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

Ministry of Environment
State of Qatar
2011

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FOREWORD

It is a pleasure to present, on behalf of the State of Qatar, the initial national communication (INC) under the United Nations Framework Convention on Climate Change (UNFCCC). Through this submission, Qatar wishes to provide to the Conference of the Parties (COP), country-specific information amenable for use within the larger climate change context. Moreover, this information could be used by Qatar to develop climate-sensitive goals and informed mitigation and adaptation policies in line with sustainable development objectives.

To Qatar, climate change presents a double jeopardy. On one hand, like other developing countries with minimal adaptive capacity, Qatar is vulnerable to the physical impact of climate change on its ecology and human systems and resources. On the other hand, due to its total dependence on the export of carbon based resources, there is an uncertainty and concerns from the potentially negative economic impact of implementation of carbon-reduction policies, by consumer countries.

The State of Qatar has ratified the UNFCCC on 18 April 1996 and Kyoto protocol on 11 January 2005. Although Qatar is not obligated under the UNFCCC to set emission control targets, it is making voluntary efforts and plans to contain the national greenhouse gas emissions. These efforts are outlined in this communication.

The INC has been prepared with full consideration of Qatar's national vision (QNV 2030) as a backdrop. The vision reflects the four pillars of sustainable development: human, social, economic and environmental. It follows the guiding principles of the permanent constitution and directions of Their Highnesses the Emir and the Heir Apparent. The environmental pillar is increasingly becoming important in Qatar and worldwide as various environmental issues are now in urgent need of serious consideration. Global Climate Change stands out as one of the most critical issues that need to be addressed.

This First National Communication has been prepared in accordance with the guidelines published by the Intergovernmental Panel on Climate Change (IPCC) and reflects the best available information at the time of writing the report. We intend to provide rigorous assessments, particularly on the ecologic and economic vulnerability and adaptation to climate change, in the second national communication.

Finally I would like take this opportunity to thank H. E. Abdullah Bin Hamad Al-Attiyah, Deputy Premier, Minister of Energy and Industry for his continuous guidance, support and stewardship and H.E. Dr. Mohammed Al-Sada, State Minister of Energy and Industrial Affairs. I also would like to thank the working group for their appreciated efforts that led to presenting the report in this satisfactory fashion.

Abdulla Mubarak Al-Moadhadi
Minister of Environment

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The National Project Coordinator would like to acknowledge the contributions made by members of the NCCC as follows.

Incumbent members:
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Dr. Hassan Al-Fadala, former Dean of Engineering, Qatar University

During the preparation of the INC, a number of stakeholders including government & non-government organizations have played important roles, e.g. provision of data and participating in data review meetings. The contributions by the following institutions are gratefully acknowledged.

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Qatar Fertilizer Co.	Qatar Petrochemical Co.	Qatar Fuel Additives Co.	WOQOD
Qatar Vinyl Co.	Maersk Oil	OXY Petroleum	Dolphin Energy
Qatar Power	Ras Laffan Power Co	Qatar Electricity & Water Co.	Qatar National Cement
Qatar Planning Council	QP Directorate of Operations	QP Strategic Planning & Policy Directorate	QP Directorate of HSE Regulations & Enforcement
			Civil Aviation Authority

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Acronyms

CDM	Clean Development Mechanism	NAF	National Action Framework
COP	Conference of the Parties	N_2O	Nitrous Oxide
CH_4	Methane	NCCC	National Committee for Climate Change
CWP	Cogeneration of water and power	NMVOC	Non-methane volatile organic compound
EPA	Environmental Protection Agency	NOS	non-oil and gas sectors
EV	Corporate Environment & Sustainable Development Department, Qatar Petroleum	NOx	Nitrogen Oxides
GCM	General Circulation Model	OPEC	Organization of Petroleum Exporting Countries
GDP	Gross Domestic Product	PJ	Peta Joule (10^{15} joules)
Gg	Giga gram (10^9 grams)	PSU	Practical Salinity Unit
GHG	Greenhouse Gas	QP	Qatar Petroleum
GMO	Genetically Modified Organisms	QPC	Qatar Planning Council
GTL	Gas to Liquid	QPEERU	Qatar National Plan for Energy Efficiency, Optimization and Resource Utilization
INC	Initial National Communication	RCM	Regional Circulation Model
IPCC	Intergovernmental Panel on Climate Change	SCENR	Supreme Council for the Environment & Natural reserve
IUCN	International Union for Conservation of Nature	SO_2	Sulfur Dioxide
LNG	Liquefied Natural Gas	SLR	Sea level rise
MoE	Ministry of Environment	SST	Sea surface temperature
Mt	Million tones	TJ	Tera Joule (10^{12} joules)
MTBE	Methyl Tertiary Butyl Ether	UNESCO	United Nations Educational, Scientific & Cultural Organization
MW	Mega watt (10^6 watt)	UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

The State of Qatar is a small peninsula projecting from the Arabian mainland in the Arabian Gulf. Having a total area of 11, 437 km^2, Qatar extends northward in the Gulf for about 160 km and from east to west for approximately 88 km. Qatar peninsula adjoins Saudi Arabia and United Arab Emirates to the west and east. The population is estimated to be 1 million in 2007. It increased to 1.4 million in 2008 and is estimated as of June 2009 at 1.6 million. The economy is highly dependent on oil and gas which constitute over 90% of the national exports. The total export of crude oil and liquefied natural gas (LNG) during 2007, expressed in energy units was, 3590 PJ, mainly consisting of crude oil (1890 PJ) and LNG (1209 PJ). Exports of condensate and Gas to Liquid (GTL) fuels were 423 PJ and 72 PJ, respectively. Historical record of the Gross Domestic Product (GDP) shows that nominal GDP has more than doubled during 1990-2000 and almost quadrupled between 2001 and 2007. Analysis of the GDP suggests its overwhelming dependence on revenues generated from the oil and gas industry (>55% of the total). Other non-oil economic sectors of sizable contribution to the GDP include: finance, real estate and insurance (12.5%); manufacturing industries (8%); building and construction (7%). The dependency of the GDP on oil and gas revenues results in high economic vulnerability due to fluctuations in the oil and gas prices and subsequent irregularity in the annual growth rates of the GDP. Climate Change adds a further uncertainty to Qatar National GDP. Economic diversification, within the hydrocarbon sector and away from it, is critical to Qatar so as to maintain a steady and robust economy.

Terrestrial biodiversity in Qatar is unique. It supports a relatively diverse range of habitats. Approximately 1900 documented species have been identified in Qatar including about 1000 terrestrial and 900 marine species. The biodiversity inventory indicates that about 78% of the terrestrial species in Qatar are rare. Qatar has a terrestrial plant diversity consisting of 371 species of flowering plants belonging to 236 genera in 61 families.

The marine environment supports 955 known marine species. They include three documented mammals, 15 reptiles, 136 fish species, and 379 species of plants. The marine environment includes coral communities, intertidal mud flats, algal beds, seagrasses beds, pearl oyster beds and mangroves. Environmental and biological factors profoundly influence the occurrence and distribution of mangroves mostly found in the intertidal zone in the eastern coast of Qatar. High sea surface temperature coupled with high irradiance is known to be the primary factors in summer coral bleaching. The common marine mammals in Qatar are whales, dolphins and porpoises.

In arid regions like Qatar with high climatic variability, any further climatic change could produce large effects on the eco-systems and environment. Qatar Climate records show that the annual mean temperature has increased by 0.3^o C over the last 40 years. This is mainly due to a significant steep increase in the mean minimum temperature (0.63^{o}C/40 yr) or night time temperature. However, no significant trend was found in the annual rainfall.

Qatar's national GHG inventory was estimated for the year 2007 as baseline year. Following the IPCC Guidelines for 1996 and 2007, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions were estimated using the best available information and tier 2 country-specific emission factors, developed for each sector. Similar to GHGs, nitrogen oxides (NOx), sulfur dioxide (SO_2), and non-methane volatile organic compounds (NMVOCs) were estimated by using bottom up approaches, engineering calculations & industry approved emission factors.

The net carbon-dioxide emission for 2007 amounts to over 62.4 million tones (62,400 Gg). Carbon dioxide constituted over 93% of the total, methane 6% and N_2O < 1%. The predominant source of GHG emissions from Qatar is the energy sector, accounting for 92% of the total national inventory of CO_2 and N_2O and approximately 81% of the methane emissions. Out of this amount flaring mainly from the oil and gas production operations is responsible for 43% to 50 % of the methane and sulfur dioxide emissions. Overall the Energy Sector emitted 52,816 Gg of CO_2, 136 Gg CH_4, and 1.4 Gg N_2O from combustion activities which include productive and fugitive emissions. Out of the total emission by the energy sector the oil & gas was responsible for 50%, power & water approximately 27% and road transport 7%. The industrial process activities emitted 5.3 million tones of CO_2 equivalent, mostly in the form of CO_2 ((97%). This amount

represents 8.5 % of the national emission from Qatar in 2007. The combined total of GHG emissions from the waste and agriculture sectors in Qatar was relatively small, accounting for <1% of the national total. Most of the emissions were in the form of methane.

Climate change presents a double jeopardy to Qatar. On one hand, like other developing countries with minimal adaptive capacity, Qatar's ecological and human systems are vulnerable to the adverse impact of climate change. On the other hand, due to its total dependence on the export of carbon based resources, Qatar economic welfare and prosperity is uncertain & depends on the outcome of the climate change negotiations which seeks, as an ultimate objective, complete phase out of fossil fuel energy sources from the world energy market. In view of this, a detailed assessment of the vulnerability and adaptive capacity of Qatar's economy & its ecological and human systems to the impact of climate change is critical.

Under the increased temperature conditions with no increase in the rainfall pattern due to climate change, there will be no off-set for the moisture losses from the water-stressed land in Qatar. There will be two broad effects emerging out of this situation. The first one is a further desertification of the desert and the second is increased water needs in the water scarce area. Since most of the water needs are met from desalination process, the energy need and consumption is bound to increase. This will lead to increased greenhouse gas emissions and waste heat causing changes in climate. Energy needs will increase further due to the additional air conditioning requirement of a warmer environment. It will lead to the release of additional waste heat and greenhouse gas emissions. Some of the salient policy options to be considered in Qatar include: improvement in energy efficiency by better building codes, adopting mandatory energy star products/appliances, improved auditing and energy management, and enhanced public awareness and education programs.

Published world climate change risk assessment studies for Qatar are limited. In one study (Maplecroft, 2009) Qatar is considered one of three countries in the Arabian Gulf exhibiting "extreme" vulnerability to Sea Level Rise along with Kuwait and Bahrain. The study estimated that Qatar is susceptible to inland flooding at less than 5 m sea level rise with 18.2% of its land area and 13.7% of its population being adversely impacted. In another study by a World Bank group, it has been suggested that a 1 meter Sea Level Rise could impact 2% of the population & GDP and 1% of urban land.

In another relevant study for neighboring Bahrain it has been estimated that at a SLR of 0.2 meter, 5% of the total land area of Bahrain will be inundated. At a higher scenario of 1 meter SLR 10% of Bahrain land will be affected. The effects could be much higher for some specific areas like pristine islands where inundation of 22% for 1 meter SLR is estimated.

Climate change scenarios coupled with heat island effects in urban areas would lead to increased air pollution in urban areas of Qatar (Zhang, et al, 2005). Considerable increase in heat exhaustion, suspended particulates, photochemical oxidants and secondary pollutants such as ozone are bound to increase. All these changes will have adverse effects on human health.

Due to shallow water depths of marine waters in Qatar, any small change in climate will have profound influence. The marine sensitivity atlas (SCENR, 2008) prepared by the Ministry of Environment, classified mangroves, coral formations, deep coral assemblages and shallow seagrass beds as highly sensitive ecosystems. Furthermore, scientific studies suggest that climate change in Qatar could adversely impact primary producers, and causes coral bleaching, and extinction of turtles, dolphins, dugongs and whales. Migratory patterns also could change for some marine species and sea birds.

Qatar is pursuing voluntarily a national initiative to reduce greenhouse gas emissions as long as they are in line with sustainable development. A national plan for energy efficiency, optimization and resource utilization has been proposed to serve as a driver for the greenhouse gas mitigation, under the UNFCCC. Its objectives and building blocks reflect both the current national sectoral emission profiles and the potential win-win sustainable development opportunities to reduce emissions. It is worthy to note that since some of the mitigation initiatives represent potential future investment opportunities under the Clean Development Mechanism (CDM), it is prudent to enhance the catalytic role of the NCCC so as to effectively enhance the implementation of the QPEERU. The available opportunities are listed below.

- Assess potential flare mitigation opportunities from the oil and gas operations within the context of the UN CDM.

- Assess potential opportunities for further efficiency improvement of the combined cycle cogeneration of water and power (CWP) within the context of the UN CDM.
- Raise energy efficiency and reduce energy consumption and wastage per unit of output through technological improvements.
- Establish policies and regulations to manage energy conservation throughout the entire process of energy production, transport, processing and utilization.
- Adjust the value structure of the society towards energy use and utilization.

The Oil & Gas Sector has the greatest opportunities for GHG mitigation mainly by optimizing energy use for productive operations and minimizing energy wasted in flaring and venting. The potential opportunities amount to over 8 million tones annually.

Potential GHG mitigation opportunities for the Power & Water Sector may be accomplished through the following mitigation policies and measures: (i) Improved Efficiency for Cogeneration of water and power (CWP); (ii) Energy Efficient Building Code; (iii) Energy Efficient Appliance Standards; (iv) Implement energy auditing and energy management in enterprises; (v) Exchanges in the study of energy conservation; and (vi) Public awareness of energy conservation initiatives.

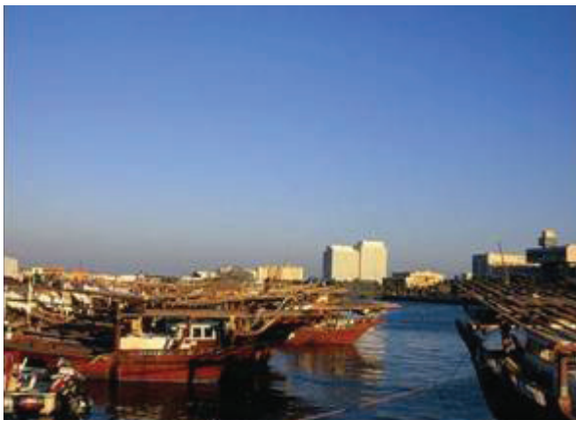
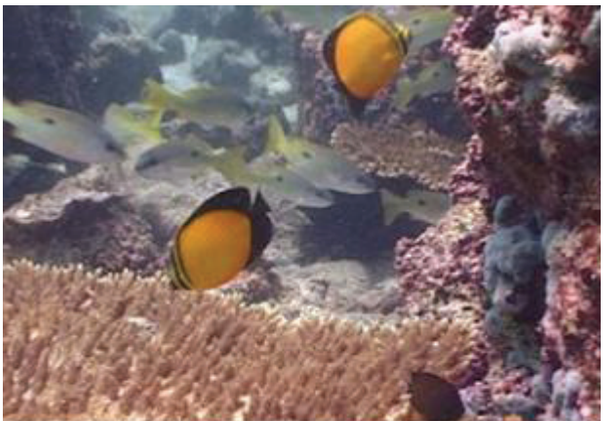
A National Action Framework (NAF) to build capacities and raise public awareness on issues relating to climate change shall be developed by the NCCC to implement the Convention. The plan shall be built around the most critical challenges and opportunities posed by climate change. Necessary strategies shall be formulated for their effective implementation.

