



ADVANCING SUSTAINABLE DEVELOPMENT

QATAR NATIONAL VISION 2030

SECOND NATIONAL HUMAN DEVELOPMENT REPORT



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QATAR'S SECOND HUMAN DEVELOPMENT REPORT

**GENERAL SECRETARIAT FOR DEVELOPMENT PLANNING
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Foreword

The *Qatar National Vision 2030* (QNV 2030), launched in October 2008 by His Highness Sheikh Tamim bin Hamad Al Thani, Heir Apparent, defines long-term development outcomes for Qatar, and provides a framework within which national development strategies and implementation plans can be prepared. The QNV 2030 is based on the Guiding Principles of Qatar's Permanent Constitution and is underpinned by four interrelated pillars:

- *Human Development*: development that expands the opportunities and capabilities of all the people of Qatar to enable them to sustain a prosperous society;
- *Social Development*: development of a just and caring society based on high moral standards and supportive social policies, and where Qatar plays a significant role in the global partnership for development;
- *Economic Development*: development of a competitive and diversified economy capable of meeting the needs of, and securing a high standard of living for, all its people both for the present and for the future; and
- *Environmental Development*: management of the environment such that there is harmony between economic growth, social development and environmental protection – the three dimensions of sustainable development.

Each of these Pillars has clearly defined long-term outcomes with important interlinkages. To achieve these outcomes and remain true to its values, Qatar has committed to balance five critical challenges: (i) modernization and preservation of traditions; (ii) the needs of this generation and the needs of future generations; (iii) managed growth and uncontrolled expansion; (iv) the size and quality of the expatriate labour force and the selected path of development; and (v) economic growth, social development and environmental management.

Qatar has, and continues to make, conspicuous progress in improving human development – moving from 57th to 34th out of 179 countries in the United Nations Development Programme's (UNDP) *Human Development Index* between 1997 and 2006 (as reported in 2008).

Human and economic development and the protection of the environment are competing demands that must be reconciled with each other. Exceptionally high economic growth, too rapid urban development and high population growth can have an adverse impact on sustainable development. In order to minimise risks, Qatar has adopted several initiatives to protect its natural environment, including projects to monitor air and water quality, reduce carbon emissions and maintain biological diversity.

Nevertheless, Qatar is facing major environmental challenges that need to be appropriately resolved, particularly achieving water security, reducing carbon emissions and increasing energy efficiency, and mitigating risks that threaten the safety of the marine environment. Assessing the severity of risks and dealing with anticipated changes will require mobilizing resources, coordinating efforts and putting appropriate policy and regulatory frameworks in place.

As part of GSDP's efforts to support the achievement of the QNV 2030, and cognizant of the growing national and international imperative to address environmental challenges, in June 2008 GSDP decided to begin the preparations of Qatar's Second Human Development Report (HDR), *Advancing Sustainable Development*, focusing on sustainable development themes. Qatar's first HDR, *The State of Qatar 2006*, reviewed the various dimensions of human development.

This 2009 HDR identifies issues and challenges related to three critical environmental stress points for Qatar, namely, (i) water security; (ii) threats to the marine environment; and (iii) the effects of climate change. If left unattended, these concerns have the potential to halt or reverse the significant development progress that the nation has achieved thus far. Maintaining progress, especially in the midst of the current severe global and financial crisis, necessitates addressing these sustainable development challenges. The 2009 HDR thus concludes with a set of recommendations that will help overcome the challenges. These recommendations will be carefully reviewed by key stakeholders, and following refinement, will serve as inputs to preparing Qatar's first *National Development Strategy 2010 - 2015*.

Qatar's efforts in protecting the environment will not be sufficient on their own. Qatar is a part of the Gulf region, which constitutes an ecological system that is affected by the practices and activities of every country in the region. Thus, Qatar is playing and will continue to play a proactive and significant regional and international role in efforts to promote sustainable development.

Qatar's second HDR was prepared in strong partnership with relevant ministries and government agencies, the private sector, civil society and the UNDP Abu Dhabi office. It has benefited from the guidance of a multi-stakeholder National Steering Committee. It is based on several background papers commissioned by GSDP and the outcome of a national seminar, 'Towards Achieving the Environmental Outcomes of the QNV 2030', which was held on 27 January 2009.

In conclusion, I would like to sincerely thank Sheikh Hamad bin Jabor bin Jassim Al-Thani, Director General, GSDP, Chair of the National Steering Committee, for his leadership and professionalism in preparing this HDR. I would also like to thank all members of the HDR Project Report Team (listed on page v) for their tremendous efforts, commitment and professionalism in putting this publication together, as well as those persons who contributed background papers. Special appreciation is extended to members of the National Steering Committee and UNDP for providing helpful comments on an earlier draft of this Report. I am sure that the analysis and recommendations that it contains will prove to be useful in the context of the preparations of Qatar's first *National Development Strategy*, as well as to policy makers and planners outside of Qatar interested in promoting sustainable development.



Ibrahim Ibrahim

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Acronyms and Abbreviations

°C	Degrees Celsius
AWARENET	Arab Integrated Water Resource Management Network
AWC	Arab Water Council
BOD	Biochemical Oxygen Demand in Water Bodies
CBD	Convention on Biological Diversity
CCS	Carbon Capture and Storage
CDIAC	Carbon Dioxide Information Analysis Center
CO ₂	Carbon dioxide
CDM	Clean Development Mechanism
CSA	Continental Shelf Associates
DAWR	Department of Agricultural and Water Research
EIA	Environmental Impact Assessment
EIT	Economies in Transition
EMRQ	ExxonMobil Research Qatar
ET	Emissions Trading
FAO	Food and Agriculture Organisation
GCC	Gulf Cooperation Council
GDP	Gross domestic product
GGFR	Global Gas Flaring Reduction Partnership
GHG	Greenhouse gas(es)
GSDP	General Secretariat for Development Planning
GtCO ₂	Gigatonnes to CO ₂
GTL	Gas to liquids
HDI	Human Development Index
HDR	Human Development Report
ICZM	Integrated Coastal Zone Management
IMSP	Integrated Maritime Spatial Planning
IWRM	Integrated Water Resource Management
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
ka BP	Thousand years before present
km ²	Square kilometres
LNG	Liquefied Natural Gas
m	Metres
m ³	Cubic metres
MDGs	Millennium Development Goals
mg/L	Milligrams per litre
MoE	Ministry of Environment, Qatar (formerly SCENR)
MSF	Multi-stage Flash
NCCC	National Committee for Climate Change, Qatar
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of the Petroleum Exporting Countries
ppb	Parts-per-billion
PEPC	Permanent Environment Protection Committee, Qatar
ppm	Parts-per-million
ppt	Parts-per-thousand
PWRC	Permanent Water Resources Committee

Qatargas	Qatargas Operating Company Limited
QF	Qatar Foundation
QNRF	Qatar National Research Fund
QNV 2030	Qatar National Vision 2030
QP	Qatar Petroleum
QSA	Qatar Statistics Authority
QSTP	Qatar Science and Technology Park
R&D	Research and Development
ROPME	Regional Organisation for the Protection of Marine Environment
SCENR	Supreme Council for the Environment and Natural Resources (now MoE)
UAE	United Arab Emirates
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UN ESCWA	United Nations Economic and Social Commission for Western Asia
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Cultural and Scientific Organisation
UNESCO-WWAP	UNESCO-World Water Assessment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WCED	World Commission on Environment and Development
WGP-AS	UNDP Water Governance Programme for Arab States
WRI	World Resources Institute

Overview

Qatar has experienced a remarkable social and economic transformation within a period of less than a generation. By capitalising on its rich natural resource base, the nation has achieved spectacular gains in income while avoiding rising income inequality. All health outcome indicators have improved markedly and basic schooling of Qataris is now universal.

Qatar's long-term development outcomes, as articulated in the *Qatar National Vision 2030* (QNV 2030), are built on the principles of sustainable development. Emphasis is placed on sustaining a careful balance between the interests of the current generation and the interests of future generations.

The country's huge economic advances provide a solid foundation from which to launch its long-term vision. But Qatar's exceptionally rapid development has a potential downside: an adverse impact on the environment that could undermine sustainable development. At risk are the aims of achieving water security, preserving and protecting the marine environment, reducing long-term impacts of climate change (mitigation), and adjusting to the expected consequences of climate change (adaptation). Qatar's second Human Development Report (HDR) focuses on these sustainable development challenges. It identifies critical environmental parameters, and concludes with several policy and management recommendations for *Advancing Sustainable Development*.

Sustainable Development: Ensuring Intergenerational Fairness

At the heart of sustainable development is the need to ensure intergenerational fairness. This requires judicious use of Qatar's non-renewable resources so as to ensure opportunities for future generations to enjoy new sources of prosperity. For this to be achieved, returns from the current use of non-renewable resources need to be further channeled into both physical and human capital formation.

Sustainable development is the need to ensure intergenerational fairness, requiring judicious use of Qatar's non-renewable resources

Qatar is developing at an unprecedented speed. Its rapid spatial development, natural resource use and exceptionally high population growth are posing major environmental challenges. In order to ensure that future generations of Qataris can sustain the opportunities enjoyed by current generations, economic development and protection of the environment must be balanced.

The achievement of intergenerational equity with high human development necessitates that Qatar improves its environmental management, and promotes sustainable production and consumption of its natural resources. This entails building institutional and human resource capacities and addressing knowledge and data gaps. It also calls for the use of monitorable indicators of sustainable development for evidence-based policy-making. The nation has already taken some steps towards meeting these challenges. They will also be taken into account in Qatar's first National Development Strategy 2010-2015.

Water Security: Sustaining A Basic Necessity

Water security is a basic human right. Delivering clean water and providing safe sanitation are fundamental for human progress. In many countries, water stress is rising due to overuse and competing demands from population growth, industrialisation, urbanisation and agriculture.

Water stress is rising due to rapidly growing demands from population growth, industrialisation, urbanisation and agriculture

Nevertheless, many of the vulnerabilities related to water insecurity can be overcome through better water resource management. More efficient use of water through behavioural change and investment in technologies could dramatically expand available resources. And an integrated approach to water governance could lead to a more efficient allocation of water resources across multiple sectors.

Qatar is water resource-poor, and water resources are under significant stress because of the country's rapid development and exceptionally high population growth – itself mainly due to large inflows of expatriate labour. Qatar needs to consider the extent to which it can sustain such a rapidly growing expatriate population with all the implications it has on water consumption. The nation faces many challenges in ensuring an adequate supply of water to meet increasing consumer demand. These include dependence on desalinated water, the long lead time required to scale-up production of desalinated water and limited water storage capacity.

Qatar's water security can be improved through better management of water resources. A major challenge is to encourage a participatory management approach that is capable of prioritising among competing demands, utilising appropriate technologies, and regulating and expending the available supply to meet justified demand. A well thought-out water resources management strategy and a water development master plan would help meet this challenge.

In general, under-pricing or zero-pricing practices sustain overuse and do not reflect the scarcity value of water. They potentially compromise intergenerational equity. Water pricing needs to reflect the true value of water so that governments do not end up subsidising the depletion of an essential natural resource.

Marine Environment: Protecting and Preserving Ecosystems

Marine ecosystems are among the most productive in the world and function as a major source of nutritious food, as areas of recreation and tourism, as a medium for transportation, as a repository of biodiversity and as sinks for wastes. Most marine pollution emanates from land-based activities and impacts negatively on the most productive areas of the marine environment. The productive capacity of coastal waters is also threatened by the reclamation and physical modification of the inshore environment through the destruction of aquatic habitats.

Besides being a natural source of food, water and wealth, Qatar's marine environment provides a unique habitat for its diverse marine life. In recent years, a number of alarming incidents have been recorded in Qatar's waters such as, *inter alia*, the mortality of certain marine life, the destruction and bleaching of corals, the increased erosion of shores and associated habitats and increased coastal flooding. The encroachment of human activities is threatening the health, productivity and biodiversity of the country's marine environments.

Policy decisions therefore need to address the trade-offs between economic activities, such as oil and gas industries, water and energy production, construction, recreation and fisheries, and the impact that these activities have on marine environments. A national marine policy, with strong institutional backing, is required to ensure the sustainable use and conservation of marine resources. Such a policy should be based on solid research and reliable data. Active engagement of civil society is crucial to enlist public support for Qatar's environmental protection and conservation measures. This in turn will help to leverage the private sector to focus on their corporate social responsibilities and ensure that their commercially driven actions are not detrimental to Qatari society.

The encroachment of human activities is threatening the health, productivity and biodiversity of marine environments

Climate Change: Reducing the Carbon Footprint

Climate change has been identified as the most pressing global environmental problem with potentially catastrophic consequences for human development. Addressing climate change is not only a cross-border phenomenon, but also a cross-generational challenge. Because climate change is a long-term problem with cumulative outcomes, mitigation measures implemented today, no matter how stringent, may not appear beneficial within the lifetime of the present generation. Action must instead be taken on the basis of the longer-term interests of ensuring intergenerational justice.

Qatar, with its large hydrocarbon industries, is vulnerable to climate change impacts. The nation's total carbon emissions from fossil fuels have recorded a substantial increase over the last two decades. Without direct action to ameliorate the rising trend in emissions, Qatar's carbon footprint can be expected to expand over the next decade, with potential long-term negative consequences for human development.

Climate change is a pressing global environmental problem with potentially catastrophic consequences for human development

Mitigating climate change in Qatar requires well-coordinated global, regional and local action to reduce causal factors such as greenhouse gas emissions. Adaptation to the consequences of climate change is complex and needs to be addressed at all levels. Qatar's abundant oil and gas reserves offer a window of opportunity to make the transition to a post-carbon economy, to help develop and exploit environmentally friendly and energy efficient technologies, and to invest in sustainable development. Changes in global markets will open up new opportunities for Qatar to take a leadership role in emerging fields such as emission-reduction approaches, energy-efficient technologies, green buildings and financing of low carbon activities.

Advancing Sustainable Development: Towards a New Horizon

With environmental concerns attracting global attention and people growing more worried about pollution, climate change and depletion of resources, a critical challenge for Qatar is to combine economic progress with sustainable environmental policies. This approach will not only support sound national economic policies but also enhance the quality of life for all Qataris for generations to come.

A critical challenge is to combine economic progress with sustainable environmental policies

A sound environmental management framework in Qatar is essential for building a modern state as well as for laying the foundation for a sustainable environment. Qatar needs to develop an integrated set of sustainable development indicators to provide reliable information for evidence-based decision-making.

Policy options and institutional reforms should identify links between national, regional and global concerns. Qatar's efforts to protect the environment will not be sufficient on their own. Many problems faced by Qatar also confront other countries. Regional and international alliances should be continued and expanded. Qatar has the capacity and resources to take a leadership role in spearheading best practices in sustainable development.

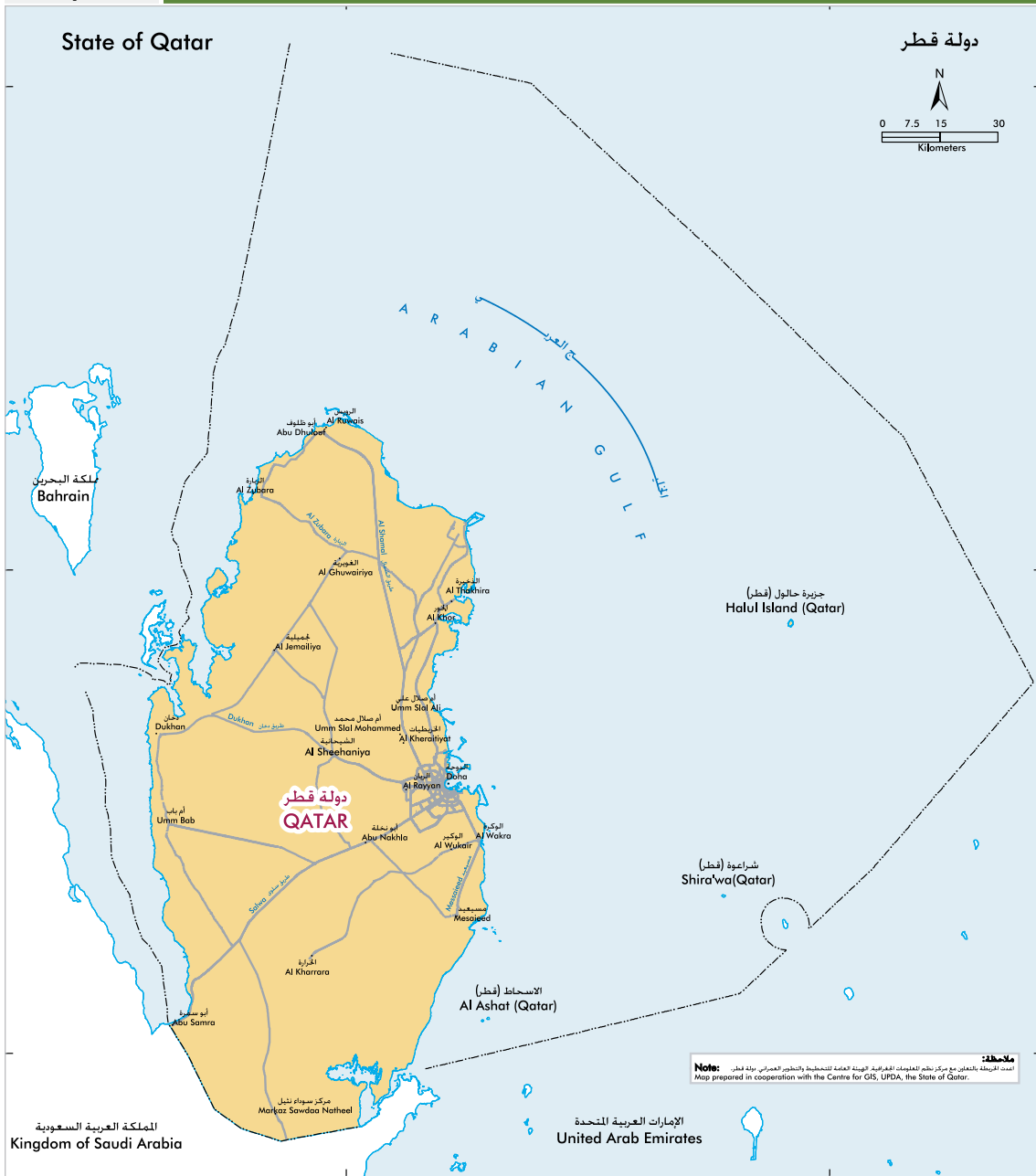
This 2009 HDR makes key recommendations that include the need to:

- Ensure an integrated and comprehensive policy framework for sustainable development;
- Strengthen the institutional framework for sustainable development;
- Develop credible and reliable data and information for evidence-based decision-making;
- Build national capacity for developing, implementing, monitoring and evaluating environment-related policies and programmes; and
- Promote effective participation and national ownership.

Taken together, they provide a considered view of how Qatar can *Advance Sustainable Development*.

Sustainable Development
Economic Growth,
Social Development and
Environmental Management

Map 1.1 State of Qatar



Source: QSA, 2008

Sustainable Development

Economic Growth, Social Development and Environmental Management

Sustainable development is a process that seeks to meet the needs of the present generation without compromising the ability of future generations to meet their needs. This is often called intergenerational justice. The rights of future generations would be threatened if the depletion of non-renewable resources were not compensated by the creation of new sources of wealth... Qatar National Vision will choose the development path that carefully balances the interests of the current generation with the interests of the future generations.

GSDP, 2008

The Qatar National Vision 2030 (QNV 2030) foresees a vibrant and prosperous future with economic and social justice for all, and where nature and humanity are in harmony with the principles of sustainable development. The QNV 2030 commits to maintaining harmony between economic growth, social development and environmental management in building a bright future for the people of Qatar. It identifies the goal of the environmental pillar, one of four interrelated pillars, as an increasingly important challenge (Box 1.1). It recognises that while there are environmental costs to be paid for economic progress, economic development and protection of the environment are two demands neither of which should be sacrificed for the sake of the other. Qatar's future development path must be compatible with the requirements of protecting and conserving the environment.

The QNV 2030 commits to maintaining harmony between economic growth, social development and environmental management in building a bright future for the people of Qatar

In line with this, Qatar's second Human Development Report focuses on the theme of sustainable development. This Report identifies key issues and challenges that need to be overcome to meet the environmental development outcomes specified in the QNV 2030 and in *Advancing Sustainable Development*. In particular, it focuses on the themes of water security, marine environment, and climate change, and their interactions and implications for human development in Qatar.

There are, of course, other environmental concerns that Qatar is facing. For example, although rapid urbanisation and urban development are contributing positively to more modern lifestyles for an increasingly affluent Qatari society, they are being accompanied by, *inter alia*, pressures on social services, traffic congestion and air pollution, as well as increasing volumes of waste disposal. While these issues merit serious reflection, for a variety of reasons, they are not considered here. They will, however, be reviewed and assessed during the preparation of Qatar's first National Development Strategy, 2010-2015.



Human Development

Development that expands the opportunities and capabilities of all the people of Qatar to enable them to sustain a prosperous society



Social Development

Development of a just and caring society based on high moral standards, and capable of playing a significant role in the global partnership for development



Economic Development

Development of a competitive and diversified economy capable of meeting the needs of, and securing a high standard of living for, all its people for the present and for the future



Environmental Development

Management of the environment such that there is harmony between economic growth, social development and environmental protection

The QNV 2030's environmental pillar will be increasingly important as Qatar is forced to deal with local environmental issues, such as the impact of diminishing water and hydrocarbon resources, and the effects of pollution and environmental degradation, as well as international environmental issues such as the potential impact of global warming. Assessing the severity of risks and dealing with anticipated changes will require mobilizing capacities and coordinating efforts to tackle problems that arise.

To achieve a balance between development needs and protecting the environment, including air, land, water and biological diversity, the QNV 2030 foresees the following environmental outcomes:

- Preserving and protecting the environment, including air, land, water and biological diversity, through:
 - An environmentally aware population that values the preservation of the natural heritage of Qatar and its neighbouring states;
 - An agile and comprehensive legal system that protects all elements of the environment, responding quickly to challenges as they arise; and
 - Effective and sophisticated environmental institutions that build and strengthen public awareness about environmental protection, and encourage the use of environmentally sound technologies. These institutions will also conduct awareness-raising campaigns, employ environmental planning tools, and carry out environmental research.
- A comprehensive urban development plan for Qatar that adopts a sustainable policy with regard to urban expansion and population distribution.
- Encouragement of regional cooperation to put in place preventive measures to mitigate the negative environmental effects of pollution arising from development activities.
- A proactive and significant regional role in assessing the impact of climate change and mitigating its negative impacts, especially on countries of the Gulf.
- Support for international efforts to mitigate the effects of climate change.

Source: GSDP, 2008

Sustainable Development: Future Prospects and Present Lives

Sustainable development means different things to different people, but a widely accepted definition is: *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (WCED, 1987).

The idea of sustainable development is not new (Box 1.2). Over the course of human history, most cultures have adopted practices that enabled them to sustain their resources in order to meet their communities' present and future needs. What is new is an articulation of these ideas in the context of a globalised world. Sustainable development is taken to refer to three interdependent and mutually reinforcing pillars: economic growth, social equity and environmental protection.

Box 1.2 Tracing the History of Sustainable Development

"Sustainable development" - the reconciliation of society's developmental goals with its environmental limits over the long term - is a conceptual focus linking the collective aspirations of the world's peoples for peace, freedom, improved living conditions and a healthy environment. These four conditions frequently emerged as key ideals of the last half of the 20th century.

Many concepts now incorporated within the concept of sustainable development can be traced back to the 1980 World Conservation Strategy of the International Union for the Conservation of Nature and the 1972 United Nations (UN) Stockholm Conference on the Human Environment. Today's understanding of the links between environment and development stems from the UN-sponsored Brundtland Commission report, *Our Common Future*. The idea of sustainable development was given additional impetus at the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro or 'Earth Summit' which issued a detailed Agenda 21 of desired actions, international agreements on climate change and biodiversity, and a statement of principles on forests. Ten years later, in 2002, the commitment to sustainable development was reaffirmed at the World Summit on Sustainable Development in Johannesburg, South Africa.

At the heart of sustainable development is an attempt to reconcile the real and potential conflicts between the economy and the environment and between the present and the future. Thus, the Brundtland Commission, in its widely accepted statement, defines sustainable development as the ability of humanity "to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."

Within this general framework, an extraordinarily diverse set of groups and institutions have taken the concept of sustainable development and projected upon it their own hopes and goals. From the reviews of these diverse concepts and definitions, four key differences emerge. While sharing a common concern for the fate of the earth, proponents of sustainable development differ in their emphases on (i) what is to be sustained, (ii) what is to be developed, (iii) the types of links that should hold between the entities to be sustained and the entities to be developed, and (iv) the extent of the future envisioned.

Source: Derived from Kates et. al., 2005

Economic Growth

Markets do not adequately price or provide a wide range of environmental goods and services. Indeed, there are many kinds of environmental goods and services that markets do not provide at all.

For example, while markets in carbon are now developing, they do not stretch into the distant future. Carbon futures are now traded X years ahead, but not at longer horizons. The reasons for these “market failures” are manifold and include: an absence of property rights; problems of “non-excludability” and “non rivalry” that diminish willingness to pay; information failures and uncertainty and technical difficulties in pricing and trading environmental goods. This combination of factors provides a rationale for government action that aims to better match outcomes with society’s preferences about the natural environment. Governments may also feel obligated to act if they consider that the preferences of the current generation risk injustice for future generations.

Dealing with these issues is far from easy. Even if information was complete and would allow for the identification of an “optimal” strategy, there would still remain distributional concerns both within and between generations. Ultimately there is no scientific resolution of what “economic sustainability” might mean, only one that is based on moral judgments and principles.

One such principle, that is widely accepted, is that of intergenerational justice. Substitutability in production and consumption implies a general capacity to create well-being rather than preserve any particular resource. Preservation of the resource base does not imply, for example, that all exhaustible mineral and fossil fuel resources must be conserved, but rather the replacement of non-renewable resources that have been utilised with something else that is renewable, whether physical or human (Anand and Sen, 2000). Proceeds from a shrinking asset should be reinvested so that the yield from these investments compensates for the dwindling resource.

Expanding opportunities and capabilities, including through health, education and the empowerment of women, provides the path for advancing sustainable development

Human development is a major contributor to the achievement of sustained economic growth. It is both a means and an outcome of it. Expanding opportunities and capabilities, including through health, education and the empowerment of women, provides the path for advancing sustainable development.

Social Equity

The ultimate goal of social development is to improve and enhance the quality of life of all people. It requires good governance, respect for human rights, fundamental freedoms and the rule of law, increased social and economic opportunities, gender equity, active involvement of civil society and the promotion of respect for cultural diversity. Empowerment and participation, including the active participation of women, are essential for human progress.

Promoting and sustaining social development requires an orientation of values, objectives and priorities towards the well-being of all, and the strengthening and promotion of supportive institutions and policies. The pursuit, promotion and protection of these values provide the legitimacy of all institutions and promote an environment in which human beings are at the centre of sustainable development.

Environmental Protection

Achieving environmental sustainability requires a mode of development which maintains a stable environment that predictably and reliably provides resources such as clean water, food, energy and clean air, and that protects people from floods, droughts and disease. The causes of environmental change are complex and interconnected and include direct as well as indirect factors that lead to deterioration of ecosystems (Box 1.3). The information in Box 1.3 is of special importance because several of the indirect drivers of environmental degradation described apply in the case of Qatar.

Box 1.3**Global Environmental Deterioration Driven by a Host of Complex and Synergistic Factors**

Human actions have affected the natural environment, resulting in rapidly diminishing forests and coral reefs, increased consumption of scarce water and energy resources, desertification, the spread of invasive alien species, loss of biodiversity, and global climate change. If left unmanaged, the environment will continue to deteriorate, impeding efforts to achieve the Millennium Development Goals (MDGs). The five most significant drivers of environmental deterioration are:

- *Land use change*, resulting from urbanisation, conversion to agriculture, road construction, and human habitation that impair the functioning of ecosystems;
- *Excessive exploitation of natural resources* reducing them below sustainable levels such as over fishing and the degrading of aquifers;
- *Pollution* of air, soil, and marine environment that affect human health and damage natural ecosystems;
- *Waste*, especially industrial and hazardous waste generated by industry, and the lack of appropriate treatment facilities, resulting in pollution of soil and ground water and affecting human health;
- *Climate change* which is altering precipitation patterns, causing greater frequency of extreme weather events and raising sea levels; and
- *Incursions of invasive alien species* that choke out native species or reduce biodiversity.

