ABU DHABI STATE OF ENVIRONMENT REPORT 2017

CLIMATE CHANGE

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Rapid growth in demographic, social and economic development and the ever-increasing demand for water and energy are the main drivers for the increasing pressure exerted by greenhouse gas (GHG) emissions. The principal source of GHGs in Abu Dhabi Emirate is the combustion of fossil fuels by the energy and transportation sectors.

The current pressures of climate change are shifting. Earlier concerns of ozone-depleting substances have diminished due to effective regulatory controls and awareness. However, there are new concerns about GHG emissions from power and fuel production, road transport, metal production and other manufacturing, and waste disposal sectors.

The emirate is particularly vulnerable to the impacts of climate change. This is due to the extreme arid climate and low-lying coastal areas, which are home to the majority of people and economic activity. Impacts include increased storm surges and erosion, which affect coastal development and coastal nesting species such as turtles, as well as habitat loss and die-off, such as coral bleaching.

Abu Dhabi Emirate’s existing plans and proposed strategies for sustainable development will achieve a reduction in the rate of GHG emissions in the mid-term against a business-as-usual scenario. The Abu Dhabi Government is committed to the implementation of the Intended Nationally Determined Contributions (INDCs) through economic diversification, which will yield mitigation and adaptation co-benefits.

Globally, the impacts of climate change are already being observed. The Climate Change Challenge

Climate is usually defined as the ‘average weather’ in a place over a period of time, ranging from months to thousands or millions of years. The classical period is 30 years. Climate includes patterns of temperature, precipitation, humidity, wind and seasons. Climate patterns play a fundamental role in shaping natural ecosystems as well as the human economies and cultures that depend on them. Climate change manifests itself in a variety of ways, including changes in temperature, rainfall and sea level, in addition to natural climate variability observed over comparable time periods.

Global studies indicate that the climate is changing more rapidly now than at any time in the recent past, with disruptive impacts. Analysis of Antarctic ice cores shows us that the concentration of carbon dioxide (CO₂) was stable over the last millennium until the early 19th century. It then started to rise, with concentrations now nearly 40 % higher than before the Industrial Revolution. Other measurements (e.g. isotopic data) confirm that the increase must be due to emissions of CO₂ from fossil fuel usage and deforestation. Measurements from older ice cores confirm that both the magnitude and rate of the recent increase are almost certainly unprecedented over the last 800,000 years [1].
Because so many systems are tied to climate, changes can affect many related aspects of where and how people, plants and animals live. Those effects include food production and availability, the use of water and various health risks [2].

The Global Policy Framework for Climate Action
In 1992, many countries joined the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty that provides the framework for international cooperation on combating climate change by limiting average global temperature increases and coping with its impacts. By 1995, countries under the UNFCCC launched negotiations to strengthen the global response to climate change and, two years later, adopted the Kyoto Protocol. In 2015, the Paris Agreement marked the latest step in the evolution of the UN climate change regime, charting a new course for global efforts against climate change. It provides a framework for climate action post-2020, after the second commitment period of the Kyoto Protocol ends. It was entered into force in 2016 at a record-breaking pace. The UAE ratified the Agreement on 21st September 2016, becoming the first in the GCC to do so. As of February 2017, 132 out of 197 parties have ratified the Paris Agreement. Under this new framework, signatories have pledged to take action to maintain global temperatures at less than 2°C above pre-industrial levels. Signatories should also prepare, communicate and maintain Nationally Determined Contributions (NDCs) that they intend to achieve, which are measured through a global stocktake every five years from 2020 and become progressively more ambitious [3]. Currently the NDCs submitted are insufficient to meet the goals of the Paris Agreement as they will lead to a 2.7°C rise in global temperatures. However, the terms of the Agreement include a ratchet mechanism to scale up ambitions with the aim of closing this gap. The UAE will also need to submit GHG mitigation and adaptation contributions, which will have a knock-on effect on the country’s own local policy work, making it important to ensure timelines are set in advance of these global stocktakes.

The Local Policy Framework for Climate Action
In 1992, many countries joined the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty that provides the framework for international cooperation on combating climate change by limiting average global temperature increases and coping with its impacts. By 1995, countries under the UNFCCC launched negotiations to strengthen the global response to climate change and, two years later, adopted the Kyoto Protocol. In 2015, the Paris Agreement marked the latest step in the evolution of the UN climate change regime, charting a new course for global efforts against climate change. It provides a framework for climate action post-2020, after the second commitment period of the Kyoto Protocol ends. It was entered into force in 2016 at a record-breaking pace. The UAE ratified the Agreement on 21st September 2016, becoming the first in the GCC to do so. As of February 2017, 132 out of 197 parties have ratified the Paris Agreement. Under this new framework, signatories have pledged to take action to maintain global temperatures at less than 2°C above pre-industrial levels. Signatories should also prepare, communicate and maintain Nationally Determined Contributions (NDCs) that they intend to achieve, which are measured through a global stocktake every five years from 2020 and become progressively more ambitious [3]. Currently the NDCs submitted are insufficient to meet the goals of the Paris Agreement as they will lead to a 2.7°C rise in global temperatures. However, the terms of the Agreement include a ratchet mechanism to scale up ambitions with the aim of closing this gap. The UAE will also need to submit GHG mitigation and adaptation contributions, which will have a knock-on effect on the country’s own local policy work, making it important to ensure timelines are set in advance of these global stocktakes.