The main elements of the NAF shall consist of the following:

- Strengthen technical and institutional capacities
- Establish web-based climate change information center
- Raise public awareness
- Other elements that will be identified by the NCCC.

CHAPTER 1

National Circumstances


1. National Circumstances

1.1 Geographic Background

The State of Qatar is a rapidly developing country located half way along the western coast of the Arabian Gulf and borders with Saudi Arabia to the west (see Fig 1-1). The country includes a number of islands, reefs and shoals in the coastal waters of the peninsula. Table 1.1 is a summary of the geographical features of Qatar.

Table 1-1 Geographical Features - Qatar

Latitude	$24^0$27' & $26^0$10' North
Longitude	$50^0$45' & $51^0$40' East
Dimension	185km long and 85km wide
Area (mainland)	11580 km^2
Coastline	563 km (main), 700+ km (incl. islands)
Highest Altitude	103 m above mean sea level
Territorial Waters	95 nautical miles East 51 nautical miles North

Source: QSA, Qatar National Atlas, 2006

The country has a flat rocky surface with its landmass consisting of scrubby desert terrain covered in sand and loose gravel overlaying limestone & clay deposits.

Figure 1-1 Location Map of Qatar

1.2 Climate

Qatar's climate can be described as hot desert type BWh (Koppen's classification) and is characterized by a) hot and humid summer, and b) semi-dry short winter with scanty rainfall.

Although the land heating is very high during summer months, depending on the time/season of the year, strong northerly/northwesterly winds called "*summer shamals*" or "*winter shamals*" occur.

Table 1-2 Climatic Summary - Qatar

	Summer	Winter	Transition
Months	**May-Sept**	**Dec-Feb**	**Mar, Apr, Oct, Nov**
Mean Max. Temp.	41.3^0C	23.6^0C	$25.9\text{-}34.8^0$C
Mean Min.Temp.	29.2^0C	12.9^0C	16.6^0C
Annual Rainfall	82mm (1990-2008)		
Mean RH	56%	73%	60-68%
Prevailing Wind Direction	Northwesterly and Northerly (Other directions occur, less frequently)		
Annual Mean Wind Speed	16.5 km per hour		

Summer shamals usually occur for about 40 days between May and July with considerable inter-annual variation. On many occasions, sand/dust storms are associated with "*shamals*".

There is a high rainfall variability which depends on the location, month, season and year. The frequency of thunderstorms, developed by the mid-latitude lows passing over the region, is well correlated with rainfall distribution. There are perceivable variations in temperature and humidity between the coastal north and the south connected to landmass.

Huge solar pumping and lack of water exchange with the open ocean makes the Gulf more saline and hot, therefore making the dispersion of pollutants slower.

1.3 Demography & Human Development

Industrialization and infrastructure development has contributed to the population growth from around 422,000 in 1990 to 1.6 million by Sept-2009 – almost quadrupling within a short period of 18 years.

The population growth rate between 2005 and 2008 averaged around 16% per annum. Most of this growth is attributable to unskilled and semi-skilled labour migration. Qatar's population density is 138 per square km. and 96% of population lives in urban areas. Such statistics are relevant to the management of climate

change in Qatar given the increase in industrial output as well as use of energy and water resources due to population increase.

Qatar ranked 33rd in the world on the Human Development Index in 2009 compared to 57th a decade earlier.

Given the rapid economic development of Qatar and its people, a substantial positive change in literacy rate, gender equality, health and incomes was achieved. These are detailed in the Table below:

Table 1-3 Positive Social Change Indicators

Indicator	1990	2007
Literacy Rate	78%(1986)	99.1%
Literacy Ratio – Female/Male (15-25 years)	96.5%	99.9%
Girls – Boys Ratio in higher education		209.3
New Born Mortality Rate	0.85%	0.37%
Life Expectancy	69.2	75.5
Fertility Rate	4.4	2.7
Physicians per 100,000 people	179	208
GDP Per Capita (PPP, US$)	15,004	61,528

The Millennium Development Goals in the State of Qatar (QSA), 2008

1.4 Environment

In recent history Qatar has made several achievements and commitments designed to protect and conserve the environment at local, regional and international levels. These encompass policy, regulatory and institutional arrangements at various levels of economic development.

1.4.1 Regulatory Framework & Institutional Arrangements

This section covers actions and legislative instruments enacted by the State of Qatar to achieve legal compliance with the national and international treaties to which Qatar is signatory.

- Elevating the Supreme Council for Environment & Natural Reserves (SCENR) into the Ministry of Environment (MoE) in 2008.
- Creation of the Directorate of HSE Regulations and Enforcement under the Ministry of Energy and Industry in 2007 with specific mandate relating to HSE aspects of the petroleum industry. This is in addition to the existing corporate HSE department of Qatar Petroleum.
- Legislative instruments in place:
  - Law No.30 (2002) and Executive Law No. 4 (2005) for environmental protection
  - Law No.31 (2002) for Radiation Protection
  - Law No.19 (2004) for protection of Wild Fauna and Flora and its natural habitats
  - Law No. 4(1997) as amended by Decree Law No. 35 (2002) for the conservation of petroleum resources and to ensure implementation of and compliance with HSE laws in energy industry
  - Emiri Decree No 21 (1985) for the Protection of World Cultural and Natural Heritage
  - Law No. 21 of 2007 on controlling of materials depleting the Ozone Layer (2007)
- Major environmental treaties / conventions / partnerships:
  - Prevention of Marine Pollution by Dumping of Wastes and other Matter (1992)
  - International Maritime Organization Convention on Marine Pollution (MARPOL) (2006)
  - Basel Convention on the control of Trans-boundary Movements of Hazardous Wastes (1996)
  - Nuclear Non-Proliferation Treaty (1989)
  - Nuclear Test Ban Treaty (1999)
  - United Nations Framework on Climate Change (1996) and Kyoto Protocol (2005)
  - Montreal Protocol on Substances that deplete Ozone layer and its annexes (1999)
  - UN Convention to Combat Desertification (1999)
  - Convention on International Trade in Endangered Species of Wild Flora & Fauna (2001)
  - UN Convention on the law of the sea (2002)
  - Global Gas Flaring Reduction Partnership (2009)
  - Stockholm Convention on Persistent Organic Pollutants (2004)

1.4.2 Terrestrial Environment

The State of Qatar's terrestrial biodiversity comprising flora and fauna is unique and supports a relatively diverse range of habitats that are well adapted to the hot and arid environment.

Sand and limestone covers greatest area and supports most diverse flora. The types of native vegetation in Qatar are shown in Fig 1.2. Birds included in IUCN Red List are shown in Fig 1.3. The Ministry of Environment (MoE) has prepared the National Biodiversity Strategy and Action Plan (NBSAP) in 2004 for the State of Qatar to support the conservation of biodiversity and for ensuring equitable sharing of the consequential benefits.

Figure 1-2 Types of Habitat in Qatar

White Sand Habitat

Silt Habitat

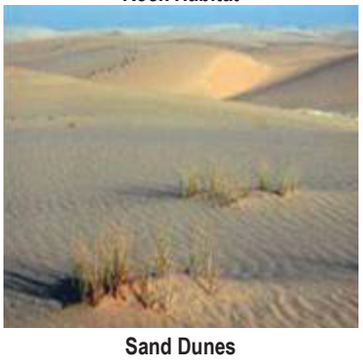
Sabkha Habitat

Coastal Sand Habitat

Rock Habitat

Gravel Habitat

Sand Habitat



Sand Dunes

Sand & Limestone Habitat

Figure 1-3 Birds Listed in the IUCN Red List and Present in Qatar

Socotra Cormorant

Imperial Eagle (V)

Ferruginous Duck (NT)

Main threats to wild terrestrial flora and fauna typically include hunting and collection, grazing and increased access to livestock and vehicles, habitat loss, air quality and climate change and the level of public awareness (NBSAP, 2004).

The NBSAP indicates that approximately 1,021 terrestrial species exist in Qatar and these have been documented in Qatar Biodiversity Inventory (2003) and a summary is included in Table 1-4

Table 1-4 Terrestrial Biodiversity in Qatar

Type	Number of Species
Plants	378
Fungi	153
Mammals	8
Birds	242 (23 Local Breeders, 46 Migratory)
Amphibian	1
Invertebrates	230
Reptiles	29

p.264, Annual Statistical Abstract-2007-8, QSA, 2007

Table 1-5 summarizes the key species with common names identified in the NBSAP that would require a level of positive intervention to reduce current risk level.

Table 1-5 Terrestrial Species Requiring Intervention in Qatar

Risk Level	Common Name	Biological Name	Class
Endangered (EN)	Arabian oryx	*Oryx leucoryx*	Mammals
Vulnerable (VN)	Greater spotted eagle	*Aquila clanga*	Birds
	Lesser kestrel	*Falco naumanni*	Birds
	Corn crake	*Crex crex*	Birds
	Sociable lapwing	*Vanellus gregarius*	Birds
	Socotra cormorant	*Phalacrocorax nigrogularis*	Birds
Lower Risk – Near Threatened (LR)	Great snipe	*Gallinago media*	Birds
	Ferruginous duck	*Aythya nyroca*	Birds
	Houbara bustard	*Chlamydotis undulata*	Birds
	Cinereous bunting	*Emberiza cineracea*	Birds
	Pale Harrier	*Circus macrourus*	Birds

1.4.2.1 Protected Areas for Conservation

To reduce the loss of biodiversity, Qatar has designated significant areas throughout Qatar as shown in Table 1-6 as "Protected Areas" that serve as sites for the restoration of endangered wildlife species through reintroductions. Also, UNESCO has declared Al-Reem (NW Qatar) as a World Biosphere Reserve.

Table 1-6 Increase of Protected Areas in Qatar

Year	Protected Area as a % of Total Area
1990-2003	0.17%
2005	11.12%
2007	21.72%

The Millennium Development Goals in the State of Qatar (QSA), 2008

1.4.2.2. Species Conservation Initiative

The restoration of the wild-extinct Arabian Oryx constitutes a remarkable model in this respect. A small founding herd was successfully captive bred at the Arabian Oryx Breeding Centre and animals from this stock were reintroduced in three reserves - Shahanya, Ushaijrij and Almazhabyah. The Rheem Gazelle that became locally extinct was also reintroduced following successful captive breeding.

The reintroduced populations have grown to 732 Arabian Oryx and 3,500 Rheem Gazelles and are being released in open protected areas (rather than to introduce in fenced in reserves) as fully free ranging animals. The research work in the protected areas is being expanded to include other species such as Ostrich and Houbara. Management plans for the PAs are being revised. MOE is seeking local community participation in the management of protected area to further enhance the sustainability of the program.

Recently, a rare species of snake known as Horned Viper (*Cerastes cerastes gasperetti*), the only truly poisonous snake in Qatar, was discovered in the northern parts of Qatar (*QP*, 2007).

Qatar has five important bird areas (IBA) that are recognized for their regional role for the threatened species preservation (Birdlife International, 2004). The five areas are, Khawr Al Udayd, Al Ashat Island, Al Aliyah Island and Adh Dhakhirah mangrove and Sharaiwah Island. Amongst birds listed in the IUCN Red List and present in Qatar are Ospreys, of which few pairs breed on rocky islands in Khawr Al Udayd, and Socotra Cormorant (see Figure 1-3).

1.4.2.3. Combating Desertification

Qatar has signed the UN Convention to Combat Desertification in 1999 with a focus on sustainable use of ground water resources and reversing the sand creep on agricultural lands.

Qatar is making efforts with the objective of combating desertification including the establishment of protected areas, expanding the growth of date palms, setting up of camel farms to reduce the number of camels on

rangelands, artificial recharge of groundwater, fixing sand dunes and drawing up an integrated national program for combating desertification (INPCD). The INPCD considers the inter-relationship between farming practices, water management, biodiversity, climate change and land use planning.

1.4.3 Marine Environment

1.4.3.1 General

Urbanization, industrialization, land reclamation from sea and climate change can all have a potential impact on marine habitat and biodiversity. The total coast line of Qatar is approximately 23% of the total coastline of the Gulf and the total area of its seawater is around 35,000 square kilometers or 15% of the Gulf. Qatar's marine environment is very shallow with an average depth of 20-30m depending on location. Experts believe that Qatar's marine environment is rich in character and requires detailed mapping. Table 1.7 shows the Marine Biodiversity in Qatar's waters known to date.

Table 1-7 Marine Biodiversity of Qatar

Type	Number
Mammals	More than 20 including whales, dolphins and Dugong are known in the region
Reptiles	15 (e.g. Sea Turtles)
Fish	136
Plant Species	379
Total known species	955
Most Productive habitat	Shoreline to 10-12m deep

Renee Richer in Conservation in Qatar (2008)
QSA (2008) Advancing Sustainable Development – Qatar National Vision 2030

Qatar's marine resources are surviving at their extreme tolerances of environmental parameters, e.g. high/hyper salinity, largest annual temperature variation and lack of exchange with open oceans. Qatar's extreme habitats also provides for unique adaptations to the extreme conditions. For example, the most thermally tolerant coral species, i.e., those that do not bleach when other species do in the Gulf, are found here and they host a large proportion of symbiotic zooxanthallae compared to other corals in the region. Another example is the presence of some species of endemic bacteria in the Gulf that have adapted to utilize hydrocarbons (Renee Richer, 2008).

1.4.3.2 Marine Habitat & Biodiversity

Four areas that have been identified under threat in Qatar include: Inter-tidal and sub-tidal zone, Mangrove muddy habitat, Salt marshes, and Coral around Qatari waters.

As per the IUCN Red Book, 1.4% of known species in Qatar are under threat (IUCN, 2008). Out of these a large number, unlike other regions, are marine based. Amongst them are the corals, sea turtles, and sharks.

Mangroves & Seagrass

There is only one type of mangrove species found in Qatar predominantly in the intertidal zone at the eastern coast of Qatar. Mangroves are concentrated at Al Dhakhira, Al Khor, Al Wakra, Umm Al Houl, Al Majfer and Fuwarit.