Powerful indirect drivers of environmental deterioration include:

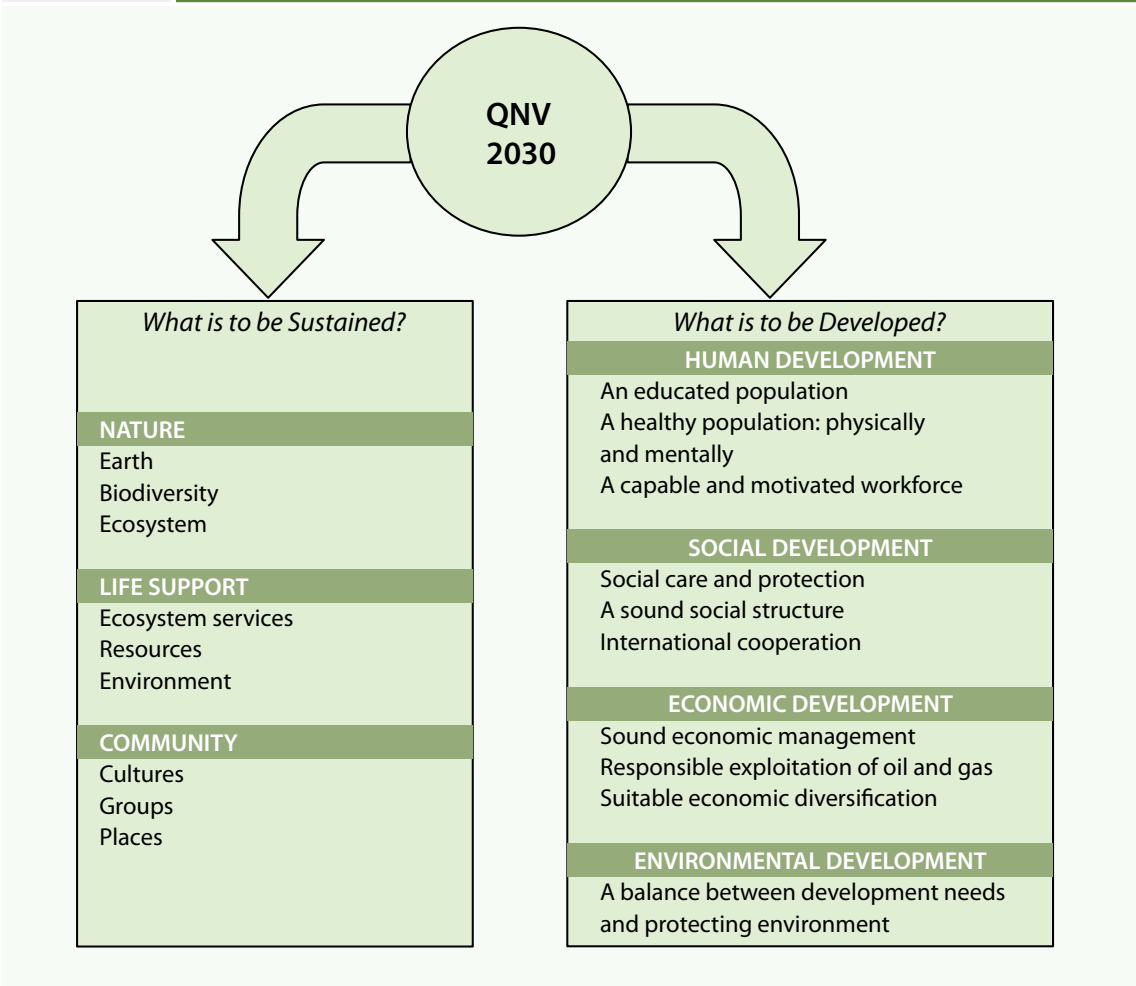
- *Demographic change* such as too rapid population growth, rural to urban migration and shifts in household economic status that tend to exert pressure on many elements in the environment;
- *Economic growth* which intensifies resource consumption, drives land use change, and generates waste – although rising incomes can also bring investments in environmental improvement and cleaner technologies;
- *Market failures and distortions* based on environmentally damaging subsidies that encourage overexploitation of natural assets such as water resources and fisheries;
- *Failure to account for resource depletion* which may result in a misleading picture of economic conditions;
- *Scientific and technological changes* that exert both positive and negative effects on environmental change: some new technologies can, for example, enable more effective pollution abatement, whereas other technologies may encourage overexploitation by increasing resource extraction efficiency;
- *Institutional gaps*, such as the malfunctioning or absence of political and regulatory institutions, leading to overexploitation of resources, and weak enforcement regimes that fail to deter damaging forms of extraction;
- *Insufficient participation* of key stakeholders in the planning and management of sustainable resource use which reduces the effectiveness of policies, their implementation and enforcement; and
- *Sociopolitical factors* arising from differences in culture and social behaviour which result in varying consumption and production patterns, and social change that produces unpredictable shifts in resource use.

Source: UN Millennium Project Task Force on Environmental Sustainability, 2005

Qatar's Human Development Progress

The goal of sustainable development is to try to ensure intergenerational fairness which requires a balance between sustainability into the future and ongoing development. This fundamental principle is incorporated in the QNV 2030. The aims are for non-renewable resources to be conserved, and renewable resources developed and substituted in the interests of the country, the region and the global community (Figure 1.1).

Figure 1.1 QNV 2030 Builds a Bridge Between the Present and the Future

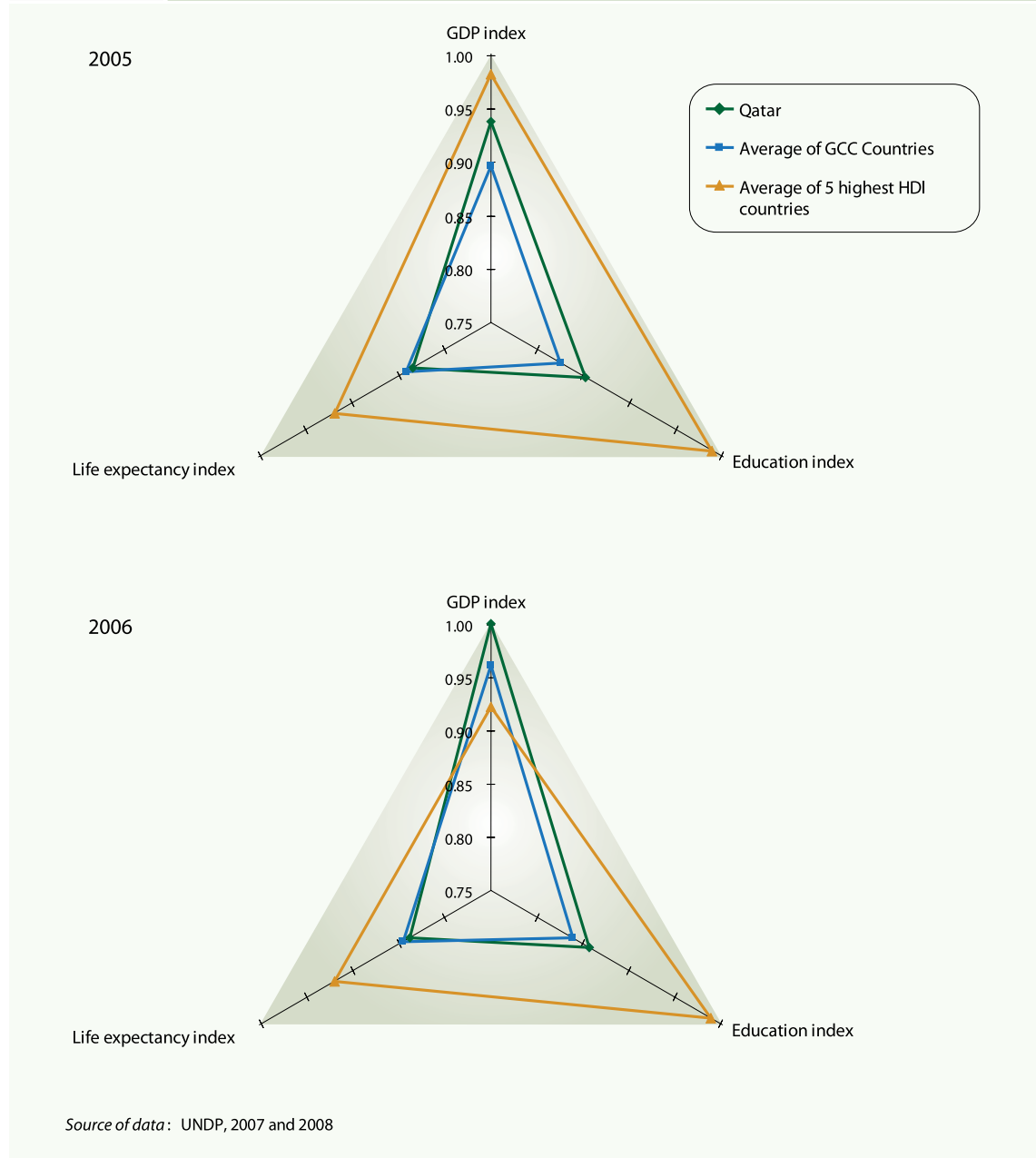


Qatar has undergone a remarkable social and economic transformation within a period of less than a generation, advancing to 34th out of 179 countries in the Human Development Index

Until the current global economic crisis, Qatar had been enjoying a period of unparalleled prosperity, with exceptional economic progress evident in the increasing standard of living of its people. As a result, Qatar has undergone a remarkable social and economic transformation within a period of less than a generation. By 2006, Qatar had advanced to 34th out of 179 countries in the Human Development Index (HDI), compared to a ranking of 57th a decade earlier (UNDP, 2008).

Qatar has achieved higher levels of performance in the gross domestic product (GDP) and education components of the HDI relative to the average of the Gulf Cooperation Council (GCC) countries, and is on par in terms of the health component (Figure 1.2). In 2006, the GDP Index for Qatar and the GCC Countries increased sharply, exceeding the average of the five highest HDI countries, due largely to the sharp increase in oil prices. Conversely, Qatar is lagging behind the five highest HDI countries, especially in terms of the education component as a result of relatively low enrolments in tertiary education. It follows that significant advances in Qatar's HDI ranking will require achieving higher post-secondary enrolments, particularly of boys, who have much lower enrolment rates than girls.

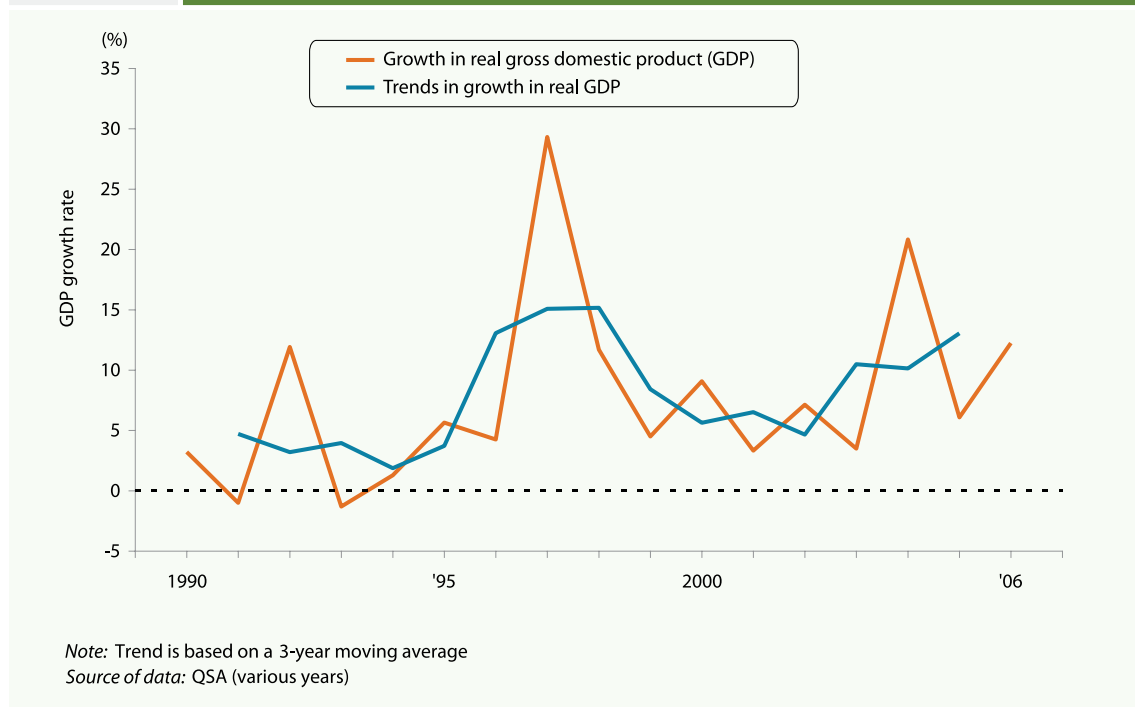
Figure 1.2 Qatar's Achievements in Income and Education Higher Than GCC Average



Progress in Qatar's human development has been made possible by the country's abundant hydrocarbon resources, especially its gas reserves, and by the wise use of the revenues from these resources. Rising oil and gas revenues, and accumulating surpluses, have been and continue to be used to fund a large and growing number of development projects in infrastructure, public utilities, health and education.

Qatar's real GDP has been growing at an impressive pace (Figure 1.3). Rising *per capita* incomes have not been accompanied by widening income inequalities. Among Qatari households, the Gini coefficient at 0.293 is relatively low and similar to that of the Scandinavian countries. Qatar has put in place an extensive social and welfare support system for its citizens.

Figure 1.3 Qatar's Economic Output Grew 8 Per Cent Annually With Fluctuations Around a Long-Term Trend



Qatar at a Crossroads

Sound management of Qatar's hydrocarbon resources will continue to secure improvements in standards of living. However, an improved standard of living cannot be the only goal of a society. As the QNV 2030 notes, Qatar must balance five major challenges:

- Modernization and preservation of traditions;
- The needs of this generation and the needs of future generations;
- Managed growth and uncontrolled expansion;
- The size and quality of the expatriate labour force and the selected path of development; and
- Economic growth, social development and environmental management.

While Qatar's considerable wealth creates previously undreamt of opportunities, the rights of its future generations could be threatened if the financial returns from hydrocarbon wealth are used inefficiently, delivering low returns, and/or overly aggressive economic development is beyond the carrying capacity of Qatar's economy and environment. A major risk for Qatar comes from falling oil and gas prices that

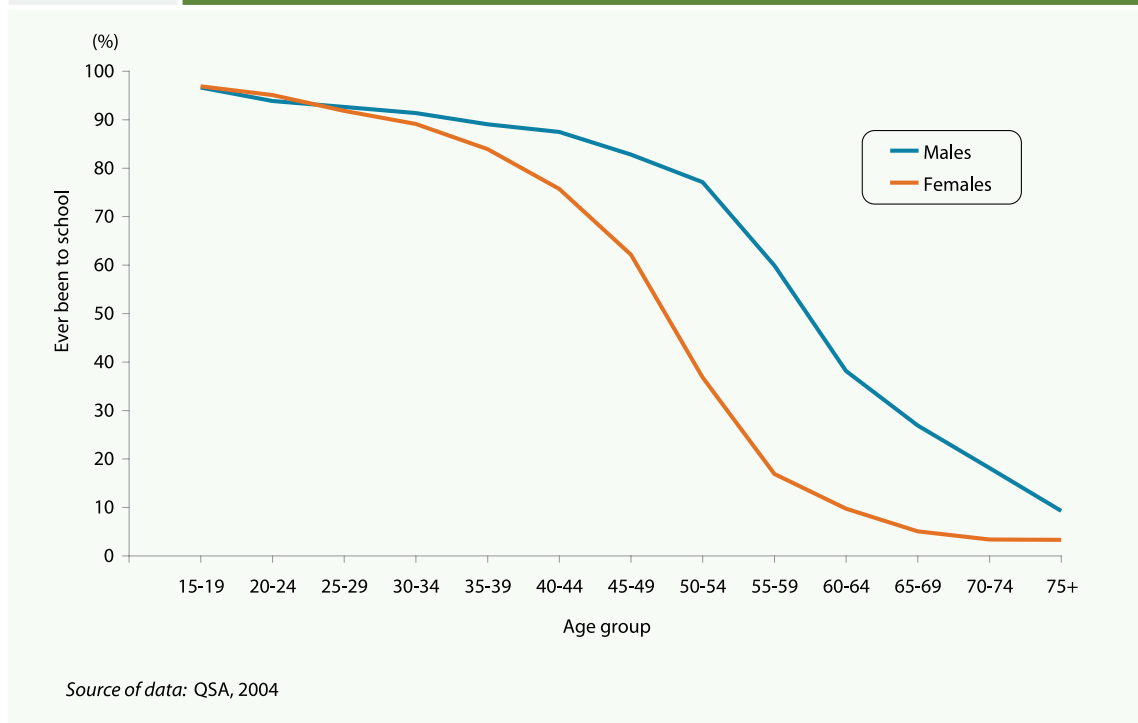
could reduce hydrocarbons and infrastructure investment plans, leading to lower economic growth. Future economic success will increasingly depend on the ability of the Qatari people to deal with a new international order that is knowledge-based and extremely competitive.

Qatar is engaged in a range of broad-based educational reforms aimed at increasing attainment levels, skills and lifelong learning. Educational policy combines a mix of strategies focusing on quality issues and expanding choice and access, including through the establishment of internationally renowned universities at its Education City. It is also attempting to strengthen links between education and training and the needs of the labour market.

Future economic success will depend on the country's ability to deal with a new international order that is knowledge-based and extremely competitive

Basic schooling of Qataris is now universal in marked contrast to the situation a generation ago (Figure 1.4). However, there is general acknowledgement that the quality of education is not yet up to international standards, with Qatari students, especially boys, markedly lagging in mathematics and science subjects (GSDP, 2009b). Further, whilst school enrollments have increased substantially at secondary level, there has been little change at the tertiary level, with relatively low male participation.

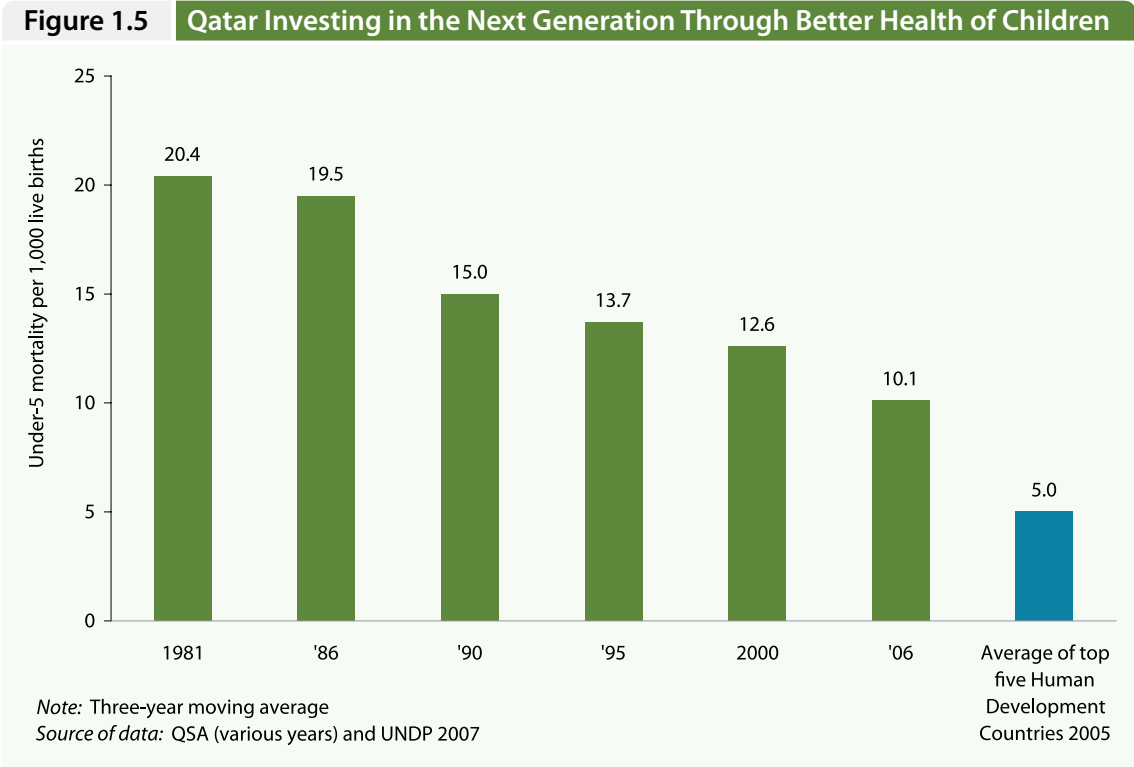
Figure 1.4 Increasing Human Capital: Over 90 Per Cent of Qataris Under 40 Years Have Been to School



At present, Qatar's labour force relies heavily on skilled and unskilled foreign workers. With the rapid expansion in development projects, especially in construction, by 2007, the ratio of Qataris to non-Qataris in the labour force was 1:12 compared to 1:6 in 2001 (GSDP, 2009a). Although there are increasing numbers of Qatari females with tertiary level education, Qatari female labour force participation is relatively low compared to more industrialised countries. This is a valuable source of

knowledge workers that needs to be tapped as Qatar moves towards becoming a knowledge-based or post-carbon economy.

Qatar is also investing heavily in expanding its health services to improve the quality of life of its citizens. All health outcome indicators have improved markedly in the past two decades and child mortality levels have halved compared with a generation ago. Many diseases have been eradicated and health coverage is now nationwide. However, lifestyle diseases such as obesity, high blood pressure, diabetes and heart disease are on the rise, putting a strain on health services. Similarly, the death and injury toll from road accidents is relatively high.

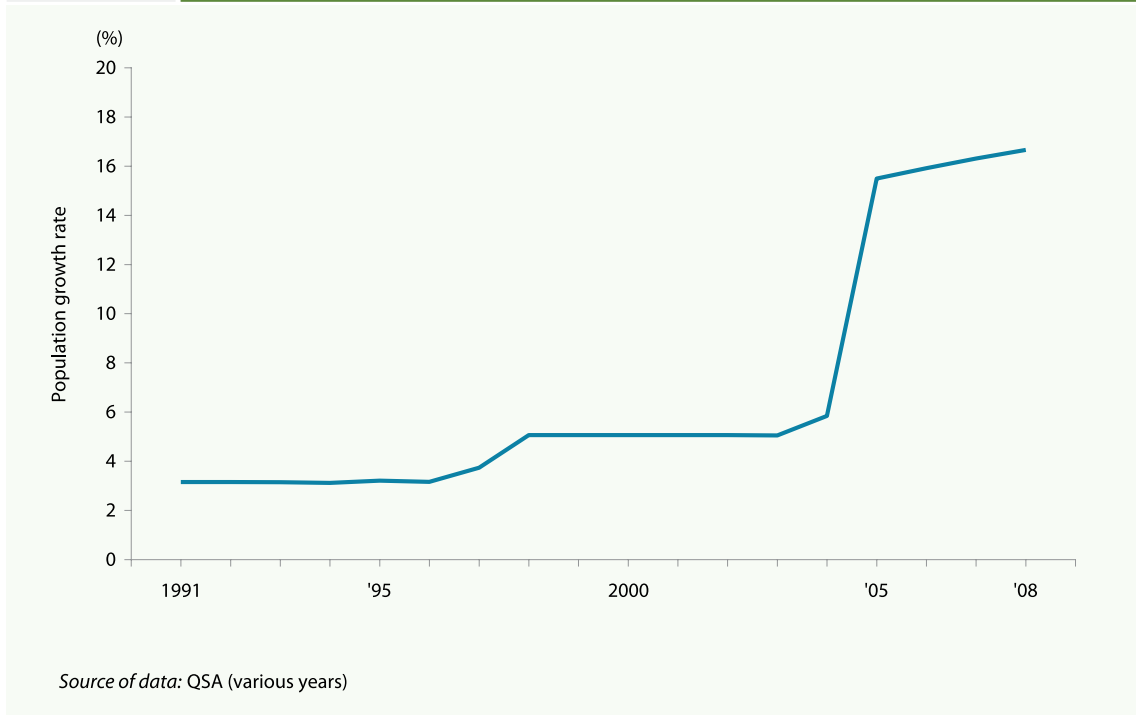


Qatar’s Environment at Risk

Increasing industrialisation and infrastructure development pose many challenges to Qatar’s environment. Environmental concerns relate, *inter alia*, to water consumption, marine and land degradation and carbon emissions. There are also concerns related to the country’s exceptional population growth that has accompanied its rapid industrialisation and development.

Qatar’s population grew from about 422,000 in 1990, to about 617,000 in 2000, and then reached 1.4 million in mid-2008 – more than tripling population size in just 18 years. Qatar’s exceptionally rapid population growth, averaging 16 per cent per year between 2005 and 2008, is virtually unprecedented historically and globally (Figure 1.6). Most of this growth is attributable to unskilled and semi-skilled labour migration from South Asia and Southeast Asia (notably Indians, Pakistanis, Bangladeshis, Nepalese, Filipinos and Indonesians) and other countries of the Middle East and North Africa. The major inflows of predominantly male expatriate workers is placing increasing demands on land for housing and recreation, energy and water, waste disposal and sewage treatment and on infrastructure and services.

Figure 1.6 Qatar's Population Grew Rapidly and Reached 1.4 Million By 2008



Extensive dredging and land reclamation, especially in Doha, has radically modified that section of the coastline. Intensive building activity is creating a new central business district in which more buildings are currently under construction than are operational, and unprecedented demand has already resulted in non-conventional water supplies (desalinated and treated wastewater) almost totally replacing conventional water supplies (from rainfall and groundwater) except for agriculture, which is rapidly depleting the remaining fossil water drawn from natural aquifers.

Achieving water security is a major challenge for water resource management in Qatar. Continued overexploitation of the fossil water reserves threatens the remaining reserves from saltwater intrusion, while overuse of ground water for agriculture is resulting in soil salinisation and desertification. There is heavy reliance on desalinated water whose production has grown markedly in recent years. Desalinated water is energy-intensive and costly, and efforts need to be taken to minimise its carbon emission and its threat to sensitive marine environments.

Qatar's total carbon emission from fossil fuels is on the rise. Combating carbon emissions is crucial for limiting the negative effects of climate change, which has the potential to stall and reverse human development in Qatar, and impact on other countries. There are five key transmission mechanisms by which this could take place: losses in agricultural production and food security; water stress and water insecurity; rising sea levels and exposure to climatic disasters; damage to ecosystems and biodiversity; and negative impacts on human health (UNDP 2007).

The challenges to the marine environment in Qatar include the global forces of climate change and the regional and local impacts of large-scale industrial development, sea transport and extraction of marine resources. It is also being threatened by the local effects of human activities such as coastal reclamation projects, the introduction of invasive species and overfishing. The degradation of Qatar's marine environment will have implications on food security, human health and sustainable livelihoods for the present and future generations.

Qatar is also suffering losses due to desertification including the loss of plant productivity, biodiversity and soil fertility. Improved access to freshwater has allowed the livestock population to increase dramatically. However, the move away from nomadic to a more sedentary lifestyle has also resulted in increased localised grazing pressure. Livestock grazing by camels, sheep and goats above the ecological carrying capacity has resulted in the reduction of many plant species, changing the shrubland to the current relatively barren landscape and contributing to the disappearance of native species such as oryx and gazelles.

Sustainable Development in Qatar: Taking on the Challenges

Achieving agreement on values, goals and actions to promote sustainable development is often difficult given the different interests of stakeholders. Environmental sustainability requires dramatic changes in the ways societies manage biodiversity and the processes of production and consumption. Direct investments in environmental management and structural changes are required at the national, regional, and global levels to address the underlying causes of environmental problems. Sustainability initiatives must ultimately be evaluated in terms of their impacts on patterns of environmental degradation and human development.

Environmental sustainability requires dramatic changes in the ways societies manage biodiversity and the processes of production and consumption

Qatar has been placing increasing emphasis on environmental conservation and protection since about 1981 when it established the Permanent Environment Protection Committee (Box 1.4). Qatar's Permanent Constitution stresses the importance of the conservation and protection of the environment in Article 33 which states that 'The State shall work to protect the environment and ecological balance so as to achieve sustainable development for the generations to come'. Notable institutional and legislative initiatives include the establishment of the Supreme Council for the Environment and Natural Reserves (SCENR) in 2000 followed by the Environment Law No. 30 in 2002, and the ratification of the executive regulations for this law in 2004. In 2008, the SCENR was upgraded to become the Ministry of Environment (MoE).

The increasing understanding and acceptance of the importance of environmental management for continued human progress has resulted in increased efforts to protect habitats and reduce biodiversity loss in Qatar. Qatar's National Biodiversity Strategy and Action Plan (NBSAP) was completed in October 2004 to promote the conservation of biodiversity, sustainable use of natural resources and equitable sharing of the benefits of biodiversity in Qatar. The NBSAP contains eleven strategic goals that identify the most pressing biodiversity issues in Qatar. Each goal is supported by an action plan that is composed of a series of proposed short term and long term activities that can be developed into practical projects. Each goal is also followed by monitoring indicators and responsible institutions.

Box 1.4 History of Environmental Management in Qatar

Environmental management in Qatar can be traced back to the establishment in 1981 of the Permanent Environment Protection Committee (PEPC). The main objective of PEPC was to provide a forum to discuss environment-related legislations and regulations. The PEPC has power to develop environmental policy, draft regulations and legislation, conduct environmental assessments and monitoring, approve development projects and raise public awareness on environmental issues.