Atmospheric GHG Concentrations
The largest contribution to global warming comes from the increase in atmospheric concentrations of CO₂, since the 1870s due to industrialisation. Concentrations of CO₂ in the atmosphere are higher now than at any time during the past 650,000 years. In the Northern Hemisphere, during the spring of 2015, the three-month global average concentration of CO₂ crossed the 400 parts per million (ppm) level for the first time [5]. Figure 8.1 shows global atmospheric concentrations of the greenhouse gases carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). Atmospheric Temperature
Abu Dhabi Emirate is already experiencing climate change, with higher temperatures and lower precipitation levels. Sea Level
Measurements from tide gauges in the region have shown that sea level has risen on average by 0.27 cm per decade over the past 50 years, accelerating to 0.45 cm per decade in the past 20 years [6]. In parts of the Gulf this rise has exceeded 0.67 cm per decade, which is three times higher than the global average [7]. Rainfall
Lower precipitation levels were noticed in Abu Dhabi Emirate between 1982 and 2013, with a decrease in precipitation of 80 mm during that period [6]. Climate change may result in higher frequency and intensity of storm events, such as those recently observed in March 2015 and Hurricane Gonu in 2007.
confirmed that the level of the Arabian Gulf has been steadily rising [5]. Researchers found evidence of relative sea level rise of 2.2 mm (± 0.5 mm) per year between 1979 and 2007 [8]. During one well-defined winter shamil event in 2004, storm surges were recorded of 10 to 20 cm in the eastern half of the Arabian Gulf, and 20 to 30 cm in the coastal shallows of the UAE [8]. The increasing occurrence of El Niño, which is the warming of sea surface temperature (SST), presents a climate phenomenon that affects regular wind patterns in the Gulf [10].

Accurate prediction of future sea level rise is essential for planning. The Greenland and Antarctic ice sheets, which will potentially raise sea levels nearly 70 metres if completely melted, dominate uncertainties in projected sea-level change. Interpreting past changes in the sea and projecting future changes require sophisticated numerical modelling using coupled ice-atmosphere–ocean general circulation models. While substantial advances have been made, these models currently poorly represent the complex interactions between the atmosphere, the cryosphere and the ocean environment. The Sea-Ice Model Intercomparison Project (SIMIP) aims to better understand how sea ice works and evolves in the coupled climate system of the planet. The results of SIMIP will be incorporated into the next IPCC Assessment Report, AR6, expected to be released by 2021.

Marine Water Quality

Chapter 6 looks at Marine Water Quality in more detail. However, climate change contributes to the quality of the marine environment, in addition to many other factors. Already, the Arabian Gulf is becoming more acidic at a faster rate than most other oceanic waters around the world and this is likely to increase in the future [11]. Coral communities generally show a decrease in diversity with increasing salinity from east to west in Abu Dhabi Emirate [12, 13, 14].

The Emirate’s marine biodiversity is impacted by a variety of stressors such as urbanisation, over-exploitation, habitat fragmentation and pollution, all of which reduce resilience [15]. Climate change acts synergistically with these factors and exerts additional pressures on biodiversity, reducing the ability to deliver critical goods and services.

Drivers of Climate Change

The Climate Report [11], which examined the causes and consequences of climate change, concluded that human activity is contributing to climate change by increasing the concentration in the atmosphere of GHG emissions.

Climate economists acknowledge that the main driving forces of GHG emissions are demographic change, social and economic development, as well as the rate and direction of technological change (see Chapter 2 – Driving Forces of Environmental Change for details).

Although the GHG emissions of Abu Dhabi Emirate do not exceed 0.26% of the world total [17], they are expected to keep growing due to the following drivers [18].

Population

Rapid economic growth driven by the discovery of oil in the 1960s has resulted in an unprecedented population boom in the UAE. This is due to high birth rates among UAE nationals, and as a consequence of immigrating expatriates seeking work in the expanding economy. In just two decades the population has doubled (see Chapter 2 – Driving Forces of Environmental Change).

The Government of Abu Dhabi predicts two more decades of rapid population growth. If it continues at the pace expected, the emirate’s overall resident population would grow to more than 4 million by 2030. Although this population growth will undoubtedly bring economic benefits to the emirate and its citizens, it may also put a strain on the already fragile environment, because of the growing demand for energy, water and mobility, the main sources of CO₂ emissions.

Affluence

GDP growth is tightly correlated with energy consumption since goods and services in an economy are produced using energy and water. In Abu Dhabi Emirate there is a strong link between water and energy, since potable water is produced through the desalination of sea water. This energy-intensive process uses fossil fuels, mainly natural gas, and releases GHG emissions into the atmosphere, contributing to global warming. The emirate’s reliance on desalinated water has resulted in very high energy and water consumption levels compared to global averages. According to SCAD’s statistical data [19] from the period 2005 to 2015, the total electric power generated in Abu Dhabi Emirate in 2012 was approximately 66,626 GWH, an increase of around 162% since 2005. The emirate’s production of desalinated water was about 1,170.5 MCM in 2015, an increase of 57.6% from 2005.

