Conservation in Qatar:
Impacts of Increasing Industrialization

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CIRS
Center for International and Regional Studies

Georgetown University
School of Foreign Service in Qatar

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Occasional Paper No. 2
ISSN 2072-5957

CIRS

CENTER FOR INTERNATIONAL AND REGIONAL STUDIES

GEORGETOWN UNIVERSITY
SCHOOL OF FOREIGN SERVICE IN QATAR

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This publication series is made possible by the generous support of Qatar Foundation for Education, Science and Community Development.

Conservation in Qatar: Impacts of Increasing Industrialization

Renee Richer

Renee Richer joined Weill Cornell Medical College in Qatar in January 2007, where she teaches biology. Richer received her B.A. in biology from the University of Chicago and her Ph.D. in biology from Harvard University in 2004. Her research experience ranges from animal physiological ecology to plant physiological ecology. Richer's dissertation work focused on climate change and savanna ecosystems in southern Africa. She was previously an assistant professor and Director of the Environmental Conservation and Research Center at the American University of Armenia. Her work with bird life in Armenia was recognized in 2007 by the Whitley Award, the United Kingdom's largest conservation award.

Foreword

Like all industrial countries, Qatar is facing environmental degradation and the challenges posed by the loss of ecosystem services. However, unlike many countries, Qatar is extremely small, hot and arid, with few obvious natural resources other than abundant gas and oil reserves. It is almost completely dependent upon imports for food and other commodities to support the burgeoning population. Social and economic changes are taking place at an alarming rate, putting at risk the natural and cultural resources of Qatar. However, such loss of natural and cultural heritage need not be the case and great economic benefits can be gained from ecologically based development. Qatar is in a unique position, given the financial resources and forward thinking leadership, to move ahead and be amongst the first countries ready to take advantage of the next economic revolution: the green revolution.

This review paper is a continuation of the CIRS panel presentation "Environmental Degradation and Conservation: Challenges and Prospects" which was held on November 12, 2007. The panel presenters addressed a variety of environmental issues being faced in Qatar in light of increasing industrialization. The presentations and more importantly, the fact that attention to environmental issues is growing, was overwhelmingly well received by academics and the public.

In response to the demand for greater awareness of environmental issues and more environmentally related work regarding Qatar, this review paper was developed. The goal is to highlight some of the major environmental issues, the challenges and opportunities in Qatar, as well as increasing the general knowledge, awareness of, and action on, the environment. It is a collaborative effort between CIRS and Dr. Renee A. Richer of Weill Cornell Medical College in Qatar.

Renee Richer
Weill Cornell Medical College in Qatar

Despite its meteoric rise in importance and its newly acquired urgency in global politics and academic studies, environmental scholarship is a largely understudied and overlooked subject in Qatar. It was this scholarly vacuum that prompted us to embark on a collaborative, multi-disciplinary endeavor to better understand the environmental challenges facing the Gulf region in general and Qatar in particular, an important part of which is presented here in the form of this Occasional Paper. I am thankful to Renee Richer for agreeing to contribute to this important undertaking.

This Occasional Paper fills a significant gap in the academic literature on the relationship between industrial growth and the environment in Qatar. The study highlights the dangers of increased environmental degradation due to growing industrial development and other human activities. Richer points out that although Qatar is an arid desert, there is a surprising abundance of life-forms that have adapted to the harshness of the climate. Richer warns that because biodiversity in Qatar is under-researched, it is also under-conserved. This could result in a number of negative consequences, not the least of which is the possible extinction of a number of species that have yet to be fully studied by scientists.

Perhaps the most important insight to be drawn from Richer's study is the fact that conservation is actually an economically viable ethos that increases, rather than decreases, business potential. Richer argues that with the necessary political will, Qatar could make great strides in and act as a pioneer of environmental conservation as well as satisfy industry demands. Richer insists that Qatar could protect its biodiversity and have thriving industries by investing in research geared towards the benefits of sustainable development.

Drawing on the insights of members of the scientific community, Georgetown University's Center for International and Regional Study will continue to engage in research and examination of environmental and policy issues of contemporary importance. Through such efforts, we hope to contribute to a deepening understanding of one of the most critical issues facing our generation.

Mehran Kamrava
Director, Center for International and Regional Studies
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Abstract

Industrial development in the State of Qatar is taking place at an unprecedented rate. Such development is putting the environment at the risk, threatening ecosystem services and biological diversity. While Qatar is currently developing the legislation, regulatory bodies, and management agencies for successful ecosystem management and conservation efforts, the full implementation of these protective measures has yet to be achieved. This is in part due to a lack of scientific expertise and trained personnel as well as the early stage of environmental development in the country. While strides have been taken by the State of Qatar, the question remains whether they can be implemented in a timely fashion to ensure that current and future development projects support the country's goal of sustainable development.

Acknowledgements

Dr. Iain Macdonald contributed significantly to the preparation of this paper and the initial panel presentation on biodiversity and conservation in Qatar. His help is greatly appreciated. Dr. Benno Boer (UNESCO), S. Faizi (SCENR), Dr. Mohamed Alaa Abdel-Moati (SCENR) and Dr. Elsadig Bashir (FEC) supplied important resources and information, greatly enhancing the paper.

Introduction

Biodiversity and Conservation are not necessarily the first things that come to mind when one visits Qatar. The stark landscape, punctuated by massive industrial sites, pipelines, and refineries belies the diversity of organisms that Qatar supports and more importantly, the diversity that Qatar could support. That stark and seemingly barren landscape is not completely natural. It is partly the result of human activity and the activities of animals that are associated with humans. Unless measures are taken to halt further degradation and maintain the current conditions or restore the environment, there is likely to be irrevocable environmental degradation. Qatar is not unique in the environmental challenges it faces, but it is unique in the role that it plays in providing habitats for species vulnerable and threatened with extinction and the species yet unknown.

The Arab world, in general, has identified the environmental challenges of water scarcity and desertification or land degradation, as the most pressing environmental issues in the region. In fact, the challenges go well beyond these two issues (El-Sayed Selim, 2004). Like all countries, Qatar faces threats from invasive species, climate change, pollution and habitat change, the four main threats to global biodiversity identified in the Convention of Biological Diversity. Most of these threats are a result of industrialization and the changes that accompany industrialization from within and outside the country.

What makes Qatar Unique?

The State of Qatar is a small peninsula, just over 11,000 km^2 with 900 km of coastline, off the Arabian peninsula and connected in the south to Saudi Arabia. It is generally flat and rocky, with sand dunes in the south of the country. Qatar is hot, dry and surrounded by a shallow, hyper-saline, semi-enclosed sea. As a subtropical desert, the annual rainfall is a mere 81mm with an average annual maximum temperature of 31^{o}C, although absolute maximum air temperatures can exceed 47^{o}C. The high temperature, strong winds, low rainfall and low nutrient availability of the soil mean that recovery of the terrestrial ecosystems from disturbance is very slow. This makes the Arabian peninsula and Qatar in particular one of the most hostile environments on earth (Brook, Al Shoukri, Amer, Boer, and Krupp, 2006), and one of the most fragile.

