of supervising and coordinating all climate change activities in the UAE. It is chaired by the Ministry of Energy and has representation of all relevant institutions (i.e., energy, agriculture, forestry, waste, industry).

The Executive Committee should be strengthened so as to be better positioned to undertake three key activities: building broad public awareness on climate change issues, coordination of data acquisition/data quality enhancement activities, and the implementation of technical capacity building initiatives.

Strengthen Institutional Capabilities

It is critical that adequate technical and institutional capacity be built within key agencies and departments. In particular, targeted training should be untaken to deepen national capability in conducting vulnerability and adaptation analyses, as well as equip the UAE to undertake the kind of macroeconomic modeling that can help to inform the economic implications on the UAE from measure taken in industrialized countries to curtail their greenhouse gas emissions.

A program for training courses, workshops, and seminars should be designed to complement the other activities of the Executive Committee. Good collaboration with counterparts from government, industry and NGOs should be a high priority, as well as participation in regional initiatives and opportunities. Every opportunity should be taken of regional training opportunities.

Develop a Climate Change Information Center

Appropriate information of sufficient quality and comprehensives is essential for adequately completing a GHG inventory, vulnerability assessment, and mitigation analysis. At present information needed for these types of assessments are distributed among several different federal/local agencies and is often difficult to acquire. A climate change information center would help to address informational challenges by centralizing key data in one place and under the oversight of the Executive Committee.

Once established, the center would establish mechanisms for data collection and reporting, training on methods and techniques of data collection, reporting and management, research to fill data gaps, and the integration of climate change data needs into the normal reporting systems for relevant institutions. The creation and maintenance of a well-designed web-based information center should greatly facilitate access to climate change data.

Raise Public Awareness

The final element in the plan is the initiation of a national dialogue to raise awareness among key policymakers, civil society organizations and NGOs about climate change issues. It is essential that these groups and individuals operate from a common understanding about the causes and challenges of climate change. This will help to mobilize public support for new policies, as well as help to ensure support for future participatory activities.

In addition to governmental policy and decision makers and non-governmental and civil society organizations, it will be important to reach out to young people. Children, youth and teachers represent the potential for a future citizenry be sensitized to the challenge of climate change.

Raising awareness among this group will likely involve updates to school curriculum. Other key groups include the scientific and academic community, religious leaders, and the private sector. Raising awareness among these groups is important as each has a role to play in achieving significant GHG emission reductions and adapting to climate change impacts.

Finally, the media should also be engaged at various levels. Television, radio, and print are effective in shaping how the message is communicated to the general public.