Technology

Between 1990 and 2006, the energy intensity of the economy in Abu Dhabi Emirate decreased by approximately 57.6% during the same period. Although this has been achieved through the introduction of new and more efficient technologies and the implementation of energy conservation measures, it is also due to the rapid economic growth driven by the discovery of oil in the 1960s. The government’s policy of economic diversification and development is aimed at reducing the dependence on fossil fuels and increasing the use of renewable energy sources.

The following table shows the contribution of different gases to the total GHG emissions of Abu Dhabi Emirate in 2012.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Contribution (%)</th>
<th>GHG Quantity (CO₂ Equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>81.4%</td>
<td>93,875</td>
</tr>
<tr>
<td>CH₄</td>
<td>10.4%</td>
<td>12,037</td>
</tr>
<tr>
<td>N₂O</td>
<td>11%</td>
<td>1,213</td>
</tr>
<tr>
<td>PFCs</td>
<td>0.0118</td>
<td>0.018</td>
</tr>
<tr>
<td>HFCs</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>SF₆</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>Global Warming Potential (IPCC SAR)</td>
<td>4.750</td>
<td>8.290</td>
</tr>
</tbody>
</table>
Abu Dhabi Emirate’s economy has decreased, reflecting the diversification of revenue sources perceptible since the year 2000. The emirate’s carbon intensity has remained constant, as there have not been significant changes in the technological mix of the energy supply system [20]. This situation is expected to change due to shifts in the structure of the economy and the diversification of the emirate’s energy mix, which may affect carbon emissions.

To address its growing energy needs, Abu Dhabi Emirate is embarking on an ambitious programme to increase the reliance on renewable and low-carbon energy for power generation and, in the long term, for water desalination. Under this new scenario, carbon intensity will decrease although fossil fuel will still remain the main source of energy for transport and industry, as well as the main export commodity.

### Pressures

**GHG Emissions**

Anthropogenic GHG emissions in Abu Dhabi Emirate have been driven largely by economic and population growth. The emirate’s GHG baseline (2010) and update (2012) inventories [21, 18] have shown that total direct GHG emissions increased from 89.1 million tonne CO$_2$-eq in the year 2010 to 115.5 million tonne CO$_2$-eq in 2012. This increase of 16.3% over the two years was in line with the increased trend of the emirate’s population (15.4%) and GDP (15.5%, in constant 2007 prices). Across the different sources activities (energy, industrial processes, agriculture, land-use change and forestry (LUCF) and waste) the energy sector was the dominant contributor (of 74.1%) of the emirate’s GHG emissions in 2012. At a local level, the UAE aims to ensure sustainable development while preserving the environment, and to achieve a perfect balance between economic and social development.

Considering the amount of emitted GHG gases in the emirate and their global warming potential (according to IPCC Second Assessment Report), CO$_2$ was the major gas mainly emitted from fuel combustion, constituting 81.4% of the total GHG emissions. Other GHG gases such as methane (CH$_4$), nitrous oxide (N$_2$O) and the F-gases (PFCs, HFCs, SF$_6$) contributed less: 10.4%, 11%, and 7.1%, respectively. In 2012, approximately 5.7 million tonnes of CO$_2$ emissions (6% of the emirate’s total CO$_2$ emissions) were sequestered by the extensive system of forestry, perennial croplands and mangrove plantations throughout the emirate.

According to the IPCC supplement for wetlands [22], the added value of Abu Dhabi Emirate’s wetlands (mangroves and seagrass meadows) is holding about 62 million tonnes of CO$_2$, where carbon is stored in the soil and biomass of the plants. This quantity may be released if the wetlands are extracted or drained. The key category analysis of GHG emissions in the emirate showed that the CO$_2$ emissions attributed to stationary fuel combustion for energy industries (oil, gas and power, combined with water desalination) and mobile fuel combustion in road vehicles require particular attention in mitigation plans (Figure 8.3). Abu Dhabi’s contribution to global GHG emissions is quite small in comparison to other developing communities. However, the per capita CO$_2$ emissions from fuel combustion were among the highest in the region, reaching 34.4 tonnes CO$_2$/capita in 2012, an increase of 5.6% from 2010.

While the CO$_2$ emissions from fuel combustion per GDP indicator increased to 0.45 kg CO$_2$/USD in 2012 (an increase of 8.6% over 2010), the carbon intensity for electricity production decreased from 424 kg CO$_2$/kWh (a reduction of 10.6% from 2010) This reflects the switch to a cleaner fossil fuel (natural gas) for electricity and water production in the year 2012. However, the main player in emission indicators is CO$_2$, with levels increasing faster than both population and GDP between 2010 and 2012. The main activities contributing to 2012’s CO$_2$ emissions were the production of public electricity and water desalination (which contributed to 53% of all CO$_2$ emissions), oil and gas extraction and processing (25%), manufacturing and industrial processes (22%) and transport (20%). The above categories are therefore key for future improvement in the emirate’s emission indicators.