High salinity and great temperature fluctuations make the Gulf surrounding Qatar unique and extreme. Tremendous solar pumping (evaporation) and the lack of water exchange with the open ocean makes the Gulf saline and hot, and the lack of exchange means that pollutants in the Gulf take longer to dissipate (Brook *et al.*, 2006). The local marine resources are typically surviving at their extreme tolerances of environmental parameters, but this does not stop them however, from displaying the ability to recover from mass mortality events (Shinn, 1976). The Gulf is relatively small and shallow with an average depth of only 35 meters and the greatest depth is only 120 meters. On the west coast, between Qatar and Bahrain, the average water depth ranges from 1-5 meters. There is little water exchange with the northern Indian Ocean through the Strait of Hormuz. Therefore, the Gulf has the largest annual temperature variation of any sea supporting corals. Water temperatures vary between below 11-15^{o}C in winter and can reach as high as 34-40^{o}C in summer (Rezai, Wilson, Claerebolidt, and Riegl, 2004). While the salinity levels of the open ocean are approximately 35 ppt (parts per

thousand), those of the Gulf are around 45 ppt and 70 ppt in the shallow areas off the northwest coast of Qatar. In the Gulf of Salwa, on the west coast of Qatar, salinity and temperature extremes may be even higher. Salinity levels as much as 200 ppt have been recorded in other areas of the Arabian Gulf (Carpenter, Krupp, Jones, and Zajonz, 1997).

Qatar is home to 1955 known species, of which 955 are marine. These species are specially adapted to the unique hyper-arid, hypersaline, thermovariable conditions. While these extreme environmental factors were previously believed to limit biodiversity in the region, the number of species recorded in Qatar continues to increase (Macdonald, 2007), some of those being new to science. Ironically, this extreme habitat is likely to be home to species with unique adaptations to the extreme conditions and a rich genetic resource for biotechnological advances. 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 around the region. Interestingly, some species of endemic bacteria in the Gulf can utilize hydrocarbons (oil) (Radwan, Al-Hasan, Ali, Salamah and Khanafer, 2005). This is thought to be a result of the natural oil seeps in the Gulf region, resulting in a relatively high level of hydrocarbons in the water providing a selective pressure for utilization or sequestration of the hydrocarbons. Such biological resources could ultimately be used to develop oil spill remediation measures.

The Challenges of Industrialization

Biodiversity is often grossly undervalued by society and by the institutions responsible for making decisions that threaten biodiversity (Dietz and Adger, 2003). This is in large part attributed to the lack of knowledge and understanding of the benefits that biodiversity provides in terms of ecosystem services. This lack of knowledge, as well as knowledge of the species and habitats, limits conservation efforts in Qatar. While some forms of environmental degradation can be remediated, biodiversity loss is considered irreversible (Dietz and Adger, 2003).

Increasing industrialization poses many different challenges to the environment. These are often associated with large scale energy production and metallurgy but also include the social and economic changes that accompany technological innovation. While there are the obvious concerns about emissions, either air or water, waste management, and land degradation associated with industry, one important aspect to consider, particularly in Qatar, is the increase in population that comes with increasing industrialization. An increasing population places demands on land for housing and recreation, waste disposal and sewage treatment, and other resources such as infrastructural improvements, particularly roads (Yasseen and Al-Thani, 2007).

Development in Qatar has occurred at an unprecedented pace. In the matter of a few years, Qatar has gone from being one of the poorest countries to being one of the richest countries in the world. Because this development has taken place at such a fast rate, there is simply a lack of capacity in regulatory and monitoring bodies to help guide the growth. Only in 1986 was an Environmental Protection Committee established which was replaced by the Supreme Council for the Environment and Natural Resources (SCENR) in 2000. In that same year, a draft environmental law was established with 100 articles, making environmental policy and implementation relatively new to Qatar.

Until relatively recently, Qatar was dominated by nomadic and semi-nomadic people whose livelihood depended on fishing, pearling, camel breeding, and dhow construction. However, the discovery of oil and gas has spurred not only socio-economic changes, but environmental changes as well (Khan, 2002). The tremendous economic boom seen in Qatar has been supported largely by an influx of expatriate workers. With the fastest growing economy in the Arab world and the world's third largest gas reserves, Qatar's GDP grew at an annual rate of 18% between 1999 and 2004. However, between 2003 and 2004, the annual increase in GDP was 21% with the 2005 GDP at over $47,000 US dollars (Planning Council, 2007). Crude oil and gas account for 62% of the Qatari GDP. In the oil and energy sector alone, the Qatari population is not large enough to support the labor demand, and it is unlikely they will be able to meet that demand in the future. The annual population growth for non-Qataris is 6.5%, while that for Qataris has been 2.2% between 1997 and 2004 (World Bank, 2005). In sharp contrast, 40% of expatriates in Qatar fell below the poverty line compared with only 1% of Qataris (Khan, 2002). Such poverty among the workforce may exacerbate environmental pressures.

The annual increase of expatriate workers is likely to have increased significantly since this last census. In fact, World Bank (2005) estimates of population growth for Qatar were to reach approximately 600,000 by 2006. In actuality, the population increased to nearly 800,000. Predictions by the UN for Qatar for the year 2025 placed a high estimate at 850,000, while the Planning Council figures for 2015 was 1.4 million (2007). However, both predictions were gross underestimates because by the end of 2007, the population had reached 1.5 million (*Gulf Times*, 2008).

Qatar's Natural Resources

Marine Resources

Qatar's marine environment supports 955 known marine species. These include 3 documented mammals (although more than 20 are known in the region), 15 reptiles, 136 fish species and 371 species of plants (Abushama and Abdel Bari, 2003). The marine environment includes coral communities, intertidal mud flats, algal beds, seagrass beds, pearl oyster beds, and mangroves. These habitats, generally the most productive, are located in waters from the shoreline to only 10-12 meters deep, and therefore closest to areas of human activities (Khan, 2007). They support a range of marine mammals including dugong, and about twenty species of whales and dolphins including the Humpback whale, Brydes whale, and the Bottlenose dolphin. Sharks are common and include the Tiger shark, Hammerhead shark, and the White shark (SOMER, 2003).

Eighty percent of the mangroves in the Gulf occur on the Iranian side of the Gulf. However, mangrove (*Avicennia marina*) occurs along the coast of Bahrain, Qatar, and the United Arab Emirates, while not generally found in Kuwait or Saudi Arabia (Al Habshi, Youssef, Aizpuru, and Basco, 2007). The mangrove stands stabilize the sediments, protect the coastline, provide shelter for animals, particularly commercially important juvenile fish, and their leaf fall provides an important food source for marine species (Brook *et al.*, 2006). Mangrove habitats in general are globally threatened as a result of coastal development, fish and shrimp farms, and other environmental stressors.

The seagrass beds, the most productive of the marine habitats especially for commercially important marine species, occur in shallow, protected waters. They support a wide variety of organisms, over 600 animal species recorded (SOMER, 2003), including molluscs, crustaceans, fish, turtles, and the unique marine mammal, the dugong (*Dugong dugon*) (Loughland, Darwish, Saddiqui, Fadel, Al-Ali, and Crawford, 2007, and Brook *et al.*, 2006). Known as the sea cow, the dugong feeds by grazing on the seagrass beds in the shallows. The dugong is the only species within the Gulf to be highlighted as an EDGE species (Evolutionary Distinct and Globally Endangered), which is a scheme set up by The Zoological Society of London. At one time, the dugong was actively hunted for food, but that has now decreased with industrialization (i.e., the decrease in subsistence fishing) and the introduction of local regulations to prevent such hunting. However, dugongs are still accidentally caught in nets, hit by small boat propellers, and may be hunted illegally (Sheppard, Price, and Roberts, 1992). A large herd of over 600 individuals has been observed off the west coast of Qatar in the Gulf of Salwa. Estimated at 7,000 individuals, the Gulf population 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 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 dugong and its habitat. Unfortunately, signatories of the MoU failed to include Bahrain and Qatar (*Khaleej Times*, 2007).