In 2000, the PEPC was superseded by the establishment of the Supreme Council for Environment and Natural Reserves (SCENR). The SCENR was initially a department under the Ministry of Municipal Affairs and Agriculture before becoming an independent entity. Its responsibilities include:

- Develop and implement plans to protect the environment;
- Establish principles for determining impacts on the environment;
- Monitor and document pollution episodes;
- Develop and set-up emergency response plans;
- Implement measures to mitigate pollution impacts;
- Conduct studies on the effects of pollutants and ways of minimising these impacts;
- Evaluate and approve environmental impact assessment studies for government or private sector projects;
- Provide technical staff trained in the fields of environmental monitoring and pollution prevention;
- Enforce environmental laws and standards;
- Collect data on the state of the environment;
- Supervise and control the import, transport, disposal and storage of hazardous chemicals; and
- Implement environmental awareness programmes.

In 2008, the SCENR was superseded by the establishment of the Ministry of Environment (MoE). Employees of MoE have the capacity to act as law enforcement officers in cases of contravention against the provisions of laws and regulations.

Several legislative decrees on environmental protection have been issued, prominent of which is Law No. 30 in 2002 and Executive By-law No. 4 in 2005 on environmental protection, Law No. 4 in 2002 on the hunting of birds and reptiles, Law No. 31 in 2002 on 'Radiation Protection', Law No. 19 in 2004 on 'Protection of Wild Fauna and Flora and its Natural Habitats'. Emiri decisions have also been issued calling for the protection of the marine environment from pollution from ships and land-based sources.

While there has been a steady evolution in the institutions handling environmental management in Qatar, limited institutional and human resource capacity, as well as gaps in related data and research, have constrained their effectiveness. Policy and regulatory controls have by and large not kept pace with the nation's rapid development.

Source: Derived from Al Ansi, 2009

Likewise, Qatar's Protected Area Action Plan (SCENR 2007) outlines the current status of protected areas as well as a set of action plans to advance the protected area program between 2008 and 2013. 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, Shahaniya, Khor Al Udaid, Al Weseil, Al Oraiq, Al Isheiriq and Al Mas'habiya. Together they comprise about 22 per cent of the terrestrial area of Qatar. Shahaniya, Al Mas'habiya and Al Isheiriq were wildlife farms developed into captive breeding sites for endangered species.

Qatar is also a signatory to all of the major international environmental treaties (Box 1.5) and to a number of other international and regional conventions in support of environmental sustainability including the Basel International Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1995; and the Protocol for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1996.

Box 1.5 International Environmental Treaties Signed by Qatar

- Convention concerning the Protection of World Cultural and Natural Heritage (Emiri Decree No. 21 of 1985)
- International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties and annexes (Emiri Decree No. 52 of 1988)
- Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf (Emiri Decree No.36 of 1989)
- Nuclear Non-Proliferation Treaty (Emiri Decree No.38 of 1989)
- Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (Emiri Decree No.55 of 1992)
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Emiri Decree No.15 of 1996)
- United Nations Framework Convention on Climate Change (Emiri Decree No.47 of 1996)
- Convention on Biological Diversity, 1992 (Emiri Decree No. 90 of 1996)
- Vienna Convention for the Protection of the Ozone Layer, 1985, and Montreal Protocol on Substances that Deplete the Ozone Layer, 1985 and its annexes, 1990 and 1992 (Emiri Decree No. 23 of 1999)
- United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (Emiri Decree No. 29 of 1999)
- Comprehensive Nuclear Test Ban Treaty (Emiri Decree No.54 of 1999)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (Emiri Decree No.19 of 2001)
- Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons (Emiri Decree No.32 of 2001)
- United Nations Convention on the Law of the Sea (Signatory in 2002)
- Decision No. 3/1 issued at the third meeting of countries signatory to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Emiri Decree No.22 of 2003)
- International Convention on Civil Liability for Oil Pollution Damage, 1992 (Emiri Decree No.33 of 2003)
- International Oil Pollution Compensation Fund, 1992 (Emiri Decree No.39 of 2003)
- Convention on the Conservation of Wildlife and Natural Habitats in the Countries of the Gulf Cooperation Council (Emiri Decree No.43 of 2003)
- Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (Emiri Decree No.58 of 2003)
- Stockholm Convention on Persistent Organic Pollutants, 2001 (Signatory in 2004)
- Convention on the Physical Protection of Nuclear Material, 1980 (Emiri Decree No.123 of 2004)
- Kyoto Protocol to the Framework Convention on Climate Change, 1997 (Signatory in 2005)
- International Maritime Organisations Convention on Marine Pollution (MARPOL 73/78) (Signatory in 2006)
- Cartagena Protocol on Biosafety, 2000 (Signatory in 2007)

However, while Qatar has moved quickly to ratify international conventions and establish regulatory and managerial bodies, progress on implementing sustainable development plans has been slow. Qatar faces numerous challenges in its transition to sustainable development and putting theory into practice, especially on account of its institutional and human capacity constraints.

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Consumption and Production Patterns: Subsidising Degradation

Achieving sustainable development necessitates a change in mindset and in consumption and production patterns. Governments serve as a trustee for future generations and play an important role in regulating markets in order to eliminate market failures related to negative externalities such as pollution. Government policies on taxes, subsidies and regulation can adapt the incentive structure in ways that protect the global environment and resource base.

Many European countries, for instance, correct market failure from fuel use by imposing heavy taxes, which has resulted in greater product efficiency and provided funds for healthcare and environmental clean-up. Hence taxes not only support the elimination of various forms of pollution but also curb consumption of the taxed products. Subsidies may have the opposite effect, encouraging excessive and indiscriminate use of fuel or energy or water and other products, and promoting degradation without regard for the immediate or long-term consequences of consumption now or in the future.

Currently, non-renewable hydrocarbon resources are being used inefficiently in Qatar (Richer 2009). Subsidising manufacturing by providing energy resources at below market costs results in overuse of the resource, decreased efficiency, fewer technological advances and greater environmental degradation. Supplying water and electricity to Qatari residents for free and at heavily subsidised rates for non Qatari residents is also resulting in serious challenges for developing sustainable use of an already scarce resource. While subsidies may be useful for attracting industry and expatriate labour, it is at the expense of the environment, the health of citizens and ultimately at the expense of Qatar's future generations. Qatar therefore needs to review its existing policies to ensure that present levels and patterns of consumption are sustainable and resource productivity is within the country's carrying capacity.

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Evidence-based Policy Making: From Theory to Practice

A key challenge for Qatar in achieving sustainable development lies in translating the national goals of the QNV 2030 into concrete and workable programmes and projects as well as establishing appropriate regulatory mechanisms and policies. Environmental policies must be based on solid research, sound scientific knowledge, and international norms and standards (Salman 2009). How best to measure sustainable development and the environment has been the subject of international debate and the focus of some controversy (Box 1.6).

There have been many questions raised about the adequacy of current measures of economic performance, such as GDP, as measures of societal well-being. These measures do not generally take into account the impact of human activities on exhaustible natural resources and the environment. Researchers have for a long time recognised and attempted to measure these effects. Many types of indicators and conceptual frameworks have been proposed (UN DESA 1996, 2003, 2007; Esty et. al. 2005), but no single set has gained widespread recognition and use.

In one recent response, the President of the French Republic decided to form a Commission on the Measurement of Economic Performance and Social Progress, chaired by Joseph Stiglitz. The Commission will make suggestions for developing alternative indicators and modifying existing ones. The Commission selected three main areas for their deliberations, namely:

- Issues with the GDP measure;
- Sustainable development and the environment, and
- Quality of life.

The Commission's views on sustainable development and the environment is particularly relevant for countries like Qatar whose GDP is heavily determined by the exploitation of non-renewable hydrocarbon resources.

Investigators have for a long time recognised and attempted to measure the impact of human activities on exhaustible natural resources and the environment. Many types of indicators have been developed but no single set has gained widespread recognition. Thus, it has been argued that the inability to measure progress in sustainable development has hindered attempts to improve environmental sustainability.

A clear distinction has to be made between measuring the impact of the environment on current well-being, and measuring its sustainability, that is the ability to maintain the current level of well-being in the future.

The first task is to quantify the direct effect of environmental factors on measures of current well-being, and to integrate these with current indices of well-being by valuing them in monetary terms. If this cannot be done, then some type of composite indices, based on arbitrary weights, will have to be devised.

In order to measure sustainability of current well-being, a line of research has focused on the preservation of an extended capital stock. This is conceptualized as being a mix of different production factors including natural resources, physical and human capital - it is defined broadly to include social institutions that contribute to productivity. The World Bank has labeled the changes over time of this extended capital as "Net Adjusted Savings" (NAS). Sustainability requires that NAS must be positive. The NAS approach appears to be a promising one, but raises important measurement and conceptual issues, and has yet to be fully operationalised and adopted internationally.

Source: Derived from CMEPSP, 2008

Sustainable development indicators are essential to provide information on how, and to what extent, progress is being made in navigating a transition toward sustainability. Regularly repeated observations of natural and social phenomena facilitate the provision of systematic feedback and form a sound basis for decision making. They provide both quantitative and qualitative descriptions of human well-being, the economy, and the impacts of human activities upon the natural world and *vice versa*.

Sustainable development indicators are essential to provide information on how, and to what extent, progress is being made in navigating a transition toward sustainability

To monitor progress towards sustainability, efforts are now underway in Qatar to collect and analyse indicators on sustainable development including social, economic and environment indicators. However, data on sustainable development in Qatar, especially in relation to the environment, remain partial and weak. Sustainable development concepts are generally difficult to measure because they are abstract and multidimensional in nature. There is no international consensus on the appropriateness of the current sets of indicators or the scientific basis for choosing among them. Data challenges frequently take the form of data gaps, lack of comparability and timeliness and inconsistencies (Box 1.7). Much more work is required to close existing data gaps, improve their timeliness and to develop indicators that better reflect the situation in Qatar.

Box 1.7 Data Challenges for Qatar in Measuring Sustainable Development

Challenges in monitoring progress towards sustainability arise because the data required to measure changes in environmental variables often cannot be met from traditional sources. The concepts involved, such as loss of marine biodiversity, are generally difficult to measure because they are abstract, often not well defined, and are multidimensional.

Statistical measurement involves (i) the selection of relevant concepts, (ii) the drawing up of operational definitions, (iii) the collection of data, and (iv) the development of indicators and composite indices.

Data gaps arise because some or all of the above four requirements have not been met. Most often data collection is not undertaken because of the expense involved. Often the data collection agency is not aware of the need for the new information, and thus dialogue between data producers and consumers is essential. Some information may be available but not compiled. Private sector contributions to sustainability in industry or agriculture may not be formally documented, or the data that are compiled may not be published. As a stop-gap-measure, estimates are sometimes made on the basis of available data from neighbouring countries, or through the use of proxy measures.

Discrepancies between international and national estimates sometimes arise as national estimates are often adjusted by international agencies using internationally agreed methodologies to enable cross-country comparisons. There may also be a time lag between international and national estimates.

Inconsistencies within and between time series data are often only revealed when the series are analysed. Thus it is useful for data producers to evaluate and analyse their own data. Data users can also provide valuable inputs in this process if they provide feedback and highlight inconsistencies.

Capacity Development and Knowledge Sharing: Towards a Post-Carbon Economy

Qatar is currently experiencing great expansion in its economic activities. The development of state-of-the-art infrastructure projects has grown markedly, placing strains on its environment. Given the scale and rapidity of change it is essential that there should be adequate institutional capacity for regulatory and monitoring mechanisms capable of effectively guiding and evaluating development and its impact on the environment. However, as the pace of development has been unprecedented, the institutional capacity in regulatory bodies and management agencies for successful environmental management and conservation efforts is still lagging. Similarly, scientific expertise and a highly skilled labour force are at an early stage of development. The implementation of effective environment management and conservation programmes have not kept pace with the nation's rapid development and economic growth.

Qatar has invested heavily in education as one of the basic pillars of social progress. Human capital is important not just for raising productivity, but also for advancing sustainable development. In 1995, the Qatar Foundation (QF) was established with a fund of USD 2 billion to support education, research, capacity building and open dialogue at all levels. At Education City, QF supports elite international education institutions to provide world-class quality education to Qataris and non-Qataris alike, and to help build a skilled human capital base for its present and future development.

QF also supports research and development through the establishment in 2009 of the Qatar Science and Technology Park, which focuses on research on energy, the environment, health sciences and information and communication technology, and the Qatar National Research Fund, which administers funding for original, competitively selected research and fosters collaborations within academia, and through public/private partnership. In 2006, His Highness the Emir of Qatar announced that the government would spend 2.8 percent of its GDP on research, comparable to developed nations such as the United States (2.62 per cent in 2006), Japan (3.33 per cent) and the European Union (1.74 per cent in 2005) (OECD, 2008).

This move towards a post-carbon economy will require structural changes involving greater transparency and accountability in decision making, free and open access to knowledge and information, and the encouragement of open discussions and dialogue. A comprehensive base of ecosystem knowledge, openly available to scientists, researchers and policy makers, can significantly improve environmental management and conservation efforts in Qatar.

The move towards a post-carbon economy will require structural changes involving greater transparency and accountability in decision making, free and open access to knowledge and information, and the encouragement of open discussions and dialogue

Corporate Citizenship and Sustainable Development: A New World Order

In today's world, business decisions can and do have a greater impact on people's welfare and the environment than the decisions of most governments. Business is the primary source of economic growth, employment creation and public revenues that pay for national development programmes. Business corporations, especially those in the energy sector, have the potential to support Qatar in achieving its national development aspirations through corporate social responsibility initiatives (Box 1.8).

The production, distribution and consumption of energy services have implications on the social, economic and environmental dimensions of human development. Some of the issues and challenges faced by the oil and gas industry in Qatar and the broader Arab region are summarised below.

Social Development

Energy-based products and services are essential inputs to meet basic needs such as water and electricity. The industry also provides employment opportunities, leading to improved standards of living. Some key social considerations include:

- Health and safety standards: The resources used and produced in the production, refinement, processing and transportation of oil and gas are potential health hazards and the processes involved may sometimes be dangerous. There needs to be continuous risk evaluation and monitoring at all stages of operations, including adequate training, education and supervision at production and distribution centres.
- Community outreach: The oil and gas industry forms an integral part of the communities in which they are located. There should be efforts made for greater social integration through carefully planned programmes for infrastructure investment, employment, education and communication. These programmes should be developed through extensive consultations with the communities affected.

Economic Development

Energy-based products and services are essential for modern productive activities. The oil and gas industry supports economic development by raising productivity and providing economic opportunities through job creation and industrial development. Some key economic considerations include:

- Product stewardship: Health, safety and environmental protection standards are integral to the design, manufacture, marketing, distribution, use, recycling and disposal of products and associated wastes. This is a collective responsibility that requires cooperation among players throughout the value chain.
- Technology and innovation: Energy efficient technologies and management systems are critical for sustainable development. As a key engine for growth, the industry plays an exemplary role in technology development and innovation leading to the adoption of clean and affordable energy technologies.

Environmental Development

The environmental effects of energy production and consumption can occur at many levels and include such consequences as desertification, air and water pollution and climate change. Some key environmental considerations include:

- Biodiversity: Emphasis should be placed on designing operations, whether at sea or on land, that are specifically designed to co-exist with habitats that are important to a wide variety of biological species, and where possible, to minimise interactions altogether.
- Climate change: The industry plays a big role in the reduction of greenhouse gases through the development and implementation of advanced technologies that are cleaner and energy efficient.
- Oil spill prevention and recovery: Oil spills can have a considerable impact on natural ecosystems, can harm wildlife and disrupt people's livelihoods. Efforts should be taken to prevent oil spills, and where they still occur, to minimise any damage caused.
- Water resource management: Water is essential to many producing and refining processes. In countries like Qatar where water is scarce, there is a growing demand for energy-based products, and a need to balance these imperatives through reductions in raw water abstraction and increased reuse, recycling, on-site treatment and research into new sources.

Source: Derived from UNEP 2003b

Sustainable Development in an Interdependent World: Think Global, Act Local

Qatar's efforts in protecting the environment will not be sufficient. Qatar is part of the Gulf region, which forms one ecological system that is affected by the practices and activities of every country in the region. It will be necessary to engage and to encourage all of the Gulf States to protect and conserve the environment.

GSDP, 2008

The economies and societies of the world are becoming increasingly interdependent. Trade and capital flows, migration, and technological innovations, communications and cultural exchanges are shaping the global community – a community threatened by environmental degradation, severe food crises, epidemics, various forms of intolerance, violence and criminality and the risk of losing the richness of cultural diversity. Governments increasingly recognise that their responses to changing circumstances and their desires to achieve sustainable development and social progress require increased solidarity and international cooperation.

Qatar and the Gulf region in general has recently been experiencing very high rates of economic growth, due mainly to the exploitation of abundant oil and gas reserves, together with increased trade and investments. However, resource exploitation, rapid spatial development and increased consumption have led to major environmental degradation including, *inter alia*, severe coastal erosion, depletion of freshwater resources, and rising land-based pollution of Gulf waters. There is also an emerging recognition of the potential for natural disasters deriving from climate change.

The main challenge facing regional decision makers is how to effectively formulate, integrate and implement multi-sectoral sustainable development policies. This challenge is exacerbated by the predominantly centralised, yet compartmentalised, nature of governance in the region (UNEP, 2003a). The region relies heavily upon regulatory mechanisms rather than economic instruments and voluntary arrangements.

In the Arab region, the adoption of the 2002 Arab Initiative on Sustainable Development provides an opportunity for the League of Arab States to coordinate efforts in promoting and monitoring progress towards sustainable development. The Arab Initiative asserts the commitment of the Arab countries to implement Agenda 21, the development objectives of the Millennium Declaration, and the outcome of the World Summit on Sustainable Development, taking into account the principle of common but differentiated responsibility. It aims to address the challenges and difficulties that Arab countries are facing in achieving sustainable development.

Given its abundant resource and bold leadership, Qatar has the opportunity and ability to take a lead role in the field of sustainable development. Qatar needs to continue to partner with its neighbours to enforce international protection standards and encourage investment in advanced technologies that protect the environment while promoting economic advancement.

Conclusion

With the adoption of QNV 2030, Qatar has chosen a development path that seeks to manage growth and balance the needs of current and future generations. The pursuit of sustainable development entails reconciling potential conflicts between the economy and the environment, and between the present and the future. This does not imply that all non-renewable resources must be conserved, but that opportunities for future generations should not be compromised, consistent with the principles of intergenerational equity.

With massive investments in infrastructure and the social sectors, Qatar has made remarkable progress in human development. The nation has compressed into the space of less than two decades improvements in well-being that have taken several decades in most other countries. It has achieved spectacular gains in income, while avoiding rising income inequality. Impressive improvements have also occurred in health outcomes. Progress in educational outcomes has been less spectacular.

While Qatar's exceptionally rapid economic growth and development has opened up previously unforeseen opportunities, it has also led to severe environmental stresses. Investments in numerous large-scale infrastructure projects have resulted in massive flows of expatriate labour, predominantly of lower skilled workers. As a consequence, Qatar's population has grown at an unprecedented rate, more than tripling in size in the 18 years up to 2008.

Uncontrolled economic and population growth are threatening sustainability. They are adversely affecting Qatar's environment in terms of land use and air quality, water and energy resources and marine biodiversity. They are also increasing stresses on housing and basic social services.

Qatar's chosen development path entails a transition from uncontrolled development relying on low-productivity, low-skilled and low-paid expatriate workers, to a diversified post-carbon economy relying on a high productivity, highly-skilled and highly-educated labour force

Qatar's chosen development path entails a transition from uncontrolled development relying on low-productivity, low-skilled and low-paid expatriate workers, to a diversified post-carbon economy relying on a high-productivity, highly-skilled and highly-educated labour force. This calls for policies and structural changes, including greater use of technology and automation, that limit the flow of low-skilled foreign workers, and that develops local talent supported by higher-skilled expatriates.

The attainment of intergenerational equity with high human development demands that Qatar improves its environmental management, and promotes sustainable production and consumption of its natural resources. This entails building institutional and human resource capacities and addressing knowledge and data gaps. It also calls for the use of monitorable indicators of sustainable development for evidence-based policy-making. The nation has already taken some steps towards meeting these challenges, and they will be further developed as part of Qatar's first National Development Strategy.

The next three chapters of this Report focus on three of the most critical areas of environmental stress facing Qatar, namely water security, marine environment and climate change. In reviewing these three thematic areas, this Report analyses the interrelationships between economic growth, social development and the environment in a national, regional and global setting. It explores the implications of these three environmental stresses on the nation's ability to achieve the goals of the QNV 2030, and considers some of the national responses to them. The Report concludes with some broad policy, programme and management recommendations for *Advancing Sustainable Development*.

References

Al Ansi, M. 2009. "Marine Environment and Human Development in the State of Qatar: Problems, Challenges and Opportunities." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.

Anand, S. and Sen, A. 2000. "Human Development and Economic Sustainability." *World Development* 28 (12): 2029-2049.

CMEPSP (Commission on the Measurement of Economic Performance and Social Progress). 2008. "CMEPSP - Issues Paper." (J.E. Stiglitz, A. Sen, and J. Fitoussi, eds.).

Esty, D. C., Levy, M., Srebotnjak, T. and de Sherbinin, A. 2005. *2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*. Yale Center for Environmental Law and Policy, New Haven.

GSDP (General Secretariat for Development Planning). 2008. *Qatar National Vision 2030*. Doha.
_____. **2009a.** Social and Human Development Profile No. 1: Qatar's Labour Force, Trends and Patterns. Doha.
_____. **2009b.** Social and Human Development Profile No. 2: Features of Education in Qatar, Trends and Patterns. Doha.

Kates, R. W., Parris, T. M. and Leiserowitz, A. A. 2005. "What is Sustainable Development? Goals, Indicators, Values and Practice." *Environment: Science and Policy for Sustainable Development* 47(3): 8-21.

OECD (Organisation for Economic and Co-operation and Development). 2007. *OECD Factbook 2008: Economic, Environmental and Social Statistics*.
[<http://oberon.sourceoecd.org/vl=5324306/cl=20/nw=1/rpsv/factbook/>]. Accessed February 2009.

QSA (Qatar Statistics Authority). 1996. Annual Statistical Abstract. Doha.
_____. **2001.** *Annual Statistical Abstract*. Doha.
_____. **2004.** *The General Population and Housing Census*. Doha.
_____. **2005.** *Annual Statistical Abstract*. Doha.
_____. **2007.** *Annual Statistical Abstract*. Doha.
_____. **2008.** *Digital Atlas of Qatar*. Doha.

Richer, R. 2009. "Sustainable Development Challenges in Qatar: Issues and Opportunities." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.

Salman, S. R. 2009. "Sustainable Environmental Development." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.

State of Qatar. 2004. "National Biodiversity Strategy and Action Plan."
[<http://www.cbd.int/doc/world/qa/qa-nbsap-oth-en.doc>]. Accessed February 2009.

UN DESA (United Nations Department of Economic and Social Affairs). 1996. *Indicators of Sustainable Development: Guidelines and Methodologies*. New York.

_____. **2003.** *Indicators of Sustainable Development: Guidelines and Methodologies*. New York.

_____. **2007.** *Indicators of Sustainable Development: Guidelines and Methodologies*. New York.

UNDP (United Nations Development Programme). 2007. *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World*. Palgrave Macmillan, New York.

_____. **2008.** Human Development Indices: A Statistical Update 2008

[<http://hdr.undp.org/en/media/HDI2008Tables.xls>]. Accessed February 2009

UNEP (United Nations Environment Programme). 2003a. *State of Environment in the Arab Region. A Progress Report*. Bahrain.

_____. **2003b.** Energy and Environment: A Framework for Action in the Arab Region. Discussion Paper. Environment and Energy Conference and Exhibition 2003, Abu Dhabi, UAE.

United Nations Millennium Project Task Force on Environmental Sustainability. 2005.

"Environment and Human Well-Being: A Practical Strategy." (D. Melnick, J. McNeely, Y.K. Navarro, G. Schmidt-Traub and R.R. Sears, eds.).

[http://www.unmillenniumproject.org/documents/EnvironSust_summary.pdf]. Accessed February 2009.

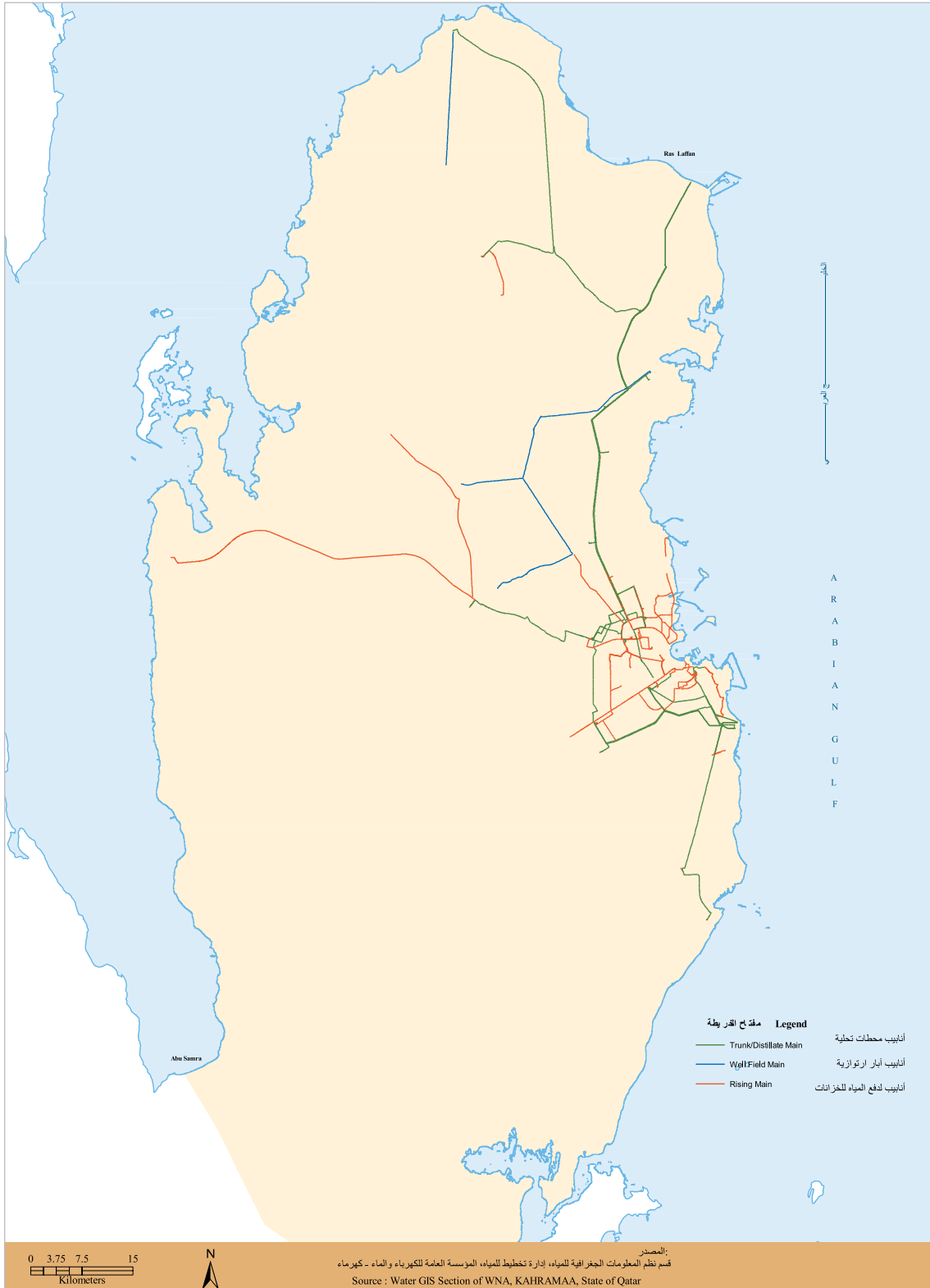
WCED (World Commission on Environment and Development). 1987. *Our Common Future*. Oxford University Press, New York

2

Water and Human Development **Access and Sustainability Challenges**

Map 2.1

Water Network, Qatar



Source: QSA, 2009

Water and Human Development: Access and Sustainability Challenges

The State of Qatar seeks to preserve and protect its unique environment and nurture the abundance of nature granted by God. Accordingly, development will be carried out with responsibility and respect, balancing the needs of economic growth and social development with the conditions of environmental protection.

GSDP, 2008

Water pervades all aspects of human development. Delivering clean water, removing wastewater, and providing sanitation are three of the most fundamental requirements for human progress. When people are denied access to clean water at home or when they lack access to water as a productive resource, their choices and freedoms are constrained by ill health, poverty and vulnerability. Water gives life to everything, including human development and human freedom.

While the world is not running out of water, it is running down a finite natural resource and running up an unsustainable ecological debt for future generations. Water stress is mounting due to overuse and competing demands from population growth, industrialisation, urbanisation and agriculture. Rivers are drying up, groundwater tables are falling and water-based ecosystems are being rapidly degraded.