### Soil Carbon Sequestration

The added value of Abu Dhabi Emirate’s wetlands (mangroves and seagrass meadows) is holding about 62 million tonnes of CO$_2$, where carbon is stored in the soil and biomass of the plants. This quantity may be released if the wetlands are extracted or drained. The key category analysis of GHG emissions in the emirate showed that the CO$_2$ emissions attributed to stationary fuel combustion for energy industries (oil, gas and power, combined with water desalination) and mobile fuel combustion in road vehicles require particular attention in mitigation plans (Figure 8.3). Abu Dhabi’s contribution to global GHG emissions is quite small in comparison to other developing communities. However, the per capita CO$_2$ emissions from fuel combustion were among the highest in the region, reaching 34.4 tonnes CO$_2$/capita in 2012, an increase of 5.6% from 2010. The switch to a cleaner fossil fuel (natural gas) for electricity and water production in the year 2012. However, the main player in emission indicators is CO$_2$, with levels increasing faster than both population and GDP between 2010 and 2012. The main activities contributing to 2012’s CO$_2$ emissions were the production of public electricity and water desalination (which contributed to 53% of all CO$_2$ emissions), oil and gas extraction and processing (25%), manufacturing and industrial processes (22%) and transport (20%). The above categories are therefore key for future improvement in the emirate’s emission indicators.

Compared with neighbouring countries in the GCC, Abu Dhabi Emirate’s emission indicators linked to the economy or electricity production were low (Figure 8.4). This reflects the effective performance of economic development with low emission intensities in Abu Dhabi Emirate, and the use of efficient technology and clean fuel compared to other countries in the region.

It should be noted that no single indicator can provide a complete picture of a country’s CO$_2$ emissions performance or its relative capacity to reduce emissions [23].

Figure 8.2 helps to identify how best to respond.
8.3 Impacts

Sea Level Rise and Coastal Vulnerability
In a world affected by climate change, stronger than normal winds in the Arabian Gulf region (known as ‘shamal systems’) could be strengthened, amplifying the impact of sea level rise through storm surges on cities in the UAE [25]. Such increased frequency and amplitude may also impact the ability of the offshore oil and gas sector to operate by increasing the number of down days. Shamel systems, in combination with climatic changes in atmospheric pressure, sea surface temperature, coastal topography and tidal effects, could result in higher peaks of storm surges in Abu Dhabi Emirate and a greater risk of inundation and coastal disasters.

Through modifications to our natural coastal systems due to the growing intensity of human activities and climate change, the emirate’s exposure to storm-induced erosion and flooding could be affected. An overwhelming majority of the UAE’s population lives near the coast and a dominant share of economic activity occurs in inundation-vulnerable, urban centres such as Abu Dhabi City [26]. Many coastal residents and economic activities can be found in areas that are backfilled or reclaimed from the sea for development projects. These areas are valuable commercial property and are particularly vulnerable to sea level rise impacts because of their low elevation above sea level. Consequently, the infrastructure supporting such properties and activities (such as roads, telecommunications, tourism facilities and wastewater networks) will face varying degrees of risk [10].

Of particular interest is the extent to which Abu Dhabi Emirate’s natural coastal systems can provide important climate change adaptation benefits. Such systems provide a basis for building resilience to the coming adverse impacts in coastal areas associated with climate change. The underlying perspective is that healthy coastal-marine ecosystems are part of the emirate’s natural capital that is essential for sustaining human life.

Impacts to Biodiversity
Despite extreme climatic conditions, Abu Dhabi Emirate’s terrestrial and marine habitats provide many ecosystem goods and services, including the production of food, fisheries, tourism, recreation, protection from coastal erosion and sequestration of atmospheric carbon dioxide. However, the emirate’s biodiversity is impacted by a variety of stressors, such as urbanisation, over-exploitation, habitat fragmentation and pollution, which reduce their resilience. Climate change acts in synergy with these factors, exerting additional pressures on biodiversity and reducing the ability to deliver critical goods and services.

Marine and Coastal Biodiversity
The major impacts of climate change on marine biodiversity are the effects of sea level rise and increased temperatures: salinity and acidification. An increase in the frequency and length of positive seawater temperature anomalies is likely the greatest threat to coral reefs. Mortality associated with coral bleaching events resulted in a 98 % loss of branching corals (Acropora) in 1998 on reefs in Abu Dhabi Emirate’s waters, as well as the mortality of many of the remaining colonies during the 1998 bleaching event [27]. Coral communities in Abu Dhabi Emirate have still not recovered from the bleaching events of the 1990s [14].

Bleaching events have recurred with increasing frequency in recent years, hampering the recovery of coral communities [28]. The reproductive output of several coral species has been shown to be impacted by bleaching events, suggesting that this may limit recovery through the next generation [29]. These changes are also impacting other reef-associated fauna such as fish, with reef-dependent species showing increasing vulnerability to extinction on southern Gulf reefs [30].

The threats of climate change to fisheries include changes in distribution, migration patterns and abundance due to increasing sea water temperatures. Changes in habitat quality and primary production may also affect productivity. There are also increasing risks of larval failing to mature, particularly given that many larvae are considered to be close to their thermal tolerance limits [31, 32, 33].

Degradation of reefs caused by recent thermal stressors is considered a major threat to reef-associated fish in the UAE [30]. Predicted declines in fish yields will also have negative socio-economic implications for fisheries.

Marine life in the Gulf is much less diverse than elsewhere in the Indo-Pacific due to the extreme environmental conditions and constraints on larval supply [34, 35]. For example, some species of reef fish are considered to live within 1°C of their thermal tolerance limits, at least for part of the year [36]. In addition to increased temperatures, increasing salinity levels are also expected to impact marine biodiversity, particularly in the coastal zone. Coral populations show systematic decreases in numbers of species with increasing salinity along the coast of Abu Dhabi Emirate [12, 13]. As such, it is expected that increasing salinity levels will also reduce species’ diversity.