Five species of sea turtle are known in the Gulf, including the globally endangered Green turtle (*Chelonia mydas*), the critically endangered Hawksbill turtle (*Eretmochelys imbricata*), the critically endangered Leatherback turtle (*Dermochelys coriacea*, the endangered Loggerhead turtle (*Caretta caretta*), and the endangered Olive Ridley turtle (*Lepidochelys olivacea*) (SOMER, 2003). The Green Turtle feeds within the seagrass beds and the Leatherback Turtle has been observed on the coast of Qatar but is not officially recorded. The Hawksbill Turtle is also known in Qatar and is reported to breed on various offshore islands (SOMER, 2003) and along the northeastern coastline on suitable beaches. In general, the males tend to stay offshore and the females come to shore for nest production and egg laying. Unfortunately, anecdotal evidence suggests that despite protective measures, turtle eggs are still collected along the shore.

The shallow water surrounding Qatar supports a large coral community which may extend as much as 48-80 km from the shoreline (Ahmed, 2002). Because the water is shallow, light can penetrate to support photosynthetic organisms. This light ultimately provides the energy to support the entire community. However, only 8 species of coral have been reported for Qatar. This seems unusual given that 31 species are recorded in Bahrain and 34 species in the United Arab Emirates (SOMER, 2003). This low species count could be attributed to lack of adequate data in the region or may be as a result of natural causes such as salinity.

Finally, marine species are important commercially and species such as lobster, octopus, and many local fish species such as grouper and bream are locally exploited (Ahmed, 2002). Landings of emperor (*Lethrinus sp.*) and grouper (*Epinephelus sp.*) accounted for 42% of total landings in 2001 (FAO, 2003). Shrimp exploitation has been stopped in order to increase the local population. However, given that Bahrain

and Saudi Arabia still catch shrimp, recovery of the population is unlikely under these circumstances. Qatar manages the fishing industry by regulating the inputs, i.e. the number of artisanal vessels, rather than limiting the catch size. In 1995, the number of vessels was 493 and between 2001 and 2003 the number of fishing vessels stayed constant at 515. However, small vessels could have been replaced with larger vessels; 49% of the vessels are 16.4 m or greater in length (FAO, 2003). This may be responsible for the rise in the number of fishermen increasing from 3,101 in 1995 to 4,721 in 2001. The total annual fish catch also increased from approximately 70,000 tons to 140,000 tons between 2000 and 2005, an annual increase of over 14%. It is important to note that Qatar has no seasonal ban on fishing (*Peninsula*, 2007).

Terrestrial Resources

Qatar's terrestrial environment supports 1,000 known species, including 8 mammals, 255 bird species, 29 reptiles, 1 amphibian, and 228 invertebrates. There are 371 species of plants from 61 families and 142 known species of fungi (Abushama and Abdel Bari, 2003). Of the terrestrial species about 26 are at risk; these include the Greater spotted eagle, Lesser kestrel, Socotra cormorant, and Houbara bustard. Arabia's only antelope, the Arabian oryx (*Oryx leucoryx*), inhabited the deserts until a century ago (Brook *et al.*, 2006). It is now extinct in the wild, but re-introduction programs are attempting to re-introduce it along with the Rheem gazelle (*Gazella subgutturosa marica*) back into the wild (Brook *et al.*, 2006). Other mammals present in Qatar include the Desert hare (*Lepus capensis*), the Ethiopian hedgehog (*Paraechinus aethiopicus*), and at least two species of fox: the Sand fox (*Vulpes reppells*), the Red fox (*Vulpes vulpes*), and possibly the Arabian fox (*Vulpes vulpes Arabica*).

Bird surveys, which unfortunately are dated, suggest there are approximately 255 bird species recorded in Qatar. Of those, 23 are local breeders, 78 are winter visitors, and 50 are vagrants. The remaining 104 species, 44% of the species known in Qatar, are migrants which simply pass through Qatar (FEC). Updated information should be available soon, pending a recent survey supported by industry. The invertebrates, which comprise the majority of the animal life, are little studied and comprehensive lists of species or groups are not available. In terms of terrestrial plants, seven species of plant are present in Qatar that are known to be threatened with extinction (Planning Council, 2006).

Environmental Risks in Qatar

Environmental risks include the global risks associated with large-scale international actions, regional actions, and local activities that can be modified or controlled. Although Qatar currently has the largest CO_2 per capita emission rate at 69 tons CO_2 /per person/per year which dwarfs the second largest emission rate of 39 tons CO_2 / per person/per year by the UAE (WRI, 2007), that number reflects the fact that Qatar produces a vast amount of the world's energy resources and has a relatively small population. However, in May of 2007, Qatar Petroleum successfully registered the first UN Clean Development Mechanism (CDM) project under the Kyoto protocol in the Gulf region (CDM, 2007). That project is designed to decrease CO_2 emissions by reducing flaring.

Globally, current climate change predictions for the Gulf region vary based

on different models and the IPCC scenario, especially for precipitation (Chaudhary and Husain, 2006). Because precipitation is influenced by local conditions and complicated teleconnections, predictions for precipitation changes are particularly difficult to construct. Model predictions for temperature and humidity all show an increase for the Arabian peninsula, the only question being how large a temperature increase (Chaudhary and Husain, 2006). Since Qatar is a desert region with low annual precipitation, small changes in precipitation, either an increase or decrease, can be expected to cause significant changes in species associations for both the marine and terrestrial environments. As disease vectors are also expected to change, the incidence and occurrence of disease may play a significant role in altering species associations (Chaudhary and Husain, 2006).

"Water, water everywhere, nor any drop to drink"

One of the most critical issues associated with increasing industrialization and the concomitant population increase to support such industry, is the availability of water. Qatar is well below the World Bank "water poverty line" of 1,000 cubic meters per person per year, with only an average of 91 cubic meters available per person per year (El-Sayed Selim, 2004). On the Arabian peninsula in general, fossil water resources are believed to have accumulated during the pluvial period between 10,000-30,000 years ago (Alsharhan, Rizk, Nairn, Bakhit and Alhajari, 2001). Current rate of water use is about six times the natural renewal rate of water resources, while over half of the water used is desalinated water or treated wastewater (Brook, Houqani, and Mugrin, 2006). Nearly 96% of the domestic water in Qatar is provided by desalination, while ground water supplies are largely used for the small agricultural industry. Continued over-exploitation of the fossil water reserves threatens the remaining reserves from saltwater intrusion, while over-use of ground water for agriculture is resulting in soil salinization and land degradation (Child, 2006).

Over-exploitation has resulted in increasing salinity levels in ground water from 71% to 1,160% as a result of saltwater intrusion (Brook, Al Shoukri, Amer, Boer, and Krupp, 2006). Importantly, over-use of ground water has resulted in the disappearance of many springs in the Arabian peninsula in general. These natural oases were an important habitat for reptiles, birds, and mammals, including rare and endemic species. As demands increase, the need for desalinated water will increase. Demand simply cannot be met by renewable or fossil resources. Currently, among the GCC countries, there are 15 desalination plants located in the Gulf, releasing gases, hot brine, treatment chemicals, and other trace elements (Abderrahman and Husain, 2006). At this time, the effects of the desalination plants on the Gulf as a whole are limited in scope, but the effects are greater locally. As the number of desalination plants increases, their impact on the sensitive marine environment may become devastating. A recent study in Kuwait showed that the hot water released by a power and desalination plant reduced sea grasses and coral reefs by 15-20% just from the increase in temperature alone (Abderrahman and Husain, 2006).