The State of Qatar, through the environmental pillar of the Qatar National Vision 2030, recognises the need to address the challenges of ensuring sustainable access to safe water and sanitation. The scarcity of renewable water resources and the escalating competition for water is a major challenge. Water security is further compounded by Qatar's harsh and fragile environment (high temperature, strong winds, low rainfall and low nutrient availability in the soil) and the increasing threats of climate change. With continued rapid population growth and economic development, water security is critical in the sustainable development agenda for Qatar.

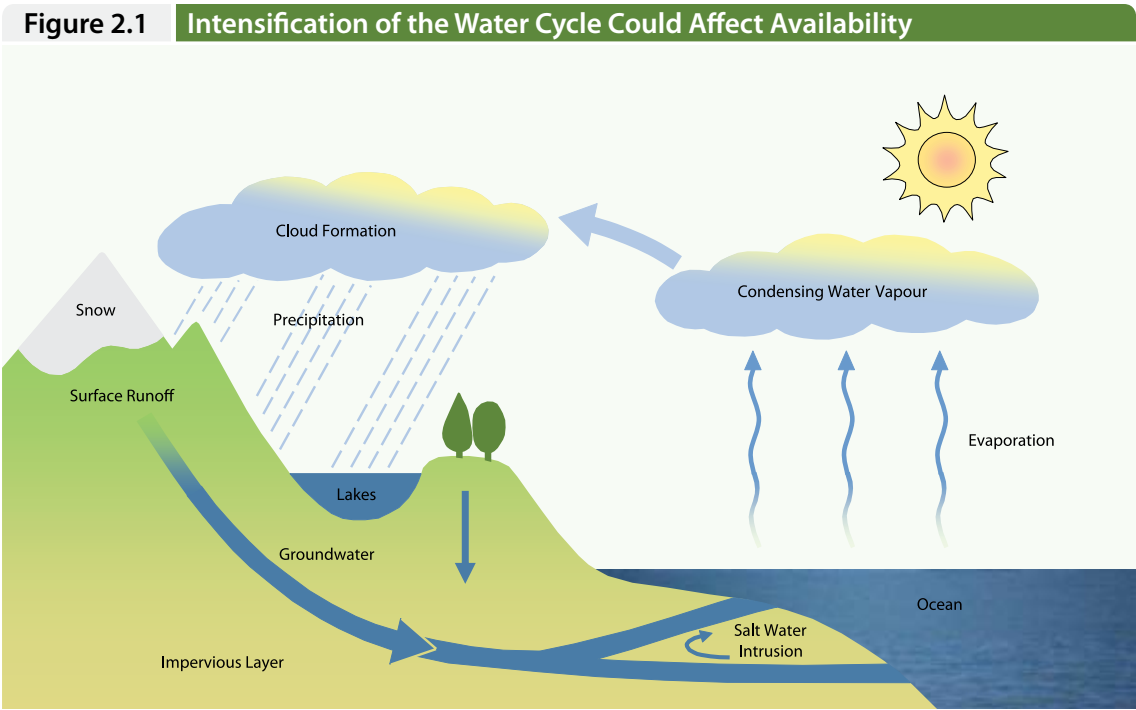
The scarcity of renewable water resources and the escalating competition for water is a major challenge in the sustainable development agenda for Qatar

Water for Life: Basic Needs, Livelihoods and Sustainable Development

Water resources can best be understood within the context of the dynamic water cycle (Figure 2.1). Although water is one of the most widely occurring substances on earth, only 2.5 per cent is freshwater and the remaining is salt water. Some two-thirds of this freshwater is locked up in glaciers and permanent snow cover and the available freshwater is unequally distributed between and within countries. With the exception of some examples of groundwater, water resources are renewable, but only within specific limits as in most instances water initially flows through catchments that are more or less self-contained.

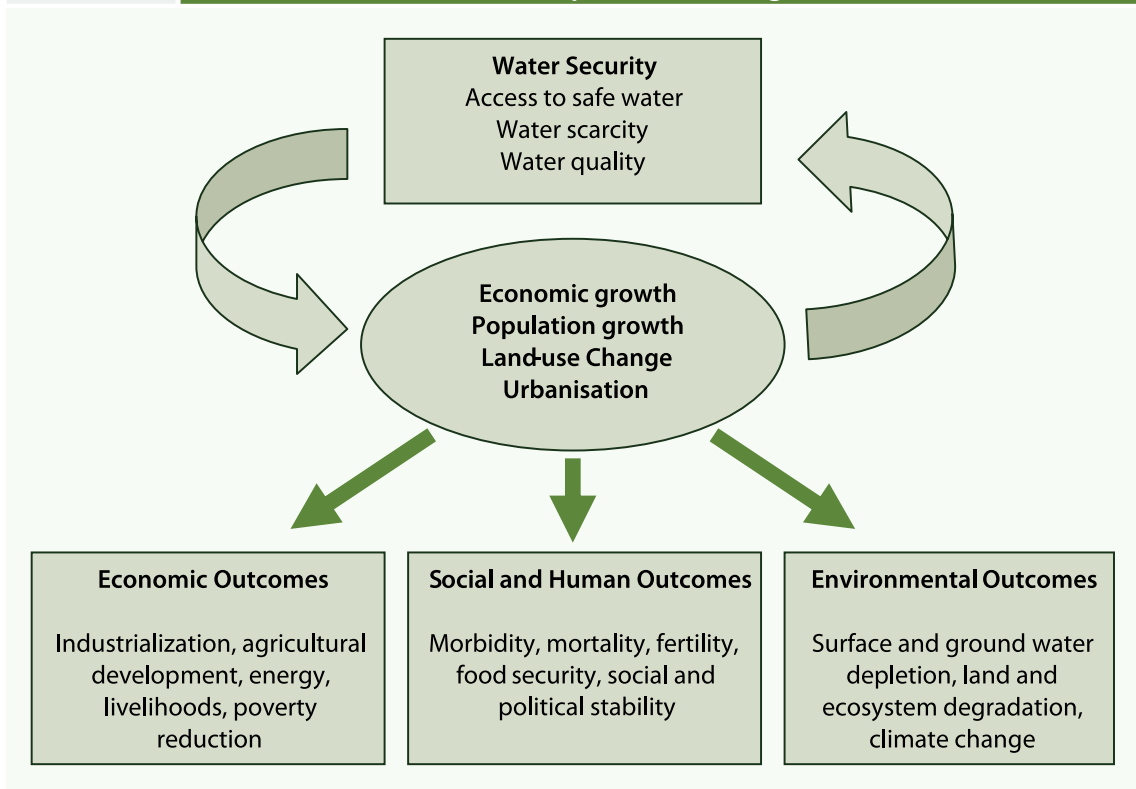
The precipitation that falls on land surfaces in the form of rain, snow, hail, sleet and dew is the predominant source of water for human consumption, agriculture and food production, waste disposal processes, and the support of natural and semi-natural ecosystems. Some of this water is absorbed by soil and plants, thus supporting forests, cultivated and pastoral land, and a variety of ecosystems, and eventually

returning to the atmosphere through the process of evapotranspiration. The remainder drains into the sea via rivers, lakes and wetlands except where human intervention diverts the runoff for domestic consumption and other uses such as irrigation, industry, and waste disposal.



Water is integral to all three pillars of sustainable development – economic, social and environmental (Box 2.1). Water is most obviously related to the issue of social development through its impact on health. Without safe drinking water, humans, animals and plant life cannot survive. Water quality is critical since water-related diseases are among the most common causes of illness and death. Good sanitation facilities and hygienic practices can significantly reduce the threat of many serious diseases.

Beyond meeting basic human needs, water contributes to sustainable development through various other means. Water is necessary for agriculture and for many industrial processes. In some parts of the world, water is a major source of energy and in many countries water networks form an integral part of transport systems. Freshwater ecosystems are also crucial for the conservation of biodiversity and the reduction of risks from water-related and other natural disasters, such as flood control, storm protection and water purification.



Water Security at Risk

In the 21st Century, water security is at risk. Competition, environmental stress and unpredictability of access to water as a productive resource are resulting in water insecurity for a large proportion of the global population. While the availability of water is a concern for some countries, viewed at a global level, there is more than enough water to meet all of humanity's needs. Water scarcity, which lies at the heart of the global water crisis, is rooted in power, poverty and inequality, and is induced by policy failures (UNDP, 2006). A wide range of human uses and transformations of terrestrial environments are placing undue pressure on freshwater ecosystems, with consequential implications for human development (Box 2.2).

Box 2.2**Pressures from Human Activity May Seriously Alter the Integrity of Freshwater Ecosystems**

Human Activity	Potential Impact	Function at Risk
Population and consumption growth	Increases water abstraction and acquisition of cultivated land through wetland drainage; increases requirement for all other activities with consequent risks	Virtually all ecosystem functions including habitat, production and regulation
Infrastructure development (dams, dykes, levees, diversions and so on)	Loss of integrity alters timing and quantity of river flows, water temperature, nutrient and sediment transport and thus delta replenishment and fish migrations	Water quantity and quality, habitats, floodplain fertility, fisheries, delta economies
Land conversion	Eliminates key components of aquatic environment; loss of functions, integrity, habitat and biodiversity; alters runoff patterns; inhibits natural recharge, fills water bodies with silt	Natural flood control, habitats for fisheries and waterfowl, recreation, water supply, water quantity and quality
Overharvesting and exploitation	Depletes living resources, ecosystem functions and biodiversity (groundwater depletion, collapse of fisheries)	Food production, water supply, water quality and water quantity
Introduction of exotic species	Competition from introduced species; alters production and nutrient cycling; and causes loss of biodiversity among native species	Food production, wildlife habitat, recreation
Release of pollutants to land, air or water	Pollution of water bodies alters chemistry and ecology of rivers, lakes and wetlands; greenhouse gas emissions produce dramatic changes in runoff and rainfall patterns	Water supply, habitat, water quality, food production; climate change may also impact hydropower, dilution capacity, transport, flood control

Source: UNESCO-WWAP 2003

Achieving water security therefore is an essential element in meeting human needs. Water security is about ensuring that every person has reliable access to safe water at an affordable price to lead a healthy, dignified and productive life, while maintaining the ecological systems that both provide and depend on water. When these conditions are not met, or when access to water is disrupted, people face acute human security risks transmitted through poor health and the disruption of livelihoods.

Water security is about ensuring every person has reliable access to safe water at an affordable price to lead a healthy, dignified and productive life

There are three main threats to water security: water scarcity, water quality and water-related disasters.

Water Scarcity in a Wealthier and Thirstier World

Many developing countries have difficulty in supplying the minimal annual *per capita* water requirement of 1,700 cubic metres (m³) of drinking-quality water necessary for an active and healthy life (UNDP, 2006). Countries with water resources of between 1,000 and 1,700m³ per person per annum are

considered to be 'water-stressed'. Countries with less than 1,000m³ per person per annum are classified as suffering from serious 'water scarcity'; where reliable water supplies are below this level, people are deemed to be living in 'water poverty'. Early in the 21st Century it was estimated that half the population of developing countries lived in conditions of water poverty.

Water stress worldwide is increasing. *Per capita* availability of water is shrinking due to high population growth, economic development and changing societal views on the value of water. Countries are drawing more water from the system than can be replenished, creating serious ecological stress. River systems no longer reach the sea; disappearing lakes, shrinking aquifers and falling groundwater tables epitomize overuse; consumption at rates that deplete water resources compromises future supplies. The result is a growing water-based ecological debt that will be transferred to future generations.

Per capita availability of water is shrinking globally due to high population growth, economic development and changing societal views on the value of water

Water availability depends on rainfall, capacity for storage and the degree to which river flows and groundwaters are replenished. Water resources are extremely variable over both space and time with huge differences in availability in different parts of the world and considerable variation in seasonal and annual precipitation in many places. This variability in water availability is one of the most critical issues of water resource management and it is exacerbated by continuing population growth – often in regions where water resources are already under pressure. As water is not readily transferable like food and oil, there is limited scope for trade to even out the variability in distribution. The emphasis therefore is on local availability and access through water infrastructure.

Clean Water and the Right to Health

Even where there is enough water to meet current needs, many rivers, lakes and groundwater resources are becoming increasingly polluted. The most frequent sources of pollution are human waste, industrial wastes and chemicals, and agricultural pesticides and fertilisers. The situation is particularly bad in developing countries where institutional and structural arrangements for the treatment of municipal, industrial and agricultural waste are inadequate, and waste is commonly dumped into waterways making them toxic and an inappropriate source of water for most forms of consumption occurring downstream. Such degradation of water resources is both a national and international problem, accentuated by the failure of national and regional institutions to protect downstream users from upstream polluters.

As much as half the population of the developing world is exposed to polluted sources of water that increase the incidence of serious diseases. Furthermore, the poor, many of whose livelihood systems depend directly or indirectly on water resources, feel the impacts of such pollution disproportionately. For example, where fishing is a key livelihood activity, the destruction of fish and their habitats through eutrophication (major changes to aquatic habitats through release of excess nutrients from fertilisers and human or animal wastes), toxicity and other types of water pollution can have a devastating impact on communities dependent on fishing as a major source of protein.

Water-Related Disasters and the Threat to Human Progress

Damage to the environment is causing an increase in natural disasters. Floods are increasing where deforestation and soil erosion are preventing natural water attenuation. The draining of wetlands for agriculture (50 percent lost in the last century) and the appropriation of evapotranspiration (water lost to the atmosphere from the soil through evaporation and from plants through transpiration) changes due to land clearance will lead to further disturbance of natural systems (UNESCO-WWAP 2003).

The majority of natural disasters that cause widespread death and injury are water-related. Growing concentrations of people and increased infrastructure in vulnerable areas such as coasts and floodplains and on marginal lands mean that many people are at risk. While low-income countries are especially vulnerable, it is the poor, the elderly, and women and children who are especially hard hit in every country during and following disasters. Worldwide, floods are generally the most frequently reported disaster event whereas, in terms of loss of life, droughts tend to claim the greatest number of victims.

Climate Change Threatens Water Resources

Climate change is transforming the water cycle, thus affecting the availability of water (Box 2.3). While climate change is unlikely to have a major effect on municipal and industrial water demands in general, it may substantially affect irrigation withdrawals due to higher temperatures and therefore higher crop evaporative demand. Climate change could also further decrease the streamflow and groundwater recharge in many existing water-stressed countries in central Asia, southern Africa and countries around the Mediterranean Sea, but may increase it in others. Flood magnitude and frequency could increase in many regions, exacerbated by land-use change, and water quality could degrade through higher water temperatures and increased pollutant load from runoff and overflows of waste facilities (IPCC, 2001).

The adverse effects of climate change on water resources will aggravate the impact of other water stresses such as population growth, economic development, land-use change and urbanisation. Current water management practices may not be robust enough to cope with the impacts of climate change. There is a need to fill existing knowledge gaps and improve understanding and modelling of climate change and water. To be effective and to assist adaptation to longer-term climate change impacts, water resource management systems should incorporate data and information about climate variability.

Current water management practices may not be robust enough to cope with the impacts of climate change

Box 2.3**Freshwater Resources are Vulnerable to the Effects of Climate Change**

Observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide ranging consequences for human societies and ecosystems.

Observed and projected changes in climate as they relate to water include:

- Precipitation increases in high latitudes and parts of the tropics, and decreases in some sub-tropical and lower mid-latitude regions.
- Annual average river runoff and water availability are projected to increase by the middle of the 21st Century as a result of climate change at high latitudes and in some wet tropical areas, and decrease over some dry regions at mid-latitudes and in the dry tropics.
- Increased precipitation intensity and variability are projected to increase the risks of flooding and drought in many areas.
- Water supplies stored in glaciers and snow cover is projected to decline in the course of the century.
- Higher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution – from sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt, as well as thermal pollution, with possible negative impacts on ecosystem, human health and water system reliability and operating costs.
- Globally, the negative impacts of future climate change on freshwater system are expected to outweigh the benefits.
- Changes in water quantity and quality due to climate change are expected to affect food availability, stability, access and utilisation.
- Climate change affects the function and operation of existing water infrastructure – including hydropower, structural flood defenses, drainage and irrigation systems – as well as water management practices.

Source: IPCC, 2008

Qatar's Water Resources

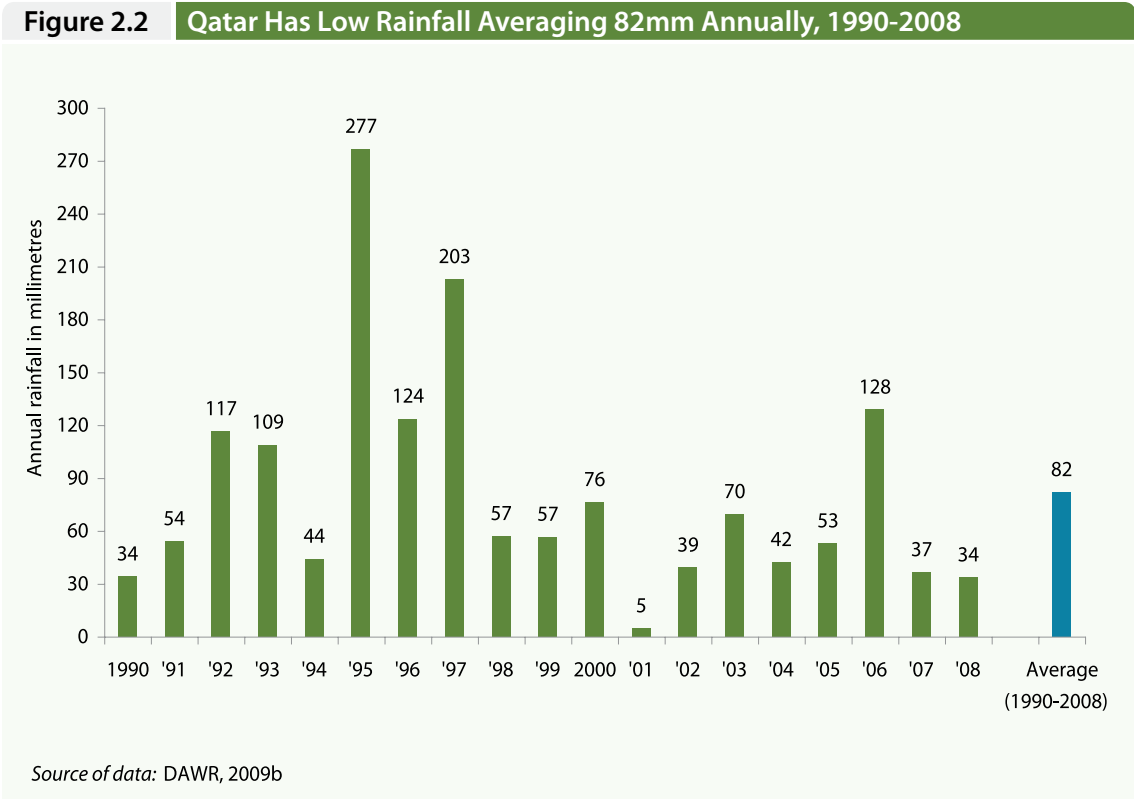
Qatar is an arid country that suffers from a severe lack of natural water resources, a feature shared with the other member states of the Gulf Cooperation Council (GCC) countries. With an average of less than 200m³ available per person per year, Qatar falls far below the internationally recognised 'water poverty line' of 1,000m³ per person per year (Al Mohammadi 2009). Because of rapid agricultural, industrial and social development, and the massive increase in Qatar's population, conventional water resources have become seriously depleted and non-conventional alternatives such as desalinated water and, to a lesser extent treated sewage effluent, now have an increasing role in the planning and development of an expanded water supply.

Conventional water resources have become seriously depleted and non-conventional alternatives such as desalinated water have an increasing role in expanding water supply

In 2005, an estimated 56 per cent of Qatar’s total water supply was from groundwater and treated wastewater, and was used for agricultural purposes; the remaining 44 per cent came largely from desalination and was used for household and commercial consumption (computed from Table 5 in Al Mohammadi, 2009). With marked increases in the production of desalinated water to support increased urbanisation and a doubling of population size between 2005 and 2009, it is expected that more than half of total water supply will be desalinated water.

Conventional Water Sources

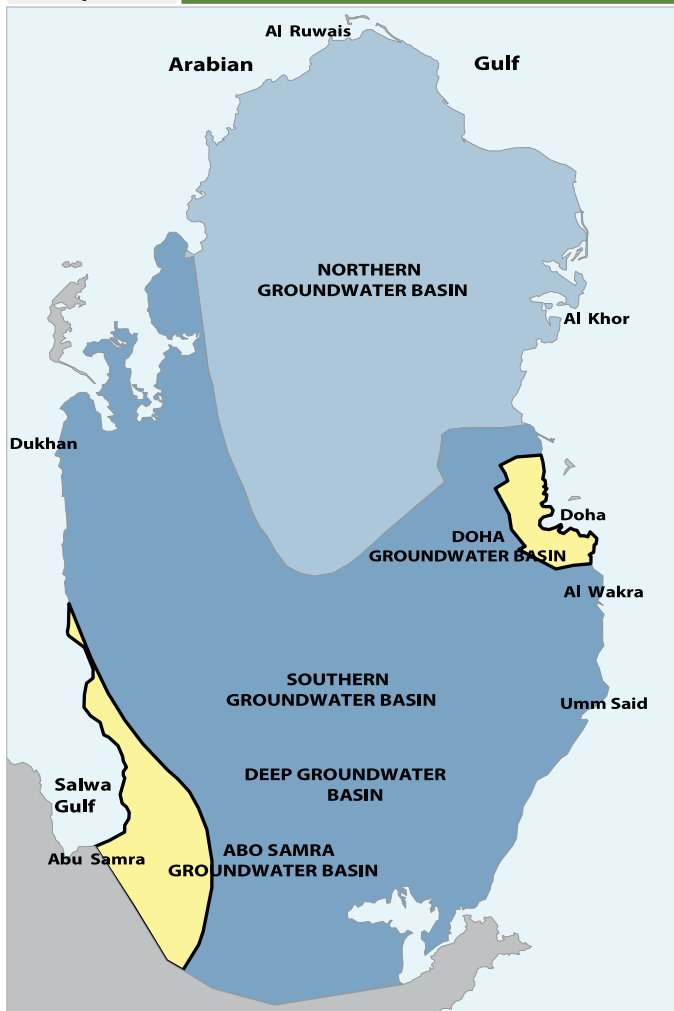
Qatar has no rivers or lakes. The only accessible and renewable conventional source of water is the groundwater that is replenished principally by the light rainfall within Qatar, supplemented by a small amount from Saudi Arabia. Qatar experiences scanty winter rainfall from November to April with an annual mean of 82 millimetres (mm) (Figure 2.2). There are significant temporal and spatial variations in distribution with rainfall about 30 per cent greater in the north of the country than in the south. Isolated and sporadic thunderstorms are prevalent during the rainy season, especially February and March. The light rainfall and variability, coupled with high evaporation rates, limits groundwater replenishment from this source.



Due to the low and variable rainfall and the high evaporation rates, there is no permanent surface water in Qatar. Until the middle of the 20th Century, groundwater was the main source of water for all purposes in Qatar. Currently, the contribution of groundwater to municipal use (excluding water used for agricultural purposes) is less than 1 per cent (Amer and Abdel-Wahab, 2009).

The two main groundwater basins are the Northern and Southern Groundwater Basins, and three secondary ones comprise the Abu Samra, Doha and Deep Groundwater Basins in the southwest of the country (Map 2.2). Both the Northern and Southern basins rely on rainfall for replenishment.

Map 2.2 Groundwater Basins in Qatar



Source: Redrawn from Amer and Abdel-Wahab, 2009, derived from FAO Studies Project, 1981

The Northern Groundwater Basin is a complex system and is considered the most important source of water of acceptable quality for agriculture (water salinity ranges between 300–3,000 parts-per-million (ppm)). This aquifer covers an area equivalent to 19 per cent of Qatar's total land area and the depth of water is between 10 to 40m below ground.

The Southern Groundwater Basin extends for about half of the land area of Qatar and has been much less replenished than the Northern Groundwater Basin. Within the basin, water levels are mostly at least 30m below the surface. The geological formation has resulted in irregular and perched water bodies that create a poor aquifer lacking continuity with adjacent aquifers. Water salinity in this area is high and not fully suitable for agriculture (water salinity ranges between 3,000-6,000 ppm).

The Southwestern Groundwater Basin draws on the Alat artesian aquifer in Abu Samra. The depth of water is between 25-80m below ground and water salinity ranges between 4,000-7,000ppm. Replenishment of the aquifer occurs from rainfall over the outcrop of the upper Dammam Formation in Saudi Arabia (Amer and Abdel-Wahab, 2009, derived from FAO Studies Project, 1981). The annual reliable yield is considered to be up to 2.2 million m³, but comprises brackish water of variable quality.

The Doha Groundwater Basin is of recent origin and is recharged mainly from rainfall in Doha, surplus landscape irrigation, and leaking water pipes and septic tanks. Unlike the inland aquifers, its water levels are rising but this water is contaminated by municipal sewage in many localities.

The annual through flow of the Deep Groundwater Basin is small at about 0.5 million m³, and the aquifer is probably not recharged from within Qatar. The quality of the water declines along the hydraulic gradient in a northerly direction.

Non-Conventional Water Sources

Qatar depends heavily on desalination to meet both domestic and industrial water demand. The first desalination plant was commissioned in 1953 with a capacity of 680 m³ (KAHRAMAA, 2008). Since then, a number of additional units and plants have been added, and some decommissioned, at various locations (Table 2.1). Desalination provides more than 99 per cent of Qatar's municipal water demand (Amer and Abdel-Wahab, 2009). The largest desalination facility, Ras Abu Fontas, located in the southern part of Doha, meets most of the civil sector demand. Other desalination plants are mainly used to supply water to the industrial sector in Dukhan, Ras Laffan, Messaied, Umm Bab, the remote outskirts of Abu Samra and the Al Shamal military camp (Al Mohannadi, 2009).

Table 2.1 Production Capacity of Major Desalination Plants, Qatar, 2007			
Desalination Plant	Desalination Units	Capacity Per Unit (m³/day)	Total Production Capacity (m³/day)
Ras Abu Aboud		Decommissioned on 23 December 2007	
Ras Abu Fontas (A)	14	22,730	318,226
Ras Abu Fontas (B)	5	30,004	150,021
Ras Laffan A	4	45,461	181,843
Ras Laffan B*	2	68,191	136,383
TOTAL	25	166,386	786,473

* Ras Laffan B expected to reach 272,766 m³/day in 2008

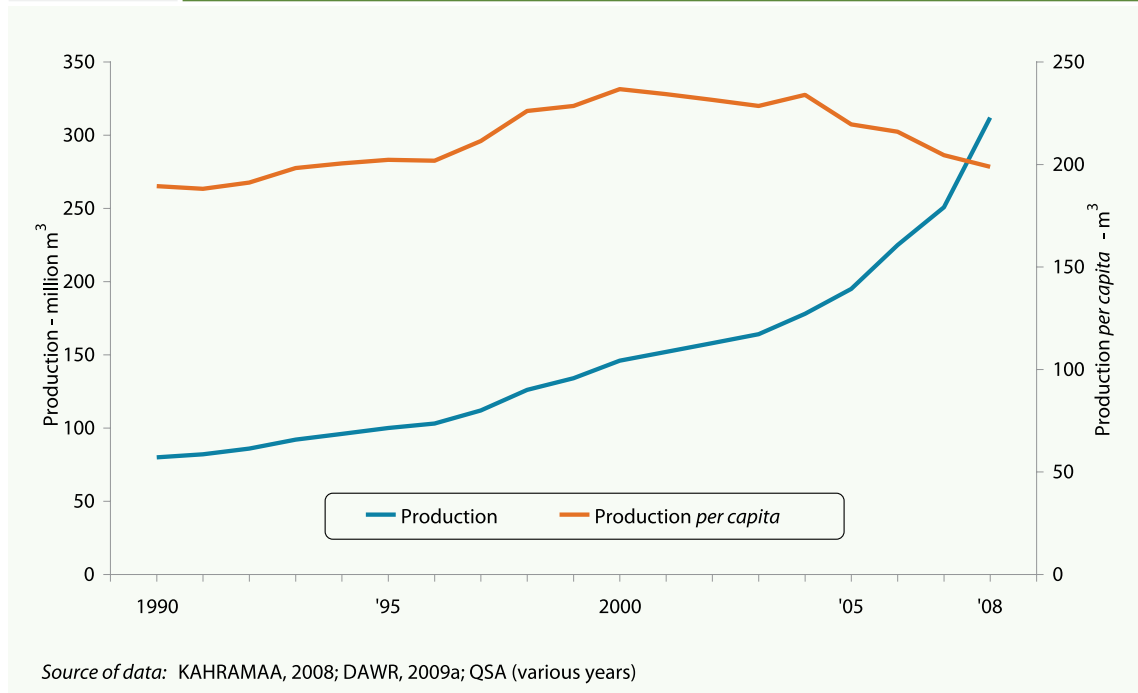
Source: KAHRAMAA, 2008

The rapid expansion in annual production of desalinated water is illustrated in Figure 2.3. Since 1995, the total production of desalinated water has more than tripled, reaching 312 million m³ in 2008. But in spite of massive increases in production, production *per capita* has been declining in recent years indicating increasing water-stress (Figure 2.3). Qatar is investing heavily in new projects and new technologies to further increase the production of desalinated water.