Figure 1-4 Coastal Salt-Tolerant Vegetation/Mangroves

In addition to providing shelter and nutrients to marine species, mangrove swamps have an important function in reducing the sediment load into the shallow waters by stabilizing the shoreline.

Figure 1-5 Shallow Seagrass Beds

Seagrass beds are common along the coast at depths of 3-8m and are the most productive of the marine habitats. Seagrass support a range of marine animals including dugong, whales, turtles and dolphins. Protection of seagrass is therefore important for marine biodiversity (Somer, 2003).

Figure 1-6 Dugong *(Dugong dugong)*

Sea Turtles

Five species of sea turtles are known in the gulf including the globally endangered Green turtle (Chelonia mydas), critically endangered Hawksbill turtle (Eretmochelys imbricate) and Leatherback turtle (Dermochelys coriacea) as well as endangered Loggerhead (Caretta caretta) and Olive Ridley turtle (Lepidochelys olivacea) (Somer, 2003). At Ras Laffan, an eight kilometer beach where turtles lay eggs was protected by the industry in Ras Laffan Area. MRF-URS study indicates that conservation efforts are on-going and found that marine litter, foxes and lighting management can add to the conservation efforts.

Figure 1-7 Hawksbill Turtle

Like other turtles, hawksbills are migratory and change their benthic feeding habitat when they approach coastal areas. They become regular inhabitants of hard substrates where their diet consists of corals, tunicates, algae, especially sponges. It is the only known spongivore marine turtle. Sponges of the groups *Demonspongia Codium* and *Echeuma* are reported to have been found in their stomach contents. From an ecological point of view, hawksbill turtle help to maintain the balance of benthic fauna on coral reefs, because the sponges they eat compete with corals for space on the reef so that in the absence of the hawksbill turtles, sponges displace the corals.

Turtles in Qatar inhabit the south-eastern parts of the sea. They are commonly found at Halul Island, Ras Rukum, Umm Tais Island, Sharaowa Island, Fuwairit beach, Ras Laffan beach and Al Thakhira beach. Turtles are air breathing reptiles with streamlined bodies and large flippers and well adapted to life in the marine environment. The green turtle is solitary animal and feeds on seagrasses and algae. In adulthood, they are the only herbivorous turtle. Ecologically, green turtle both help to maintain the seagrasses and make them productive, because without green turtle, seagrasses beds grow tall and trap sediments that obscure the light and promote disease.

IUCN Red Book (2008) identifies that the sea turtles and sharks are threatened species in Qatari waters.

Sea Birds

In Qatar around 20 species of seabirds could be found, of which the prominent are flamingo, seagull and herons. Breeding in offshore islands in the Gulf area (Gallagher et al. 1984) recorded massive numbers of seabirds especially Socotra Cormorant and terns (Bridle Tern, White-cheeked Tern, Lesser Crested Tern).

During the winter in the northern hemisphere, about four (4) million seabird waders visit Qatar on their migratory path and are dependent on intertidal zones for sustaining the life of migratory birds.

Twenty (20) other water birds species including grebes, cormorants, herons, flamingos, gulls and terns are found in the intertidal and shallow sub-tidal zones of Qatar during the migratory season. Mudflats support higher wader feeding densities than either rock flats or sand flats.

Marine Mammals

The common marine mammals in Qatar are whales, dolphins and porpoises. They are distributed along the waters between Qatar and Bahrain and between Qatar and UAE. As per the IUCN Red Book (IUCN, 2008), the status of the mentioned mammal species has been listed as vulnerable to extinction

Dugong (*Dugong dugong*, see Figure 1-6) is one of only four species of the order Sirenia. A significant

population of world's dugong can be found in the Arabian Gulf consisting more than 5,000 dugongs.

In Qatar dugongs are more commonly sighted on the west coast and south eastern coast. During winter huge groups of dugongs flock together in the sea around Qatar to feed exclusively on the seagrasses.

The baleen whales (4 species) and toothed whales (7 species) are cetaceans found in the Arabian Gulf. Since the mammals have been hunted indiscriminately in the past, they are now listed as endangered or vulnerable to extinction on the IUCN Red List. The bottlenose dolphin (Tursiops truncatus) is most commonly found cetacean in Arabian Gulf, and most of the time found in groups of up to 35 individuals (SCENR, 2008).

1.4.4 Ambient Air Quality

The Ministry of the Environment (MoE) is the central environmental regulatory authority in Qatar. It has promulgated the national ambient air quality and source emission standards. Table 1-8 shows a summary of the national ambient air quality standards in Qatar.

In order to make a quick assessment of the state of the atmospheric environment in Qatar, validated air quality and meteorological monitoring data sets collected by QP HSE-Corporate Environment & Sustainable Development Department (EV), are examined in this section. It is essential to point out here that the primary objectives the EV air quality monitoring program are to determine the state of ambient air quality at QP oil and gas operational areas and identify excursions beyond the environmental protection standards promulgated by the MoE. More importantly, the QP monitoring network provides essential data that can be used to optimize QP air pollution control strategy, in addition to its use as an input to air quality modeling, a needed tool for long term economic planning. Based on the above data sets the major features of Qatar's air quality may be summarized as follows: (1) air quality in Qatar is remarkably homogenous with few exceptions in the industrial cities; (2) although, generally, the ambient concentrations of SO_2, NOx and CO are very low and within the national standard limits, a significant increase in the NOx concentration during 2007 compared to 2006 and 2005 was observed. This is, most likely, due to a sharp increase in the economic activities during this year particularly for the building and real estate industry and other infrastructure construction activities; (3) inhalable particulate (PM_{10}) and O_3, on the other hand, show high average concentrations over the national regulatory limits. While the high inhalable particulate levels are understandable in view of the desert environment in Qatar, the causes of the high ambient ozone is being studied by QP EV Department. This study which includes a regional photochemical modeling approach will elucidate the chemistry and physics of ozone formation in the region. Tentative results suggest that most of the O_3 in Qatar ambient air is formed in areas upwind from Qatar and that non-methane organic compounds play a significant role in the build-up of O_3 in the region. In the context of climate change scenarios, air quality is expected to deteriorate particularly with respect to photochemical pollutants and suspended particulates.

Table 1-8 Ambient Air Quality Standards in Qatar

Parameter	Averaging Period	State Standard
SO_2 µ g/m^3	24-hr	365
	Annual	80
PM_{10}µg/m^3	24-hr	150
	Annual	50
NO µg/m^3	1-hr	-
NO_2 µg/m^3	1-hr	400
	24-hr	150
	Annual	100
NOx µg/m^3	1-hr	-
O_3 µg/m^3	1-hr	235
	8-hr	120
CO mg/m^3	1-hr	40
	8-hr	10

1.5 Economic Overview

Historical record of the Gross Domestic Product (GDP) shows that nominal GDP has more than doubled during 1990-2000 and almost quadrupled between 2001 and 2007 (QSA, 2007). GDP for 2008 was 100.4 Billion USD. The components of Qatar's GDP are given in Table 1-9.

Table 1-9 Sectoral Contribution to GDP (in million US$ & %)

Sector	2000	%	2008	%
Oil & Gas + Services Incidental to this industry	10732	60.43	60915	60.67
Finance, Insurance & Property	1292	7.27	10170	10.13
Manufacturing	966	5.44	6975	6.95
Construction incl. Quarries	640	3.60	5100	5.08
Trade & Hospitality	1030	5.80	3657	3.64
Transport &Communications	551	3.10	3372	3.36
Electricity, Gas & Water	214	1.21	1499	1.49
Agriculture and Fishing	66	0.37	74	0.07
Government & Other Services	2268	12.77	8646	8.61
TOTAL	17,760	100%	100,407	100%

Qatar Statistical Authority Website (www.qas.gov.qa, 2008)

1.5.1 Dominance of Oil & Gas Industry

Oil and Gas dominates the economic landscape with a huge contribution of greater than 60% to GDP and together with chemicals constitutes some 99.2% of the exports from Qatar. Over 8 years since 2000, the economy had grown almost 6 fold. The current projections for the export of LNG, condensate and GTL respectively indicate that Oil and gas will be the driving force in the foreseeable future.

The total export of crude oil and liquefied natural gas (LNG) during 2007, expressed in energy units was, 3594 PJ and the current estimates of crude, natural gas reserves, refining capacity and local energy consumption are shown in Table 1-10. Current and projected output of non-energy products are shown in Table 1-11.

Table 1-10 Reserves & Domestic Consumption of Hydrocarbons

Hydrocarbon	Reserves/Consumption
Crude Reserves	27.4 X 10^9 Barrels (~150,000 PJ)*
Natural Gas Reserves	25. 6 X 10^{12} m^3 (~900,000 PJ)*
Refining Capacity	137,000 b/day (286 PJ/yr)
Local Energy Consumption (2007)	(1,040 PJ)*, 10% Gasoline, Diesel, 90% Natural Gas

Table 1-11 Exports of Energy & Non-Energy Products in 2007

Energy Product	Exports (PJ)
LNG	1209
Crude	1890
Condensate	423
GTL	72
Total	3590
Non Energy Product	**Production (Mt)**
Fertilizers & Pet	10.0 (projected to 28)
Steel Products	2.74
Hot Briquetted Iron	2.0
Cement	0.5
Aluminium Products	10.0 (projected to 28)

1.5.2 Diversification of Qatari Economy

Given the rise in the prices for Oil and Gas, the % figures in the above table masks the enormous gains made in the diversification of the Qatari economy given that some of the other sectors have expanded at a similar rate or greater. For example, there are 361 categories of items including steel, aluminum, cement, minerals, food, livestock, leather and paper products that are exported. Quite a few of these items have been included in the exports list only recently showing significant potential over time.

The major sub-sectors of the Manufacturing sector are petroleum refining, industrial, chemicals, fertilizers and steel, which utilize natural gas as feed-stock and/or fuel. Other important activities include the production of flour, cement, concrete, plastics, textiles and footwear, household articles and paint.

The high dependency of the GDP on oil and gas revenues results in high economic vulnerability due to fluctuations in the oil and gas prices and subsequent irregularity in the annual growth rates of the GDP. Climate change adds a further uncertainty to Qatar National GDP. Economic diversification, within the hydrocarbon sector and away from it, is critical for Qatar so as to maintain a steady and robust economy. Up to now, Qatar has chosen a policy of diversification that encompasses the following:

- Expansion of LNG facilities and setting up of GTL Projects.
- Development of the petrochemical industry.
- Development of non-metallic and metallic industries (ferrous and non-ferrous).

- Adoption of ambitious programs for top quality higher education in association with the world's leading universities and academic institutions.
- Maritime and Airline transport sector expansion.

In addition to the above actions, the State of Qatar is accelerating the privatization process to enhance the growth of the small and medium scale industries through two vehicles, the Qatar Industrial Manufacturing Company (QIMCO) and the Qatar QIDB is government owned and gives loans to small and medium scale companies in Qatar at competitive rates of interest. Industrial Development Bank (QIDB). The Government owns 15% of the shares in QIMCO, with the remaining 85% of QIMCO's shares held by private investors (Doha Stock Exchange).

1.5.3 Agriculture & Fishing

Despite the relatively small contribution of the agriculture and fisheries sector to the GDP, it is important to point out that, through experimental farming projects (currently 1000), partial self sufficiency was attained in certain food stuffs in 2000 e.g. fruits and vegetables (35% sufficiency), milk (60%) and meat (30%). Given the scarcity of water resources and the fact that this industry consumes 74% of freshwater use in Qatar (GSDP, 2009), all opportunities in water and energy efficiency will need to be implemented.

The QSA data indicates that the agriculture/farm area is 650 km^2 of which 75 km^2 is under crops producing 5000 tons of food grains and 23000 tons of vegetables. There are 34000 camels, 300,000 goat and sheep and two thousand horses. Overgrazing of rangelands principally by Camels has decreased the vegetation density from 10% land cover to 1% land cover and the grass community has largely been replaced by perennial shrubs that are thorny toxic or unpalatable (Renee Richer, 2008).

Fishing in Qatar's territorial water increased from 4,271 tons in 1995 to 17,960 tons in 2008, a four fold increase in a short time. This is mainly attributed to rapid increase in population and technology improvement. Fishing has kept pace with population growth and will remain a key activity for providing food security rather than for its contribution to the economy. Further Investment is being pumped into this sector to ensure food security in the medium to longer term for Qatar. Over-fishing of the marine waters has been recognized as an issue since the observation of reduction in the catch of Needle and Parrot Fish (NBSAP, 2004).

1.5.4 Government Services Sector

The State of Qatar has invested the proceedings from the Oil & Gas and Petrochemical Industry wisely into the government services sector that includes the health services, education, municipalities, youth and sports and infrastructure development.

This investment reflects the rise of Qatar from 57th place to 33rd place in Human Development Rankings within a decade as well as achieving some of the Millennium goals ahead of time. This is a remarkable achievement of historic proportions. This sector is expected to further grow as the population and their collective wealth increases.

1.5.5 Construction

The growth of the construction sector is quite evident around Doha over the past few years, and as such this sector continues to be a major contributor to the GDP and employment of labor force, especially in roads, high-rise buildings, private water and power projects, hospitality infrastructure and residences.

Credit facilities extended by commercial banks to the land, housing and construction sector has grown to reach US$ 12.3 billion in 2008 and the trend is likely to continue in the coming years given the focus on diversification of economy and consequent growth of skilled and unskilled migrant population.

1.5.6 Transport and Communications

This sector contributed US$3,372 million to the overall GDP in 2008 with contributions principally from Qatar Airways, (National Carrier), Qatar Telecom and Vodafone Qatar. Qatar Airways currently operates a fleet of 68 aircraft and has announced that it will grow its fleet to 110 by 2013. (Qatar Economic Review, May 2009).

The telecom sector has been opened up and the new licensee Vodafone Qatar is offering services in Qatar since the beginning of 2009. This is likely to grow the communications sector commensurate with population growth as well as the need for increasing the Internet uptake by the population. Further, the expansion of Q-Tel internationally will add to the GDP contribution of this sector in coming years.

The single-minded focus of H.E. Sheika Mozah Al-Misnad to transform Qatar into a premier technology

hub in the world through collaborative partnerships with best practice institutions, setting up of Qatar Science and Technology Park as well as through international and national leadership as UNESCO Ambassador and Chair of the Qatar Foundation respectively will create new opportunities in areas such as e-learning, environmental remote sensing and compassionate health services that are at infancy in most parts of the world. Therefore, this sector will be a high quality performer well into the future.

1.5.7 Electricity and Water Resources

Qatar has no major fresh water resources, such as rivers and lakes. The annual rainfall based on long-term statistics is 82mm per annum principally in winter months, with the rainfall 30% greater in the northern part of the country than in the south. The evaporation rate is high and therefore the groundwater replenishment is limited. The current use of ground water principally for agricultural uses is orders of magnitude greater than the rate of replenishment. The per capita water use in Qatar is in the top few countries in the world. The losses from water transmission and distribution together with leakages contributed to 45% of the total water consumption (Amer and Abdel-Wahab, 2009). The annual per capita water consumption has increased from182m^3 in 1990 to 247m^3 in 2005. Nearly 96% of the water needs in the State are met from desalinated water.