Threats to the Marine Environment

The challenges to the marine environment include global changes such as climate change as well as local effects of industrialization from land-based sources such as the emissions from power and desalination plants and sewage treatment plants, pollution

from the petrochemical industry, coastal reclamation projects, ballast water, invasive species, eutrophication, overfishing, and threats from increased tourism (Khan, 2007).

Coastal development is a major threat to the marine environment. Activities associated with coastal development such as dredging and land reclamation for projects in residential areas, industry, causeways, fishing ports, airports, and harbours takes its toll (SOMER, 2003). Dredging has been important in providing access to major ports for shipping. However, these activities result in siltation and increased water turbidity, which can inhibit photosynthesis, clog fish gills, and essentially smother the algal mats, seagrasses, and coral communities (Al-Ghadban and Price, 2002). This is a continuing stressor on the coral communities and the intertidal and shallow tidal ecosystems. In the case of corals, the increase of sediment in the water column decreases light levels and affects the health of the coral and can also prevent coral recovery (Rezai *et al.*, 2004). Coastal development utilizing infill and dredging, such as the artificial island developments, affects the shores. This has stressed fish stocks as a result of damage to nursery and feeding grounds of the fish (Jones, Ealey, Baca, Livesey, and Al-Jamali, 2007). The causeway, currently under construction from Bahrain to Qatar, will utilize reclaimed areas of coral from Fasht Al Adhom. Besides the obvious damage to the coral community, water currents may also be disrupted in the Gulf of Salwah (Rezai *et al.*, 2004). Much of the development taking place on the coastal areas of Doha lack appropriate impact assessments or restoration plans (Yasseen and Al-Thani, 2007). This development affects mangroves (*Avicennia marina*) and as many as 16 species of xerophyte and halophytes.

Because the water surrounding Qatar is shallow with little exchange, characteristic of the Gulf in general, this area is susceptible to temperature extremes. Coral bleaching events, as a result of high sea temperatures, occurred in 1996, 1998, and 2002, reducing live coral cover to as little as 1% in shallow areas. The temperature anomaly in 1998, when temperatures exceeded 37.3^{o}C in central regions of the Gulf, was more than 2^{o}C above average (Riegl, 2002). This was the largest temperature rise in the southern Gulf since 1870 and emphasizes an increase in sea surface temperature of at least 0.2^{o}C per decade for the last fifty years (Sheppard and Loughland, 2002). Recovery has been largely limited to deeper water areas where there is less human impact. Estimates of reef destruction are as low as 1% for Oman and as high as 97% for Bahrain. Along with the loss of coral is a significant decrease in fish stocks and species richness (Riegl, 2002).

Although the awareness of the importance of coral conservation is increasing in the region, conservation in these areas still lags behind much of the world (Rezai *et al.*, 2004). As climate change continues and temperatures increase, it is questionable whether the corals will be able to recover. Most likely there will be changes in species composition and cover (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^{o}C in the 20th century and the predicted increase for the 21st century ranges between 3.0-5.9^{o}C (Mitchell and Hulme, 2000).

Industrial cooling water is also a threat to the marine environment. Cooling water is often discharged into the sea from co-generation desalination and power plants. The water can reach 10^{o}C above ambient and contains chlorine and other chemicals to prevent scaling in the machinery. In 2006, the "International Cooling Seawater Specialists and Operators Conference" was held in Doha to discuss temperature and

chlorination challenges posed by cooling water. With a focus on Qatari industries, local experts developed management recommendations for SCENR (*Peninsula*, 2006). Important to note is that the recent adoption of new water treatment techniques, such as pulse chlorination, has proven successful in decreasing the amount of chlorine in cooling water releases by as much as 56%. Driven by increasingly strict regulation concerning chlorine release, Qatargas has recently implemented this BAT (Best Available Technology) by the European Union (Qatargas, 2007). Other threats to the coral communities of Qatar include physical damage from anchors, propellers, abandoned fishing nets, traps, and overzealous sport divers (SOMER, 2003).

As the demand for gas and oil increases, the transport of both products will increase through the Gulf. Currently, over 60% of the world's total crude oil exports are transported through the Strait of Hormuz. Oil tankers pollute in many ways, including exhaust, routine leaks, ballast exchange, and spills that are both war and error related. If we combine these risks with pipeline ruptures and well blowouts, this makes the Strait one of the world's highest oil pollution risk regions (SOMER, 2003). Given that the water exchange in the Gulf is so slow and pollutants are slower to dissipate, spills can be devastating to the Gulf environment. The annual spill rate into the Gulf is 1.2 million barrels of oil from marine transportation (SOMER, 2003). Even now, more than fifteen years after the Gulf war, when more than 9 million barrels of oil were spilled in the Gulf, the environment has yet to completely recover from this disastrous oil spill (Barth, 2007). A comprehensive study of the effects of that spill has not been done in Qatar, and restitution has not been claimed by Qatar.

Ballast water from tankers poses a threat by introducing invasive species. As ships move globally from region to region they often release non-native organisms into the water, disrupting local communities as well as introducing new species that can pose expensive problems for industry (Hushak and Deng, 1997).

As the population increases, discharge into the sea will likewise increase. In the case of sewage, approximately 20-30% of sewage discharged into the Gulf is not treated or only partially treated, promoting eutrophication (SOMER, 2003). At one time, Qatar disposed of domestic sewage directly into the Gulf. However, as of 1999, Qatar had thirteen sewage treatment plants and claimed to no longer be releasing sewage into the sea, opting for land-based containment. In addition, the treated water from the sewage treatment plants is used for irrigation of fodder crops, gardens, and the city landscaping (SOMER, 2003).

The State of Qatar has made moves toward protecting its natural environment including public awareness campaigns, implementing a legal structure for the protection of species and habitats, and by participating in regional programs such as ROPME and the Convention on Biological Diversity. However, large-scale land reclamation projects, dredging, and the discharge of cooling water will remain important issues for the marine environment (Rezai *et al.*, 2004).

Desertification in the Desert?

It may seem ironic that Qatar, party to the Convention to Combat Desertification, is itself suffering losses due to desertification. How can desertification happen in the desert? It is important to understand the process of desertification and the impacts associated with desertification. The United Nations Convention to Combat Desertification defines desertification as land degradation in arid, semi-arid, and dry

sub-humid regions, partly as a result of fluctuating climate, but also as a result of human agricultural activities such as grazing and crop production. Land degradation can include the loss of plant productivity, biodiversity, and soil fertility.