The direct effects of a rise in sea levels will be an increase in water depths, changes in tidal variation, altered water movement and greater seawater intrusion [37]. Tidal height and tidal range affects available light, current velocities, depth and salinity distribution, factors that regulate the distribution and abundance of shallow water marine ecosystems such as mangroves, coral reefs and seagrass beds. Therefore, a major impact of climate change will be a redistribution of existing habitats.

The impact of sea level rise on important marine wildlife populations will primarily be due to the loss of habitat. Nesting sites for marine turtles and seabirds, such as the globally threatened Socotra Cormorant (Phalacrocorax nigrogularis), may also be affected by rising sea levels. When coupled with storm surges, shoals containing seabird nesting colonies and areas of turtle nesting beaches may be periodically inundated or badly eroded. An increase in sand temperature will influence the sex ratio and viability of turtle hatchlings, with negative impacts for some critically endangered species such as the Hawksbill Turtle (Eretmochelys imbricata).

Terrestrial Biodiversity
Given that many plants in the region exhibit adaptation to extremes of heat and drought [38], much of the emirate’s vegetation may be considered already highly resilient to climate change. However, species in drylands often exist near the limits of their physiological tolerances [39]. Climate change will likely act as an additional stressor that exacerbates ongoing degradation from the severe impacts of over-grazing and change in land use in many areas [40]. Perhaps more significantly climatic and other conditions required for regeneration can differ from those in which established plants can persist [41], and
Climate change is expected to have severe consequences across a wide range of species, including mammals, birds, and reptiles. For example, desert mammals exist near the upper lethal limits of temperature and have limited access to water. As is the case with other dryland taxa, many desert mammals are expected to have the most extensive reductions in suitable habitat, which covered nearly the entire study region for these taxa. In contrast, non-breeding birds, plants, and reptiles were projected to gain suitable habitats across much of the study region.

As with many desert animals, desert species have severe consequences across a wide range of desert animals [43].

Water Nexus

Under current conditions, the Arabian Gulf is already one of the most stressed marine environments on earth. Furthermore, an increasing share of the water supply comes from desalinated water, which requires energy to produce. This suggests that reliance on desalination is as much of an energy challenge as it is a water challenge [44].

The intensification of desalination activities within an already stressed Arabian Gulf may pose a range of environmental implications under climate change. Desalination processes separate seawater into freshwater, which is then distributed to meet the freshwater demands of households, businesses, amenities and industry. Hot brine concentrate from the desalination process is disposed into the Arabian Gulf, leading to localised changes in temperature and salinity levels [44].

Completed in 2016, the AGEDI National Water Nexus study investigated the following dimensions:

i) the impact of increasing ambient temperatures and changing precipitation on both water and energy demands in the context of socioeconomic growth, and

ii) the costs and benefits associated with a transition to more efficient and renewable-intensive water/energy production and consumption patterns [45].

Health and Wellbeing

Climate change will have significant impacts on public health, affecting key social and environmental determinants such as clean air, safe drinking water, sufficient food and secure shelter [5, 46]. The World Health Organisation (WHO) considers a changing climate as the greatest threat to global health in the 21st century. It noted that climate change already claims tens of thousands of lives each year due to heat waves and other extreme weather events, outbreaks of infectious diseases, the effects of malnutrition and environmental pollution.

The major impacts of climate change on the UAE’s public health are expected to be increased heat stress, potentially increased water- and vector-borne diseases, reduced water availability and impacts on food security [47]. The total burden of disease from climate change is difficult to ascertain, as there are many mechanisms through which climate change can affect public health [5]. The WHO global burden of disease model estimates for the UAE and the Middle Eastern region show low health effects from climate change relative to other countries, with an estimated 14 Disability-Adjusted Life Years (DALYs) per 100,000 people [48]. For the UAE, models have shown that climate change currently has minimal effects on human health relative to other modelled priority areas: approximately only 410 (0.2%) additional healthcare facility visits and 2 to 3 (0.1%) additional premature deaths from cardiovascular disease in 2008 were due to added risks of climate change. Assuming a ‘do-nothing’ scenario, the health burden due to climate change in Abu Dhabi Emirate is expected to increase to an approximate additional 27 premature deaths and 3,545 healthcare facility (HCF) visits per year. This figure would be approximately 16 premature deaths and 2,130 HCF visits if CO₂ levels could be stabilised at 550 ppm or 750 ppm levels. No estimates are available for non-cardiovascular health effects, such as malaria, malnutrition, flooding deaths and diarrhoea; however, these are expected to be low [49, 50].

Food Security

Considering the UAE’s heavy dependence on food imports and limited supply of fertile land and fresh water, food security is a key issue for Abu Dhabi Emirate. The Economist’s annual Global Food Security Index for 2016 ranks the UAE 30th out of 113 countries, according to criteria based on food affordability, availability and quality. However, the UAE may be vulnerable to food supply constraints and any associated price shocks associated with climate change impacts in food-exporting countries. The combination of climate change-induced declining agricultural productivity in food-exporting countries, tightening of world food markets and price speculation pressures could lead to several adverse circumstances in the UAE. These may include recurrent retail food price spikes and a need for substantial food subsidies. Households that have annual incomes at the lower end of the national range could find themselves subject to spending a growing share of the household budget on food [51].