While there is scope for further improvement through utilization in higher value activities, utilization of the treated wastewater is up and running. Between 2000 and 2006, the electricity generated in Qatar increased 64% from 9.133TWh to 14.983 TWh. QNB Economic Review May 2009 estimates that Qatar's power generation capacity will exceed 9000 MW by 2012. 87% of Qatar's electricity generation capacity comprises of gas turbines, which are fuelled by natural gas, with the rest being generated through the use of Oil (IAEA EEDRB Country Profile). Water desalination is achieved in tandem with electricity generation and the desalination technologies are being improved.

The water generation capacity currently is 205 million gallons per day. The State is investing about US$ 7.5 billion until 2010 to expand its electricity and water production network. The seawater desalination capacity will increase to 400 million gallons per day by 2012.

UNDP has supported a groundwater recharge project that had lead to the drilling of 341 recharge wells in some of the depressions in Qatar. This was a means to maximize recharge of groundwater aquifers from rainfall. Currently 80% of the total treated wastewater was distributed for growing fodder (63% to two farms) and for landscape irrigation in Doha (17%). There is an opportunity to use this water for higher order uses in agriculture and industry. Opportunity exists for the implementation of supply and demand side strategies will be employed in a balanced manner to achieve triple bottom line.

1.6 Special Considerations under Article 4.8 of UNFCCC

Article 4.8 of the UNFCCC states that Parties shall give full consideration to actions to meet the country specific needs and concerns of the developing signatory country arising from the adverse effects of climate change and/or the impact of the implementation of responsive measures. The sub-clauses that affect Qatar are:

- Small island countries (Qatar is a peninsula with a majority of its perimeter being on the sea coast)
- Countries with low-lying coastal areas
- Countries who economies are highly dependent on income generated from the production, processing and export, and/or consumption of fossil fuels and associated energy –intensive products

Qatar is impacted by rising sea level with 96% of its population living in coastal towns/cities and there is a potential for some of the coastal area to be inundated. Qatar is one the top ten countries in the world that would be most impacted by sea-level rise in terms of percentage land area and wetlands affected. In addition, Qatar being a small country does neither have sufficient arable land nor the water resources decoupled from energy use.

Qatar, with largest reserves of fossil fuels in the world and the largest per capita emission of greenhouse gases, used 90% of its energy for Oil & Gas, manufacturing, electricity and heat production for desalination. Given its large production and small population, Qatar is disadvantaged when production-based emissions accounting is employed. Such accounting does not consider the large proportion of oil & gas products produced are exported and used in other countries. Qatar's emissions data would be

greatly reduced if a consumption based accounting system is followed (Second National Human Development Report). Also, as the developed world decreases the use of fossil fuels, the revenue from Oil & Gas can decrease leading to economic impacts and potentially the quality of life of its residents.

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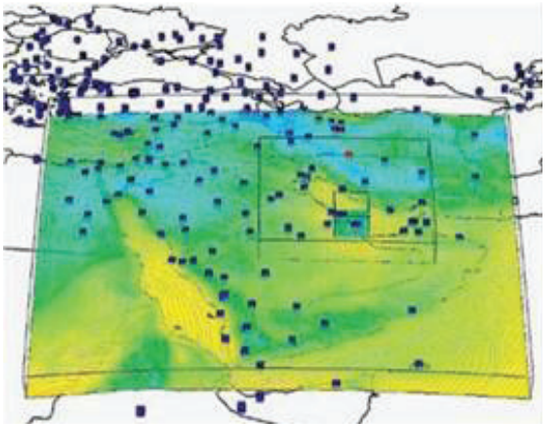
CHAPTER 2

Greenhouse Gas Inventory



2 GREENHOUSE GAS INVENTORY

2.1 Introduction

Under Articles 4.1 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) Qatar, like other Parties to the Convention, is required to develop and periodically update, publish and submit to the Conference of the Parties (COP), its national inventory of anthropogenic GHG emissions by sources and removals by sinks. The inventory includes carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The primary objectives of the national inventory are to:

- Provide to the Conference of the Parties (COP) country oriented GHG emission profile to be used in the larger global context;
- Support national efforts to develop climate-sensitive sustainable development goals and informed mitigation and adaptation policies.

The Ministry of the Environment (MoE) is the national focal point for climate change in Qatar. In order to support its mandated responsibilities, a national policy formulating body, the "*National Committee for Climate Change"* (NCCC), was created by a decision from HH the Heir Apparent. Residing in the MoE, the NCCC is chaired by H.E. the Minister of Environment. It consists of nine members drawn from Qatar University, Qatar Petroleum, the Office HH Heir Apparent, the Civil Aviation General Authority, Ministry of Agriculture and Municipal Affairs, and MoE.

The primary objectives of the NCCC are to: (i) establish a comprehensive national program for climate change that includes policies to manage the national Greenhouse gas (GHG) emissions; and (ii) meet international commitments required by the climate convention and the Kyoto Protocol including preparation and publication of the national communications under the UNFCCC (INC). The responsibility of preparation of the INC including development of the national greenhouse inventory was entrusted to Qatar Petroleum Corporate Environment & Sustainable Development Department, (EV), Corporate HSE. The manager of the EV department, who is a member of the NCCC, was assigned as the national project coordinator. A dedicated team of specialists from the EV department was charged with the responsibility of preparing the INC.

2.2 Methodology, Data Sources & Reliability

For all sectors considered in Qatar's national GHG inventory, the year 2007 was chosen as the base line year. Following the IPCC Guidelines for 1996 and 2006, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions were estimated using the best available information and tier 2 country-specific emission factors, developed for each sector. Similar to GHGs, nitrogen oxides (NOx), sulfur dioxide (SO_2), and non-methane volatile organic compounds (NMVOCs) were estimated by using bottom up approaches, engineering calculations & industry approved emission factors. Furthermore, due consideration was made to the following elements: technology of emitting sources; physical and chemical characteristics of fuel used; and fuel consumption statistics. The combustion efficiency for all sources apart from flaring was assumed to be 99.5%, flare combustion efficiency was estimated at 95% (E&P Forum, 1994). In the instances where source emission monitoring data is not available, emission estimates were derived on basis of measurement data and fuel consumption statistics provided by the stakeholders.

Since Qatar has no published systematic national source emission inventories for GHG or criteria pollutants, a new national database had to be put in place. Based on a series of questionnaires, workshops, close consultation with stakeholders in addition to literature surveys a comprehensive national data base for GHG emission was created using bottom up and top down calculations and activity data provided by stakeholders. The database also contains pertinent information relating to source characteristics in terms of technology and fuel, methodologies of computation and country specific emission factors. Table 2-1 below shows weighted average, country-specific emission factors and parameters developed for the major sectors considered in the national GHG inventory.

Table 2-1 Weighted Country-Specific GHG Emission Factors Computed for Qatar (2007)

SECTOR	Fuel calorific value (MJ/NM3)	Emission Factor-CO_2 (t C/TJ)	Emission Factor-CH_4 (t/TJ)	Emission Factor-N_2O (t/TJ)	Emission Factor-NMVOC (t/TJ)	Emission Factor- NOx (t/TJ)	Emission Factor-SO_2 (t/TJ)
Power & water desalination	34	14.9	0.09	0.0013	0.009	0.109	0.035
Aggregate upstream oil & gas operations	28.0-55.6	14.9	0.21	0.001	0.117	0.088	0.213
Petroleum refining	38	12.2	0.042	0.001	0.423	0.083	0.004
Petrochemicals	13.7-15.6	14.0	0.068	0.001	0.034	0.080	0.157
Construction combustion	38.2*	20.2	0.004	0.016	0.120	1.30	0.022
Road transport	36.1*	19.8	0.02	0.002	0.770	0.606	0.006

Notes: * MJ/Liter

The CO_2 weighted national average due to combustion of natural gas from all sectors is 14.8 t C/ TJ, approximately 4% lower than the average default emission factor published by the IPCC (1996, 2006 IPCC Guidelines). Qatar petroleum refinery's CO_2 emission factor, which averages 12.2 t-C/ TJ, is one of the world lowest coefficients reported in the literature for a refinery fuel. The IPCC default factor is 15.7 t-C/ TJ (2007 IPCC Guidelines). After its submission and subsequent review by the editorial board of the IPCC GHG Emission Factors database, Qatar refinery's CO_2 emission factor was approved and published by the IPCC (IPCC GHG EFDB, 2006)

2.3 Energy Sector Inventory

The primary sources of energy in Qatar are fossil fuels, mainly natural gas and refined petroleum products. GHGs emitted from the energy sector are mainly CO_2, CH_4, N_2O, NMVOC and NOx. CO and SO_2 are also emitted. The national total energy consumed locally in 2007 was 1041 PJ, approximately 29% of the total energy produced (3059 PJ) which include crude oil, LNG, condensates, natural gas and GTL fuels. Consumption due to the energy sector was 916 PJ accounting for 88% of the total, the rest, approximately 125 PJ (12%), was used for industrial manufacture of petrochemicals. The share of natural gas to the total energy use in Qatar in 2007 was 90%. Refined petroleum products, mainly in the form of gasoline and diesel accounted for 10% of the total energy use. Out of this amount road transport consumed 62 PJ (6%) and non-road building equipment 43 PJ or 4% of the national total energy use.

The predominant share of the energy sector consumption in Qatar during 2007 was due to upstream oil and gas production and processing operations, accounting for approximately half of the total national use. 37% of this amount was consumed for productive combustion and the rest, 12%, represents wasted, non-productive, energy in the form of flaring. Electricity and water services, comes second to the oil and gas industry in terms of energy consumption and GHG emissions (28%). In 1999 (QPC 2001) approximately 46% of total electricity produced in Qatar was used for domestic/family consumption and only about 16% for industry. The shares in 2007 were as follows: family use (43%), industrial (32%), commercial consumption (17 %), and losses (7%).

GHG emissions from the energy sector are summarized in Table 2-2 below. Overall 52,816 Gg of CO_2, 136 Gg CH_4, and 1.4 Gg N_2O were emitted from combustion activities which include productive and fugitive emissions. Emissions of NOx, CO, NMVOC, and SO_2 were, respectively, 163, 43, 104 and 127 Gg (or thousand tones). Table 1 also shows emissions from the energy sector disaggregated by subsectors (energy industries, manufacturing industries, transport) and by sources of fugitive emissions.

The results suggest that GHG emissions from the energy sector account for 92% of the total national inventory of CO_2 and N_2O and approximately 81% of the CH_4 emissions. Out of these estimates fugitive emissions, mainly due to flaring from oil production operations, are responsible for approximately 43% to 50% of CH_4 and SO_2 emissions; 12% of CO_2, 37% of NMVOC.

Table 2-2 Sectoral Report for National Green House Gas Inventories for Energy (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total Energy	**52,924**	**137**	**1.36**	**163**	**43**	**104**	**127**
A Fuel Combustion Activities (Sectoral Approach)	**46,507**	**68**	**1**	**158**	**23**	**65**	**73**
1 Energy Industries	**38,124**	**66**	**1**	**75**	**22**	**12**	**67**
a. Public Electricity and Heat Production (plus Water Production)	15,943.71	26.22	0.38	32.03	7.62	2.73	10.38
b. Petroleum Refining	638.86	0.59	0.016	1.09	0.37	0.68	0.06
c. Manufacture of Solid Fuels and Other Energy Industries (Oil & Gas)	21,541.83	39.14	0.46	41.86	13.62	8.37	56.49
2 Manufacturing Industries and Construction	**3,106**	**1**	**0**	**39**	**1**	**6**	**6**
a. Iron and Steel	57.61	0.22	0.0045	0.39	0.24	0.06	0.79
b. Non-Ferrous Metals							
c. Chemicals	0	0	0	0	0	0	0
d. Pulp, Paper and Print							
e. Food Processing, Beverages and Tobacco							
f. Other (please specify: Cement + construction engines)	3,048.36	0.55	0.12	38.15	0.42	5.79	5.41
3 Transport	**5,277**	**1**	**0**	**45**	**1**	**48**	**0**
a. Civil Aviation	596	0	0	3	1	0	0
b. Road Transportation	4,489	0.86	0.15	37		48	0
c. Railways							
d. Navigation	191	0.0030	0.0048	4.35	0.45	0.14	
e. Other (please specify)	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0
4 Other Sectors	0	0	0	0	0	0	0
a. Commercial/Institutional	0	0	0	0	0	0	0
b. Residential	0	0	0	0	0	0	0
c. Agriculture/Forestry/Fishing	0	0	0	0	0	0	0
5 Other (please specify)	0	0	0	0	0	0	0
B Fugitive Emissions from Fuels	**6,417**	**69**	**0**	**4**	**19**	**38**	**54**
1 Solid Fuels	**0**	**0**	**0**	**0**	**0**	**0**	**0**
a. Coal Mining	0	0	0	0	0	0	0
b. Solid Fuel Transformation	0	0	0	0	0	0	0
c. Other (please specify)	0	0		0.00	0	0	0
2 Oil and Natural Gas	**6,417**	**69**	**0.22**	**4**	**19**	**38**	**54**
a. Oil	5,166	62	0.17	3	14	36	37
b. Natural Gas	1,232	7	0.04	1	3	2	15
c. Venting and Flaring (all others)	20	0.26	0.0005	0.28	2	1	2

2.4 Industrial Processes Inventory

Industrial production activities in Qatar include production of cement, steel, ammonia & urea, methanol, methyl tertiary butyl ether (MTBE) and plastics. During 2007 the industrial manufacturing sector contributed a significant share to the GDP, totaling 8% (QPC, 2008). In order to estimate GHG emissions from industrial processes detailed information and statistics of the industry-specific physical and chemical transformation processes are required. Since part of this information was unavailable at the time of preparation of the inventory, there is a degree of uncertainty in the estimates made for a number of industries considered in the inventory. Nevertheless, the estimates computed for cement manufacture and for ammonia & urea production are more certain as they were based on complete data sets provided by the stakeholders. This information enabled the development of industry-specific emission factors that reasonably reflect GHG emissions due to process and combustion activities.

GHG emissions from the industrial processes activities are summarized in Table 2.3 below. Overall 4687 Gg of CO_2, 7.5 Gg CH_4, and 110 Mg N2O were emitted. Emissions of NOx, NMVOC, and SO_2 were, respectively, 13.5 Gg, 820 Mg, and 16.6 Gg. Out of these totals the chemical industry accounted for most of the CO_2 emissions (approximately 82%), mineral products (cement manufacture) 17%, and metal production (steel) 1%. Overall industrial processes have contributed about 8.5% to the total national inventory of CO_2 from Qatar in 2007.