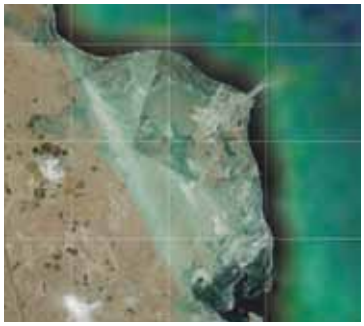
Much of the Arabian Peninsula, including Qatar, has suffered from livestock grazing well above the ecological carrying capacity. To date, there are 925 productive farms in Qatar located on 9,800 hectares of land (Brook, Al Shoukri, Amer, Boer, and Krupp, 2006). Although agriculture accounts for only 1% of GDP, it accounts for 74% of freshwater use (Al Yousef *et al.*, 2000). In the past, the number of animals a family could support depended on their ability to provide water. Traditionally, that involved labor- intensive maintenance of wells that often provided brackish water. Now that traditional herding practices have changed, combined with the collapse of the *hima* conservation system, there has been a decline in natural rangelands (Breulmann, Boer, Wernery, Wernery, Shaer, Alhadrami, Gallacher, Peacock, Chaudhary, Brown, and Norton, 2007). Today, fresh water can be easily transported, and deep wells utilizing fossil ground water supplies are used to grow non-native feed and supply water, which has allowed the livestock populations to increase dramatically. In addition, there has been a move away from the nomadic life to a more sedentary life resulting in increased localized grazing pressure (Brown, Peacock, Loughland, and Alhadrami, 2006). Starting in the late 1950s, the number of farms began to increase steadily such that, by the late 1960s, the effects of ground water over-exploitation were becoming evident (Al Yousef, Abdalla, and Akbar, 2000).

Beyond water use, animals can place a tremendous stress on the local plant resources. The grazing and browsing pressure seen in Qatar is a result of not only camels, but sheep and goats as well which, unlike camels, eat the plants down to the roots. As of 1999, Qatar supported nearly 4,000 horses, 14,000 cattle, 205,000 sheep, 175,000 goats, and 47,000 camels (Al Yousef *et al.*, 2000 and Bourn, 2003). Qatar has the highest density of camels in the Middle East and the third highest amongst seventeen surveyed North African countries. The United Arab Emirates has the second highest camel density in the Middle East with nearly one half the density of Qatar (Brown *et al.*, 2006). With increasing industrialization and expansion of the urban environment, those animals will be further confined to even less land, exacerbating what is already a significant problem. Such intensive grazing and browsing has resulted in the reduction of many plant species, changing the shrubland to the current, relatively barren, landscape witnessed in Qatar. Therefore, the population of Rheem gazelles reintroduced into the Al Reem reserve must be supported with additional food resources (Brown *et al.*, 2006).

Before the grazing and browsing pressure increased, the plant species composition and habitat structure was significantly different with greater plant cover. Large areas of grassland once covered Qatar, but due to overgrazing, the grass community has largely been replaced by perennial shrubs that are thorny, toxic, and generally unpalatable. The change from traditional to modern rangeland management has resulted in a decrease in vegetation density from 10% of land cover to approximately 1%. The change in cover associated with grazing and browsing animals is illustrated by satellite images of the Ras Laffan industrial area. This area is surrounded by a security fence, which also prevents the introduction of domesticated animals such as sheep, goats, and camels. The satelltite photo in Figure 1 illustrates higher vegetation cover, with its darker green color, within the triangle of the security fence. It is likely that other secured

areas may provide protection for vulnerable species, which is an important aspect of conservation that could be pursued.

Figure 1: Satellite image of area within security fence



Source: NASA, 2008, Terrametrics, DigitalGlobe, and Europa Technologies

The loss of vegetation cover and edible plant species as a result of grazing and browsing by the camel and other domesticated animals has contributed to the disappearance of oryx and gazelles. The shrubland habitat at one time was able to support hyena, leopard, oryx, and gazelle. Likewise, the loss of plant cover has led to an increase in wind erosion and a decrease in soil fertility, which in turn lead to declines in species diversity. This has been exacerbated by the fact that these large populations of domesticated animals are now supported by non-native species such as alfalfa and Rhodes grass which demand fresh water irrigation that promotes desertification (Breulmann *et al.*, 2007). As such, reintroduction of species will require restoration of the shrubland habitat.

Restoration of the desert rangeland is possible in areas where the land has not been irrevocably damaged. This will require a commitment from all stakeholders as well as introduction of laws to manage grazing and the availability of resources for full implementation of the program (Breulmann *et al.*, 2007). UNESCO is currently supporting a demonstration "Camel Farm" as a first step in the restoration of rangelands. Camels make ideal animals for the desert with their ability to drink water with a salt content of up to 3% and to eat native halophytes that would be toxic to other species. Unlike cows, they do not require air conditioning or sprinkling to keep cool, nor do they need large amounts of fresh water for drinking and fodder. In addition, they provide excellent meat and milk. In this way, local fodder species could be produced that are less reliant on fresh water, pesticides, and herbicides (Breulmann *et al.*, 2007). Camel farms would lead to a reduction in the number of camels on rangelands, allowing the habitat to recover.

Ecosystem Management

Economic development need not be in conflict with environmental protection. In most cases, the technology to be much more efficient is already available. What is often lacking is the political willpower to lead. In fact, as we become increasing aware of the true dollar value of ecosystem services and develop novel technologies and management techniques, environmentally friendly development is becoming much more economical. Full implementation ultimately involves the cooperation of industry, the public, and government.

Successful conservation programs work with the local community, with regards to their values and practices, to protect the natural environment. In the case of Qatar, and Arabia in general, the unique concept of *hima*, an area set aside specifically for the sustainable use of natural resources by and for local communities, can be encouraged (Seddon and Mallon, 2007). How the traditional institution of *hima* can be used in the region is increasingly being debated among local and trans-boundary environmental protection bodies.

Coastal management plans have been developing in the region with the aid and support of stakeholders including NGOs, industry, and the general public. However, most of the coastal management plans have not been fully developed and full implementation has yet to be achieved (Krupp *et al.*, 2006). In addition, the use of Environmental Impact Assessments has been increasing. Environmental Impact Assessments is an evaluation of the impacts of a project, whether bad or good. The process includes not only an assessment of the effects on the environment, but also the social and cultural impacts as well as suggestions or requirements for mitigation or bioremediation. In this way, decision-makers are fully informed of the expected impacts of a project. Environmental Impact Assessments may ultimately result in alteration of the project, relocation, or even abandonment of a poorly designed project. This is crucial given the coastal dredging and landfill projects including those currently taking place in Qatar that are largely associated with industrial, tourism, and port developments.

It has been suggested that coastal developments projects such as waterways, canals, and land reclamations can be designed to improve productivity. This could include spawning grounds and nursery areas (Krupp *et al.*, 2006). An example of this type of development is the West Bay Lagoon area in Doha. This development project introduced a new waterway through the relatively unproductive sabkha creating intertidal and subtidal areas. The hope is that, if carefully planned and managed, these waterways can act as a nursery for commercial fish species since seagrass species such as *Halodule uninervis* have been able to occupy these areas (Jones *et al.*, 2007). Although the seagrass species may be established, it is still unknown whether they will develop beds large enough to support other species.

Environmental Impact Assessment and Industry

The Environmental Impact Assessment (EIA) also referred to as the Environmental, Social and Health Impact Assessment (ESHIA) process is a very important aspect of sustainable development and managed development. The Environmental Impact Assessment process in Qatar is under the review of the Supreme Council for Environment and Natural Resources (SCENR). Unfortunately, an official translation

of the guidelines and criteria for EIA in Qatar from Arabic to English is currently not available. Environmental Impact Assessments are overseen by the technical affairs section of the SCENR which is responsible for permitting. Initially, a "Scope of Work" is submitted to SCENR and then a decision is made as to whether or not the project requires a full EIA. If a project results in environmental damage, that damage must be remediated by the developer. In the event that the damage cannot be remediated, then the developer is responsible for providing compensation for the damage. Such compensation is not a fixed amount, but is a percentage of the project budget. The percentage is decided on a case by case basis. Ultimately, the EIA committee, a team of five internal and external experts, makes a recommendation and SCENR has the final decision-making ability. However, there does not appear to be exact criteria stipulating what factors make a project successful or unsuccessful. That seems to be decided on a case by case basis depending on the scale and scope of the project.