Additionally, climate change is predicted to have significant adverse impacts on commercial fisheries in the Gulf. This is illustrated in Figure 8.6, which shows the impacts of climate change on species richness and habitat suitability for the set of 47 priority species, as obtained from the three modelling frameworks. The models project a high rate of local extinction (areas in red) in the Arabian Gulf by 2090, relative to 2010 under the RCP 8.5 scenario (see Figure 8.8 and Box 8.1).

Climate change could also impact domestic agriculture in the UAE, due to a number of factors leading to an overall decline in agricultural output. These include increased mean temperatures, reduced availability of freshwater resources, increased short-term weather hazards, soil erosion and loss of arable land, and increased disturbance from fires, plant diseases and pest outbreaks [51, 5]. In the absence of adaptation, the production of vegetables, fruit crops and field crops is threatened by climate change as it increases vulnerability to existing stresses [5].
8.4 Responses

The UAE Government is fully committed to the United Nations Framework Convention on Climate Change negotiating process. The UAE’s INDC in terms of mitigation and adaptation actions is described in Figure 8.7. These are mainly based on a strategy of economic diversification that will yield co-benefits in terms of both mitigation and adaptation as summarised below [52]. EAD supported the preparation of the INDCs through preparing the content for Abu Dhabi Emirate in cooperation with emirate-level stakeholders. At a federal level, MIDCACE is coordinating all climate change-related activities.

Mitigation Energy Sector Clean Energy Targets Abu Dhabi Emirate is following a whole-of-government approach to meet its commitment in contributing to national targets. These aim to increase the contribution of clean energy to the total energy mix from 0.2 % in 2014, to 27 % by 2021. This will be achieved through the use of renewable and nuclear energy.

Energy-intensive industries and the oil and gas sector will continue to use innovative technologies to improve efficiency and reduce emissions. Abu Dhabi National Oil Company (ADNOC) was the first in the region to reduce gas flaring, in order to lower GHG emissions. In energy intensive industries, overall performance indicators will be improved through carbon abatement measures and increased resource efficiency. In 2016, Abu Dhabi Emirate launched the region’s first commercial-scale network for carbon capture, usage and storage. The project notably captures and compresses emissions at the Emirates Steel facility in Musaffah. This is compressed and transported to oil fields, where it is used to enhance oil recovery and ultimately stored underground, providing one of the first viable mechanisms to de-carbonise essential energy-intensive industries.

Energy and Water Efficiency In addition to supply side targets, Abu Dhabi Emirate is undertaking comprehensive policies to reduce energy and water demand and promote the prudent use of resources. This includes the following actions:

- Tariff reform: the emirate recognises the value of energy and water tariff reform in reducing inefficiencies and promoting low-carbon development, as well as addressing energy security concerns. To this end, utility authorities have introduced a number of initiatives and policies, revising tariffs over the years for commercial and industrial customers, so as to reflect the cost of generation by 2021.
- Building and efficiency standards: Abu Dhabi Emirate is comprehensively targeting emissions from its building sector, which account for a significant percentage of the country’s electricity and water consumption. This is being achieved through green building regulations, efficiency standards, retrofit programmes and support structures for energy service companies.
- Demand side management: Abu Dhabi Emirate also launched a number of initiatives based on consumer awareness and demand management, including new formats for water and electricity bills that give residents detailed consumption and subsidies information.
- District cooling: given the harsh climate in Abu Dhabi Emirate, air-conditioning accounts for a significant share of energy consumption. Comprehensive infrastructure investments are being undertaken to move away from decentralised cooling and towards district cooling and improved efficiency.
- Appliance efficiency standards: Abu Dhabi Emirate collaborates with other emirates in developing the region’s first efficiency standards for air-conditioning units, eliminating the lowest performing 20 % of units on the market. It is also introducing efficiency standards for refrigeration and other appliances.

Transport and Infrastructure The Emirate of Abu Dhabi has adopted a comprehensive urban structure framework plan to optimise the city’s development until 2030. The emirate is undertaking the following investments and initiatives, which will have significant mitigation co-benefits in addressing the transport sector’s GHG emissions, including:

- The introduction of a new fuel pricing policy, by which will put the UAE in line with global prices. This aims to support the national economy, lower fuel consumption and protect the environment.
- A federal freight rail network crossing the country that will be eventually integrated into the GCC network.
- The Emirate of Abu Dhabi target is to convert 25 % of government vehicle fleets to compressed natural gas, and 15 % to electric vehicles.
- Strategies for Low Emission Vehicles (LEVs) and Low Emission Zones (LEZs), both aiming to reduce air pollutants and GHG emissions from the transportation sector.
Water Management

Adaptation actions do have mitigation co-benefits. equally as important as mitigation, and in some cases by a changing climate. Because of this, adaptation is Abu Dhabi Emirate is expected to be affected severely by a changing climate. Since this, adaptation is equally as important as mitigation, and in some cases adaptation actions do have mitigation co-benefits.

Waste Sector

Abu Dhabi Emirate will increase the amount of treated waste and waste diverted from landfill through a number of key initiatives, including:
- Developing laws to regulate and oversee waste management.
- Defining a federal roadmap for integrated waste management.
- Creating a database to gather and collect information regarding waste.