2.5 Solvent Paints & Dry Cleaning

GHG emissions due to solvent use in Qatar during 2007 are shown in Table 2-4. Only NMOVC emissions from paint applications, dry cleaning and solvent related activities were considered. Emission factors published by the US-EPA (1994) and Australian GHG methodology (2004) and statistics from Qatar Planning Council were used to estimate national emissions. The total emission was 28 Gg.

2.6 Agriculture Sector Inventory

Agriculture is a small sector in Qatar economy accounting for 1% of the GDP in 2007 (QPC 2007). GHG emissions from this sector were estimated for enteric fermentation and manure management from data provided by the Planning Council and default factors published by the IPCC (QPC 2007, IPCC 2006).

2.6.1 Enteric Fermentation

Methane is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. Ruminant livestock (e.g. sheep, cattle, camels, deer, etc) are the major sources of methane with minor amounts from non-ruminant livestock (e.g. horse, etc). Ruminant livestock have an expansive chamber called the rumen at the fore-part of their digestive track that supports intensive microbial fermentation of their diet. Using the emission factors provided by UNFCCC the amounts of CH_4 emitted from ruminant animals were determined.

2.6.2 Manure Management

The methodology used to estimate CH_4 emissions from manure management follows tier 1 default emission factors published by the IPCC (2006 IPCC Guideline). This simplified methodology requires only livestock population data by animal species/category and climate region or temperature.

Table 2-5 summarizes the GHG inventory from agriculture sector. The total CH_4 emission from this sector during 2007 was approximately 4 Gg, 95% of which from enteric fermentation by camels, goats and sheep. The rest of the emissions result from manure management.

2.7 Waste Management Inventory

There are three main sources of GHG from wastes in Qatar. They are (1) Municipal solid waste landfills; (2) Sewage treatment, disposal and reuse system and (3) Waste incineration.

Domestic solid wastes in Qatar are collected by the municipality and disposed at the State's landfill. The amounts of solid wastes generated are monitored and reported by the Qatar Statistical office. Using this data and the 2006 IPCC Guidelines for 'First Order Decay Method' the amounts of CH_4 emitted from the landfill were estimated.

Table 2-3 Sectoral Report for National Green House Gas Inventories for Industrial Processes (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total Industrial Processes	**4,687**	**7.49**	**0.11**	**13.54**	**0.00**	**0.82**	**16.58**
A Mineral Products	**798**	**0.36**	**0.01**	**6.12**	**0.00**	**0.14**	**5.41**
1 Cement Production (Process)	798	0.36	0.0072	6	NA	0.14	5.41
2 Lime Production	0	0	0	0	0	0	0
3 Limestone and Dolomite Use	0	0	0	0	0	0	0
4 Soda Ash Production and Use	0	0	0	0	0	0	0
5 Asphalt Roofing	0	0	0	0	0	0	0
6 Road Paving with Asphalt	0	0	0	0	0	0	0
7 Other (please specify)	0	0	0	0	0	0	0
Glass Production	0	0	0	0	0	0	0
Concrete Pumice Stone	0	0	0	0	0	0	0
B Chemical Industry	**3,831**	**7**	**0**	**7**	**0**	**1**	**10**
1 Ammonia Production	253	0	0	0	0	0	0
2 Nitric Acid Production	0	0	0	0	0	0	0
3 Adipic Acid Production	0	0	0	0	0	0	0
4 Carbide Production	0	0	0	0	0	0	0
5 Other (Fertilizer, plastics & chem. Additives)	3,578.45	6.91	0.10	7.03	0.00	0.63	10.38
C Metal Production	**58**	**0.22**	**0.004**	**0.39**	**0**	**0.06**	**1**
1 Iron and Steel Production	58	0.22	0.004	0.39	NA	0.06	1
2 Ferroalloys Production	0	0	0	0	0	0	0
3 Aluminium Production	0	0	0	0	0	0	0
4 SF_6 Used in Aluminium and Magnesium Foundries	0	0	0	0	0	0	0
5 Other (please specify)	0	0	0	0	0	0	0
D Other Production	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 Pulp and Paper	0	0	0	0	0	0	0
2 Food and Drink	0	0	0	0	0	0	0

Table 2-4 Sectoral Report for National Green House Gas Inventories for Solvent and Other Products Use (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total Solvent and Other Product Use	**0**	**0**	**0**	0		**28.00**	0
A Paint Application	0	0	0	0	0	0	0
B Degreasing and Dry Cleaning	0	0	0	0	0	0	0
C Chemical Products, Manufacture and Processing	0	0	0	0	0	0	0
D Other (please specify)	0	0	0	0	0	28.00	0

Table 2-5 Sectoral Report for National Green House Gas Inventories for Agriculture (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CH_4	N_2O	NO_x	CO	NMVOC
Total Agriculture	**4.04**	**0**	**0**	**0**	**0**
A Enteric Fermentation	**3.84**	0	0	0	0
1 Cattle	0.3383	0	0	0	0
2 Buffalo		0	0	0	0
3 Sheep	0.8428	0	0	0	0
4 Goats	0.7781	0	0	0	0
5 Camels and Llamas	1.6809	0	0	0	0
6 Horses	0.0370	0	0	0	0
7 Mules and Asses	0	0	0	0	0
8 Swine	0	0	0	0	0
9 Poultry	0	0	0	0	0
10 Other (please specify) : Deer	0.1634	0	0	0	0
B Manure Management	**0.20**	**0.00**	0	0	0
1 Cattle	0.0327	0	0	0	0
2 Buffalo	0	0	0	0	0
3 Sheep	0.0337	0	0	0	0
4 Goats	0.0342	0	0	0	0
5 Camels and Llamas	0.0935	0	0	0	0
6 Horses	0.0045	0	0	0	0
7 Mules and Asses	0	0	0	0	0
8 Swine	0	0	0	0	0
9 Poultry	0	0	0	0	0
10 Anaerobic	0	0	0	0	0
11 Liquid Systems	0	0	0	0	0
12 Solid Storage and Dry Lot	0	0	0	0	0
13 Other (Deer)	0.001798	0	0	0	0
C Rice Cultivation	**0**	0	0	0	0
1 Irrigated	0	0	0	0	0
2 Rain fed	0	0	0	0	0
3 Deep Water	0	0	0	0	0
4 Other (please specify)	0	0	0	0	0
D Agricultural Soils	0	**0**	0	0	0
E Prescribed Burning of Savannas	**0**	**0**	**0**	**0**	
F Field Burning of Agricultural Residues [1]	**0**	**0**	**0**	**0**	0
1 Cereals	0	0	0	0	0
2 Pulse	0	0	0	0	0
3 Tuber and Root	0	0	0	0	0
4 Sugar Cane	0	0	0	0	0
5 Other (please specify)	0	0	0	0	0
G Other (please specify)	0	0	0	0	0

Domestic sewage in Qatar is collected in three central sewage treatment plants. There are four pathways for sewage in Qatar and these are: (a) Centralized aerobic treatment plant; (b) Anaerobic digester for sludge; (c) Anaerobic deep lagoon; and (d) Septic tank system. Based on these pathways and using the IPCC Guidelines the CH_4 emissions were estimated.

Qatar Petroleum operates an offshore domestic solid waste incinerator. Domestic and office wastes from offshore platforms are incinerated in this facility. Based on combustion calculations the amount of CO_2 emitted per year is determined.

Table 2-6 summarizes the national emissions of GHGs due to waste management in Qatar during 2007. The total emissions from this sector were about 20 Gg (20kt) of CH_4 and 140 tons of CO_2. Managed land disposal of solid wastes is the primary source of CH_4 emissions from this sector accounting for > 80% of the emissions. The rest is contributed by the wastewater sewerage plants which emit an annual amount of CH_4 about 4 Gg. Incineration of domestic solid waste in offshore industrial locations emits annually about 140 ton of CO_2.

2.8 National Summary

The results of Qatar's national GHG Inventory are shown in Tables 2-7 to 2-9 and Figures 2-1 & 2-2 and may be summarized as follows:

- The net carbon-dioxide emission for 2007 amounts to over 62.4 million tones (62,400 Gg). Carbon dioxide constituted over 93% of the total, methane 6% and N2O <1%.
- Understandably, the predominant source of GHG emissions from Qatar is the energy sector, accounting for 92% of the total national inventory of CO2 and N2O and approximately 81% of the methane emissions. Out of this, flaring mainly from the oil and gas production operations is responsible for 43% to 50 % of the methane and sulfur dioxide emissions. Overall the Energy Sector emitted 52,816 Gg of CO2, 136 Gg CH4, and 1.4 Gg N2O from combustion activities which include productive and fugitive emissions.
- Out of the total emission by the energy sector the oil & gas was responsible for 50%, power & water approximately 27% and road transport 7%.
- The industrial process activities emitted 5.3 million tones of CO2 equivalent, mostly in the form of CO2 (97%). This amount represents 8.5 % of the national emission from Qatar in 2007.
- The combined total of GHG emissions from the waste and agriculture sectors in Qatar was relatively small, accounting for <1% of the national total. Most of the emissions were in the form of methane.

Table 2-6 Sectoral Report for National Green House Gas Inventories for Waste Management (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2(1)	CH_4	N_2O	NO_x	CO	NMVOC
Total Waste	**0.14**	**19.69**	**0.00**	0	0	0
A Solid Waste Disposal on Land	0.00	16.00	0.00	0	0	0
1 Managed Waste Disposal on Land	0	16.00		0	0	0
2 Unmanaged Waste Disposal Sites	0	0		0	0	0
3 Other (please specify)	0	0		0	0	0
B Wastewater Handling	**0.00**	**3.69**	**0.00**	0	0	0
1 Industrial Wastewater	0	0.00		0	0	0
2 Domestic and Commercial Wastewater	0	3.69	0.00	0	0	0
3 Other (please specify)	0	0	0	0	0	0
C Waste Incineration	**0.14**	0	0	0	0	0
D Other (please specify)	0	0	0	0	0	0

Table 2-7 National Total GHG Inventory

	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
National Total, Gg	57,612	168	1.5	177	43	105	144
CO_2 Equivalent, Gg	57,612	3,532	456				
National Total, Mt CO_2 Equivalent	62						

Table 2-8 Qatar National GHG Emissions (tCO2-Eqv., %)

Major contributors	Qatar Total Emissions (tCO_2 Eqv.)	% contribution
1. Oil & Gas	31,174,617	49.95
2. Power & Water	16,611,469	26.62
3. Road Transport	4,553,199	7.30
4. Industrial Process	5,312,667	8.51
5. Waste	413,538	0.66
6. Building Ind.	3,599,838	5.77
7. Refinery	656,353	1.05
8. Enteric & manure	84,865	0.14
TOTAL	62,406,545	100

Table 2-9 Breakdown of Total Emission CO2 equivalents

Major contributors	CO_2 Equiv (Mt)	% contribution
CO_2	58	93
CH_4	3	6
N_2O	<1	<1
TOTAL	62	100

Figure 2-1 Sectoral Contribution CO2 Equivalents

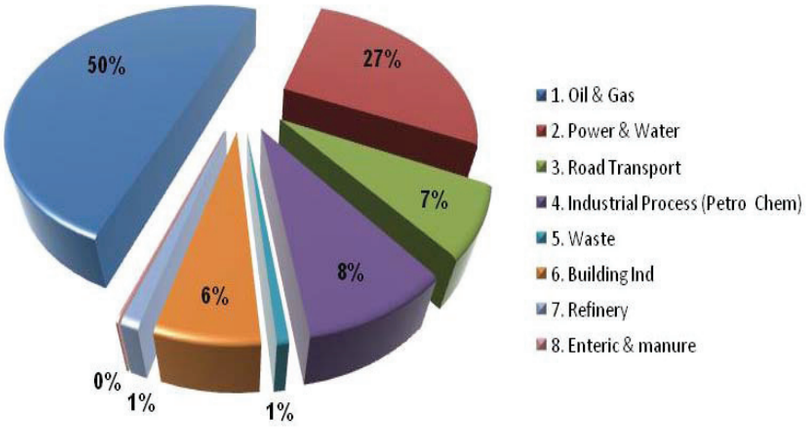
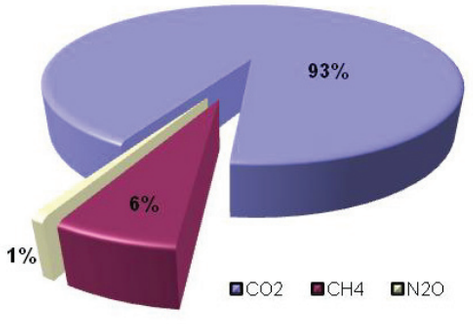


Figure 2-2 Disaggregation by GHG



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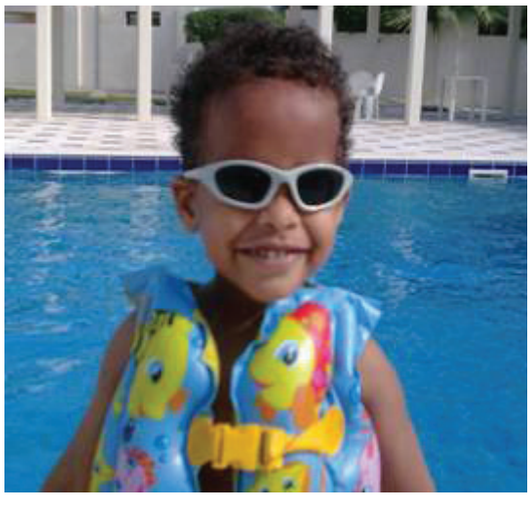
CHAPTER 3

Vulnerability and Adaptation



3 VULNERABILITY AND ADAPTATION

3.1 General

Climate change presents a double jeopardy to Qatar. On one hand, like other developing countries with minimal adaptive capacity, Qatar's ecological and human systems are prone to the adverse impact of climate change. On the other hand, due to its total dependence on the export of carbon based resources, Qatar economic welfare and prosperity depends on the outcome of the climate change negotiations which seeks, as an ultimate objective, complete phase out of fossil fuel energy sources from the world energy market. In view of this, a detailed assessment of the vulnerability and adaptive capacity of Qatar's economy & its ecological and human systems to the impact of climate change is critical. The following broad aspects need to be addressed in full:

- Develop and generate reliable, high resolution climate change scenarios applicable to Qatar using a regional climate model;
- Use the above generated high resolution climate change scenarios, for detailed assessment of the vulnerability and adaptation of the ecological and human systems;
- Establish socio economic adaptation scenarios in terms of economic diversification within the context of climate change; and
- Formulate policies and implement appropriate national adaptation programs of actions.

In the absence of high resolution regional climate change scenarios and based on available published literature, a preliminary assessment covering the vulnerability and adaptation issues relevant to Qatar has been made in this report.