Despite massive increases in production of desalinated water, production per capita has been declining in recent years indicating increasing water-stress

Almost all water used for desalination comes from seawater from the Arabian Gulf. Most of Qatar's desalination plants use the multi-stage flash (MSF) distillation method which was first adopted in 1959. In this process, seawater is heated and evaporated, after which the steam is condensed to produce desalinated water. A MSF facility is therefore typically co-located with a power plant so that it can use the steam from the electricity generation facility. Other desalination methods adopted are vapour pressure and reverse osmosis technologies.

Figure 2.3 Qatar's Production of Desalinated Water Increasing, But Declining on a Per Capita Basis



In Qatar, only about one-third of the potable water fed into the system finishes up being recycled as treated effluent. The main reasons for this are loss of water through the utilisation of desalinated water for garden irrigation and washing cars, industrial consumption of desalinated water that is not fed into the wastewater system, leakage in the water mains and suburbs that are not connected to the sewer system (Amer and Abdel-Wahab, 2009).

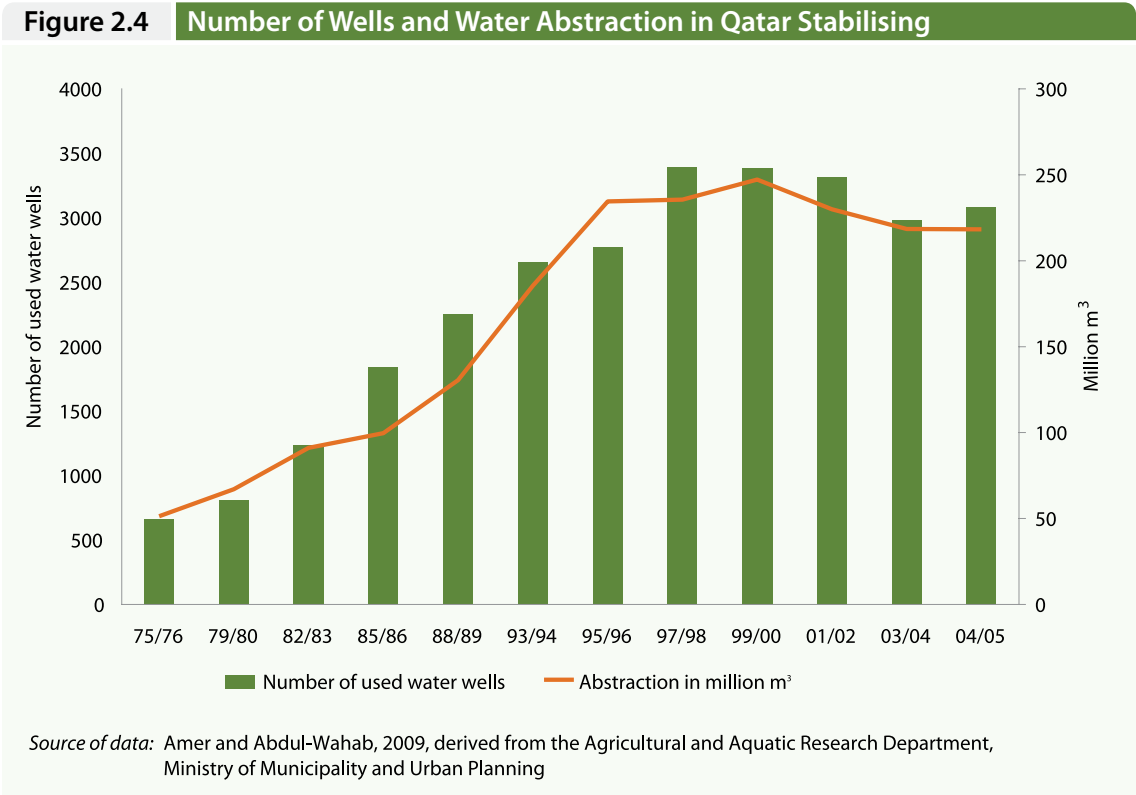
Qatar is considered a pioneer in the Gulf region in wastewater treatment (Al Mohannadi, 2009). It began utilising recycled water in 1971. By 2005, the flow of treated effluent from the two main treatment plants in Doha had reached between 140,000 and 150,000m³ per day. The two main sewage treatment plants use tertiary treatment technology and account for 96 per cent of the treated sewage effluent, while a number of smaller plants serving smaller communities account for the remainder. These facilities were considerably expanded during 2008, and another treatment plant in the vicinity of Doha is scheduled for completion in 2012. These developments are expected to increase Qatar's annual wastewater treatment capacity to 194 million m³ per year (Amer and Abdel-Wahab, 2009).

Additionally, demand for bottled water is on the rise due to greater preference for bottled water by Qatari consumers. Since the introduction of the Lebanese bottled water into Qatar's market about 40 years ago, annual consumption has increased significantly to about 80 – 90 million litres. Bottled water is imported from at least 23 countries (Al Mohannadi, 2009).

Uses of Water Resources

During the pre-oil era, agriculture in Qatar was very limited, but following the huge expansion in oil and gas production the government invested in the sector to improve food security. The country's current water strategy is to use groundwater for agriculture, build desalination plants to provide potable water, and limit the use of treated sewage effluent to irrigation of forage crops and landscaping.

Farming areas are highly fragmented and scattered throughout the north and central regions of the country where groundwater is accessible and of adequate quality – unlike the south where the water is deeper and more saline (Amer and Abdel-Wahab, 2009). This distribution roughly correlates with the occurrence of wells throughout the country in the mid-1980s: 42 per cent in the north, 51 per cent in the centre, and just 7 per cent in the south. Extraction of groundwater from both the Northern and Southern Groundwater Basins steadily increased from about 4.0 million m³ in 1959/60 to about 220.2 million m³ in 2004/2005. This has resulted in a water abstraction rate that is almost four times the natural groundwater recharge rate. The increasing demand was boosted by the increase in the number of working wells from 660 in 1975/1976 to 3,083 in 2004/2005 (Figure 2.4).

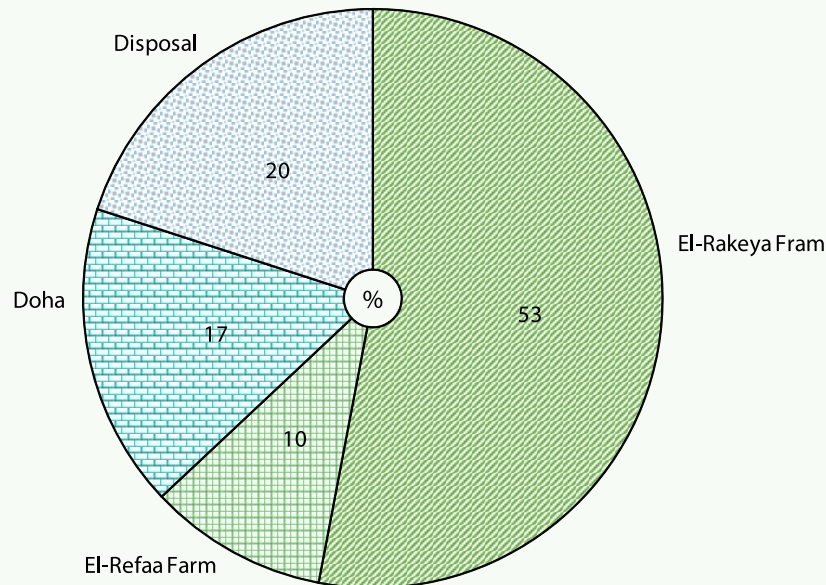


Agricultural use of groundwater for irrigation is inefficient as a result of the employment of traditional irrigation methods. According to the 2000/01 agricultural and aquatic survey, the overall efficiency of irrigation is estimated at less than 50 per cent, and possibly as low as 40 per cent (Amer and Abdel-Wahab, 2009). Modern, central-pivot sprinkler irrigation, most of it installed by joint venture enterprises, irrigated about 25 per cent of the total cultivated area of about 6,600 hectares, and is much more efficient in delivering water to planted areas. Generally, however, appreciation of water resource conservation and the efficiency of modern irrigation technology is low (DAWR, 2009a).

In 2005, about 80 per cent of total treated wastewater was distributed to El-Rakeya and El-Refaa farms for growing fodder and to Doha for landscape irrigation; the remainder was discharged into an emergency lake at Abu Nakhla area (Figure 2.5). Treated wastewater using tertiary level treatment of municipal wastewater was found to be adequate for irrigating ornamental plants and growing fodder. The recycled wastewater may also be suitable for irrigating trees. However, a more advanced treatment technology would be required for irrigating vegetables and other crops for human consumption,

or for recharging groundwater aquifers. The potential of treated wastewater has therefore not been fully captured and efforts are being taken to upgrade wastewater treatment facilities in Qatar (Al Mohannadi, 2009).

Figure 2.5 Use of Treated Wastewater, Qatar, 2005



Source of data: Amer and Abdel-Wahab, 2009

Distribution Networks and Storage Capacity

The consumption of potable water is concentrated in the Greater Doha area. Water is transmitted to consumers through water mains or water tankers. The water distribution system in Qatar is primarily controlled from a Telemetry Control Center in Doha. This Center controls production, pumping, storage and flows through wireless links and telephone lines. The Qatar General Electricity and Water Corporation (KAHRAMAA) is currently studying future network requirements and plans to manage the network as two regions: the Northern Region served by the Ras Laffan plants and the Southern Region served by the Ras Abu Fontas plants.

Water to rural areas is supplied from potable stations or well fields. KAHRAMAA's policy is to keep water tankers outside the Greater Doha area wherever possible, and increase the usage of tanker filling stations on the outskirts of the city.

In 2004, the water networks covered 97 per cent of the dwellings in Doha, 86 per cent in Wakra, 85 percent in Al Rayyan, 60 per cent in Al Ghuwairiya, 1 per cent in Al Shamal, and 2 per cent in Al Khor. By 2004, 83 per cent of buildings in Qatar were connected to the water network, but this proportion rose to 97 per cent in Doha (Amer and Abdel-Wahab, 2009). As more areas are covered by the water network, the percentage of customers served by water tankers declined steadily from 6.3 per cent in 2004 to 4.9 per cent in 2007 (KAHRAMAA, 2008).

Although the water networks are constantly being expanded, consumer demand has been rising steadily and considerable numbers of residents are not yet connected. In 1971, there were 9,500 consumers but by the end of 2007 this number had increased to 151,486 (KAHRAMAA 2008). The growth of the distribution mains systems has led to a reduction in water supply by tankers to urban areas. However, the number of water tankers serving rural areas has increased, rising to 2,133 in 2007.

Water storage capacity is currently insufficient to provide full water security

Qatar uses various means of water storage including reservoirs, ground tanks, elevated tanks and water towers (Table 2.2). The growth of water storage from 2003 to 2007 mirrors the growth pattern of the number of consumers over the same period. Water storage capacity is currently estimated to be slightly less than 2.0 million m³, which is insufficient to provide full water security. Storage capacity is being expanded to improve water security and to diminish Qatar’s vulnerability in the event of a crisis. KAHRAMAA plans to increase water storage capacity to 2.2 million m³ per day by 2013 (KAHRAMAA, 2008).

Table 2.2	Water Storage Capacity in Qatar, 2007	
Storage Facility	Storage Capacity (m ³)	Percentage
Reservoir	1,927,542*	97.2
Ground Tank	25,167	1.3
Elevated Tank	2,987	0.1
Water Tower	27,640	1.4
TOTAL	1,983,336	100

* Excludes non-operating reservoir under refurbishment or maintenance
 Source: KAHRAMAA, 2008

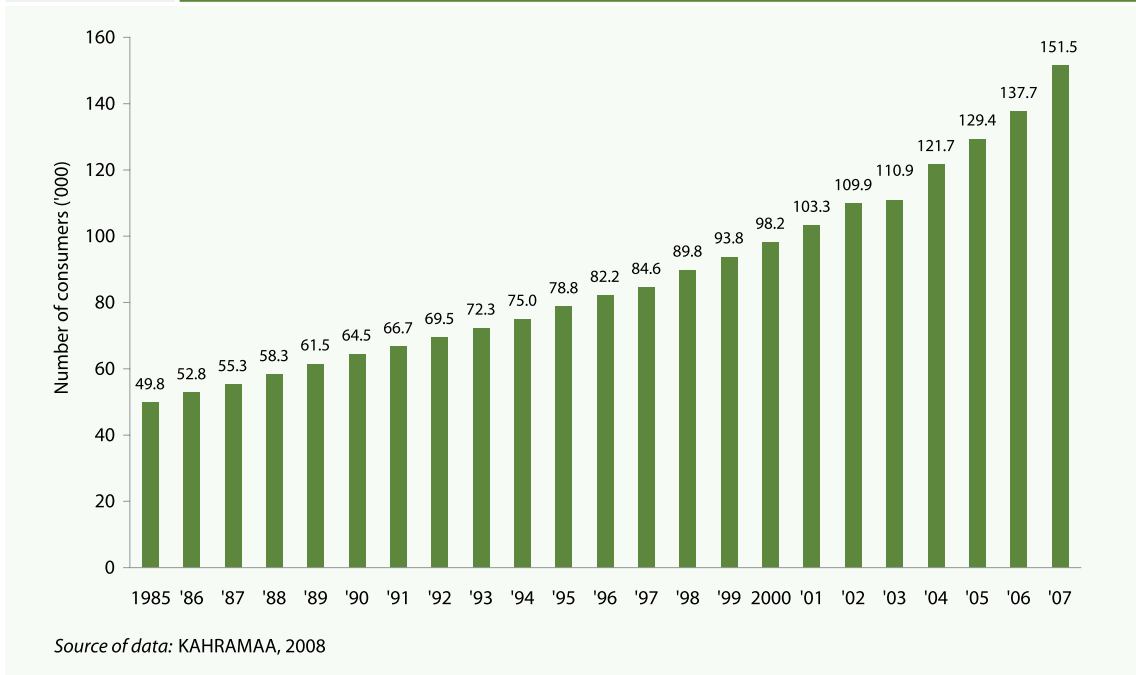
Emerging Risks and Vulnerabilities for Qatar: A Case for Action

Unsustainable levels of water extraction will markedly affect the natural ecosystem, with a profound impact on the future availability of water resources. The environment has a natural absorptive self-cleaning capacity that when exceeded, will result in loss of biodiversity, livelihoods and natural food sources. In a water-stressed country such as Qatar, there are many challenges to ensuring a constant supply of water to meet increasing consumer demand. Given the dependence on desalinated water, the long lead time required to scale up production, as well as the limited water storage capacity, Qatar is vulnerable in times of crises or in emergency conditions, such as in the event of a serious oil spill in its waters.

Water Security: Wastage and Consuming Beyond Sustainable Means

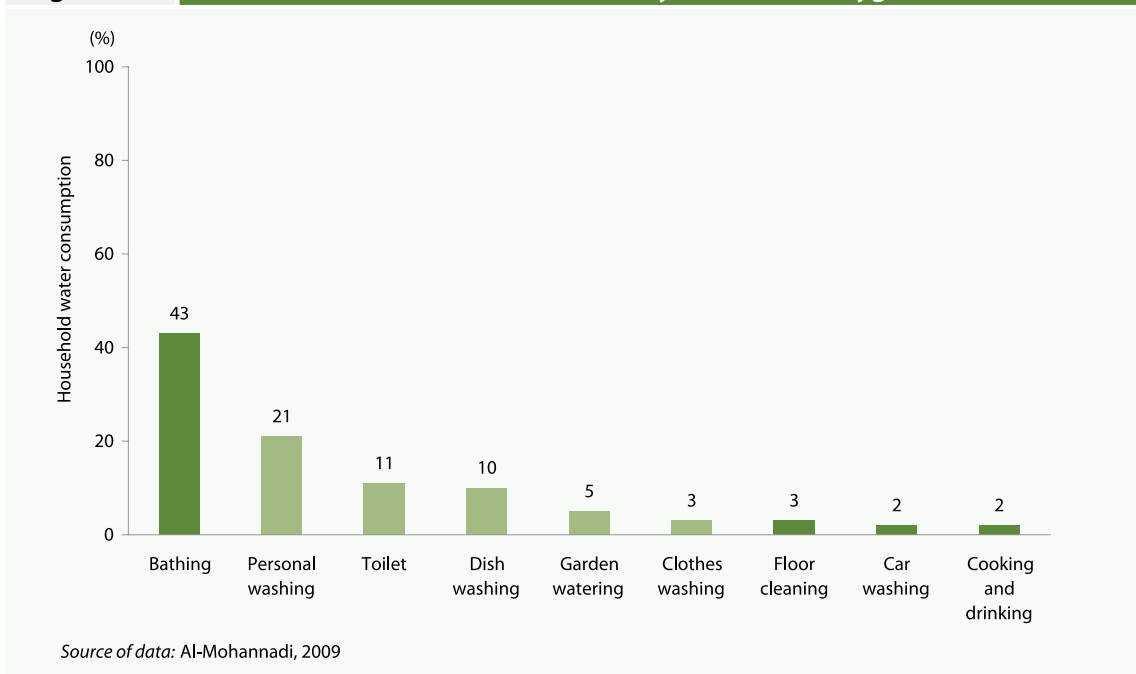
Sustainable development of water resources in Qatar is impeded by a number of factors, most notably a chronic water scarcity and rapid population growth. Qatar’s rapid population growth, averaging 16 per cent per year between 2005 and 2008, is virtually unprecedented historically and globally, and stems from the big demand for expatriate workers to support many large-scale development projects. This sharp increase in the number of consumers is posing a threat to water security in Qatar (Figure 2.6).

Figure 2.6 Desalinated Water Consumers in Qatar Growing at 5 Per Cent Annually



Higher standards of living are also changing water demand patterns. This is reflected mainly in increased domestic water use, especially for personal hygiene (Figure 2.7)

Figure 2.7 Households in Qatar Use Water Mainly for Personal Hygiene



The cost of desalination and distribution is largely borne by the government as Qatari nationals do not pay for the water they consume and non-Qataris pay a subsidised price. In 2005, water tariffs were revised for non-Qataris to Qatari Riyal (QR) 4.4 per m³ for residential and industrial sectors, and QR5.2 per m³ for commercial and tourist sectors. In 2003, the cost of production of one m³ of desalinated water was about QR6.0 per m³ while the operation and distribution cost reached about QR4.0 per m³. In 2003, government subsidy for this sector amounted to QR829 million, of which 63 per cent went to Qatari residents (Table 2.3). Consequently, there is little awareness of the extreme scarcity of potable water or of the substantial cost in producing desalinated water, and therefore no incentive to curb use.

There is little awareness of the scarcity of water or the substantial cost in producing desalinated water and therefore no incentive to curb use

Table 2.3 Water Consumption and Government Subsidy in Qatar, 2003

Sector	Subsidy Per Unit (QR per m ³)	Total Consumption (million m ³)	Total Subsidy (QR million)	Percentage Distribution of Subsidy
Residential (Qatari)	10	52.3	524	63
Residential (non-Qatari)	5.6	24.6	138	17
Commercial	5.6	10	56	7
Government	10	3.6	36	4
Industrial	5.6	13.4	75	9
TOTAL	8.0	103.9	829	100

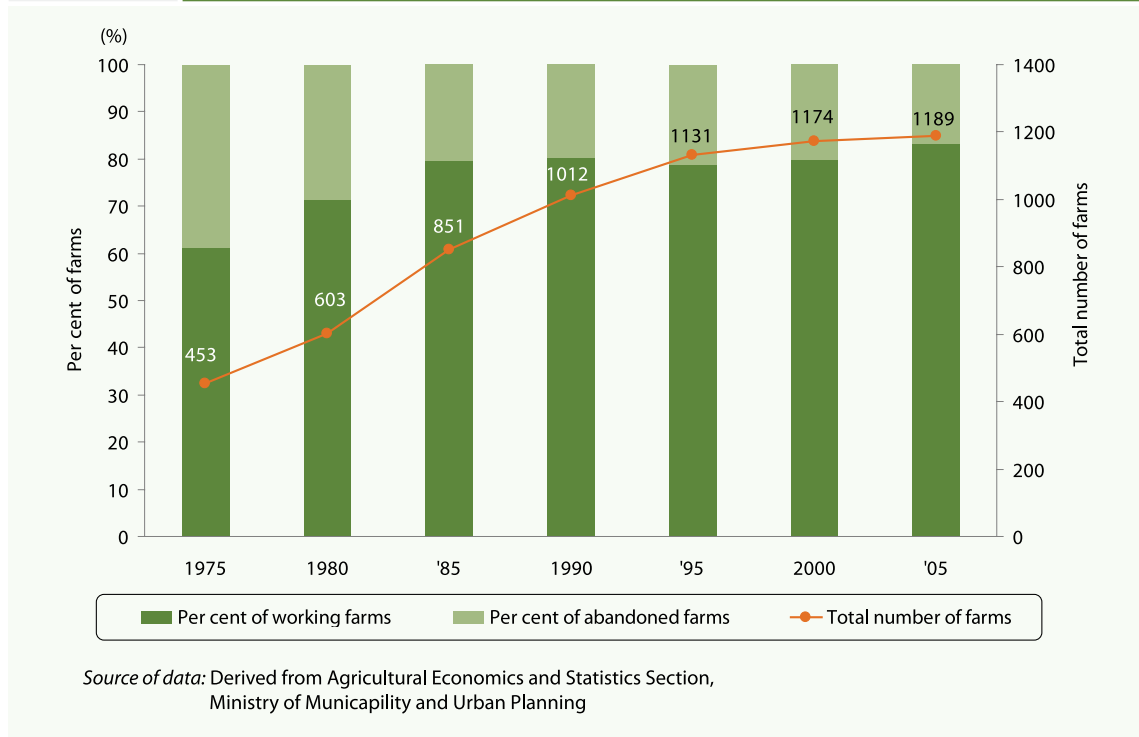
Note: Figures are independently rounded

Source: Al Mohannadi, 2009

Since water for irrigation is free, although farmers must pay pumping costs, and the prices of diesel and electricity are minimal, the farming community is relatively immune to the urgency of water conservation and management. Consequently, the pressure on water resources continues, and the reserves of groundwater are steadily being reduced. This not only results in the depletion of groundwater resources but also in deterioration of water quality and the abandonment of some farms (Figure 2.8).

The issue of a rising water table (the upper level of an underground surface in which the soil or rocks are permanently saturated with water) is also posing a problem in many parts of Doha as a result of water-main leakages (Amer and Abdel-Wahab, 2009). Most water leakages occur because of the corrosive soil, poor installation techniques and maintenance, and improper design. In 2007, estimated losses from water transmission and distribution amounted to about 45 per cent of total water consumption (KAHRAMAA, 2008). There is some speculation that these leaks help to replenish the groundwater aquifer and also contribute to the high water table in the Doha area. Plans are in hand to reduce leakage to a more acceptable 15 per cent, but implementation must compete with continuing demands for expansion of the network.

Figure 2.8 Rising Number of Farms in Qatar with the Proportion of Abandoned Farms Stabilising



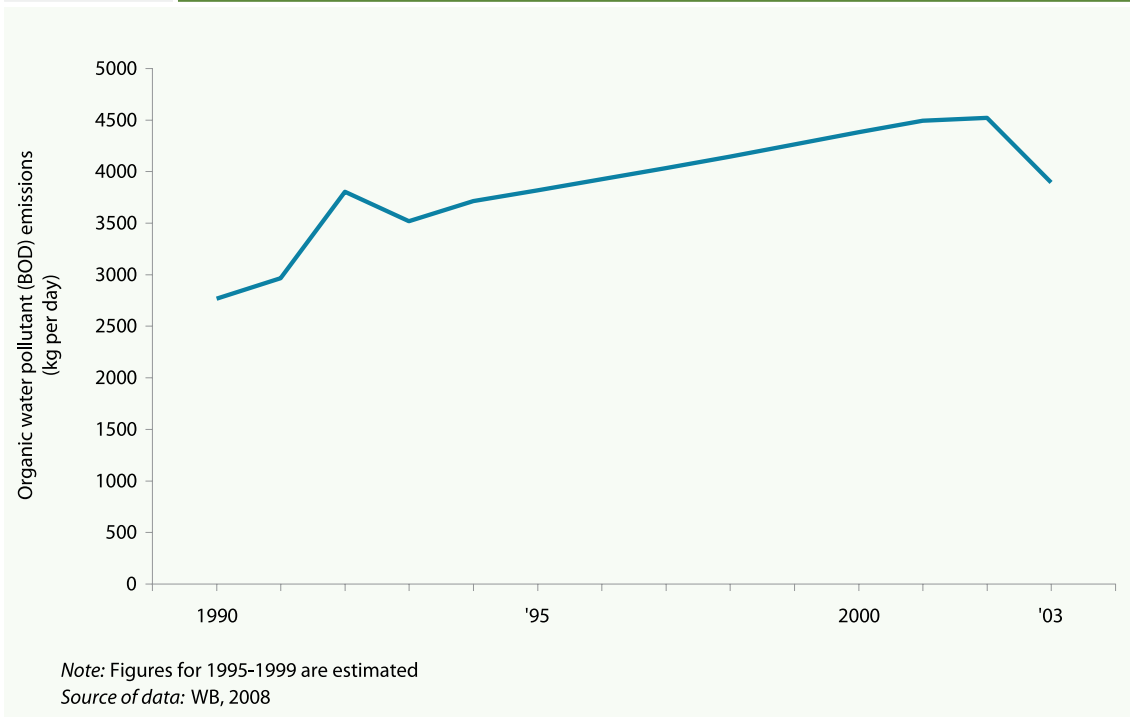
Water Quality: Monitoring Health Hazards

Water pollution has an impact on human health, the cost of drinking water and aquatic ecosystems. This is caused by wastewater discharged by households and industries and from fertilizer use in agriculture and livestock rearing. Water pollution can also arise from poor quality water distribution networks.

The rate of extraction of groundwater is commonly several times greater than the rate of recharge of the aquifers, resulting in serious water quality deterioration in the northern and southern groundwater basins (Amer and Abdel-Wahab, 2009). Overuse of groundwater for agriculture is resulting in the deterioration of water quality, sea water intrusion, destruction and pollution of aquifers, increase in cost of pumping and hence decrease in available freshwater for various uses.

Contaminated water poses both a threat to human health and to a variety of aquatic organisms including fish. Globally, diarrhoeal diseases are largely responsible for morbidity and mortality among children. Even without fatal consequences, children's development and education can be disrupted by frequent diarrhoeal episodes. Three important indicators of water quality are (i) the presence of faecal coliforms in freshwater, (ii) biochemical oxygen demand in water bodies (BOD) and (iii) wastewater treatment. BOD measures the amount of oxygen required or consumed for microbiological decomposition of organic material in water. A low level of BOD indicates high water quality. Figure 2.9 shows that the trend in water quality in Qatar, as indicated by BOD emissions, appears to have deteriorated.

Figure 2.9 Water Quality in Terms of BOD Emissions Appears to Have Deteriorated



Increasing Water Demand Placing Pressures on Natural Ecosystem

Water consumption in Qatar is exerting pressures on its natural ecosystem. Measures taken to cope with water scarcity and increasing water demand have contributed to serious ecological problems that encompass loss of biodiversity and desertification.

Continued over-exploitation of the fossil groundwater reserves threatens the remaining supply with saltwater intrusion, and overuse of this groundwater for agriculture has resulted in the disappearance of many springs, localised salinisation and land degradation. Improvement in technology and management is required if groundwater is to be conserved and continue to be available for irrigation in the requisite quantities in the future. Present indications are that, given the existing level of agricultural development, the demand for water for irrigation cannot be met from groundwater resources alone.

With rapid population growth expected to continue along with expansion in industrial and commercial activities, resource managers in Qatar will increasingly be looking for alternative means of meeting the growing demand for potable water. Satisfying the demand by seawater desalination may still be the best solution. All desalination plants in the country adopt internationally recognised environment-friendly technology as they use natural gas as a source of energy for the desalination process. But critics continue to point out the substantial economic and environmental costs of desalination (Box 2.4).

Box 2.4**Seawater Desalination: Balancing the Pros and Cons**

Desalination plants have the potential to adversely affect the environment in a number of ways. To achieve ready access to feedwater, desalination plants are generally located as close as possible to the sea which results in significant impact on coastal environments. Inshore seawater provides the habitat for a large variety of marine or aquatic life and appropriate intake design can mitigate many of the potential impacts on larger life forms, but the inevitable long-term impact is the destruction of small life forms such as plankton, eggs and fish larvae that are critical to the maintenance of fish stock and other marine life.

Because the predominant multi-stage flash (MSF) distillation method of desalination is a thermal process, the heavily concentrated brine solution discharged from the desalination plant is commonly at high temperatures, raising concern over the critical concentrate parameters of temperature, density and total dissolved solids. The concentrate may also contain low amounts of the chemicals used during the pre-treatment and post-treatment cleaning processes that can potentially be a lethal mixture for marine organisms. Although the brine solution contains the natural ingredients of seawater it may damage marine life because of the unnatural concentrations near the outlet. A related concern is that chemicals from the pre-treatment process and from periodical membrane cleaning can harm the habitat. For example, the use of biocides such as chlorine, which is used to clean pipes or to pretreat the water, can be harmful and needs to undergo treatment before being released into the sea in order to minimise ocean acidification.