Adaptation

Abu Dhabi Emirate is expected to be affected severely by a changing climate. Because of this, adaptation is equally as important as mitigation, and in some cases adaptation actions do have mitigation co-benefits.

Water Management

The booming economy and industrial development in the UAE have increased water demand over the last few decades. This demand has largely been met by desalination, with seawater desalination plants producing 98% of the water consumed in the municipal sector (including potable, industrial and commercial use). Climate change, rapid population growth, industrial development, urbanisation and demand for agricultural irrigation will all have an impact on future water resources in the UAE and Arab region as a whole.

In the UAE, there is concern about further growth in the demand for agricultural water, particularly during the productive winter months, when, in the event of climate change, temperatures will be higher and evapotranspiration greater. This could further stress scarce groundwater resources.

The economic and environmental cost of desalination will also increase with climate change. Abu Dhabi Emirate is undertaking a Water Conservation Plan and more efficient forms of desalination.

Wetlands, Coastal and Marine Environment Conservation (Blue Carbon)

The coastal and marine environments of Abu Dhabi Emirate are diverse and include mangrove forests, salt marshes, sabkha, intertidal mudflats with cyanobacterial mats, and extensive sub-tidal seagrass meadows.

The emirate is undertaking significant restoration and plantation efforts, as well as conservation planting of both mangroves and seagrass, both of which support ecosystem-based adaptation resulting in mitigation of CO₂, with co-benefits of adaptation.

In 2013, the UAE and AGEDI initiated the Blue Carbon Demonstration Project, which provided decision-makers with a stronger understanding of the carbon sequestration potential in the Emirate of Abu Dhabi. In 2014, the project’s scope was expanded to cover the entire country, and it is now known as the UAE’s National Blue Carbon Project.

Overall, Blue Carbon ecosystems in Abu Dhabi Emirate are calculated to store more than an estimated 41 million tonnes of CO₂ equivalent within the soil and biomass, more than the emirate’s annual emissions from the oil and gas (26.4 million tonnes) or water and electricity (30.9 million tonnes) sectors.

A comprehensive coastal management approach is urgently required, which will protect the wetlands and coastal habitats and address issues linked with other drivers, such as climate change in relation to coastal vulnerability and the loss of coastal and marine resources (if critical towards adaptation planning). The Marine Spatial Planning initiative, spearheaded by the Department of Urban Planning and Municipalities (DUPM), could be complemented with a broader coastal zone management programme.

Terrestrial Species and Habitats

Adaptation to climate change for terrestrial species and habitats is taking place through local and national biodiversity strategies. Resilience is being enhanced through the creation of a representative network of Protected Areas.

Food Security

In 2010, Abu Dhabi Executive Council established the Food Security Centre – Abu Dhabi (FSCAD), tasked with ensuring food security for the emirate. The centre’s mandate includes developing food security strategies, policies and regulations; establishing and managing emergency food reserves; preparing emergency plans in cooperation with the National Agency of Emergency and Crisis Management; coordinating investments in the food sector in order to ensure security and support an increase in local production (agricultural, animal resources and fish resources); and achieving self-sufficiency in some food products.

As part of these efforts, Abu Dhabi Food Control Authority (ADFGA) and Abu Dhabi Farmers’ Services Centre (ADFSC) have supported farmers in improving productivity levels and reducing the use of water and other inputs for agriculture. This has included better irrigation techniques, the adoption of protected agriculture (greenhouses and hydroponics) and crop substitution. More recently, AAD collaborated with a number of government entities to initiate the development of an aquaculture policy to promote fish farming in the emirate while ensuring the responsible utilisation of natural resources.

Innovation and Research and Development

The Abu Dhabi Government has invested heavily in world-class graduate education for sustainable energy development. It established the Masdar Institute for Science and Technology in partnership with the Massachusetts Institute of Technology. The emirate has also established the Local, National, and Regional Climate Change Assessment Programme, addressing the data challenges across the wider region related to climate change adaptation and vulnerability issues. The Zayed Future Energy Prize further supports innovation, and is one of the most prestigious accolades in the field of clean energy development.

Education, Training and Public Awareness

Abu Dhabi Emirate has begun reforming curricula in schools to improve science and training, including the field of climate change. Outside of academia, UAE Government entities have launched public awareness campaigns, including Waterwise, Powerwise, Heroes of the UAE, Watersavers, and the Sustainable Schools and Sustainable Campus Initiatives, as well as the Ecological Footprint Initiative.

The emirate’s farmers are adopting new agricultural techniques to reduce water usage and improve productivity.
8.5 Outlook

Looking Ahead
As seen in the above analysis of the driving forces and pressures of climate change, energy-related activities (such as fuel combustion) are the main sources of GHI emissions in Abu Dhabi Emirate. According to Abu Dhabi Water and Electricity Company (ADWEC) [53], the emirate’s electricity demand is growing at double or triple the pace of economic activity and is expected to continue to grow. This high demand is partly related to the climate: more than 50% of peak demand is used to meet the cooling load in summer. ADWEC estimates that increases in the demand for electricity in the near future will be dominated by electricity exports to the Northern Emirates and demand from ADNOC. In later years the demand will come mainly from industry and residential and commercial mega projects that are likely to become steadily more important as the Abu Dhabi Plan is delivered.