In arid regions like Qatar with high climatic variability, any further climatic change could produce large effects on the eco-systems and environment. Qatar Climate records show that the annual mean temperature has increased by 0.3^{o} C over the last 40 years. This is mainly due to a significant steep increase in the mean minimum temperature (0.63^{o}C/40 yr) or night time temperature. However, no significant trend was found in the annual rainfall series (Al-Mulla et al. 2002). Global climate models suggest that the average annual temperatures by the year 2050 are projected to increase by 1.5 to 3.0^{o}C and 2.3 -5.9^{o}C by 2100. This indicates that the existing hot climates with water stress conditions may put additional stress on terrestrial, coastal and marine eco-systems. The Intergovernmental Panel on Climate Change (IPCC, TAR, 2001) has projected that surface air temperature in the Arabian Peninsula could increase by 1-2^{o}C by 2030-2050, while precipitation could significantly decrease.

3.2 Economic Vulnerability

Since in achieving its ultimate objective, the UNFCCC has the potential to substantially impact the demand for fossil fuel, implementation of its Kyoto Protocol will unquestionably result in adverse economic impacts on Qatar and other oil & gas producing and exporting countries. In this section a brief review of the potential economic impacts resulting from the Kyoto and post-Kyoto Protocol implementation on Qatar is presented.

Based on a range of energy-economy models, the International Panel on Climate Change (IPCC) and the Organization of Petroleum Exporting Countries (OPEC) reported the potential economic impacts of Kyoto Protocol implementation on OPEC member countries, including Qatar (IPCC TAR 2001; IPCC 1999; OPEC 2000, 2001).

Critical reviews of the findings of these reports were made by Barnett et al. (2004) and Ahmed and Al-Maslamani (2004). The above assessments suggest the following:

- Domestic mitigation measures adopted by the developed countries (Annex B), to meet their Kyoto Protocol commitments, have adverse "Spillover" effects on the petroleum exporting countries including Qatar.
- Findings include reductions in GDP and oil revenues compared to those under "business as usual" projections. Reductions range from 0.2% to 25% of the projected GDP with no Annex-B emissions trading.
- Reductions are less than 0.05% to 13% with emissions trading in 2010.
- Revenue losses to OPEC during 2010 were estimated for full participation at between 20-40

billion US dollars per annum increasing to 80-120 billion per year by 2030 (OPEC 2000, 2001).

- The revenue loss is attributed to reduced oil demand from the industrial countries (without tax adjustment), falling oil prices and reduced oil production and exports from OPEC member countries.
- OPEC member countries whose economies are heavily dependent on oil export revenues will be harmed the most compared to those who have relatively diversified economies.
- The costs to Oil Producing counties can be reduced by removal of subsidies for fossil fuels, energy tax restructuring according to fuel carbon content, increased use of natural gas in the developed countries and diversification of the economies of oil producing developing countries (IEA 2001).
- The modeling studies suggest that, like other OPEC member countries, Qatar's economy would be adversely impacted by the measures adopted by industrial countries under the Kyoto Protocol compared to 'business as usual' projections. As these countries reduce their fossil fuel consumption and oil imports, from what they would otherwise be in the absence of Kyoto, the projected world oil prices will fall by 7.5% - 15.3% in 2010 causing a decrease in Qatar's welfare.
- Modeling results suggest that under the Kyoto Protocol and three scenarios including, 'no flexibility', 'tax cut', and 'flexibility with CDM', Qatar's export of oil may decrease in 2010 and 2030 by 9% - 10%, 4% - 5%, and 6%, respectively.
- The projected decrease in Qatar's oil exports and revenues is slightly less than the estimates made for the rest of OPEC countries. Without the participation of the USA in the Kyoto Protocol, the adverse economic impact on Qatar would be significantly reduced. In the 'Tax Cut' scenario crude oil prices actually increase between 2010 and 2030 (OPEC 2001).
- The use of the flexible mechanisms in the Kyoto Protocol will result in more efficient choices among fossil fuels leading to preference for natural gas over coal and oil (climate change mitigation benefits and environmental co-benefits). This will lessen the adverse economic impact on Qatar compared to other OPEC member countries. Redirection of Qatar's energy exports to diversified domestic energy intensive industries that produce non-energy goods (e.g. steel, petrochemicals, and chemicals) will further alleviate the adverse economic impact of Kyoto Protocol implementation on the State of Qatar.
- Finally, in the event of Annex-B countries adopting a policy of carbon tax adjustment reflecting the carbon content of fossil fuels, demand for natural gas followed by oil will increase at the expense of coal. This may occur provided that substitution is feasible (IPCC 4AR 2007, Barnett et al., 2003, Ahmed and Al-Maslamani, 2004).

3.3 Water/Moisture Availability and Agriculture

As stated in Chapter 1 of this report, most of the water needs in Qatar are met from desalination plants. The domestic water consumption in Qatar is estimated at 675 litres per day compared to 575 litres per day in USA and 200-300 liters per day in Europe (Al Mohannadi, 2008). Furthermore, the demand for water in Qatar is fast growing at a rate of 12% annually. This is to meet the accelerating demand from the industry and population growth. Added to this, there is a large increase in irrigation for agriculture. In fact, the total area under agriculture was only 109 ha in 1960 compared to 43,156 ha in 2007 (Al Mohannadi, 2008). Rainfall in Qatar is scarce and therefore most of the agriculture and horticulture is based on irrigation.

Under the increased temperature conditions with no increase in the rainfall pattern due to climate change, there will be no off-set for the moisture losses from the water-stressed land. This has been shown by large increasing trend in the evapo-transpiration reported in literature (Rao and Al-Mulla, 2001). There will be two broad effects emerging out of the situation. The first one is a further desertification of the desert and the second is increased water needs in the water scarce area. Since most of the water needs are met from desalination process, the energy need and consumption is bound to increase. This will lead to increased greenhouse gas emissions and waste heat causing changes in climate.

3.4 Energy Sector

Possible increases in the air temperatures and SLR can produce adverse impact on the energy sector which is the backbone of the economy of Qatar. Since the majority of the oil & gas, and power and water facilities are located offshore or along the coast, it is of utmost importance to make a proper assessment of the

vulnerability and adaption of this sector to climate change. Increases in the air and sea water temperature will influence the design values for power and desalination facilities. This could occur either through efficiency drop or forced reductions in the generation outputs. Energy needs will increase further for additional air conditioning due to warmer environment. It will lead to the release of additional waste heat generation and greenhouse gas emissions. It is therefore important to make full and reliable assessment for this important sector and suggest various policy options for mitigation. Some of the salient policy options include: improvement in energy efficiency by better building codes, adopting mandatory energy star products/appliances, improved auditing and energy management, and enhanced public awareness and education programs. These will be critically assessed in the mitigation chapter.

3.5 Effects on Urban Areas

Due to urbanization and increase in population, heat island effects are bound to rise. This coupled with climate warming scenarios will have greater influence on energy needs and thereby further release of greenhouse gas emissions. This shall be more prominent in summer months when higher energy demand exists for air conditioning in housing and transport sectors. Increased temperature due to coupled effect of Heat Island and climate warming would increase water needs for meeting domestic and greening demands. This will result in higher consumption of energy in desalination process. A cyclic adverse process of increasing air temperature leads to higher energy needs (cooling), emitting more greenhouse gases, and thus contributing further climatic warming. As such ambient air temperature in summer months are extremely high which will further be magnified due to heat island effect. Regional models for climate change and impacts need to consider these aspects apart from population and economic growths. Since winters are mild in Qatar, there is not much usage of heaters and thereby energy needs are much lower compared to summer.

3.6 Public Health

Thermal stress and air quality impacts are immediate and relevant effects due to climate change in Qatar. Heat exhaustion and heat-stroke cases could increase due to further warming in hot climates. Heat indices are bound to increase with temperature increase, more so with higher humidity levels. With increased density of population in the urban areas, the effects will be more. Due to a probable increase in desertification, suspended particulate matter may increase which will lead to increase in the respiratory problems of the society especially amongst children, asthmatic and elderly. Chances of increased formation of secondary pollutants, particularly photochemical oxidants, can not be ruled out. The current levels of ozone and photochemical oxidants in Qatar are already very high and have raised public health concerns. Further increase in the level of ambient photochemical oxidants under climate change scenarios may be alarming. There will be many more health related issues in the context of climate change, but their links have yet to be established through epidemiological studies. Furthermore, since the problem seems to be of a regional nature, efforts to initiate a regional convention are prudent for effective pollution control policies and strategies to protect public health.

3.7 Coastal Zone and Offshore Locations

A large proportion of Qatar's industrial investments are located along the coast and offshore. These include oil and gas upstream & downstream facilities, petrochemicals factories and oil & gas export terminals, power & water generating facilities. Therefore, it is extremely important to assess the vulnerability to climate change of the coastal zones and offshore areas so as to determine the required adaptation measures needed to protect the ecological and human systems. These systems constitute national assets. In the absence of specific Sea Level Rise (SLR) change scenarios for Qatar, lessons may be learned from the initial national communication report of neighboring Bahrain (Bahrain, 2005). In this report, a low SLR scenario, assuming 0.2 m rise above the current sea level, a moderate scenario of 0.5 m and a high scenario with a rise of 1.0 m were considered. Using digital elevation models for each climate change scenario, vulnerable areas were then identified by sector and land use class. The lowest SLR scenario results in an inundation of about 5% of the total land area of Bahrain by 2100. The high scenario of 1 m SLR inundates 10% of the total land area. These effects will be more on some specific areas like pristine islands where inundation of 22% for 1 m SLR is estimated. Thus, the lessons learnt from the first vulnerability report of Bahrain is that even

small changes in the sea level, poses serious threats in terms of land inundation, costal erosion, and a number of other adverse impacts. These include population settlements, aquatic resources, coastal erosion, etc.

In case of Qatar, a similar approach of high resolution topographic mapping is needed for a proper evaluation of the vulnerability. Since most of the population and development activities are concentrated on the east coast of Qatar, emphasis need to be given to this side. Furthermore, due to the gentle slope in the bathymetry and topography of the eastern parts of Qatar, SLR scenarios need to be superimposed on very high resolution topographic maps for reliable assessments. These evaluations will inform policy makers on important issues such as coastal erosion, mass migration of population from the coast, loss of coastal and off-shore infrastructure, loss/damage to recreational beach facilities, fisheries activities, etc. Adaptation policy framework and policy initiatives need to be proposed for enhanced and detailed impact assessment. Furthermore, a couple of studies relating to the impact of SLR on Qatar are available in the literature. The results from these broad scale studies are summarized in Table 3.1 (Susmita et al., 2007) and as discussed below.

Table 3-1 Impact of Different SLR Scenarios for Qatar

Scenario	1m	2m	3m	4m	5m
% Impact of total population	2	3	4	7	9
% Impact of GDP	1.8	2.4	4.2	6.4	9.8
% Impact of Urban extent	0.8	1.4	2.4	4.8	7.2
% Impact of wet land	22	38	52	64	75

The total wetlands area in Qatar is about 151.2 km^2 , most of which is coastal. The inland wetland is only about 0.51 km^2 which consists of small water storage reservoirs, spillage from irrigation systems, sewage treatment ponds and small bodies of water created by effluent waste water – all manmade. The coastal and marine wetlands consist of (a) Dakhira Mangrove (1) – 30 km^2, (b) Al Aliya Islands (2) – 0.65 km^2 and (c) Khor al Udeid (5) -120 km^2. The above assessment suggests that even at moderate SLR the impact on GDP, Urban extent & wet land is very significant.

The Maplecroft, a world renowned climate change risk assessor, made another risk assessment for Qatar. In this study, it was concluded that Qatar is one of three countries in the Arabian Gulf exhibiting “extreme” vulnerability to SLR along with Kuwait and Bahrain.

They have estimated that Qatar is susceptible to inland flooding with 18.2% of its land area and 13.7% of its population at less than 5 m above sea-level (Maplecroft, 2009).

3.8 Marine Environment

Global climate change affect the physical, biological and biochemical characteristics of the oceans and coasts, modifying their ecological structure, their function and the goods and services they provide (IPCC, 2001). These changes will in turn exert significant feedback on the climate system. Collectively, these changes will have profound impacts on the status, sustainability, productivity and biodiversity of marine environments. (GSDP, 2009). The marine environment is historically important for the Qatar constituting a cultural and heritage symbol and main source for food, water and wealth for the country. Qatar’s marine environment is a rare example of a shallow, restricted body of water that has developed a unique environmental character, in which marine species have adopted and developed a tolerance for extreme conditions. Protection of the marine environment in Qatar within the context of climate change is a national priority as it supports many marine species (SOMER 2003). Because the Gulf waters surrounding Qatar is shallow, any small increase in temperature will have profound influence on coastal and marine life.

While economic development should continue with availability of resources, the protection due to anticipated climatic changes is very important. Coastal management plans have to be developed taking into account the assessments made on vulnerability and adaptation studies. Along side, environmental impact assessments need to be made to protect marine living resources. Coastal management plans, their implementation and legislation will be evolved in the light of these assessments. Outcomes from the integrated assessments should culminate into the

national adaptation programs of actions (NAPA). Strategic goals will be designed to protect the coastal and marine environments through development of reliable climate change and SLR scenarios.

3.9 Sensitivity Analysis of Eastern Coast of Qatar

Due to the importance of the marine environment and the possible effects due to climate warming and industrialization, an ecologic sensitivity map for the eastern coast of Qatar (Phase I) was developed by the MoE in the year 2006 (MoE, 2008). Each ecosystem, with respect to its biodiversity and fragility, has been given a defined degree of sensitivity. The index (see Figure 3-1) and the sensitivity maps (Figures 3-2 & 3-3) for the northern and central eastern parts are shown below.

A table has been created to classify different zones and corresponding sensitivities for the eastern part of Qatar. The aim is to attract attention and areas where further detailed scientific studies would be needed prior to any project development (Table 3-2)..