The terrestrial impact of the utilisation of land by the seashore for desalination is also significant – creating an industrial zone and excluding other desirable functions such as recreation or tourism. More serious is the potential contamination of groundwater aquifers in proximity to desalination plants. Risks of damaging and polluting these groundwater aquifers occur during the drilling process to install feedwater pumps; through leakage from pipes carrying feedwater into the desalination plant; and from the highly concentrated brine being discharged from the plant percolating underground. To prevent this it is essential that plants deploy sensors and monitoring devices, and workers should be required to notify plant operators if leaks develop in the pipes.

One of the main environmental considerations of ocean water desalination plants is their impact on Qatar's environment, especially when such plants are co-located with power plants. The intake of ocean water and the wastewater discharge from the desalination process can cause damage to Qatar's marine ecosystem and biodiversity. Other environmental concerns include air pollution and greenhouse gas emissions from power plants that supply energy to the desalination plants.

Additionally, treated wastewater that does not meet acceptable standards is discharged, posing a real threat to the environment. For example, the discharge of 10,000m³ per day of treated wastewater in the Abu Nakhla area, west of Doha, has resulted in a swamp where insects and rodents multiply. In 2005, this swamp reached its maximum capacity resulting in floods in the neighbourhood (Al Mohannadi, 2009).

Wasting Water: Poor Agricultural Practices Leading to Desertification

Qatar has suffered from livestock grazing above the ecological carrying capacity (Richer, 2008). In 2005, there were 987 working farms occupying about 39,706ha. Owing to over-grazing of the extensive areas of grassland that once covered much of Qatar, there has been a reduction in plant species and grasses have largely been replaced by perennial shrubs that are thorny, toxic and generally unpalatable. The shift from traditional rangeland management has resulted in a relatively barren landscape that reflects the decrease in vegetation density. The loss of vegetation cover and edible plant species has contributed to the loss of much of the diverse wild animal life, an increase in wind erosion and a decrease in soil fertility and species diversity. The disappearance of the springs that constituted natural oases has destroyed an important habitat for mammals, birds and reptiles including some rare and endemic species.

Water Stress in a Warming World

Qatar is vulnerable to climate change impacts. If sea levels rise, coastlines and marine life may be affected, more land degradation will occur and freshwater levels will fall due to seawater intrusion. And if temperatures rise, water demand will increase but rising underground water salinity and falling freshwater levels will threaten water security and affect the efficiency of desalination plants (Raouf, 2008). However, although Qatar lacks arable land, water resources, forests and green areas, the coastline and several hundred square kilometers of *sabkha* (salt flats) can potentially be used for seawater irrigated mangrove forests, which could serve as carbon sinks.

Managing Risks and Vulnerabilities: Wiser Management Means More Water

Better water resource management is the key to managing the risks and vulnerabilities related to water security. In the short term, more efficient use of water could dramatically expand available resources, but more efficient technology alone will not be sufficient. With increasing competing demands on water resources, difficult policy choices will have to be made that reallocate water among users and sectors. Water resource management clearly impacts on many policy areas such as energy, environment, economy, health and food security. Thus adaptation and mitigation options need to be conducted across multiple water-dependent sectors, supported by a more aggressive and less fragmented approach to water governance.

Better water resource management is key to managing the risks and vulnerabilities related to water security

Global Response to the Water Crisis

While the history of the development of international water policies could go back further, the best starting point is the Dublin Conference of 1992 (UNESCO-WWAP, 2003) from which emerged the Dublin Statement on Water and Sustainable Development which contributed to the preparation of the Earth Summit in Rio. The four Dublin Principles remain at the cornerstone of much debate on international approaches to water policies:

- Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment.
- Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

- Women play a central part in the provision, management and safeguarding of water.
- Water has economic value in all its competing uses and should be recognised as an economic good.

Since then, there has been a proliferation of conferences dedicated to water and two international partnerships have emerged, namely, the World Water Council and the Global Water Partnership. Recognising that water is essential for life, the United Nations General Assembly, in December 2003, proclaimed the years 2005 to 2015 as the International Decade for Action 'Water for Life' to promote efforts to fulfill international commitments made on water and water-related issues by 2015 (Box 2.5).

Box 2.5 International Decade for Action, Water for Life, 2005-2015

The International Decade for Action, 'Water for Life', 2005-2015 was launched on 22 March 2005. The primary goal of the 'Water for Life' Decade is to promote efforts to fulfill international commitments made on water and water-related issues by 2015. These commitments include the Millennium Development Goals (MDGs) to reduce by half the proportion of people without access to safe drinking water by 2015 and to stop unsustainable exploitation of water resources. At the World Summit in Johannesburg in 2002, two other goals were adopted, namely, to aim to develop integrated water resource management and water efficiency plans by 2005 and to halve, by 2015, the proportion of people who do not have access to basic sanitation.

Among the themes that are central for the 'Water for Life' Decade are: scarcity, access to sanitation and health, water and gender, capacity building, financing, valuation, integrated water resources management, transboundary water issues, environment and biodiversity, disaster prevention, food and agriculture, pollution and energy. A special emphasis will be placed on ensuring the involvement of women in these development efforts. Achieving the goals of this International Decade will require sustained commitment, cooperation and investment.

UN-Water, the United Nations inter-agency mechanism of all relevant agencies, departments and programmes involved with water-related issues is coordinating the 'Water for Life' Decade.

Source: UN-Water, accessed February 2009 [<http://www.un.org/waterforlifedecade/index.html>]

At the regional level, water security is being threatened by water scarcity, rapid population growth and increasing demand. The discrepancies among countries in terms of economic affluence, *per capita* share of fresh water and diversity in water use constitute major challenges (ESCWA, 2007). Excessive water exploitation (particularly in the agricultural sector), and water pollution (mainly as a result of sewage pathogens, industrial waste and agricultural effluents) represent serious threats to human health and further aggravate water scarcity by reducing the availability of clean water. Several regional initiatives are underway to build capacity at the local level in integrated water management and to improve cooperation in the management of water resources, with particular attention given to countries sharing water resources (Box 2.6).

The Arab Water Council (AWC)

The AWC is a non-governmental organisation dedicated to coordinating efforts for integrated water resource management (IWRM) in the Arab World. It aims to represent the regional views of the Arab region at international and global forums, advocating for Arab water rights. Its key priorities include:

- Assessing and monitoring the water resource situation in the Arab region;
- Offering technical assistance on water management and ensuring policy coherence between countries;
- Promoting knowledge sharing through dissemination of information and facilitating exchange of expertise; and
- Assuring the appropriate participation of stakeholders in decision making processes and equitable sharing of benefits.

The Arab Integrated Water Resource Management Network (AWARENET)

AWARENET is a regional network of training and research institutes, NGOs, government authorities and experts in the field of water working on IWRM. The aim of the network is to better provide the public with water and sanitation services, protect precious water resources and the environment, and promote socio-economically constructive uses of water by improving the implementation of IWRM concepts in the countries of the Arab region. In this context, AWARENET provides training programmes to enhance knowledge on IWRM and runs a scientific research grant programme to strengthen research capacity of member institutions in the field of sustainable water resource management.

UNDP Water Governance Programme for Arab States (WGP-AS)

The WGP-AS was launched at the end of 2008 to improve the effective use and management of scarce water resources in Arab countries. It aims at supporting the achievements of the Millennium Development Goal 7 (MDG 7) particularly with respect to improved water supply and sanitation, by promoting an integrated approach to water resources management in the Arab Region.

The WGP-AS is composed of the following main four components:

- Integrated water resources management;
- Local management of water resources, water supply and sanitation;
- Capacity building and institutional strengthening; and
- MDG 7 water targets monitoring and State of the Water Report for the Arab Region.

In addition, the WGP-AS is addressing cross-cutting dimensions including adaptation to climate change, transboundary water management, gender mainstreaming and awareness raising. The WGP-AS will provide the following support to countries and regional partners:

- Technical and policy advise;
- Capacity building;
- Knowledge management; and
- Catalytic funding for project development and implementation.

Water Resource Management in Qatar

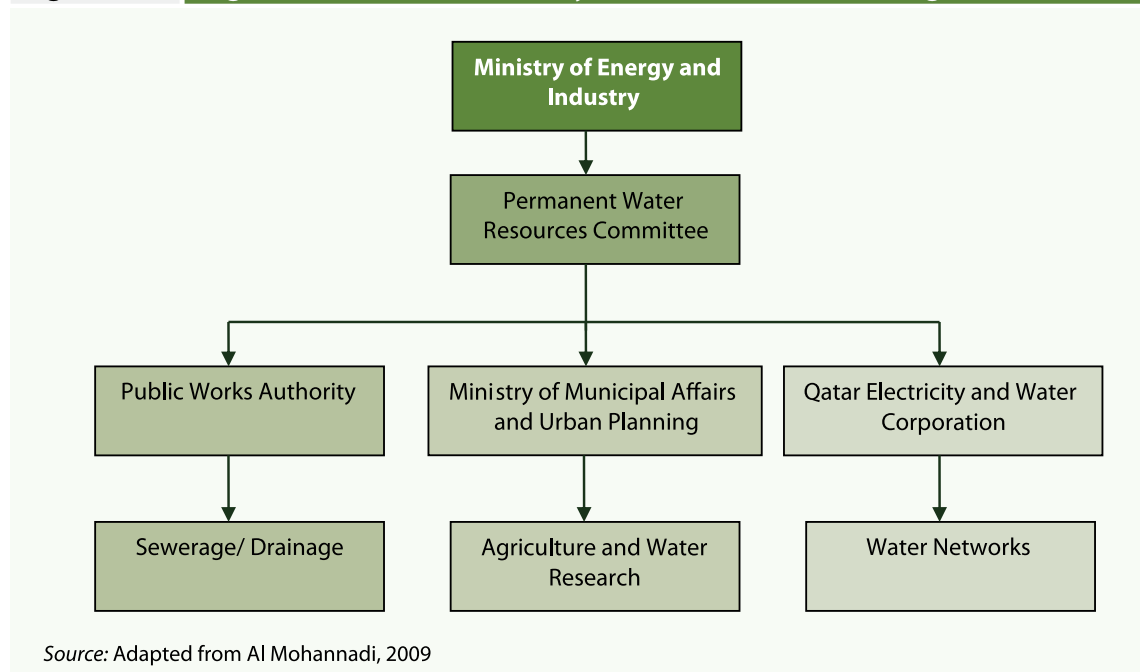
Qatar is actively working towards effective and integrated management of its scarce water resources. Water policies, plans and projects focus on the rationalisation of available water resources in parallel to strategic investments to increase water production. Further steps were also taken towards reorganising its institutional set-up to create an enabling environment for enhanced and integrated water resource management.

The main ministries and institutions responsible for water development, planning and management in Qatar are summarised in the figure below (Figure 2.10). The Ministry of Municipal Affairs and Urban

Planning is responsible for the management of groundwater use in agriculture; the Public Works Authority is responsible for the collection of wastewater, waste treatment and the distribution of treated wastewater to the farms and for landscaping; and the Qatar General Electricity and Water Corporation is responsible for providing desalinated water for drinking and industrial uses.

In April 2004, the Permanent Water Resources Committee (PWRC) was established under an Emiri decree via the Decision No. 7/2004 of the Council of Ministers to develop a long term water strategy for Qatar. The PWRC launched a long-term programme for integrated water resource management in Qatar, which involves the formulation of a comprehensive National Water Resources Management and Development Strategy with a planning vision up to the year 2050.

Figure 2.10 Organisation Structure: Primary Water Resources-Related Agencies in Qatar



To protect groundwater resources from excessive use, Qatar enacted Law No. 1 of 1988. However, this law has not been effectively enforced and failed to achieve its objectives (Al Mohannadi, 2009). To address the problem of underground water deficit, Qatar introduced a 'Recharge Project' which involved digging wells to recharge groundwater resources. The results have so far not been encouraging. The project also involved digging deep wells to explore water quality. Again, the results were not positive as the aquifer yield was very low.

Qatar was also the pioneering state in the region to use treated wastewater. A five year plan (2005 – 2009) was developed to improve on this sector through the implementation of 44 projects with a total cost of QR7 billion (Al Mohannadi, 2009). This five-year plan outlines the need to improve the quality of treated wastewater to be used for general irrigation. It also emphasises the need to expand capacity and adopt anti-bacterial, anti-fungal systems for the first time in Qatar.

In the early 1990s, attempts were made to increase water supply by importing water from neighbouring countries, transported through pipelines (Al Mohannadi, 2009). Several projects such as the 'Peace Pipeline Project' and the 'Green Pipeline Project' were launched. However, the projects were hindered by political instability in the region, technical difficulties and economically unjustifiable high costs. There was also concern that reliance on imported water could pose a threat to national security.

Beyond Scarcity: Providing Water for Life in Qatar

In addressing water security concerns, Qatar needs to combine steps to conserve and manage water demand and supply better

The state of water resources in Qatar is determined by the availability of water, the demand for water and the institutional set-up for the management of scarce water resources. In addressing water security concerns, Qatar needs to combine steps to conserve and manage water demand and supply better.

Augmenting Supply: Every Drop Counts

For many countries the issue of water supply is mainly one of managing the resource in order to redistribute it spatially and seasonally to meet demand. For a water stressed country like Qatar, this strategy is difficult and other strategies must be adopted. Importation of bulk water by pipeline or ship offers a redistribution mechanism that is sometimes adopted but is expensive, depending on distances traversed, and vulnerable to discontinuity of supply and political intervention. Hitherto Qatar has found this option unfeasible.

Desalination appears to be the best option. While the major constraint on commercial desalination globally has been the cost of energy, Qatar is energy-rich and has been able to reduce production costs and expand production through adopting new technologies. However, to safeguard its sustainable use, innovative desalination technologies that minimise both cost of water production and the environmental impact should be further investigated. Different technical options exist including advanced systems for the intake of the seawater and the diffusion of the waste product, wastewater treatment technologies and the use of cheaper, more efficient energy sources such as natural gas or renewable energy. The benefits of such an innovative approach are already evident in the cooling seawater pulse-chlorination project by Qatargas Operating Company which reduces the amount of chlorine discharged into the sea.

Innovative desalination technologies that minimise both cost of water production and the environmental impact should be further investigated

Qatar is exploring the use of desalination technologies powered by renewable energy systems including solar energy. Qatar's National Family Safety Programme is working to develop a solar energy-powered desalination plant to provide the additional clean water required for agricultural expansion. The linkage of solar energy, desalination, agricultural development and simultaneous augmentation of water security will allow Qatar to establish the global reference project for 'green' agriculture policy for arid states worldwide. However, the use of solar energy as a main source for desalination is still at an early stage of development.

Qatar is also exploring the potential of submarine freshwater springs (a spring of water issuing from the bottom of the sea) as an additional source of water supply. The Ministry of Environment has completed Phase I of a study to identify submarine springs in Qatar with some positive indications. Phase II of the global exploration will use dedicated maritime tools to investigate selected locations in order to determine the flow, origin and quality of water.

Some simple water management policies allied to appropriate technology can also help to meet the gap between water supply and demand (Box 2.7). These supportive measures offer opportunities for greater efficiency in the use of water and the promotion of human development.

Groundwater recharge

There is considerable potential for the enhancement of groundwater recharge from rainfall: increasing rainfall replenishment of groundwater aquifers by using drilled wells can increase recharge by up to 50 per cent. This approach was attempted when a decision was made to drill 341 recharge wells in some of the recommended depressions in Qatar. It is anticipated that by utilising the findings of comprehensive evaluations, adopting a regular routine, and developing a maintenance plan to implement a rehabilitation strategy and deal with emergencies, the existing 341 recharge wells can be utilised. By learning from experience and the recorded results, recommendations can be made for a new design and the choice of new locations so that all parts of the country where this is feasible are covered. Such measures would improve the annual recharge by about 50 per cent or about 90 million m³. This contrasts with the scale of rainfall recharge currently which is only about 10 per cent of total rainfall.

In order to maximise recharge of groundwater aquifers from rainfall, recovery from recharge wells could be increased by a cloud seeding process to increase the amount and frequency of rainfall. The cloud seeding process could be performed where and when the conditions are favourable, wells are adequately maintained, types of landscape formation appropriate, and water quality in the bearing formation is worth expanding.

Wastewater for agricultural and industrial use

In areas of arid climate domestic wastewater is increasingly regarded as an important water resource. Development of cost-effective reclamation techniques could further stimulate the use of this potential resource.

Industrial reuse is a general category encompassing water use for a diversity of industries that include power plants, food processing, and other industries with high rates of water utilisation. In some cases, closed-loop recycle systems have been developed that treat water from a single process stream and recycle the water back to the same process with some additional top-up. In other cases, reclaimed municipal wastewater is used for industrial purposes such as in cooling towers.

Technically-proven wastewater treatment and engineered purification processes already exist to produce water of almost any quality desired. The feasibility of using reclaimed water for irrigation is evaluated based on several factors including: salinity, trace elements, and water infiltration rates. Long-term soil exposure to reclaimed water results in increased deposits of nitrogen and phosphorus, while potassium, calcium, magnesium, and sodium tend to be more variable. The cost-effectiveness of using reclaimed water for industrial purposes depends on the point of use relative to the waste treatment plant. In addition, the availability and cost of alternative water sources influences the degree to which reclaimed water is used.

Wastewater storage as groundwater

Groundwater aquifers provide natural storage and the potential for subsurface distribution of water. Recharging groundwater aquifers with reclaimed wastewater is an approach to wastewater reuse that results in the planned augmentation of groundwater resources. The benefits of artificial recharge of groundwater utilising wastewater include:

- Arresting the decline of groundwater levels due to excessive groundwater use;
- Protecting coastal aquifers against saltwater intrusion from the sea;
- Storing water for future use.

Groundwater recharge also occurs incidentally in the process of municipal and industrial wastewater disposal via infiltration.

Dual distribution systems

Dual distribution systems segregate the potable water from the non-potable system. Thus, a high quality system can be provided for drinking water and other high quality uses, and reclaimed water is available for agricultural irrigation, landscaping and fire protection. Dual distribution systems can be developed in two ways. One approach is to construct a city-wide system in which wastewater is returned to a municipal wastewater treatment plant for processing before being redistributed to the population. The second approach is using small-scale individual systems where 'grey water' (wastewater) from sinks, bathtubs, showers and other sources of dilute non-faecal wastewater is treated on site and recycled. Protection of public health is a prime concern in implementation of dual distribution system water reuse. There are conventions that can be adopted for identifying potable and non-potable water pipelines. This differentiation is important, especially for human health; one safety measure is to add a harmless colouring agent to the reclaimed water supply to alert users to its source.

Storage of desalinated water in groundwater aquifers

In recent years the drinking water demand in Qatar has risen dramatically due to growing population numbers combined with a high rate of national development. The production of desalinated water to meet the demand for municipal use is carried out at a number of desalination plants in the country. However the current storage capacity for desalinated water to meet any emergency situation is limited to few days. It was therefore recommended that, in order to meet the strategic needs of the country, the available storage should be expanded. Consequently, it was decided to use the available aquifer storage as an economical, large volume option capable of achieving this strategic goal.

Desalination and storage of highly brackish groundwater

The missing source of water in Qatar is the medium to deep groundwater aquifer (Middle Umm El Radohma) and Aruma aquifers. There is potential for desalinating water from either of these aquifers and directly using it on the ground surface instead of drawing on the shallow aquifers (RUS and Upper Umm El Radohma); or storing the desalinated water in the shallow aquifers for emergency use. This approach would depend mainly on vertical integration between different aquifers.

Zero liquid discharge systems

Because of the undesirable impact of industrial waste on the environment, the regulations for wastewater disposal need to be stricter: minimisation of wastewater and zero liquid discharge (ZLD) are the demanding targets for several applications. Both are normally reached by a combination of several steps in treatment, concentrating and reducing waste, finished off by a thermal process. Implementing ZLD systems helps further alleviate water supply issues.

Source: Derived from Amer and Abdel-Wahab, 2009 and Al Mohannadi, 2009

Managing Demand: Waste Not, Want Not

Water management in Qatar is oriented towards water supply management with inadequate attention given to demand management. Demand-side policies are likely to be more effective in managing water scarcity, risk and vulnerability. Regulating demand for water involves increasing physical productivity or 'more crop per drop' through substituting technology and knowledge for water. Consideration needs to be given to the design of subsidies so that they best promote sustainable or responsible consumption.

In general, under-pricing or zero-pricing sustains overuse, does not reflect the scarcity value of the water, and raises the issue of cross-generational equity (UNDP, 2006). Water pricing needs to reflect the scarcity value of water so that governments do not end up subsidising the depletion of an essential natural resource (Box 2.8). The implementation of fully cost-reflective tariffs could be considered as an effective means for demand and water wastage management.

Water pricing needs to reflect the scarcity value of water so that governments do not end up subsidising the depletion of an essential natural resource

Box 2.8 Valuing and Charging for Water

The importance of water for public health means that governments generally attempt to provide some minimal level of water supply and sanitation services, whether or not the full cost of these services can be recovered from users. There are certain socially and politically determined principles that must be taken into consideration when assessing the value of any water policy or programme:

- *Economic efficiency:* Given the growing competition for freshwater, making more efficient use of the resources available is critical. Efficiency contributes to equity to the extent that if some users are discouraged from wasteful use, more water will be available for others.
- *User pays:* Consumers should pay an amount equivalent to the burden that their consumption places on society. This social cost includes both the capital, operating and maintenance expenditures to keep the system operating, and also the opportunity costs. It would also include the costs of damage resulting from the water pollution imposed on society – the ‘polluter pays’ principle.
- *Water security:* Often perceived to conflict with the ‘user-pays’ principle, water security holds that resources should be distributed according to need. All individuals have the right to adequate, reliable and affordable supply of potable water. Water is usually regarded as a ‘merit good’, meaning that in certain cases, people deserve more water than they are willing or able to pay for.

Criteria applied to tariff-setting

Multiple criteria influence policy decisions on how to finance water services and how much revenue to collect from beneficiaries. In addition to the goals of safe and affordable water for all and maximum net social benefits, the following criteria are important in the implementation of any charging plan:

- *Financial sustainability,* requiring the collection of sufficient revenue to meet present and future financial obligations.
- *User pays principle,* which implies that charges should attempt to recover full costs.
- *Simplicity,* which means that the selected tariff plan should be open, understandable and straightforward with users able to see how usage patterns affect the amount payable.
- *Transparency,* enabling consumers to understand how their own tariffs and those of other user classes are set, and
- *Predictability,* permitting customers to reasonably anticipate and plan for their water-related expenses.

Although previously water was widely regarded as a public good to be made available to all without charge and financed from public revenues, policy is changing to one of full cost recovery based on the principles of fairness and sustainability, except where poverty is an issue. Less well-off customers may be charged according to ability to pay rather than full costs.

Source: Derived from UNESCO-WWAP, 2006

Under the current distribution system for desalinated water in Qatar, the cost to the state is substantial with relatively little cost recovery. Since consumers are little affected by the cost of production, water tends to be used with little restraint which results in considerable wastage. In effect, the government of Qatar is subsidising the depletion of a precious natural resource and transferring the costs to future generations.

Public awareness therefore could be one of the most effective measures for mitigating water-related hazards. Proper education and training programmes could result in considerable water saving, primarily through behavioural change and good practices such as collecting rainwater. In fact, Qatar has launched several innovative public awareness, training and education programmes on conserving water resources through various ministries and agencies, the private sector and non-governmental organisations. However, these campaigns are *ad hoc* and not tailored to the needs of different user-groups. A continuing long-term awareness programme needs to be instituted taking into account the socio-economic and ecological dimensions prevalent in Qatar (Al Mohannadi, 2003).

Education and training programmes could result in considerable water saving primarily through behavioural change and good practices

Managing Uncertainty: Integrated Water Resource Management

In order to manage uncertainty related to scarce water resources, Qatar needs to realign supply and demand within the frontiers of ecological conservation, water availability and sustainable development. Qatar needs to develop short-term, medium-term and long-term investment plans, complemented by operational plans that address water supply, sanitation and recycling networks, based on a comprehensive review of future water resources and demand projections.

There are four basic ingredients for success with national water plans (UNDP, 2006):

- Establishing clear goals and benchmarks for measuring progress through a national water policy;
- Ensuring that policies in the water sector are backed by secure financing provisions in annual budgets and in a medium-term expenditure framework;
- Developing clear strategies for overcoming structural inequalities based on wealth, location and other factors; and
- Creating governance systems that make governments and water providers accountable for achieving the goals set under national policies.

At the heart of this lies political leadership. Water resource issues are complex and transcend the water sector to form part of the wider challenge of achieving sustainable development. Responsibility for water resources is typically disaggregated across several line ministries and agencies, each dealing with wider issues. In Qatar, the absence of integrated water administration and management structures pose serious problems; the existing institutional arrangements are too complex and prone to competition and inefficiency. PWRC could serve as a political structure capable of overcoming the risk of fragmentation of policy and the resultant under-resourcing.

To be effective, Qatar's national water master plan should be evidence-based. The absence of adequate and accurate water data precludes development of prediction models that would enable water resource assessments and calculation of water demand and supply projections. This should be supplemented with relevant human capital development. In this context, Qatar should perform a self-assessment of its knowledge base, existing capacity and capacity needs.

To secure buy-in by all producers and consumers, water management requires active and consistent consultation with all relevant institutions and stakeholders, including the private sector and civil society. Qatar's national water plan should adopt a bottom-up approach. Public participation in developing water policies is important to facilitate implementation and monitoring of these policies. Such a participatory approach will promote transparency and translate into greater accountability for and responsibility towards water conservation practices by the public.

Qatar's national water plan should adopt a participatory approach and be evidence-based

Mitigating Climate Change for Water Security

Climate change is transforming the nature of water security in Qatar through its implications for the water cycle. As a result of global warming, water stressed areas will get less water, and water flows will become less predictable and more subject to extreme events (UNDP, 2007).

Actions to ensure that the needs of the environment are taken into account as a central part of water management are critical if present trends are to be reversed. Mitigation measures can reduce the magnitude of impacts of global warming on water resources, in turn reducing adaptation needs.

Coordination and Integration with Other GCC countries

Given the region's severe water deficit, there are good reasons for at least some of the countries of the GCC to coordinate their efforts in undertaking joint feasibility studies. These might include water importation; research on improved desalination technologies; the use of brackish or saline water in agriculture; sharing a hydro-meteorological information network for water resources; and the development of a shared water resources database.

Conclusion

Qatar, with low rainfall, is water resource poor and water resources are under significant stress for many reasons, especially rapid development and exceptionally high population growth. Water needs far outstrip the availability from natural resources. Limited available water resources and the anticipated increase in water demand pose significant threats to both water security and human development in Qatar.

Qatar's water crisis is essentially a crisis of governance. Better management of water resources is critical to mitigating water scarcities in the future. A key challenge is to encourage a participatory management approach that is capable of prioritising among competing demands, utilising appropriate technologies, regulating and expending the available supply to meet justified demand, within the context of sustainability. A detailed water resources management strategy and a water development master plan would help meet this challenge.

Qatar's water policies, plans and projects need to strike a balance between competing demands for water, increasing water scarcity and ecological considerations, within the broader context of sustainable development. There should be a balance of both supply side and demand side management strategies.

Supply-side considerations include:

- Researching into and adoption of innovative desalination technologies that minimise both the cost of water production and the environmental impact, while relying on alternative/renewable energy sources (for example solar power and so on);
- Developing programmes to optimise and monitor the collection and distribution of water resources from rainfall, groundwater, desalination, aquifers and recycling, and direct each of these to its most appropriate and efficient use;
- Improving the existing water reticulation system by extending it throughout all built-up areas, and adopt modern technology to detect and radically reduce leakage; and
- Expanding the capacity of water storage facilities to ensure the reliable supply of water, especially potable water, for months instead of merely days.

Demand-side considerations include:

- Developing a strategy to manage demand and ensure efficiency of use in all sectors, coordinating and integrating the work of water agencies, eliminating wasteful practices, adopting advanced and appropriate technology, and constraining extravagant or unnecessary consumption;
- Undertaking a comprehensive assessment of real demand based on rational levels of consumption and water qualities, and develop a schedule of forecast annual demand by type of usage (residential, industrial and agricultural); and
- Instigating measures in schools and throughout the community at large to raise awareness of the critical issues of water and efficient utilisation, including raising awareness of the costs of water.

Overall, effective implementation of water strategies and plans necessitates the development of an enabling environment for enforcement through the use of legislation and fiscal measures.

There is a need to consider the extent to which Qatar can sustain such a rapidly growing expatriate population with all the implications this has for housing, basic social services and water and energy consumption

Beyond the measures relating directly to the management of water resources, there is a need to consider the extent to which Qatar can sustain such a rapidly growing expatriate population with all the implications this has for housing, basic social services and water and energy consumption. The recent fall in oil and gas prices from their peak in 2008, provides an opportunity to rethink public investment priorities, and to invest more in quality education and skills training to support the transition to a post-carbon economy for *Advancing Sustainable Development*.