However, given the pace of development and the need for EIAs, there is a demand for increased capacity in SCENR. More than 1,000 projects were submitted to SCENR for EIA in both 2006 and 2007 including large scale and medium/small scale projects. In many cases, the company is asked to change the design or location of the project. In 2007, 5% of the projects did not pass the EIA. Currently, the process is considered slow, taking one to two months to complete and resulting in delays. Therefore, SCENR stressed the great need for an increase in local experts (SCENR, personal communication). It is important to note however, that comparable EIAs for large scale industrial projects in other countries can take much longer to complete, with final project approval taking years.

The Supreme Council for Environment and Natural Resources employs a surveillance department to detect any illegal projects and activities. Of the 650 Council employees, 300 are involved in the twenty-four hour a day surveillance department with 120 designated to marine activities and 180 designated for terrestrial activities. The most common types of violations include use of illegal fishing nets and fishing in restricted areas, amounting to two or three violations occurring daily. Other common violations include illegal dumping, unauthorized jetties, and dust and noise production at construction sites. Ultimately, the prosecution of environmental violations takes place under the district attorney designated specifically for environmental affairs (SCENR, personal communication).

The mitigation costs assigned to industry often involve funding research projects and conservation programs, but may not result in remediation of the environment itself. These studies are generally not available to the public and are reserved for government and industry use. However, members of the public may request a study. In such cases, a summary report may be issued to the inquiring person (FEC, personal communication). Dolphin Energy developed a pipeline project in Ras Laffan. Remediation for that project involved funding a three-year project studying the coral communities from Qatar to UAE, including full mapping of the reefs. Similarly, the Ras Laffan port expansion project will affect the seagrass beds and coral communities in the region. Compensation for that project will amount to $50 million over a five-year period designated for conservation projects (SCENR, personal communication). Artificial reefs (Dolphin Energy and others) as well as coral translocation (Qatargas) are being pursued by industry to promote coral conservation and development, although the true impact of these measures is unknown.

Ras Laffan Environment Association (RLEA), a consortium of oil and gas companies, sponsors a variety of environmentally related work. RLEA is currently sponsoring the Qatar Bird Project. Funding for the first year of the project began in July 2007, and the first report was issued in December 2007. The goal of the project is to assess bird life and Important Bird Areas (IBA) in Qatar. In 2007, Qatar became a member of Birdlife International, which is a globally recognized bird conservation organization represented locally by Friends of the Environment Center (FEC). Birdlife International has developed the Important Bird Area concept as a conservation tool. Each country may have designated IBAs which are the focus of conservation efforts to maximize the conservation of species. Based on dated surveys from the 1970s, 1980s, and 1990s Birdlife International suggested five IBA sites in Qatar. The Qatar Bird Project is designed to review and reassess the status of the suggested sites and investigate potential new sites.

As of November 2007, FEC, with the aid of representatives of Birdlife International, completed an extensive survey confirming three of the five suggested IBAs as indeed being prime bird conservation sites in Qatar. Those sites include Al Thakira mangroves, Khor Al Udaid, and Alshat Island. The two remaining sites have yet to be surveyed. In addition, five other sites were recommended for IBA consideration. These include Um Tais, Ras Rukon, Abu Nakhla pond, Ashat Island, and Shahanniya.

National Biodiversity Strategy and Action Plan

The increasing international understanding and acceptance of the importance of biodiversity and ecosystem services for continued development has resulted in increased efforts to protect habitats and reduce biodiversity loss. Qatar, as part of this movement, is party to several conventions including the Convention on Biological Diversity, the Convention to Combat Desertification (CCD), select annexes of the International Convention for the Prevention of Pollution from Ships (MARPOL), and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Qatar will be hosting the CITES international conference in 2010, drawing attention to Qatar's unique environment. Most recently, Qatar ratified the Cartagena Biosafety protocol of the Convention on Biological Diversity in early 2007, and is now in the process of implementing the treaty.

The Convention on Biological Diversity (CBD) entered into force on December 29, 1993, with the goal of conserving biological diversity, sustainable use of species and habitats, and the sharing of benefits derived from them. As party to the Convention on Biological Diversity, the State of Qatar has a legally binding obligation to implement the provisions of the Convention. Most signatory countries, of which Qatar is no exception, have Biodiversity Action Plans that outline the philosophy, policies, and procedures of the country to successfully implement the Convention. The National Biodiversity Strategy and Action Plan (NBSAP) was completed in October of 2004 with the goal of reaching the 2010 target of reducing the rate of biodiversity loss.

The NBSAP for the State of Qatar has eleven strategic goals encompassing the following themes:

- protected areas
- ecotourism and protected area facilities

- sustainable use of marine and coastal resources
- desertification and rangelands
- desertification and agro-biodiversity
- environmental legislation
- scientific research
- education and public awareness
- invasive species and genetically modified species (GMOs)
- environmental monitoring and impact assessments and
- multilateral environmental agreements.

The first and second of these strategic goals deal with the development of management plans and the basic services needed to support these plans in the protected areas. The first strategic goal is concerned with the development of protected areas, both terrestrial and marine. At this time, Qatar has five terrestrial protected areas and three marine protected areas. The terrestrial areas account for about 18% of the land surface of Qatar and include most of the habitat types. This strategic goal highlights the need for a protected area system plan and a localized management plan as well as increasing public awareness of and participation in protection of the areas. The second strategic goal outlines the development of ecologically based tourism in the scenic areas of Qatar. This would include developing facilities and visitor centers at the sites. In addition, local residents would act as guides and there would be an economic benefit to the local community through revenue sharing.

The third strategic goal is designed to protect coastal and marine resources through the development of sustainable fishing and marine recreation. This would require the implementation of a coastal management plan as well as introducing legislation to regulate fishing and other activities that can threaten marine resources.

Desertification is the focus of the fourth and fifth strategic goals. Given the seriousness of the threat of desertification in Qatar this seems appropriate. The fourth strategic goal deals specifically with managing rangelands to prevent overgrazing, reducing the numbers of grazing animals, and utilizing the traditional conservation ideas such as the *hima*.

The sixth strategic goal is to improve the environmental legislation and implement existing environmental legislation by improving the enforcement mechanisms.

The seventh and eighth strategic goals are aimed at increasing knowledge across all sectors of society from scholars to students. The seventh strategic goal aims to encourage basic scientific research by increasing funding, supporting surveys, and publishing the results. This will provide government leaders with the necessary information on which to base decisions that may significantly impact the environment. The eighth strategic goal focuses on increasing public awareness of biodiversity and improving environmental education through support of institutions and educators.

The ninth, tenth, and eleventh strategic goals are concerned with utilizing modern tools to control modern threats. The ninth strategic goal aims to protect the natural ecosystem, as well as humans, from the impacts of invasive species and genetically modified organisms (GMOs). This could be achieved by the establishment of a certification program for food and other imported products. The tenth goal is to strengthen the Environmental Impact Assessment process by finalizing rules, regulations, and guidelines for the process. Finally, the eleventh strategic goal is to

strengthen multilateral and multinational environmental agreements by developing a planning process that would be comprehensive in fulfilling the requirements of these agreements. The dangers posed by GMOs and invasive species are of lower priority than the immediate threats to the marine and terrestrial environment (Third National Report, 2007).