Figure 3-1 Sensitivity Index

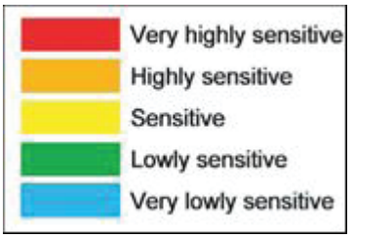


Figure 3-2 Northeastern Part of Qatar

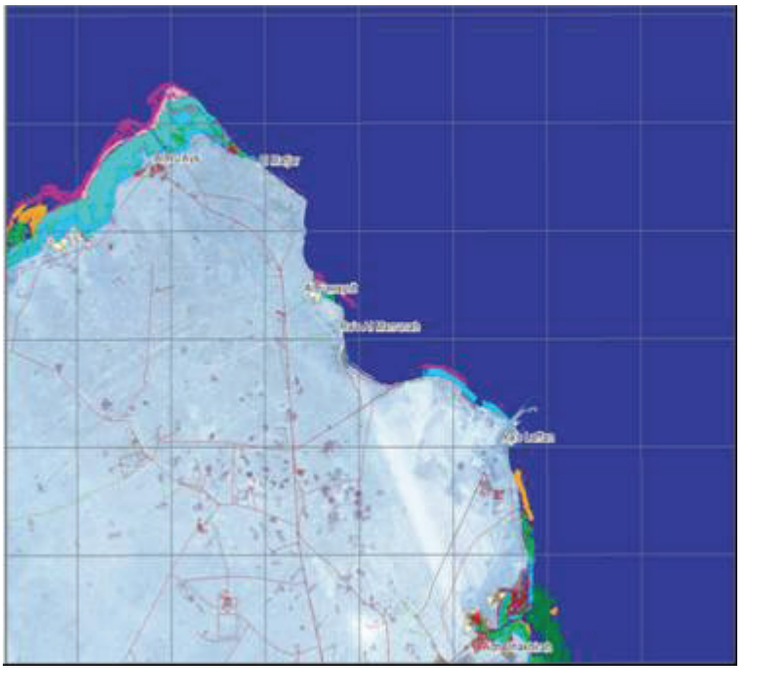


Figure 3-3 Central Eastern Part of Qatar

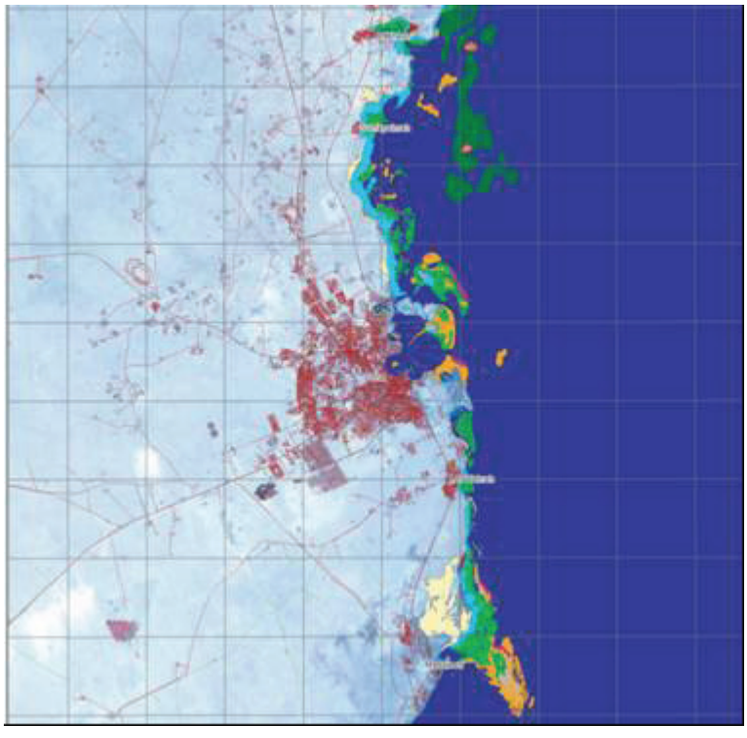


Table 3-2 Classification of Different Zones and Degree of Sensitivity (SCENR, 2008)

No.	Classification Zone	Sensitivity
1	Coastal Sabkha	Low Sensitivity (low plant and animal area)
2	Inter-tidal Mud Flats	Medium Sensitivity (feeding and resting migratory birds)
3	Beach rock and Shallow cap rock	Low Sensitivity (low biodiversity)
4	Rocky Shore	Medium Sensitivity (low biodiversity)
5	Mangrove	Very High Sensitivity (stabilizing coastal area, controlling seawater intrusion, producing nutrient and creating breeding ground for marine life and seashore birds)
6	Scattered Mangrove	High Sensitivity (scattered dense mangrove)
7	Inter-tidal Sand Bank	Very Low Sensitivity (Common ecosystem , no endangered fauna and flora)
8	Sub-tidal Sand Bank	Medium Sensitivity (often coral biodiversity encountered)
9	Shallow Lagoon	Medium Sensitivity (hosts massive coral patches)
10	Inner slope	High Sensitivity (high coral density)
11	Coral Formation	Very High Sensitivity (high coral diversity , provide shelter for marine life)
12	Deep Coral Assemblages	Very High Sensitivity (high coral diversity)
13	Shallow Seagrass Bed	Very High Sensitivity (major food source refuge and nursery for marine life)
14	Deep Seagrass or Macro Algae Bed	Low Sensitivity (low biodiversity)
15	*Sea or Tidal Channel*	*Very Low Sensitivity (no specific biodiversity)*

From the above table, it can be concluded that the most vulnerable marine species from climate change perspective in Qatar are mangroves, seagrass and corals. Therefore, under increased air and water temperature scenarios, due consideration should be given to these most vulnerable species with the objective of developing a national action plan to protect the natural reserves.

3.10 Effects on Corals

The shallow water surrounding Qatar supports a large coral community, which extend for 48-80 km from the shoreline (Ahmed, 2002). Because the coastal water is shallow, light can penetrate to support photosynthetic organisms which provide the energy to support the entire community. About 20 species of corals have been reported in Qatar territorial water. This seems unusual given the fact that 31 species have been recorded in Bahrain and 34 species in the United Arab Emirates (SOMER, 2003). Recently, it has been reported that the number of coral species in Qatari marine environment are close to the numbers cited for neighbouring States (Abdelmoati, personal communication, MoE, 2009).

Due to limited water exchange, a characteristic of the Arabian Gulf, the sea water is prone to temperature extremes. As a result of high sea temperatures, coral bleaching events occurred in 1996, 1998 and 2002, thus reducing living coral cover to as little as 1% in the shallow areas. The temperature anomaly in 1998, when temperatures exceeded 37.3°C in central regions of the Gulf was more than 2°C above the average (Riegl, 2002). This was the largest temperature rise in the southern Gulf since 1870 and that emphasized the increase in sea surface temperature in the Gulf of at least 0.2 °C per decade for the last 50 years (Sheppard and Loughland, 2002). Recovery has largely been observed in deep water areas with less human activities. Estimates of reef destruction are as low as 1% for Oman and as high as 97% for Bahrain. Along with the loss of coral was a significant decrease in fish stocks and species richness (Riegl, 2002).

As climate change continues and temperatures increase, it is often questioned whether the corals will be able to recover to its natural level. Signs of regeneration started to appear off Ras Laffan and Doha. It is likely that there will be changes in species composition and cover due to the stated fact (Sheppard, 2003). Since 1950 extreme weather events, both hot and cold, have been increasing significantly in the Middle East region (Zhange et. al., 2005). Qatar experienced an increase of 0.10°C in the 20th century and the predicted increase in the 21st century ranges from 3.0-5.9 °C (Mitchell and Hulme, 2000).

Figure 3-4 Coastal Sabkha and Mangrove at Adh Dhakhirah

3.11 Effects on Mammals

Marine mammals have evolved to live in the ocean, but the effects of climate change may be altering their primary food producers and habitats more rapidly than they can adapt to the changes. Many marine mammal species require specific temperature ranges in which they must live and thrive. The warming of the ocean will cause changes in species ranges. Those species that cannot relocate due to some barriers will be forced to adapt to the increasingly warming sea waters or else risk going extinct. Many species ranges are being pushed further and further to the north as water temperatures increase and will soon have no where else to go. Marine mammal distribution and abundance will be determined by the distribution and abundance of its prey. Migration of migrating marine mammals may also be affected by the changes in primary productivity.

It is reported that the dugong population has decreased significantly with rapid industrialization and hunting practices for food. Thus, local and regional regulations have been introduced to prevent such hunting. However, dugongs are still accidentally caught in nets, hit by small boat propellers and may be hunted clandestinely (Sheppard et al. 1992). A large herd of over 600 individuals has been observed off the west coast of Qatar in the Gulf of Salwa. An estimated 7,000 dugongs live in the Gulf area. Notably, this number is the world's second largest population of dugongs and is important for the continued success of the vulnerable species (SOMER, 2003). However, with the long gestation and calf period, population replenishment is predicted to be slow. A memorandum of understanding (MoU) signed by the UAE and other States such as Australia, France and Iran (November 1, 2007) was designed to protect the dugongs and its habitats.

3.12 Gaps and Immediate Needs

In order to comprehensively assess the impact of climate change on Qatar, the first and foremost requirement is developing scenarios for future changes of climate on a high resolution scale. Although sensitivity studies using general circulation models (GCMs) provide broad information on the impact assessments and adaptation planning, they do not provide in-depth information especially for smaller states like Qatar. Most studies conducted in the Middle East region were based on GCMs. However, these coarse models of low resolution (300 km^2) are limited in providing reliable predictions for smaller scales. It is therefore necessary to have outputs from Regional Climate Models, in order to obtain fine-scale climate prediction information for smaller countries like Qatar.

Regional climate models (RCMs) with high resolution (typically 50 Km^2) are being developed for smaller areas and for shorter time scales (20 years). Qatar would need such model outputs to make better estimations of vulnerability and adaptation. Along with the regional climate model outputs, other tools and data such as sea level change models, digital elevation models (GIS), population distribution, human settlements, infrastructure and natural resources are required. Once reliable high resolution climate and sea level change scenarios are generated a detailed impact assessment for cities, off-shore installations and different coastal zones and habitats can be done. With integrated analysis of outputs from all such models, a detailed vulnerability assessment would be possible. With these assessments, potential impacts are to be addressed in terms of social, economic and natural systems whose degree of vulnerability can vary considerably with different temperature and sea level rise scenarios. The targeted areas for assessment include coastal zones, dry land terrestrial ecosystems, marine ecosystems, human settlements, public health, energy and infrastructure etc., which are sensitive to projected future climatic conditions.

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CHAPTER 4

Greenhouse Gas Mitigation

4 GREENHOUSE GAS MITIGATION

4.1 Introduction

The State of Qatar, a Party to the UNFCCC, is committed to submitting national communications on measures and initiatives in response to the challenge of climate change. A practical step along this course is to identify potential options that can be pursued to reduce the national GHG emissions cost effectively.

Qatar further understands that it has no obligation under the UNFCCC to implement mitigation actions for the express purpose of reducing its GHG emissions. Nevertheless, the initiatives discussed in this chapter will be pursued in earnest as long as they do not constitute a disadvantage or hindrance to the national economic growth. This consideration is not only important to Qatar but also to the global efforts of GHG mitigation at large. Qatar is a primary supplier of cleaner, efficient, lower carbon and pollutants emitting fuels that include natural gas, natural gas condensate, liquefied natural gas (LNG) and gas to liquid fuels. Within the last decade Qatar has made significant investments in its oil and gas industry leading to a substantial increase in the production and subsequent availability of these cleaner fossil fuels to consumers worldwide. As a result of consumer countries' switching to these premium fuels, particularly to LNG, Qatar has been contributing indirectly to the global efforts to mitigate climate change. Moreover, Qatar's exports of lower carbon cleaner fuels are helping Annex 1 consumer countries to realize their reduction commitments under the Kyoto Protocol and to improve domestic environmental conditions as an ancillary benefit e.g. better air quality conditions (IPCC 2001, 2007).

In this chapter a summary is made of some of the national initiatives available to Qatar to reduce or sequestrate greenhouse gas emissions. Judging by the brisk pace of economic development during the past decade and the desire and commitment by the State for further development, greenhouse gas emission from Qatar will, most likely, continue to increase in the foreseeable future. It is important to point out; however, the mitigation measures proposed below are consistent with Qatar National Vision 2030 and the general direction of the State policies which promote sustainable development and environmental protection. In view of this, the proposed initiatives stand a good opportunity to be implemented at the national level. It is worth noting that enforcement of these measures will require significant coordination and cooperation among the relevant governmental, semi-governmental and non-governmental institutions. This can be accomplished through a facilitation process under direct supervision by the NCCC that includes workshops and consultation among all stakeholders. Prior to these meetings, it is important to indicate that the cost-effectiveness and technical feasibility of the national mitigation initiatives and measures must be scrutinized through specialized techno-economic studies.

It is worthy to note that recently Qatar has put in place a number of voluntary initiatives to address climate change and sustainable development objectives. They include the following:

- QP's Corporate objective of achieving zero gas flaring;
- The State of Qatar's membership of the World Bank Greenhouse Gas Reduction Program;
- The recovery and utilization of associated gas from the Al-Shaheen Field and subsequent registration of this project under the Clean Development Mechanism;
- The development of the Al Karkara Oil field - the latest field to be developed in Qatar and the first to have zero gas flaring. In addition waste heat recovery system is in place.
- The State of Qatar's $15 million contribution to the energy research and climate change fund announced at the recent OPEC summit held in Riyadh;
- The $70 million 10-year joint research project with Shell, Qatar Petroleum, Qatar Science and Technology Park and Imperial College London focusing in Carbon Capture and Storage technologies;
- The State of Qatar's $210 million investment into the UK venture capital fund for clean energy projects;
- The funding of research into clean technologies being undertaken at the Qatar Science and Technology Park;
- The investigation of energy and water use efficiency measures as part of a comprehensive

study conducted by UN Economic and Social Commission for West Asia;

- A recent investigation by QP into the use of renewable energy in Qatar;
- The establishment of formal institutions to manage climate change issues (e.g. the National Climate Change Committee);
- The development of public transport systems including the investigation of electric taxis and buses and plans for a mass transport network.
- The initiation of a national team on "environmental policies for renewable energy". The team chaired by the Ministry of Environment (MoE), has members from the Ministry of Energy and Industries, Ministry of Municipal Affairs and Urban Planning and Qatar Foundation.

Based on the analysis of sectoral GHG emissions, discussed earlier (Chapter 2), it is evident that the greatest mitigation potential for Qatar is offered by the energy sector, particularly the oil and gas industry and the power and water supply sector (see Tables 4-1 to 4-4 below).

Table 4-1 Qatar National Sectoral Energy Consumption (2007)

Sector	Energy, TJ	% Share
Production Oil & Gas	386,574	36.72
Flared Oil & Gas	134,211	12.75
Power & Water, Public	293,310	27.86
Road Transport	61,728	5.86
Production Petro Chem.	119,630	11.36
Petro Chem. Flared	280	0.03
Building Ind.	43,202	4.10
Production Refinery	11,469	1.09
Flared Refinery	2,435	0.23
TOTAL	**1,052,839**	100.00

Table 4-2 Productive & Non-Productive Sectoral Energy Profile (2007)

Sector	Total Energy, TJ	% share of National Energy Consumption	% productive energy	% Flared energy
Ups Oil & Gas	520,785	49	74	26
Refinery	13,904	1	82	18
Petrochemical	119,910	11	99.77	0.23
Power & water	293,310	28	100	0
Building Ind.	43,202	4	100	0
Road	61,728	6	100	0
TOTAL National	**1,052,839**	100		

Table 4-3 Qatar GHG Emission Profile 2007 (CO2 Equiv.)