References

- Al Mohannadi, H. I. 2003.** *Controlling Residential Water Demand in Qatar: An Assessment*. Royal Swedish Academy of Sciences 32(5).
- _____. **2004.** *Water Resources in the State of Qatar: Toward Holistic Management*. University of Qatar, Doha.
- _____. **2009.** "Water Resources in the State of Qatar: Shortages and Alternatives." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.
- Amer, K. M. and Abdel-Wahab, A. 2009.** "Water and Human Development in Qatar: Challenges and Opportunities." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.
- DAWR (Department of Agricultural and Water Research). 2009a.** Water Resources in Qatar. Introduced to the Qatar National Food Security Policy Committee.
- _____. **2009b.** Qatar Average Annual Rainfall, 1972-2008. Water Research Section, Agro-Hydro-Meteorological Sub-Section, DAWR.
- _____. **2009c.** Agricultural Land Use Statistics, 1975 – 2008. Agricultural Economics and Statistics Section, DAWR.
- IPCC (Intergovernmental Panel on Climate Change). 2001.** *Climate Change 2001: Impacts, Adaptation, and Vulnerability. A Report of Working Group II of the Intergovernmental Panel on Climate Change*. (B. Metz, O. Davidson, R. Swart and J. Pan, eds.). Cambridge University Press, Cambridge.
- _____. **2007.** *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, eds.). Cambridge University Press, Cambridge.
- _____. **2008.** *Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change*. (B. Bates, Z.W. Kundzewicz and S. Wu, eds.). IPCC Secretariat, Geneva.
- GSDP (General Secretariat for Development Planning). 2008.** *Qatar National Vision 2030*. Doha.
- KAHRAMAA (Qatar General Electricity and Water Corporation). 2008.** *Statistics Report 2007*. KAHRAMAA Publications, Doha.
- QEWC (Qatar Electricity and Water Co). 2009.** *Annual Report 2008*. Doha.
- QSA (Qatar Statistics Authority). 1996.** *Annual Statistical Abstract*. Doha.
- _____. **2001.** *Annual Statistical Abstract*. Doha.
- _____. **2005.** *Annual Statistical Abstract*. Doha.
- _____. **2007.** *Annual Statistical Abstract*. Doha
- _____. **2008a.** *Annual Statistical Abstract*. Doha
- _____. **2008b.** *Digital Atlas of Qatar*. Doha
- Raouf, M. A. 2008** "Climate Change Threats, Opportunities and the GCC Countries." *Policy Brief 12*. The Middle East Institute.

Richer, R. 2008. *Conservation in Qatar: Impacts of Increasing Industrialisation*. Georgetown University School of Foreign Service in Qatar, Doha.

UN (United Nations). 1992. Agenda 21. Programme of Action for Sustainable Development. Official Outcome of the United Nations Conference on Environment and Development (UNCED), 3–14 June 1992, Rio de Janeiro.

UNDP (United Nations Development Programme). 2006. *Human Development Report 2006. Beyond Scarcity: Power, Poverty and the Global Water Crisis*. Palgrave Macmillan, New York.

_____. **2007.** *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World*. Palgrave Macmillan, New York.

UNESCO-WWAP (United Nations Educational, Cultural and Scientific Organisation – World Water Assessment Programme). 2003. *First UN World Water Development Report: Water for People, Water for Life*. UNESCO Publishing and Berghahn Books, Barcelona.

_____. **2006.** *Second UN World Water Development Report: Water, A Shared Responsibility*. UNESCO Publishing and Berghahn Books, Barcelona.

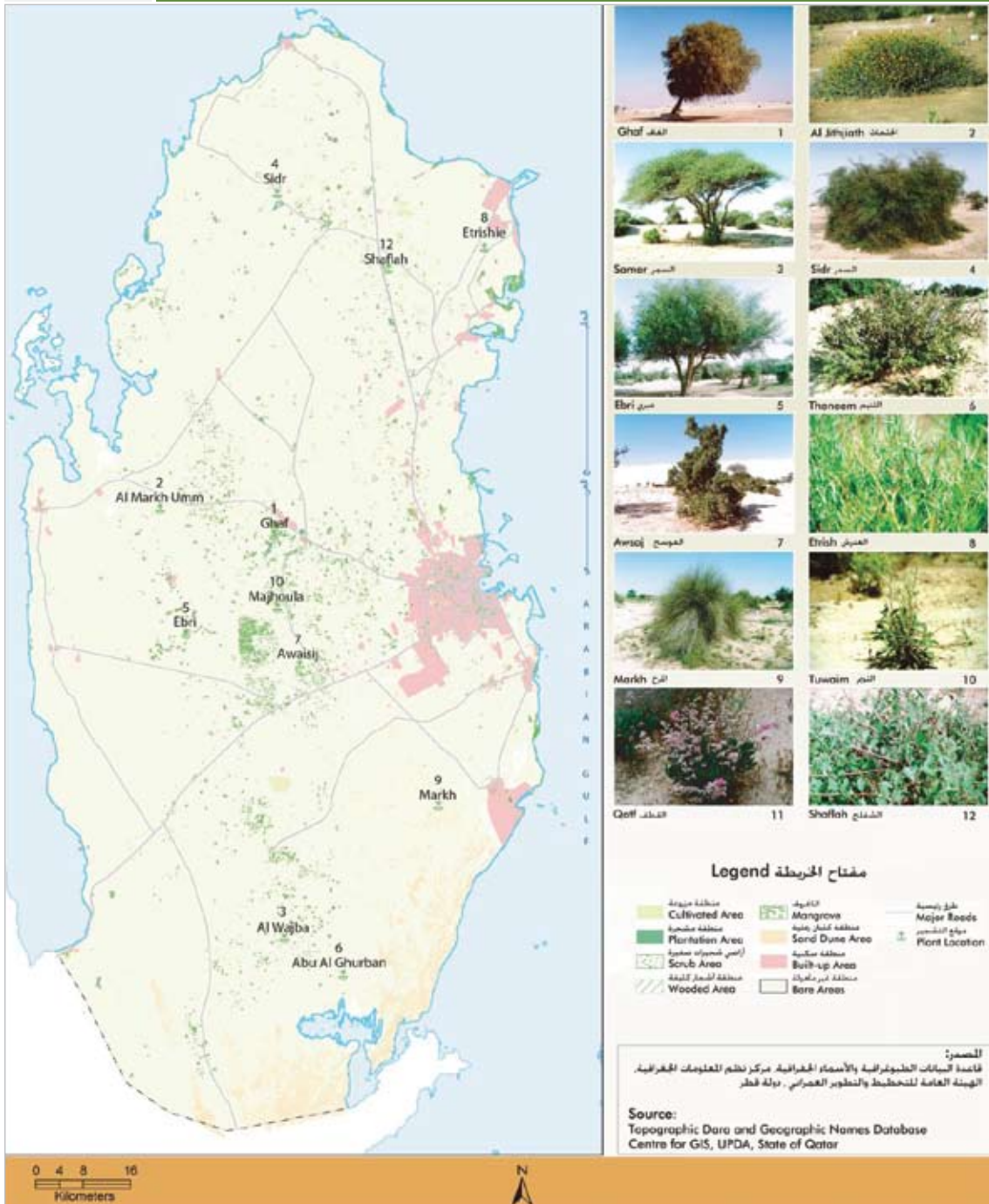
UN ESCWA (United Nations Economic and Social Commission for Western Asia). 2005. *Water Resources Issues in the Western Asia Region*.

_____. **2007.** *ESCWA Water Development Report 2: State of Water Resources in the ESCWA Region*. New York.

WB (World Bank). 2008. *World Development Indicators Online Database*. Washington DC

Marine Environment and Human Development Management and Conservation Challenges

Map 3.1 Natural Vegetation, Qatar



Source: QSA, 2008

Marine Environment and Human Development Management and Conservation Challenges

Economic development and protection of the environment are two demands neither of which should be sacrificed for the sake of the other...The country must also commit to making its future path of development compatible with the requirements of protecting and conserving the environment. Wherever there is an environmental cost to be paid for economic progress, it must be compensated with investments in technologies that help improve the environment

GSDP, 2008

The oceans cover 70 per cent of the Earth's surface and play a vital role in regulating the global environment and promoting human development. Marine environments are among the most productive, yet threatened, ecosystems in the world. Humankind depends on oceans and coasts and their resources for survival. More than one third of the world's population live in coastal areas and small islands that make up just over 4 per cent of the Earth's total land area, and this population is rapidly increasing (UNEP, 2006).

Global climate change and the expansion of development activities in coastal areas and their related catchments are increasingly causing degradation to marine environments. Fisheries are in global decline, coastal habitats have been altered resulting in loss of ecosystem services and biodiversity, and food security and livelihoods are being threatened.

A healthy interconnection between land and marine environments is crucial to achieving Qatar's sustainable development aspirations

Qatar National Vision 2030 recognises the need to protect and conserve the country's marine environment. It is imperative to address and arrest the degradation of its coastal and marine ecosystems so as to ensure greater food security, lower health impacts and sustainable livelihoods for the present and future generations. A healthy interconnection between land and marine environments is crucial to achieving Qatar's sustainable development aspirations.

Marine Environment and Human Development: Interdependent and Indivisible

For the purpose of this Report, the marine environment is divided into two major sets of systems: (i) marine fisheries ecosystem and (ii) coastal ecosystem. Marine and coastal ecosystems provide a wide range of services to human beings (Box 3.1).

Provisioning services

- Provisioning services are the products people obtain from ecosystems such as food, fuel, timber, fibre, building materials, medicines, and genetic and ornamental resources.
- Food provisioning in the form of fisheries catch is one of the most important services derived from marine environments. Overall, coastal and marine fish landings are stagnating or declining largely due to overfishing. Fleets now fish further offshore and in deeper water with greater precision and efficiency, compromising areas that acted as refuges for the spawning of many species of commercial interest.
- Growth in demand for fish as a food source is partly met by aquaculture. While aquaculture on its own will not stem the overexploitation of wild fish catches, the use of fishmeal, especially those derived from already depleted fish catches, will have negative impacts on the trophic (the feeding habits or food relationship of different organisms in a food chain) structure.

Regulating services

- Regulating services are the benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification.
- It has been widely assumed that ocean ecosystems are in a steady state at present but there is now much evidence of large-scale trends and variations. Changes in marine ecosystems, such as increased phytoplankton (microscopic plants that live in the ocean) growth and shifts in species composition, have the potential to alter the oceanic carbon sink. The net impact of biological changes on global carbon dioxide fluxes is yet unknown.

Cultural and amenity services

- Cultural services encompass such things as tourism and recreation, aesthetic and spiritual services, traditional knowledge, and educational and research services.
- Tourism and recreation is one of the most important cultural services provided by marine environments but tourism development without proper planning and management standards and guidelines poses a threat to biodiversity. This is compounded by the fact that environmental impacts are often not clearly visible until their cumulative effects have destroyed or severely degraded the natural resources.
- The seas and coasts and some marine species are of considerable cultural and spiritual importance to many people around the world, although such values are difficult to quantify. Traditional ecological knowledge is an integral part of the dynamics of some island ecosystems and the islanders who live there.

Supporting services

- Supporting services include provision of habitats, photosynthesis and primary productivity, nutrient cycling and fertility, and soil formation.
- A large number of marine ecosystems such as beaches, sandy shores, dune systems, salt marshes, mangroves, estuaries and mudflats provide feeding and nesting habitats to numerous species of birds, fish, crustaceans, and other ecologically and commercially important organisms.
- There has been a substantial loss of estuarine habitat and associated wetlands globally. Many of the world's mangrove areas have also become degraded due to population pressures, widespread habitat conversion and pollution.

Source: Derived from UNEP, 2006

Coastal ecosystems are characterised by high productivity. Coastal inhabitants on average experience higher well-being than those of inland communities, which partly explains the higher rates of population increase in coastal areas (UNEP, 2006). Marine environments are important sources of economic benefits through fisheries, aquaculture, offshore oil and gas, marine tourism, and trade and shipping. Coastal ecosystems also provide other types of marketable goods such as genetic, medicinal and ornamental (aquarium trade) resources.

Fisheries, including aquaculture, have traditionally been, and remain an important source of food, employment and revenue in many countries and communities (FAO, 2009). Fish catches and aquaculture supplied the world with about 110 million tonnes of fish in 2006, providing a *per capita* supply of 16.7 kg (live weight equivalent), which is among the highest on record. Overall, fish provided more than 2.9 billion people with at least 15 percent of their average *per capita* animal protein intake. In the last three decades, employment in the primary fisheries and aquaculture sector has grown faster than the world's population and employment in traditional agriculture. In 2006, an estimated 43.5 million people were directly engaged, part time or full time, in primary production of fish and a further 4 million people were engaged on an occasional basis. For each person employed in the primary sector, it has been estimated that there could be four employed in the secondary sector (including fish processing, marketing and service industries).

Besides economic benefits, marine environments provide natural amenities that are highly valued by people and contribute to human welfare (UNEP, 2006). The seas and coasts are of great spiritual and cultural significance, although such values are difficult to quantify. Benefits include aesthetic enjoyment, recreation, artistic and spiritual fulfillment and intellectual development.

Marine environments are also closely linked to human health. Human health is affected by pollution of coastal waters through consumption of fish or other marine products that contain heavy metals and other toxins. Cholera and other waterborne diseases are also on the rise in coastal areas due to degraded ecosystems. These impacts have the potential to reverse progress in human development, and may have severe economic impacts on coastal communities.

Further, coastal communities are at risk from natural disasters such as hurricanes, tsunamis, storms, flooding and coastal erosion, which can have significant economic costs and serious health consequences.

Marine Environment at the Edge: Humans at Fault

Marine environments are often grossly undervalued by society and the institutions responsible for making decisions that affect marine biodiversity and resources. This is largely attributable to a lack of knowledge and understanding of the benefits that marine resources provide in maintaining food chains and ecosystems.

The major threats to the health, productivity and biodiversity of the marine environment result largely from human activities. Land-based activities affect the runoff of pollutants and nutrients into coastal waters and degrade, alter or eliminate natural habitats, whereas ocean-based activities extract resources, add pollution, and change species compositions. Contaminants which pose risks to human health and living resources are transported long distances by watercourses, ocean currents and atmospheric processes.

Threats to the health, productivity and biodiversity of the marine environment result largely from human activities.

Land use change and habitat loss have resulted in negative impacts on marine biodiversity. The expansion of agriculture in coastal hinterlands has disrupted marine and coastal ecosystems, releasing sediment and agricultural chemicals into estuaries and coastal waters. The rapid growth of industrial-scale aquaculture in many areas is also bringing a similar set of threats, as well as pest and disease problems, to mangroves and other prime fish breeding habitats. Mangroves, mudflats and saltmarshes have been converted for coastal zone development, aquaculture and agriculture and coastal muds in many areas are highly contaminated by heavy metals and other persistent organic pollutants. Coral reefs are especially at risk from these damaging pollutants and from human activity such as destructive fishing and tourism.

Overfishing and coastal development are damaging fish breeding and nursery grounds, thus reducing fish populations and undermining the sustainability of fisheries. Coastal population growth and the resulting increases in demand for food and income, together with the use of more efficient and often inappropriate fishing practices, are driving overfishing at a local level. At the international level, the fishing industry is increasingly impacting on subsistence and small-scale fisheries through direct competition for species, the discarding of huge quantities of bycatch and the use of destructive fishing practices. This is exacerbated by increasing demand for a range of other marine-based commodities such as traditional medicines, aquarium fish and construction materials. It is made worse by the introduction of invasive species most commonly through the ballast water from ships, contributing to homogenisation, the extirpation of native species and habitat alterations.

Climate Change Endangers Marine Environment and Human Development

Global climate change will affect the physical, biological and biogeochemical characteristics of the oceans and coasts, modifying their ecological structure, their functions 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 (Box 3.2).

Box 3.2**Potential Impacts of Climate Change on Marine Environments**

With global warming and sea level rise, many marine and coastal ecosystems will experience:

- Accelerated coastal erosion;
- Inhibition of primary production processes;
- More extensive coastal inundation;
- Higher storm surge flooding;
- Landward intrusion of seawater into estuaries and aquifers;
- Changes in surface water quality and groundwater characteristics;
- Changes in distribution of pathogenic microorganisms;
- Elevated sea-surface temperatures, affecting the distribution and survival of marine biodiversity; and
- Reduced sea-ice cover, affecting salinity and ocean-atmosphere thermal exchange.

Related socio-economic impacts include:

- Increased loss of property and coastal habitats;
- Increased flood risk and potential loss of life;
- Damage to coastal protection works and other infrastructure;
- Increased disease risk;
- Loss of renewable and subsistence resources;
- Loss of tourism, recreation and transportation functions;
- Loss of non-monetary cultural resources and values; and
- Impacts on agriculture and aquaculture through decline in soil and water quality.

Source: IPCC, 2001

Qatar's Marine Environment

The marine environment in Qatar is historically important and constitutes a cultural symbol and a natural source of food, water and wealth for the people of the country. The waters off Qatar are environmentally unique with an unusual faunal assemblage (Box 3.3). The harsh and arid climate influences sea salinity and temperature, which in turn influences water density, currents, water mixing and a host of other environmental parameters, with consequential effects on species composition. 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 adapted and developed a tolerance for the extreme conditions.

Qatar's marine environment is environmentally unique, in which marine species have adapted and developed a tolerance for the extreme conditions

Geography

The State of Qatar is situated halfway along the West coast of the Arabian Gulf covering an area of 11,437 square kilometres and protruding about 160 kilometres (km) along its north-south axis into the central zone of the Gulf. It includes, in addition to the mainland, several islands in the coastal waters of the peninsula, the most notable of which are Halul (the main oil storage and exporting centre), Sharauah, Al-Bashiriya, Al-Asahat, Al-Safliya and Al-Aliya islands.

Qatar measures about 80km at its widest point from coast to coast. It is surrounded by the Arabian Gulf from the north and east and by the Gulf of Bahrain from the west. Major towns are located on the eastern sea coast, such as the capital Doha, and the major cities of Al Wakra, Al Khor, Al Thakhira and Al Shamal, in addition to the industrial cities of Mesaieed, Ras Laffan and Dukhan. 83 per cent of inhabitants reside in Doha and its main suburb Al-Rayyan.

Qatar's terrain is flat and rocky with some low-rising limestone outcrops in the Dukhan area in the west and Jabal Fiwairit in the north. It is characterised by a variety of geographical phenomena including many coves, inlets, depressions and surface rainwater-draining basins known as *Riyadh* (gardens), which are found mainly in the north and central part of the peninsula. These areas have the most fertile soil and are rich in vegetation.

Seas around Qatar

The total coastline of Qatar, including the islands, is over 700km (approximately 23 per cent of the coasts of the Gulf) and the total area of its seawater is approximately 35,000 km² (approximately 15 per cent of the Gulf). The coasts have acute curves forming bays and capes such as Ras Laffan, Ras Rekn and Ras Ashirij. The coasts also include a number of environmentally sensitive areas such as mangrove forests and coastal coral reefs, which form a natural environment for a number of living organisms.

The bottom topography of Qatar's coastline is mostly flat and featureless, dominated by soft sediments. Approximately 45 per cent of Qatar's sea bed is covered by a sandy bottom and about the same proportion is covered by a mixture of mud and sand, and about 10 per cent is covered by corals. The sea bottom sediments near Qatar's coastline are mainly hard sand, rocks and coral reefs. In the productive shallows, coral reefs are common on hard substrate and grass beds are widespread on soft bottoms.

Qatar's marine environment is extremely shallow with an average depth of 30 metres (m) on the Northern and Eastern coast, and only 20m on the Western coast. The Gulf of Salwa between Bahrain, Saudi Arabia and Qatar is shallow and hypersaline, and has many islands and reefs, with productive seagrass beds which are major grazing grounds of the dugong. The waters between Qatar and the United Arab Emirates (UAE) are also very shallow and an area of restricted circulation and pronounced evaporation. A series of islands off the western UAE restrict water flow further in the shallow coastal area. Yet, despite the restricted water flow and elevated salinities around these islands, this area is still rich and productive biologically.

Temperature and salinity

Water temperatures in Qatar reflect its harsh climactic conditions. Wide fluctuations in temperature occur in nearshore waters of between 10 degrees Celsius (°C) and 39°C. However, during extreme northerly winter winds, water temperatures in shallow areas have been recorded as low as 4°C.

The high salinity in Qatar's waters is due to the high evaporation, especially in the summer, the very low rainfall, and the low inflows of freshwater from land. While the salinity of the world's oceans average around 35 practical salinity unit (psu), the salinity of Qatar's waters varies between 39psu and 41psu at the surface, and is 1-2psu higher at the bottom. Higher salinity can be found in the south-east coast at over 60psu inside the Khawr Al Udayd. Salinity is high throughout the Gulf of Salwa ranging from about 55psu at the entrance to the Gulf upwards to 70psu at its southern end. These high salinities influence many localised biological communities such as the extensive hypersaline algal mats in the Gulf of Salwa.

Currents and tides

The currents around Qatar are variable but rarely exceed 1 knot for most of the year. In winter, winds generally cross from the east or northeast. The strong Shamal winds often carry large amounts of dust and sand which are deposited in the waters around Qatar. Winds from the north can cause a dramatic temperature drop in shallow waters often resulting in mortality of large parts of the nearshore tropical fauna. In summer, strong winds are caused by differences in the temperature of the land mass and water. Less saline water enters the Straits of Hormuz at the surface and more saline water leaves the basin at the bottom, resulting in a counterclockwise flow of currents around Qatar's coast.

Around Qatar, tidal variation is in the range of 1.6m and results in the exposure of large stretches of tidal flats around the peninsula. Frequent occurrence of tidal anomalies, in comparison to the predictions in the tidal chart has also been reported. The Gulf of Salwa is protected from wave action not only by its orientation, but also by the stretch of extremely shallow water lying between Saudi Arabia and Bahrain. These shallow waters form a barrier to tidal water movements and the tidal amplitude within the Gulf of Salwa is much reduced.

Plankton and oxygen

The dissolved oxygen in the sea water is the most important factor for the breeding and growth of aquatic organisms. The dissolved oxygen in Qatar's waters average around 6.5 milligrams per liter (mg/L) for most parts of the year (aquatic life is put under stress when dissolved oxygen levels drop below 5.0 mg/L). Dissolved oxygen is relatively high in eastern and northern areas, but the level decreases in the summer due to high temperature and salinity. Biological productivity in Qatar's waters is relatively high as indicated by the plankton biomass on the northern, eastern and south-eastern coasts.

Sources: Derived from UPDA and PCI, 2008; MoE, 2008; State of Qatar, 2004; FAO, 1997

Qatar's marine environment is relatively extensive but has not yet been mapped in detail. Qatar is responsible for a significant share of the regional marine environment and the stewardship of marine resources over an area greater than its landmass. This highlights in part the nation's dependence on marine, sub-marine and maritime-based activities and resources.

Qatar's Rich Marine Biodiversity

Qatar is not unique in the environmental challenges it faces, but is unique in the habitats that it provides for its diverse marine life, some of it vulnerable and threatened with extinction, while new forms of marine life are still being discovered (Box 3.4). The various prominent marine species recorded in Qatar's rich and diversified marine environment include (Al Ansi, 2009):

- *Fish*: An important supply of protein for human beings, the fish in Qatar's waters are highly diverse with about 136 species recorded. The richest fishing grounds are situated to the northeast of Qatar where the catch consists primarily of various carangids (jacks), hamour, sherry, kana'ad, sweet lips, emperors and snappers, together with lesser quantities of goatfish, shark, groupers, barracudas, thread fins, lizard fish and rabbit fish.
- *Coral reefs*: The shallow waters around Qatar support a large coral community, with 38 types of coral reefs recorded, including 20 types of hard coral reef. The corals extend as much as 48-80 kilometres from the shoreline and the shallow waters allows light to penetrate to support photosynthetic organisms and the energy to support entire communities of fish. Coral reefs are concentrated mainly at Haloul Island and Umm Al Marshan at the northern coast of the country, and at Khor Al Udeid in the South.
- *Mangroves*: There is only one type of mangrove species found in Qatar (*Avicennia marina*). Mangroves occur on the eastern coast and are concentrated at Al Thakhira and Al Khor, with replanting along the coasts of Al Wakra, Umm Al Houl, Al Mafeer and Fuwairit. Mangrove stands stabilise the sediments, protect the coastline and provide shelter for animals, particularly commercially important juvenile fish, and mangrove leaf fall provides an important food source for marine species.
- *Seagrass*: Seagrass beds are common along the coast (depth 3-8 metres) and cover vast areas at Messaied and Semaisma on the eastern coast and the area between Eshairij and Dukhan on the western coast. They are the most productive of the marine habitats, supporting a wide variety of organisms including molluscs, crustaceans, fish, turtles and the dugong. The Gulf's dugong population is the world's second largest and is critical for the survival of this species, which is listed as globally vulnerable to extinction.
- *Plants and Algae*: Plant life is relatively rare undersea. Macroscopic algae such as sargassum and kelp can be found in Qatar's waters. Sea kelp is important to small sea creatures because they can hide from predators. Non-algae plants such as seagrass have adapted to the high salinity of the ocean environment and are found in shallow waters along Qatar's coasts.
- *Sea Turtles*: Five species of sea turtles are known in the Gulf. These include the globally endangered Green turtle, critically endangered Hawksbill turtle, critically endangered Leatherback turtle, endangered Loggerhead turtle and endangered Olive Ridley turtle. Turtles have been observed in Haloul Island, Ras Rukun, Umm Tais Island, Sharaowa Island, Fuwairit beach, Ras Laffan beach, and Al Thakhira beach.
- *Pearl Oysters*: Pearl diving was one of the oldest professions in Qatar and the Gulf region. It was one of the main sources of income in the pre-oil era and activities were concentrated on the eastern coast of Qatar. With the discovery of oil in the 1930s and the introduction of Japanese artificial pearls, pearl diving became unprofitable and people turned to other sources of livelihood.
- *Marine Invertebrates*: Marine invertebrates of the Arabian Gulf are highly diverse and abundant forming an important source of food for consumers higher up the food chain. Environmental and biological factors in the Gulf have profoundly influenced the occurrence and distribution of marine invertebrates.

- *Mammals*: Most marine mammals observed in Qatar's waters such as dolphins, porpoises and occasionally whales, are widely distributed along the Arabian Gulf between Qatar and Bahrain and the eastern coast between Qatar and the UAE. Whales visit Qatar's waters in winter.
- *Sea Birds*: Qatar's coasts host many species of seabirds, prominent among which are the flamingo and seagull.

Box 3.4 Eating Into Qatar's Marine Habitats

Qatar's many different marine habitats can broadly be split into inter-tidal and sub-tidal components. Both have been sustainably exploited in the past but are now threatened by a number of new anthropogenic pressures. The tidal variation around Qatar is relatively small with just a few metres variation at most. However, large expanses of the coast are exposed at low tide creating large inter-tidal zones. These are prone to disturbance and modification especially by activities such as reclamation.

Natural habitats within the inter-tidal zone include rocky shorelines, sandy beaches, and sabkha (salt flats) covered either by thick algal mats or, for those areas flooded less frequently, by salt pans. With the on-going restoration of mangroves, muddy habitats and salt marshes have increased their importance significantly around the coastline. All these important habitats continue to be under threat from urban encroachment, infrastructure development and industrial activity, reflecting a lack of awareness of their long-term value for their sustenance of biodiversity and the marine environment generally.

Sub-tidally, yet still very shallow, there are large expanses of seagrass beds that accommodate numerous species, providing an important nursery for juveniles and a feeding ground for commercial fish and endangered species. On rocky outcrops seasonal algal blooms allow a forest of different seaweeds to fill the shallow waters. Marginal coral communities are located along the north and east sections of the coastline and around islands where suitable substrate occurs. These once flourished in a myriad of varieties and have now started to recover from massive die-off events attributed to local warm-water anomalies in the mid-1990s. In slightly deeper waters pearl oyster beds still exist together with other mollusc agglomerations such as mussels.

Deeper waters contain predominantly sandy and muddy bottom species dominated by microscopic organisms, such as coralline algae and foraminiferans that contribute more to the sediment budgets of the local area than other organisms. Without this constant supply of sediment, erosion of the coastline is accelerated, inhibiting beach rock formation and coastline stabilisation. Some areas of the seabed are covered in pock-marks indicating episodic hydrocarbon seepage that has influenced the character of these communities.

The few islands and *fasht* (marine reefs) along the coastline, especially in the north and east of the country, provide areas of refuge for many species that comprise new feedstock coming north on ocean currents from the Gulf of Oman. These species constitute an important potential source of replenishment for coastal species after predicted future warm water anomalies lead to extensive die-off of marine organisms. Many artificial structures such as shipwrecks, pipelines, and other offshore structures that add major intrusions to otherwise barren sea bed, are typically in relatively deep water and play an as yet undetermined role as refuge locations in the conservation of marine biodiversity.