The Third National Report on Implementation of the Convention on Biological Diversity (2007), essentially a report on implementation of the NBSAP, highlights a lack of trained labor as a limiting factor in implementing many requirements of the Action Plan and Strategy. However, we can hope for increasing expertise since biological, sciences/health, and environmental studies do comprise 12% of MSc studies done abroad by Qataris. Biology and health, chemistry, and geology make up 24% of the PhD programs being studied abroad by Qataris (World Bank, 2005).

Qatar's Protected Areas

In 2004, Qatar enacted the Law concerning the Protection of Wildlife and Their Natural Habitats. This law allows SCENR to propose protected areas but not to designate protected areas. SCENR must protect species within the protected areas and can mandate regulations to do that. Unfortunately, guards deployed in protected areas are not trained in protected area management. The Protected Area Action Plan (2007) developed by SCENR outlines the current status of protected areas in Qatar as well as the actions to develop the Protected Areas management within the next five years (PAAP, 2007).

Qatar has five designated protected areas for terrestrial ecosystems and three for the marine environment. These include the newly designated Al Reem biosphere reserve, Al Thakira, Shahanniya, Khor Al Udaid, Al Weseil, Al Oraiq, and Al Mas'habiya (see Figure 2). Together they comprise about 18% of the terrestrial area of Qatar. Shahanniya, Al Mas'habiya, and Al Isheiriq were wildlife farms developed into captive breeding sites for endangered species (Protected Area Action Plan, 2007). The maintenance and regulation of the Protected Areas of Qatar is expected to improve significantly.

Currently, a management plan is being developed for the Al Reem biosphere, which covers nearly 1,200 square kilometres. Within the Al Reem area is about 18,000 people (PAAP, 2007), of whom 75% is mostly male expatriate workers. Poverty statistics suggest that 40% of these expatriate workers survive under the poverty line, which may make it difficult to control illegal hunting and gathering activities. Most other protected areas, barring the captive breeding centers, have a resident population. Khor Al Udaid is just over 1,100 square kilometres and is a unique geological site in the region that may soon be nominated as a UNESCO World Heritage Site but unlike the other protected areas, it has no resident population.

The Protected Area Action Plan (2007) outlines eleven steps that Qatar intendeds to implement for the successful development of protected areas, including the following:

- Institutional reform for Protected Area (PA) management in order to stream line the management process
- Formation of a National Advisory Committee on PAs to coordinate agencies involved in the PAs

Figure 2: Protected Areas in Qatar

Source: Supreme Council for the Environment & Natural Reserves, National Center for Environment Information

- Formation of local consultative committees for PAs to address the concerns of the local population
- Categorization of PAs as *ex-situ* conservation or *in-situ* conservation efforts to clarify management goals
- Preparation of a management plan for each PA
- Building capacity in protected area management
- Infrastructure development which aids the management of the PA
- Increase research activities such as species inventories, population monitoring, vegetation studies, etc.
- Development of a sustainable resource use plan for each PA
- Institution of a plan for the development of ecotourism
- Development of a policy guiding species reintroductions

Developments are expected to take place within SCENR which will contribute to improved conservation efforts. At this point, there is no Protected Areas Department within the structure of SCENR. Currently, the Wildlife Management Department within SCENR is responsible for the administration of protected areas. However, in the future, the organization will establish a department to deal strictly with Protected Areas and with implementing the detailed management plan of each of the areas (SCENR, personal communication).

Traditional Activities

The State of Qatar has placed an emphasis on preserving the environment so as to protect the health and livelihood of local communities (Bedouins) and looks toward traditional knowledge and culture when instituting national development plans (Third National Report, 2007). Part of this is maintaining viable land where traditional activities can be pursued. Traditional activities, as typically perceived, include fishing, agriculture, and hunting. However, when we consider the economic aspect of traditional activities, Qataris are simply are not involved in fishing, agriculture, or hunting activities for economic benefit. It is the non-Qatari population that is taking part in the economic aspect of traditional practices (World Bank, 2005).

Traditional activities such as hunting the desert hare with Siluki dogs and falconry require both access to the land and an availability of animal populations. As development continues and limits access to areas that were once used for traditional activities, there is increasing conflict between Qataris wanting to engage in traditional activities and other individuals, activities, or developments. Restoration and maintenance of the rangeland ecosystem, which could be accomplished in a relatively short period of time given favorable weather conditions, would provide the space and species for such activities to continue (Breulmann *et al.*, 2007). However, such measures would need to be instituted in a timely manner given the current rate of development. Winter camping is another traditional activity enjoyed by the local population and protected by the government. Appropriate management of winter camping and provision of facilities in areas of high use may be necessary to protect the fragile coastal environment and the species that inhabit it.

Sustainable Development

Sustainable development, as first thought of by the 1987 Bruntland Commission report, describes sustainable development as development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs." This can be thought of as economic and social development that does not threaten ecosystem services. However, in order to develop sustainably, a country must have some way to "measure" its development.

Qatar is currently in the process of developing a manageable system of sustainable development indicators for the country including social, economic, and environmental indicators (Planning Council, 2006). These indicators are based on data collected between 2000 and 2005, and show clear trends in social, economic, and environmental areas. Social indicators include a measure of social services that impact the standard of living of the population, such as the provision of health care services and education. Economic indicators include aspects of basic economic structures,

such as macroeconomic performance, measure of gender equality, and consumption (waste production). Environmental indicators include measurement of air quality, land degradation, water quantity and quality, and biodiversity. The trends witnessed in these indicators are varied. For example, between the years 2000 and 2005, fertilizer use remained about the same and pesticide use decreased slightly. However, the fish catch almost doubled while protected areas have increased dramatically.

International sustainable development indicators are used in many countries as well as by international organizations to help guide sustainable development practices. The 2005 Environmental Stability Index allows for cross-national comparison of environmental progress and is a measure of overall progress toward environmental sustainability for the 142 countries involved (ESI, 2005). The scores are based on a core of 20 indicators, which may include 2-8 variables, for a total of 68 possible variables. However, Qatar has only 37 data points of the required minimum of 45. Of the total 238 countries initially analyzed, Qatar was one of only eighteen countries that fell into this data deficient category.

The development of sustainable development indicators is an important step in the development of Qatar. These indicators allow decision-makers to measure the progress of the country with regards to what they view as the most important factors in the development of the country. Stating clear goals to be attained would provide incentives for individuals, businesses, and decision-makers.

What Limits Conservation Efforts in Qatar?

In order for conservation programs to be successful, they must be based on sound scientific knowledge such as distribution, occurrence, ecological functions, and their local and international importance. This includes knowing which species are present, what their population numbers are and how they are changing, what the threats are to the species, and what the habitat requirements are. Many well-intentioned conservation efforts have failed due to a lack of understanding of the needs of and the threats to the species. There must also be a willingness to participate in conservation measures at the cost of other activities.

The status and trends of endangered plants and animals is monitored by the IUCN, World Conservation Union. The IUCN publishes the Red List outlining the species, the status of the species (near threatened, threatened, vulnerable, endangered, and critically endangered), and the population trend. As of 2004, Qatar had 33 species listed on the Red List. However, this is likely to be a gross underestimate because data are simply lacking for Qatar. The distribution, occurrence, and local importance of many species are unknown. If the species listed in Kuwait, Bahrain, and the United Arab Emirates, which are likely to occur in Qatar, were included, then the number of Red List species would increase to 67. Some of the species that are not listed for Qatar but that are listed for neighboring countries are certainly present in Qatar. One example is the whale shark (*Rhincodon typus*). In addition, those species that are listed often fall into the category of data deficient, status unknown, or data out of date. For example, in Qatar, the population information for the critically endangered hawksbill turtle is "out of date," for the vulnerable dugong population the information is "unknown," and for the black finless porpoise there is "no data" (www.iucnredlist.org). These are just a few of many examples. Finally, there are likely to be many

species that have yet to be discovered. If an amateur group of naturalists on a field trip can discover a new species unknown to science (Macdonald, 2007), imagine what might be discovered if there were comprehensive, professional surveys conducted.