According to ADWEC’s Winter 2012/2013 Water Demand Forecast [54], the emirate’s desalination capacity is expected to double by 2030 to match demand, and its electricity generation capacity is expected to triple by 2030 to match demand. However, the emirate’s water and electricity policy is gradually moving towards the more active promotion of conservation and efficient use and supply of water and electricity. Part of the future power capacity of Abu Dhabi Emirate will be provided by low-carbon energy (renewable and nuclear). This will contribute to mitigation of future GHI emissions. In 2017, the emirate launched a project to build the biggest solar power station in the world, with a capacity of 1,177 MW. When combined with existing solar power sources, the share of renewable energy in Abu Dhabi Emirate will be 7% upon completion of the project.

If development plans continue according to the business-as-usual (BAU) scenario in 2010, future GHI emissions in Abu Dhabi Emirate are expected to increase by a factor of 3.0, from 99.1 million tonne CO₂-eq in 2010 to 297.5 million tonne CO₂-eq in the year 2030 [18], considering policies as in the base year 2010 and taking into account the expected changes in population, GDP and urbanisation. In this scenario, by 2030 sectoral GHI emissions might be increased by 330%, 220%, 150% and 300% for energy, industrial processes, agriculture and waste, respectively.

ADGEDI is collaborating with Climate Change Research Group (CCRG), National Center for Atmospheric Research (NCAR) and the University of Sao Paulo (USP). The collaboration aims to improve future climatic projections in the Gulf region by creating a high-resolution regional model that is based on the Intergovernmental Panel on Climate Change (IPCC) Regional Climate Modelling System (RCMS). The RCMS is a state-of-the-art regional climate model that is used to simulate future climate impacts in the Gulf region by combining Global Climate Models (GCMs) and a high-resolution regional model that is based on regionalisation of the GCMs. The RCMS is a tool for assessing the impact of climate change on the Gulf region and for developing adaptation strategies to mitigate the impacts of climate change. The RCMS is a tool for assessing the impact of climate change on the Gulf region and for developing adaptation strategies to mitigate the impacts of climate change.

What is an RCP?
Representative Concentration Pathways (RCPs) are four GHI concentration (as opposed to emission) trajectories the IPCC used in its 5th Assessment Report. RCPs supersede the previous GHI storylines (e.g. A1, B1), RCP8.5 can be considered analogous to a business-as-usual scenario. The other RCPs assume stabilisation of GHI concentration in the atmosphere prior to 2100.

Global Climatic Models (GCMs). These models are typically poor in regions such as the Gulf due to the complex terrain, surface winds and sea surface temperatures [45, 25]. Higher-resolution regional models better account for such complexities.

Key findings of the modelling found the potential for the following:
- Extreme weather events, such as cyclones, are predicted to take place in the late 21st century.
- Sea surface temperatures are projected to increase throughout the Arabian Gulf from 1°C by mid-century; to up to 2.6°C by late century.
- Sea surface salinity is projected to both decrease and increase, depending on location. By mid-century, an uneven distribution of salinity is observed throughout the Arabian Gulf.
- Sea level is projected to rise throughout the Gulf by mid-century. The estimation of sea level rise was very conservative (3 to 10 cm). The model only considered the effects from storm surges and ocean circulation, which typically account for up to 15% of regional sea level rise. Due to limitations in the current state-of-the-art ocean modelling, ice cap melting and thermal processes (which are the major factors contributing to sea level rise) could not be directly modelled. Therefore, further study is needed to incorporate the effects of deglaciation and global ocean thermal expansion on sea level rise.
- Dynamic sea level (DSL) rise is highest in the northern area of the Gulf, and by late century, the areas showing the lowest increases are in the central Gulf area.
- Annual circulation dynamics are expected to change in two zones: a deep zone located in the central area, and a shallow zone located along the UAE coast.
- Global climate change effects from wind patterns will have impacts on Gulf coastal currents for two locations near Qatar and the UAE. Wind effects will be more evident in shallow areas, where coastal currents are well defined and highly correlated with wind, especially northward winds.

Changing Course
Initial analysis of the future opportunities for GHI emission mitigation [18] shows that the emirate has the potential to reduce around 42% of its BAU emissions by the year 2030. This will be achieved by considering additional emission control measures and policies, in a so-called extended emission control scenario (Figure 8). The key mitigation strategies that were considered in the analysis are:
- Nuclear energy programme
- Renewable energy programme
- Electricity and water demand side management (DSM) programme
- Surface transport master plan
- Estidama programme
- Oil and gas Environment, Health and Safety (EHS) programme
- Waste sustainable management programme
- Carbon capture and storage project
- Energy efficiency programme for the production of aluminium, oil and gas, electricity and water

Looking ahead...
The largest potential for emission reductions in the year 2030 is expected to come from combined electricity and water production (22% of BAU emissions), followed by transport (12%), waste (6%), and other sectors (2%). By the year 2020, nuclear and renewables will cover around 30% of energy demand and avoid 22 million tonnes of CO₂-eq per year. However, these initial projections and analysis will need to be reviewed and updated where necessary in close coordination with MOCCAE and other relevant stakeholders.

**FIGURE 8.8** Projected Sectoral GHG Emissions until 2030, According to Business-as-Usual (BAU) as in 2010

**FIGURE 8.9** Projected GHG Emissions until 2030 for Abu Dhabi Emirate, According to Emission Control Scenario (BAU-EXEC)