Sector	tCO_2 Equiv.	% contribution
Production Oil & Gas	22,513,749	37
Flared Oil & Gas	8,519,824	14
Power & Water	16,611,469	28
Road Transport	4,553,199	7
Production Petro Chem.	4,597,371	8
Petro Chem. Flared	20,353	0
Building Ind.	3,599,838	6
Production Refinery	538,368	1
Flared Refinery	117,985	0.19
TOTAL	**61,072,155**	**100.00**

Table 4-4 Productive & Non-Productive GHG Sectoral Emissions 2007 (CO_2-Equiv.)

Sector	tCO_2 Equiv.	% contribution to Total GHG	% productive	% Flared
Ups Oil & Gas	31,033,573	51	73	27
Refinery	656,353	1	82	18
Petrochemical	4,617,724	8	99.56	0.44
Power & water	16,611,469	28	100	0
Building Ind.	3,599,838	6	100	0
Road	4,553,199	7	100	0
TOTAL National	**61,072,155**	**100**		

Although so far, tangible efforts have been exerted to minimize the impact of some of these sectors a comprehensive framework and action plan has yet to be developed. A summary of such a plan is presented in the next section.

4.2 National Plan for Energy Efficiency & Resource Utilization

The Qatar national plan for energy efficiency, optimization and resource utilization (QPEERU) will serve as a driver for the greenhouse gas mitigation initiatives, under the UNFCCC. Its objectives and building blocks, summarized below, reflect both the current national sectoral emission profiles and the potential win-win sustainable development opportunities to reduce emissions. It is worthy to note that since some of the mitigation initiatives represent potential future investment opportunities under the Clean Development Mechanism (CDM), it is prudent to enhance the role of the national CDM designated national authority (DNA) so as to accelerate QPEERU implementation.

- Assess potential flare mitigation opportunities from the oil and gas operations within the context of the UN CDM.
- Assess potential opportunities for further efficiency improvement of the combined cycle cogeneration of water and power (CWP) within the context of the UN CDM.
- Raise energy efficiency and reduce energy consumption and wastage per unit of output through technological improvements.
- Establish policies and regulations to manage energy conservation throughout the entire process of energy production, transport, processing and utilization.
- Adjust the value structure of the society towards energy use and utilization.

4.3 Opportunities for the Oil & Gas Sector

Large amounts of energy are needed, by the oil and gas sector, to extract, process and transport oil and gas products. Energy use entail a range of "productive" and "non-productive" combustion" activities. Productive combustion is required for: driving pumps to extract hydrocarbons and to re-inject water; heating the output streams to allow separation of the oil, gas and water; producing steam and re-injecting gas for enhanced oil recovery; powering compressors and pumps for transporting oil and gas through gathering pipelines to processing facilities; and driving turbines to generate the electricity and heat required for onsite operations. "Non-productive" combustion of energy occurs as a result of flaring activities. Moreover, energy is also wasted through fugitive emissions resulting from leaks and poor operation and maintenance practices.

From the discussion in Chapter 3 of this report, the main features of the GHG emissions and the inferred mitigation opportunities available to the oil and gas industry may be summed up as follows:

- The oil and gas sector consumed, during 2007, half of the total national energy budget and emitted approximately half of the total GHG emissions. Wasted "non productive" combustion emissions in the form of flaring accounted for 13% of the national energy use and approximately 26% of the total energy consumed by the oil and gas operations.
- In terms of GHG emissions flaring from all anthropogenic sources resulted in the emission of approximately 8.66 million tons CO2-Equivalents, 98% of which was contributed by upstream oil and gas operations and the rest from the petroleum refinery and petrochemical industries. Of all the "non-productive" GHG emissions from the oil and gas industry over 80% emanate from the oil production operations.
- In addition to climate change benefits, flare mitigation from the oil and gas operations in Qatar will enhance sustainable development objectives as it will lead to significant reductions in the national total emissions of SO2 and NMVOC (33%). Reduction of NOx emissions will be moderate, approximately 4000 tons or 3% of the total national emissions. Most likely, this will lead to better air quality conditions locally and perhaps regionally and may help to decrease the high levels of photochemical oxidants observed in the ambient air of the region.
- Further mitigation opportunities for the oil and gas sector include integration of the operations to improve energy efficiency along the supply chain: This could be achieved by developing energy management programs that include upgrade of operating and maintenance procedures and practices. As a result, reduced oil, natural gas and refined products losses through leaks and spills in transportation and storage by use of leak-proof valves and vapor recovery systems may be accomplished.

4.4 Opportunities for Electricity & Water Sector

Electricity consumption in Qatar has been expanding rapidly during the past decade. The strong demand was driven by buoyant economic activity and accelerated population growth due to a high fertility rate and international labor movements, technology advancements, greater penetration of highly intensive electricity appliances, and relatively low electricity tariffs. Residential demand in the form of air-conditioning, lighting, and use of appliances is the largest electricity user in the society. Other users include the industrial sectors and commercial (mainly for air conditioning and lighting).

Demand for water in Qatar is also growing due to rapid industrial diversification and economic growth. It has been estimated that the demand for electricity and water during the period 1995-2001 grew at an annual rate of 8-9%. During 2001 to 2007 the annual growth rate increased to 11-13%. This pattern will, most likely, continue into the future if not controlled (QPC 2001, 2008)

During 2007, the electricity and water sector (EWS), came second to the oil and gas industry in terms of energy consumption and GHG emissions, accounting for 28% of the total energy consumption and about 27% of the emissions (16.6 million tons CO_2-equivalent). The shares of electricity services among the various economy sectors in 2007 show that residential use (air-conditioning, lighting, and appliances) is the predominant consumer accounting for 7550 GWh or (43%) of the total electricity output. Industrial consumption was 24%, commercial use (hotels etc) 17% and losses from the network was 7%.

The reported losses from the network in 2007 are a significant improvement compared to the corresponding values published for 2001 where losses were estimated at 14%. Estimate of water losses of from the network in 2001 was 40.5% of the total production. The total national electricity demand for 2007 was about 17,634 GWh (QPC 2008). Considering an average load factor of approximately 50%, reported by the Electricity and Water Corporation (QPC 2001) the installed capacity in 2007 was over 4000 MW.

To curb the escalating demand for water and electricity and the subsequent GHG emissions, there is a need to formulate and implement supply as well as demand side policies e.g.: (i) schemes for further efficiency improvement of the combined-cycle water and electricity cogeneration (CWP) process and (ii) demand-side management schemes for the residential and commercial sectors. It is prudent, therefore, that the government institute policies and programs that promote and reward energy efficiency and water conservation in this sector. Here are some broad policy options:

- Improved Efficiency for CWP Cogeneration: The current efficiency of the combined cycle cogeneration of water and power (CWP) in Qatar is around 40% (QGEWC 2009). The IPCC 4AR (IPCC 2007) suggests that current available designs for combined heat and power cogeneration (CHP) can boost overall conversion efficiencies of over 80%. It seems from the comparison there is a large room for conversion efficiency improvements in Qatar, with corresponding economic savings and GHG emission reduction.
- Energy Efficient Building Code: Establish new codes and standards that optimize energy consumption in residential and commercial buildings. Based on international literature (IPCC 2001, 2007) good practice building codes may achieve up to 20% energy savings and lead to corresponding emission reductions. Energy conservation codes that may be introduced in Qatar to affect these changes include efficiency measures in envelops design, efficient lighting and mechanical systems and the use of energy efficient materials.
- Energy Efficient Appliance Standards: Develop and promote energy efficient appliance standards for domestic and industrial sectors. Efficiency standards could be considered for key appliances including air conditioning and refrigerators among other commercial and residential equipment. The literature suggests savings about 8% (IPCC 2001).
- Implement energy auditing and energy management in enterprises: Investigate the conditions for energy conservation in enterprises to identify gaps and shortcomings, and to tap the energy conservation potential of enterprises.
- Exchanges in the study of energy conservation: Attract foreign capital and technology for the construction of demonstration projects and personnel training.
- Public awareness of energy conservation initiatives: Use the mass media, publications and teaching materials at the primary and middle school levels to improve education about energy conservation to increase public awareness of energy conservation.

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CHAPTER 5

National Action Framework

(NAF)

5 NATIONAL ACTION FRAMEWORK

5.1 Introduction

This chapter outlines an initial national action framework (NAF) to build capacities and raise public awareness on issues relating to climate change. The plan must be built around the most critical challenges and opportunities posed by climate change and the needed strategies to effectively address them.

5.2 National Challenges

A general profile of the State of Qatar with climate change, serving as a backdrop, was presented in the previous chapters. Although the country is endowed with plentiful oil and gas resources and strong economic growth climate change presents a formidable challenge that needs to be addressed. Having a fragile natural resource base and being economically dependent on the export of carbon-based resources, Qatar is vulnerable to both the physical impact of climate change on its resources and the economic impact due to the policies and measures adopted by countries to address climate change. The dependency of the GDP on oil and gas revenues has historically resulted in high economic vulnerability due to fluctuations in the oil and gas prices and subsequent irregularity in the annual growth rates of the GDP. Climate change adds a further uncertainty to Qatar National GDP. Moreover, due to the delicate ecological setting of Qatar coupled with acute water resource needs, additional strategic risks are also eminent. Economic diversification, within the hydrocarbon sector and away from it, is critical for Qatar so as to maintain a steady and robust economy. National adaptation programs of actions for both-natural and economic risks-are not an option but a necessity to ensure continued economic and social development and prosperity.

Under the UNFCCC Qatar is not obligated to implement mitigation actions for the express purpose of reducing its GHG emissions. Nevertheless, on basis of the ultimate objective of the UNFCCC and the analysis presented in Chapter 2 (greenhouse gas inventory) and Chapter 4 (mitigation) Qatar will adopt voluntary initiatives to limit the growth of its GHG emissions. These national mitigation initiatives in addition to the necessary vulnerability and adaptation assessment programs will be pursued as long as they do not constitute a disadvantage or hindrance to the national economic growth. The programs will constitute the major elements of NAF.

5.3 Risks & Opportunities

As discussed earlier in this report the biggest challenge to Qatar relating to climate change is how to sustain its economic development and social prosperity in a future carbon-constrained world. While Qatar's economy depends on the export of fossil fuel, the ultimate objective of the UNFCCC is complete phase out of carbon-based fuel sources for the benefits of renewable energy. The literature indicates that implementation of the Kyoto Protocol will lead to serious economic impacts on Qatar and other oil & gas producing and exporting countries (chapter 3). In order to address this challenge there is a need to strengthen the capacity of local institutions and policy makers to understand the implications of climate change on the national developmental policy. Moreover, it is critical that national negotiators to the UNFCCC forums understand and actively engage their counterparts from Annex-1 country Parties in order to reach favorable conditions around Articles 4.8, 4.9, 4.10 and Bali Action Plan.

Another critical element of the NAF is to develop a strategy to enhance the capacity of local institutions to identify, assess and integrate the required adaptation programs within the national developmental policies. Also NAF must seek to develop a similar strategy to strengthen the national capabilities to identify and develop voluntary initiatives that reduce GHG emissions cost effectively. Initiatives which present investment opportunities under the UN CDM and those which are in line with sustainable development objectives may take the precedence.

5.4 Roadmap for NAF

The following elements represent key recommendations for broad actions to be pursued in order to implement NAF.

5.4.1 National Climate Change Committee

The highest national climate change institution in Qatar is the National Climate Change Committee (NCCC). The committee is chaired by the MoE and has members from all relevant institutions. Membership is drawn from senior level managers in the following organizations: MoE; Office of HH Heir Apparent; Civil Aviation Authority; QP Directorate of HSE Regulation and Enforcement and QP Corporate Environment & Sustainable Development Department.

In order to implement the NAF the NCCC needs urgent functional enhancement, so as to effectively perform its mandated responsibilities (included bellow).

NCCC Terms of Reference and Scope of Responsibilities

Pursuant to Article 2 of the founding Decision by HH the Heir Apparent in October 2007, the primary objectives of the NCCC are to:

- Establish a comprehensive national program for climate change that includes policies to manage national Greenhouse gas (GHG) emissions;
- Develop and ensure that the national climate change policies and measures, required to implement the UN Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (KP), are in line with the national circumstances and sustainable development objectives,;
- Meet international commitments required by the climate convention and the Kyoto Protocol including preparation and publication of the national communications under the UNFCCC ;
- Participate actively in climate change negotiations conducted by the UNFCCC, its Kyoto Protocol and their Subsidiary Bodies and Ad Hoc Working Groups. Also participate in other pertinent bilateral and regional meeting concerned with climate change and follow- up recommendations resulting from these meetings.
- Develop and coordinate climate change policy advice to ministries and industries and ensure the integration and implementation of these policies within the national development plans. Report periodically to MoE the progress of implementation of climate change policies within governmental and non-governmental bodies.

The present INC was prepared by the National Communication Technical Working Group (NCTWG) created for this purpose by the NCCC. The NCTWG functions under direct supervision of the NCCC and the National Project Coordinator. It is represented by QP Corporate Environment & Sustainable Development Department whose Manager is both member of the NCCC and the National Project Coordinator. The NCTWG was able to provide the resources and expertise needed for the preparation of the report internally at short notice after considerable coordination efforts with stakeholders.

Nevertheless, in order to implement the NAF, there is an urgent need to enhance the functionality of the NCCC as an initial step.

Once fully reformed and enhanced the NCCC will be better positioned to implement the NAF taking into consideration the identified gaps discussed earlier on vulnerability and adaptation (Chapter 3) and on mitigation (Chapter 4), particularly the discussion on QPEERU. The following key activities are to be addressed.

Strengthen technical and institutional capacities

It is critical that adequate technical and institutional capabilities are built within key departments in order to acquire the needed knowledge to conduct the following studies and assessments: (i) GHG monitoring and accounting with the objective of improving the national inventory; (ii) vulnerability and adaptation assessments; (iii) macroeconomic modeling to assess the impacts of policies and measures; (iv) insurance for climate change risks; (v) economic diversification and (vi) enhanced participatory activities with international global observation systems. Potential candidates that may benefit from this endeavor include Qatar University, Qatar Foundation, and other relevant stakeholders from government, non-government and the industry. This activity needs to be complemented through seminars and workshops for national stakeholders with participation by regional stakeholders if possible.

Establish web-based climate change information center

The role of a web based climate change center under supervision of the NCCC is to gather and validate the required information for vulnerability & adaptation assessments, GHG inventory and mitigation initiatives. At present this information is scattered, incoherent and sometimes difficult to obtain. Once in place the center will cater for harmonization of the methods and systems for data collection, data reporting and management and also for filling the gaps.

Raise public awareness

In order to mobilize public support for the national policies embodied in NAF, there is a need to raise awareness in climate change issues among all sectors and individuals of the society including policy makers, civil society, industry etc. Key elements in this activity are the youth, teachers and the scientific and academic institutions.

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