The scientific process ultimately depends on a strong foundation of knowledge to which scientists continually contribute. Science builds on previous scientific studies in a cumulative process. Over the last thirty years there has been research on the fauna of Arabia, but only a small portion of animals present have been officially recorded. The basic research necessary for sustainable use and conservation programs is simply lacking. Conservation and sustainable use and development programs ultimately depend on a comprehensive scientific understanding of the species, its habitat requirements, and the habitat itself (Brook, Al Shoukri, Amer, Boer, and Krupp, 2006). Here in Qatar, there is a dearth of information about the natural environment. This can be confirmed by a search of the scientific literature concerning Qatar. A search on a common science search engine (www.sciencedirect.com) returned 215 article hits for Qatar, compared to 263 for Bahrain, 557 for the UAE, 791 for Oman, and 1,123 for Kuwait. This may be one indication of the lack of scientific research concerning Qatar.

If Qatar is pursuing a science based decision-making process, then the amount of scientific work directly addressing Qatar will need to increase. Many of the studies that have been done have been performed by industry or individual research centers. The final product, the reports which contain the precious data, has not been included as part of the internationally accessible scientific literature. As a result, new studies must start from the very basics in order to build the public foundational knowledge necessary for conservation. At the least, publicizing hard to access studies and reports that have been done and making them openly available to scientists, using a resource such as the internet, would be a tremendous step forward for conservation in Qatar. This would require collaborative work between universities, government bodies, NGOs, and industry. Such an effort, lead by government, combined with multi-year comprehensive studies to document the species present, their distribution, and abundance would be another step towards a scientifically sound and successful conservation strategy in Qatar.

An accessible base of ecosystem knowledge about Qatar, that is made available for decision-makers, can significantly improve conservation efforts by the leadership. In order to properly manage and protect the environment, a thorough understanding of the conditions and needs of the species is necessary. However, this information must be in a format that can be easily used by decision-makers. Recent publications such as the Millennium Ecosystem Assessment (MEA, 2005) and the Intergovernmental Panel on Climate Change (IPCC, 2007) were designed specifically with the lawmaker in mind in order to facilitate the decision-making process. Without a well-designed guideline for decision-makers, it is important that development activities occur with the advice and cooperation of local research centers (Yasseen and Al-Thani, 2007). Research centers have been largely underutilized in their capacity to help make informed choices concerning planning as development proceeds.

Conclusion

Conservation of species and maintaining a healthy ecosystem has global as well as local benefits. The State of Qatar play a role in the protection of some of the world's

most critically endangered species, and supports many uniquely adapted organisms, some of which may still be unknown to science. However, these species and the habitats that support them are at risk from current developments. Coastal development is particularly damaging to marine species and may threaten commercial fishing. This, combined with other factors such as desertification and soil salination due to water over-exploitation, demands a response. While the State of Qatar has moved quickly to ratify international conventions and to establish regulatory and managerial bodies, the implementation has been slow. This is in part due to a lack of trained labor and a dearth of scientific expertise in the country. Yet, development of industrial and residential areas continues unabated. Therefore, the development of an effective conservation program that is strictly implemented lags behind industrial and economic development. Much of the environmentally related work has been supported or lead by industry. A concerted effort lead by the government, combining financial and scientific support, and a multi-year comprehensive terrestrial and marine survey, could greatly strengthen conservation efforts. Only then will we know what Qatar has to conserve, before it is too late.

Postscript

November 2009

Since the original publication of "Conservation in Qatar: Impacts of Increasing Industrialization" in early 2008, Qatar has witnessed a variety of changes which will undoubtedly affect the path of development and further industrialization in Qatar. Many of the changes include policy developments and the promotion of the ideals of sustainable development within government agencies. Some of those changes have taken place within the structure of government itself. The body overseeing management of the environmental and natural resources in Qatar, the Supreme Council for the Environment and Natural Resources, no longer exists as described in the paper and has now become the Ministry of Environment. The elevation of environmental management issues to that of a Ministry may prove to be beneficial, allowing a greater profile for appropriate environmental management and protection.

Increasingly, sustainable development has become the focus of long-term development and industrialization programs in Qatar. The Qatar National Vision 2030 (QNV 2030, General Secretariat for Development Planning), published in July 2008, outlines the strategic vision for the development of Qatar over the next twenty years. Combining the aspirations of the Qatari people with a long-term development framework, QNV 2030 broadly guides the future development path for Qatar. The QNV 2030 is based on four supporting themes: human development, social development, economic development, and environmental development. This vision, like many others, delicately incorporates continued economic development while maintaining a strong sense of traditional culture and protection of the environment. However, like all countries, the challenge is in the implementation of the vision. How can Qatar continue to grow economically and yet maintain strong cultural ties and traditions while protecting the environment?

The strategy for pursuing sustainable development has been the theme of Qatar's second human development report *Advancing Sustainable Development*, which was published in July 2009 (General Secretariat for Development Planning). Together, these suggest that long-term environmental protection is a major goal of Qatar, and one that is as equally important as economic, human, and social development. The tools necessary to pursue this development path are also being developed and utilized in Qatar. For example, the Qatar Sustainability Assessment System (July 2009) provides a rating system (i.e. a quantifiable system) for assessing aspects of sustainability for the built environment in Qatar. Whether or not this improves on other rating systems such as LEED (Leadership in Energy and Environmental Design) and results in a measurable change in building practices, is yet to be assessed.

Despite these visible advancements in government structures and policies, there are fewer obvious developments in land conservation, preservation areas, and species protection. Opportunities for land and species protection have yet to be fully exploited. The Al Reem biosphere reserve, designated in 2005, comprises just over 10% of the country area. In 2008, basic ecological data concerning vegetation and anthropogenic impacts in the reserve was collected (Abdul-Majid, 2008). However, full development of the reserve to support education as well as protection of species and habitats as originally envisioned, is yet to be implemented. Activities currently within the Al-Reem

reserve include agriculture; grazing of camels, sheep, and goats; artisanal fishing; and petroleum industry activities and impacts. In addition, there are currently seventy-four private farms within the reserve (Abdul-Majid, 2008). There are obvious challenges for an effective reserve area where such dominant anthropogenic activities occur. In addition, Khor Al-Udaid (also known as the Inland Sea) in the southeast of the country is geologically unique. The area supports an uncommon assemblage of cyanobacteria, archaea, and other microbial life that has yet to be accurately studied. Despite the ecological and geological riches of this region, the site has yet to be nominated as a UNESCO World Heritage Site.

The State of Qatar is taking great strides in promoting sustainable development and pursuing long-term policy in this regard. In order for this pursuit to be successful, economic development must take place within the context of social and environmental development. This would require a strictly coordinated program involving all aspects of urban development, such as transportation and the built environment, with further industrialization as well as giving full consideration to land and species preservation. For many, this goal may seem to be limiting development in Qatar. However, development need not be limited, only targeted. Because of its size, resource strength, and resolute leadership, Qatar is in the position to lead the world in novel industrial development and sustainable design.

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