Source: Macdonald, 2009

Emerging Risks and Vulnerabilities for Qatar: A Case for Action

Emerging risks and vulnerabilities for Qatar range from the global risks associated with large scale international actions to regional actions and ultimately to local activities that can be modified and controlled. In recent years, the following alarming incidents have been recorded in Qatar's waters (Al Ansi, 2009):

- Mass deaths of fish, turtles, marine mammals and other species;
- Destruction and bleaching of coral reefs;
- Increase in red tide phenomena, a naturally occurring phenomenon involving higher than normal concentrations of microscopic algae (*Karenia brevis*) which produces a toxin that affects the central nervous system of fish so that they are paralysed and cannot breathe;
- Increased erosion of shores and associated habitats;
- Increased coastal flooding;
- Erosion and flooding of nesting areas for sea turtles, resulting in poor breeding success and reduced survival rates; and
- Destruction of mangrove ecosystems, especially in Al Thakeera, Al Khor and Al Wakra.

The encroachment of human activities into marine environments builds a strong case for action to ensure that the principles of sustainable development are adhered to

Although the dependence on the marine environment is often only indirectly associated with day-to-day living for most of the population, the encroachment of human activities into marine environments builds a strong case for action to ensure that the principles of sustainable development are adhered to.

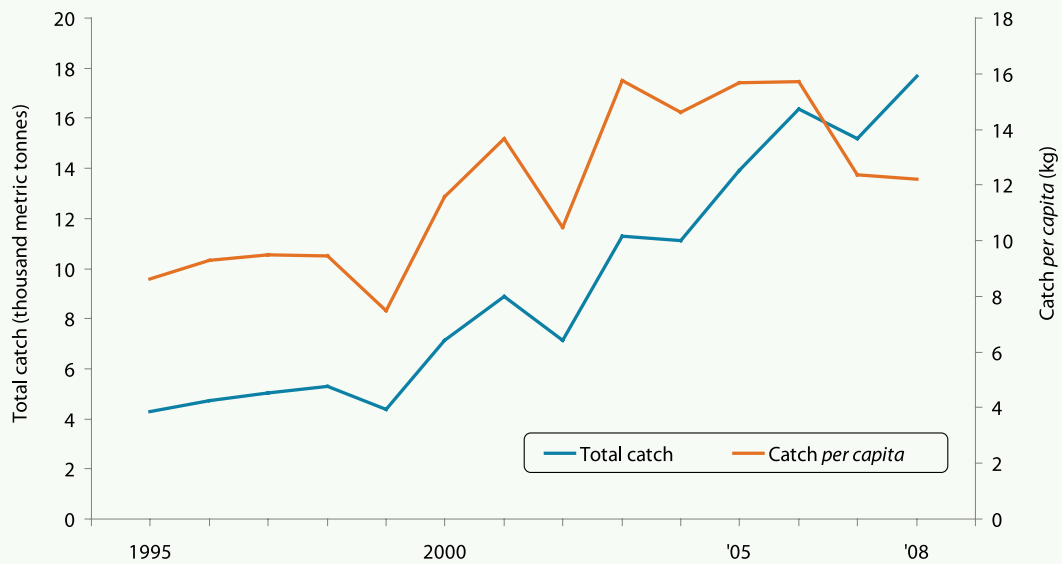
Overfishing: Emptying our Seas

Qatar has four ports that host fishing boats, namely Doha Port, Al Khor Port, Wakra Port and Al Shamal Port. The current professional fishing fleet consists of 515 boats, licensed for fishing in the regional waters of Qatar. These include 220 traditional wooden boats and 295 boats made of fibreglass. The total number of actual fishing boats in 2008 was 484.

The fisheries of Qatar are primarily artisanal in nature. Fishing methods used include gillnetting, use of large wire traps (*gargoor*), small *gargoor* and hook-and-line. Many boats use a combination of fishing gear. The most important sector of the fishery is the fish trap fishery that targets groupers, emperors and grunts. There is also an active, but unquantified, recreational fisheries sector that targets the same species as the professional fishery, in particular groupers, grunts, emperors and mackerel.

Total landings and the number of fishermen have increased steadily over the last 20 years, with landings quadrupling since 1995 from 4,271 tonnes to 17,690 tonnes in 2008 (Figure 3.1). The increase in landings has generally been for all species, and most likely reflects an increase in fishing effort for most fishery sectors. Most production is consumed locally, although some fish is exported to neighbouring countries, particularly Saudi Arabia.

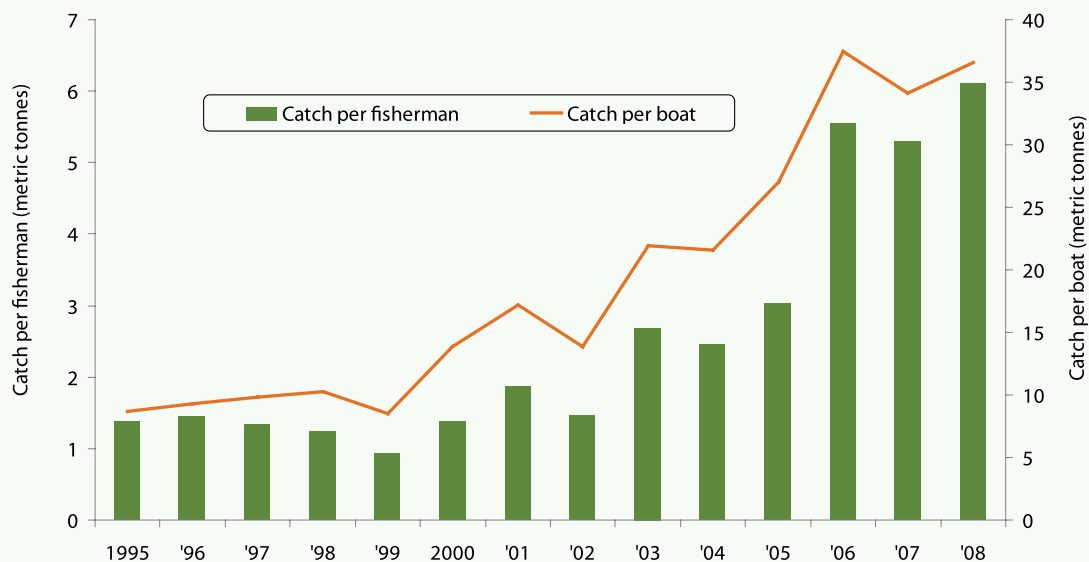
Figure 3.1 Fish Catches Barely Keeping Pace With Population Growth in Qatar



Note: Catch of fish, crustaceans and molluscs
 Source of data: QSA, 2007; DoF 2007 and 2008

Fish catches in Qatar more than kept pace with population growth until 2006 when growth accelerated, notwithstanding a ban imposed on new licences for fishing boats. The steady increase in fish catches in Qatar is largely due to increased labour productivity facilitated by new technology (Figure 3.2).

Figure 3.2 Increased Labour Productivity Leads to More Fish in Qatar



Source of data: QSA, 2007; DoF 2007 and 2008

Because of the strong growth in local production, imports of fishery products to Qatar have increased slowly (FAO, 2003). Shrimp comprise a significant proportion of these because of the prohibition on shrimp fishing in Qatar.

Although landings have increased in recent years, Qatar's fishery sector has reached maturity. The combination of increased fishing effort, limited coastline and coastal environmental issues makes for limited development prospects for the wild fishery. Aquaculture may have some potential and some fish and shrimp farms have been set up by the private sector, but commercial farming is still in its infancy. The lack of suitable marine, coastal or land-based sites may be inhibiting any significant development of this industry.

Illegal fishing and hunting coupled with modern sporting weapons also have a direct effect on the fisheries sector. Illegal and unreported fishing essentially arise from a failure to adequately enforce existing national laws. There are, however, many factors underlying enforcement failure, including notably poor levels of national governance. Further, there are obvious problems with enforcing fisheries regulations on the regional waters, including locating and apprehending the pirate ships, but solutions are available, chiefly through improved monitoring and surveillance systems.

Marine Resource Exploitation and Marine Environment: Like Oil and Water

Because of the ubiquitous nature of the oil and gas industry in Qatar, sound marine environment management by the extractive industries and their downstream counterparts is critical. Localised impacts by extractive industries occur on the seabed surrounding offshore platforms, at pipeline right-of-ways, at the point of effluent discharge to the sea and, most significantly for Qatar, through coastal development. The creation of ports and cooling seawater intakes/outfalls are currently the unavoidable result of the development of Qatar's oil and gas resources.

Sound marine environment management by the extractive industries and their downstream counterparts is critical

The potential for operational and accidental oil spills exists and has serious implications for the environment, the credibility of industries, and the reputation of the state. Persuading industries that reduction of operational spills and implementation of adequate emergency response plans are in their best business interests is key to preventing spills or mitigating their impact. Another growing source of oil pollution is the suspended oil waste from road traffic in storm water runoff. This requires special treatment facilities to prevent surface runoff flowing directly to the sea. The growing number of small boat marinas within Qatar is also an increasing source of oil waste, and education is necessary to minimise the scale of the problem.

The shipping industry introduces several further threats to marine biodiversity. Due to heavy oil traffic in the Gulf, and the Gulf's unique geographical location and sensitive biological nature, this sea could become the most polluted in the world unless strict measures are implemented and enforced (UNEP, 2002). Other than the risk of disastrous oil spills, oil tankers frequently empty ballast and wash engines on the high seas, causing residues of degraded oil to end up on the shore. Another significant and potentially devastating effect is the threat of invasive species introduced into Qatar's waters from the ballast tanks and hulls of ships. Potential problems for biodiversity include the introduction of species that can either outcompete local species or that do not have any natural predator species to keep them in check.

Operational waste-disposal methods, such as the dumping at sea of waste oils and other potentially hazardous materials, is a serious problem requiring both the education of seafarers and the provision by

the ports and harbours of adequate waste reception facilities, as mandated in regulations. Systematic waste management is needed within Qatar's waters and in neighbouring coasts given the vast quantities of waste that wash up on the shorelines. This includes an efficient surveillance system for improved monitoring and enforcement.

Table 3.1 shows indicators of the quality of coastal waters around Qatar in terms of physiochemical parameters such as mineral oils, surface active substances and phenols. Deterioration in the quality of coastal waters poses health risks to the population and can adversely affect the tourism industry. The data also provide information on the effectiveness of environmental regulations especially of wastewater and marine pollution from ships.

Table 3.1 Qatar's Coastal Water Quality Improving; Large Differences Between Locations					
Year	Free Chlorine (mg/L)	Total Chlorine (mg/L)	Total Organic Carbon (ppm)	Oil and Grease (ppm)	Phenol (ppb)
Average Values					
2004/5	0.5	0.5	29.7	5	55.3
2006	0.2	0.2	19.8	3.7	48.3
Relative Variability (Coefficient of Variation)					
2004/5	1.1	1.5	0.4	0.5	0.6
2006	0.8	1.1	0.4	0.4	0.5

Note: Based on data from Mesaieed, Doha, Al-Khor, Ras Laffan, Ras Rakan, Dukhan and Salwa
Source: QSA, 2007

Nevertheless, a number of potentially positive impacts can occur for marine biodiversity due to the development of oil and gas reserves, namely through access restriction (that is protected marine areas) and artificial habitat creation. Environmental management plans can also be of the highest standard when industry players have a strong sense of corporate social responsibility.

Coastal Development: Encroaching on Precious Waters

Coastal development involving dredging and land reclamation for projects such as residential areas, industry, causeways, fishing ports, airports and harbours takes a significant toll on the marine environment. In Qatar, most of the major developmental projects are located on the Eastern coast (Box 3.5).

Coastal development involving dredging and land reclamation for residential and industrial projects takes a significant toll on the marine environment

Coastal development using infill and dredging, such as artificial island developments, have direct and indirect environmental and socio-economic effects. The effects may be positive or negative and the impacts may be short-term or long-term. Some of the most important impacts include:

- Deterioration in water quality due to the increase in suspended sediments and potential release of contaminants during dredging or disposal;
- Destruction of marine habitats and physical stress to marine species due to alteration of bottom topography and hydrography;
- Stress to corals due to high suspended sediment concentrations and their effects on light attenuation; and
- Threat to fishing stocks as a result of damage to nursery and feeding grounds of fish.

The Pearl-Qatar: A Riviera-style man-made peninsula developed in an exclusive environment in Doha covering 400 hectares of reclaimed land.

New Doha International Airport (NDIA) Project: With a land area in excess of 22 square kilometres (km²), the new airport has a capacity to handle 24 million passengers and 750,000 tonnes of cargo annually. Over 100 hectares alongside have been reserved for commercial development and private development opportunities include a free trade zone, office and business parks, hotels, and retail malls.

The Qatar-Bahrain Friendship Bridge Project: This bridge will be the longest marine causeway in the world and will link the two nations via a twin carriageway stretching more than 40km. The Causeway will provide both rail and road connections between Bahrain and Qatar with an estimated capacity to handle and process nearly 50 million passengers every year.

Lusail City Project: A large development of approximately 21 km² located north of the city of Doha, home to a self-sustaining community, comprising residential, commercial, retail, hospitality, resort, and entertainment venues.

Urjuan, Barwat Al Khor Project: Incorporates residential, commercial, leisure, sport and waterfront projects over a land area of about 5.5 km².

Al Wakra Seaports and Beach Project: Includes the expansion of the existing seaport and the establishment of two sandy beaches with touristic-traditional features.

Oil and Gas Exploration and Expansion Projects: Several exploration and expansion projects have been implemented such as the Dolphin Project which involves the delivery of sweet lean gas to UAE through a sub-sea pipeline, the Qatar/Kuwait Gas Supply Project, and so on.

Climate Change and Marine Environment: Upsetting the Balance

Global climate change introduces new instabilities into systems that are already greatly disturbed and altered by over-exploitation. Anthropogenic greenhouse gas emissions dissolve in the oceans, altering the acidity of oceans, affecting the growth of marine plankton with a corresponding impact on their role as a source or sink of carbon dioxide to the atmosphere. Alterations in nutrient levels and temperature may also affect the species composition of phytoplankton populations, which would have serious repercussions for the rest of the marine environment. A decrease in plankton production, which could result from a changing climate, would mean less food for fish populations, and many of the seabirds that prey on fish and plankton are likely to have their food supply reduced or relocated.

Global climate change introduces new instabilities into marine environments that are already greatly disturbed and altered by over-exploitation

Unabated ocean acidification reduces the ability of marine organisms such as corals to build their skeletons, which in turn affects the reef topography that is home to local fish populations. Mangrove ecosystems are also highly vulnerable to sea level rise induced by climate change, which will change the salinity distribution and inundate mangroves. The maintenance of these coastal defense systems in Qatar is critical for the health and survival of its marine environments, the sustainability of the local fishery, and for human development.

Further, commercial fish and shellfish have thresholds of water temperature tolerance that limit the conditions under which they can reproduce and grow. Temperature influences the location and timing of spawning which affects the growth and survival of young fish. Rising temperatures, rising sea levels, and other trends are also having an effect on sea turtles. Erosion of nesting beaches caused by rising sea level and more intense storms adds the potential for further dangers to nesting beaches that are already threatened by human activity. Although sea surface temperatures are expected to reach marine organism thermal tolerance thresholds more frequently, resulting in mass mortalities of key ecological species, the actual outcomes have not been closely monitored and are not yet fully understood.

Habitat Loss: Humans Moving In

The growing trend of habitat destruction and the reduction in connectivity in the marine environment through habitat fragmentation cannot be readily determined. Little acknowledgment is made of the loss of these marine resources and the negative effects that this has on marine biodiversity.

Direct habitat loss occurs with shallow water land creation and the increase in land-based industrial and municipal pollution. The collective impact on marine biodiversity of the development of islands, peninsulas and jetties along the coast of Qatar is yet to be quantified. This is partly due to a lack of transparent and adequate baseline data, but also to the lack of appreciation of the valuable function of the destroyed habitats versus the benefits gained. Furthermore, there are no engineering techniques to restore the functionality of, for example, a seagrass bed or coral community, although there are many marketed options that purport such potential. Habitat restoration may be possible but should only be considered as a last option for environmental issues incurred in the implementation of coastal development projects.

Land-based pollution is also having a significant impact on global marine biodiversity. Qatar, along with its neighbouring states, faces this issue directly due to the structure of the Gulf and the high number of coastal industries such as hydrocarbons, power and desalination. Although many land-based pollution sources are localised, the nature of the local marine environment, with poor flushing within the region, creates a threshold potential for the use of the marine environment for land-based pollution remedies. As more industries are utilising the marine environment for product extraction, plant cooling, desalination or as a convenient sink, careful control is urgently required throughout the region as many pollutants can create cross-boundary issues.

Some of the major environmental problems from land-based discharges have potential solutions that can easily be adopted within a few years as demonstrated by industries within the European Union. Source reduction of pollutants should be preferred to end-of-pipe solutions. The type and limited extent of agriculture means that eutrophication of the marine environment is not as significant locally as it is globally. Nevertheless, monitoring is necessary to ensure that the growing local agro-based industries and treated sewage effluent are handled appropriately and do not utilise the marine environment as a disposal option.

Marine Diseases and Human Health: Travelling Up the Food Chain

There appears to be a low prevalence of marine diseases in Qatar's waters but this may be a function of the limited information available in the region and a lack of ongoing monitoring of key species. One notable exception is the occurrence of coral diseases not known in Qatar's waters but prevalent in the neighbouring states. This pattern needs to be investigated to identify causes and potential risks. Overall, global incidence of marine diseases has increased dramatically. Diseases are more prevalent when organisms are stressed, suggesting that the Qatar marine environment is a potential hotspot.

A growing local concern on a global scale is the occurrence of mass blooms of microscopic algae that have a harmful effect on local fish that are direct consumers or on marine mammals that are further up the food chain, and potentially on the local human population through food chain contamination. These harmful algae blooms are attributable to a number of potential instigators, either chemical or physical, such as eutrophication, and the introduction of invasive species. Some algal species may remain inanimate as cysts in the sediment until favourable conditions activate them. After an algal bloom, the area affected may be depleted of oxygen by the decomposing algae and other marine organisms, producing a barren area largely devoid of life.

Understanding Marine Environments: Knowledge and Attitudes

Each marine habitat provides a differing environment for numerous communities and species with complex interactions and interdependencies. The annual fluctuations and longer-term variations in the environmental parameters of Qatar's waters ensure that there are varied species present throughout the year and sometimes differing communities from year to year, decade to decade or over longer time frames. This can result in significant misinterpretation of species community datasets, although few currently exist.

The full range and extent of these habitats and their communities around the coastline are unknown and reflect the need for more extensive research into mapping the marine species and studying marine environment changes in Qatar. This is primarily due to a lack of field data describing species distribution and abundance, population trends, and life cycle. Current information indicates that Qatar is home to 955 marine species, probably a significant underestimation due to the lack of full biodiversity studies conducted to date. There are no confirmed marine species endemic to Qatar's waters, but there are regionally endemic species.

There is a need for more extensive research into mapping the marine species and studying marine environment changes in Qatar

From the limited information available it is believed that 27 marine species or 1.4 per cent of the currently acknowledged species present in Qatar's waters, are currently threatened with global extinction (Macdonald, 2009). Significantly, the majority of Qatar's listed endangered species are marine-based, whereas globally terrestrial species are the foremost endangered group. Endangered species include sea turtles and several species of shark but little is known of their population dynamics to facilitate local conservation. A comprehensive locally defined rare, threatened or endangered species list is required, which could in turn contribute to global assessment.

The effectiveness of scientific research rests on the accumulation of observations, understanding and knowledge of many scientists that is shared through peer-reviewed publications. Peer reviewing and accessibility to previous research is lacking in Qatar which can result in duplication of basic research and unnecessary limitations on research goals. Extending and continually improving local research and environmental programmes are important for extending the scientific knowledge of Qatar's natural resources. Sharing and collaboration on marine issues is especially important to effectively mitigate long-term habitat degradation. There is also no reference collection of species available in Qatar or the region for purposes of comparison; specimens are widely scattered throughout museums and research institutions around the world.

Managing Risks and Vulnerabilities: International Cooperation and National Action

People have been influencing marine environments as long as humankind has existed. However, the recent dramatic scale of harmful human impacts, many of them visible beyond national or regional boundaries, underlines the need for immediate pre-emptive and remedial action to ensure a healthy living standard for present and future generations.

Global Action to Mitigate Threats to Marine Environments

The duty to protect the marine environment from land-based activities was placed squarely in the context of sustainable development by the United Nations Conference on Environment and Development in 1992. Countries agreed:

- to apply preventive, precautionary, and anticipatory approaches so as to avoid degradation of the marine environment, as well as to reduce the risk of long-term or irreversible adverse effects upon it;
- to ensure prior assessment of activities that may have significant adverse impacts upon the marine environment;
- to integrate protection of the marine environment into relevant general environmental, social and economic development policies;
- to develop economic incentives, where appropriate, to apply clean technologies and other means consistent with the internalisation of environmental costs, such as the 'polluter pays' principle, so as to avoid degradation of the marine environment; and
- to improve the living standards of coastal populations, particularly in developing countries, so as to contribute to reducing the degradation of the coastal and marine environment.

In seeking to protect the marine environment, priorities for action need to be established by assessing the five major elements (Box 3.6) and specifically reflecting on the relative importance of impacts on food security, public health, coastal and marine resources, ecosystem health, and socio-economic benefits, including cultural values. It is necessary to consider the source of any threat (contaminants, physical alteration, and other forms of degradation and the source or practice from which they emanate); the area affected (including its uses and the importance of its ecological characteristics); and the costs, benefits and feasibility of options for action, including the long-term cost of no action.

The identification and assessment of problems is a process of combining five elements:

- Identification of the nature and severity of problems in relation to food security and poverty alleviation; public health; coastal and marine resources and ecosystem health, including biological diversity; economic and social benefits and uses, including cultural values;
- Identification of the source of threat from contaminants: sewage; persistent organic pollutants; radioactive substances; heavy metals; oils (hydrocarbons); nutrients; sediment mobilisation; and litter;
- Identification of the source of threat from physical alteration, including habitat modification and destruction in areas of concern;
- Identification of sources of degradation through:
 - Point sources (coastal and upstream) such as wastewater treatment facilities; industrial facilities; power plants; military installations; recreational/tourism facilities; construction works (dams, coastal structures, harbour works, urban expansion); coastal mining (sand and gravel); research centres; aquaculture; habitat modification (dredging, filling of wetlands, clearing of mangrove areas); and introduction of invasive species;
 - Non-point (diffuse) sources (coastal and upstream) such as urban runoff; agricultural and horticultural runoff; forestry runoff; mining waste runoff; construction runoff; landfills and hazardous waste sites; erosion as a result of physical modification of coastal features; and atmospheric deposition caused by transportation (for example, vehicle emissions), power plants and industrial facilities, incinerators and agricultural operations;
- Identification of areas of concern (areas affected or vulnerable) such as critical habitats, including coral reefs, wetlands, seagrass beds, coastal lagoons and mangrove forests; habitats of endangered species; ecosystem components (spawning areas, nursery areas, feeding grounds, adult areas); shorelines; coastal watersheds; estuaries and their drainage basins; specially protected marine and coastal areas; and small islands.

Source: UNEP, 1995

The effective development and implementation of national programmes of action should focus on sustainable, pragmatic and integrated environmental management approaches and processes, such as integrated coastal area management, harmonised, as appropriate, with river basin management and land-use plans. Countries should, in accordance with policies, priorities and resources, define specific management objectives, both with respect to source categories and areas affected (Box 3.7). Such objectives need to be identified in terms of goals, targets and timetables overall, for the specific areas affected, and for industrial, agricultural, urban and other sectors. Preventive and remedial action using existing knowledge, resources, plans and processes need to be taken as soon as possible.

Box 3.7**Identification, Evaluation and Selection of Strategies and Measures to Manage and Conserve Marine Environments**

Strategies and programmes should include a combination of:

- Specific measures, including, as appropriate:
 - measures to promote sustainable use of coastal and marine resources and to prevent/reduce degradation of the marine environment, such as substitution of substances or processes entailing significant adverse effects; introduction of clean production practices, including efficient use of energy and water in all economic and social sectors; application of best management practices; use of appropriate, environmentally sound and efficient technologies; and product substitution;
 - measures to modify contaminants or other forms of degradation after generation, such as waste recovery; recycling, including effluent reuse; and waste treatment;
 - measures to prevent, reduce or ameliorate degradation of affected areas, such as environmental quality criteria, with biological, physical and/or chemical criteria for measuring progress; land-use planning requirements, including criteria for locating major facilities; and rehabilitation of degraded habitats.
- Requirements and incentives to induce action to comply with measures, such as:
 - economic instruments and incentives, taking into account the ‘polluter pays’ principle and the internalisation of environmental costs;
 - regulatory measures;
 - technical assistance/cooperation, including training of personnel;
 - education and public awareness.
- Identification/designation of the institutional arrangement with the authority and resources to carry out management tasks associated with the strategies and programmes, including implementation of compliance provisions.
- Identification of short-term and long-term data collection and research needs.
- Development of an environmental-quality reporting and monitoring system to review and, if necessary, help adapt the strategies and programmes.
- Identification of sources of finance and mechanisms available to cover the costs of administering and managing the strategies and programmes.

Source: UNEP, 1995

National Action to Mitigate Threats to Qatar’s Marine Environment

Qatar has taken a number of internal, regional and international steps to help facilitate the conservation of marine biodiversity. There is also a growing portfolio of marine-related projects aimed at conservation or restoration of local marine biodiversity.

International Agreements and Mechanisms

Qatar is a signatory to the Convention on Biological Diversity that has included the development of the Jakarta Mandate on marine biodiversity, Agenda 21 and the more recent World Summit on Sustainable Development. The tools and processes of these agreements need to be firmly embodied in the future policies of Qatar if it is to achieve sustainable development. The recent signing of International Maritime Organisations Convention on Marine Pollution (MARPOL 73/78 - although not Annex VI that deals with air pollution) commits Qatar to significant steps to facilitate the protection of the marine environment.

There are other International Maritime Organisation conventions that Qatar, although it is not a signatory, is obligated to observe on the international aspects of trade including the convention covering hull antifouling paint. Furthermore, the United Nations Fisheries and Agricultural Organisation’s Code of

Conduct for Responsible Fisheries was created to allow the sustainable use of marine and aquatic resources protecting not only the fisheries target species but also marine biodiversity and ecosystems in general. The fisheries in Qatar are regulated, although fisheries statistics are in need of improvement. There are significant threats from reef-based fishing, illegal fishing, sport fishing, ghost fishing, and exploitation of the shallow marine areas by migrant labourers in ways that are potentially unsustainable. The damage inflicted on the inter-tidal zones in this way may be significant and long lasting but is at present unmeasured.

Where there could be significant gains in the international arena is the Convention on the Conservation of Migratory Species of Wild Animals, and in particular the resolution between Qatar and Bahrain of an agreement with other neighbouring states relating to the Dugong Memorandum of Understanding. This has become more important because of the proposed international causeway between these two states that passes through the major dugong habitat.

Regional Conventions and Protocols

Qatar participates in regional and international agreements for the effective protection of the marine environment. Qatar is a member of the Kuwait-based Regional Organisation for the Protection of the Marine Environment (ROPME), and has participated in training programmes, field visits, workshops (for example on mangrove regeneration, and coral reef protection), and the monitoring of marine pollution. The country is committed to meeting standards set by GCC countries where these are consistent with national expectations. Qatar is also a signatory to a number of international agreements relating to the marine environment including prevention of marine pollution, control of hazardous waste, intervention in cases of oil pollution, maintenance of biodiversity, trade in endangered species, issues of climate change, and conservation of natural habitats.

ROPME provides Qatar with regionally coordinated environmental legislation, studies and monitoring systems aimed at conserving marine biodiversity. Pollution legislation is well drafted but the conservation and reserves' protocols have yet to be finalised. These have the potential to significantly improve the conservation outcome for local marine biodiversity. Stakeholder engagement is also critical for the success of such initiatives.

Local Legislation and Institutional Arrangement

The Environmental Law of 2002 is perhaps the most important for conservation of biodiversity. With its by-laws that contain requirements for Environmental Impact Assessment (EIA) and pollutant discharge criteria it has become more than just a legislative statement and actually provides real measures for environmental protection.

The Ministry of Environment (MoE), established in 2008 (formerly the Supreme Council for Environment and Natural Reserves (SCENR) is the custodian of environmental protection within Qatar and exerts a growing influence for sustainable development. The MoE reviews and approves environmental impact assessments, issues Permits to Construct and Consents to Operate, and staff regularly visit industrial facilities for emission monitoring and inspection. These are critical precursors to having a full-scale system for managing environmental sustainability.

The MoE is responsible for monitoring and assessing industrial developments, the natural environment and management of reserves. The importance of having technical knowledge of any habitat designated for protection and the appropriate use of this information is vital for success. Long-term observation of biodiversity is the basis for ecosystem modelling that can lead to specifications for future system development and appropriate mitigation measures, if required. However, since the MoE is under-resourced in terms of staff and expertise, its capacity to conduct complex ecosystem modelling exercises is limited. To address this limitation, MoE-industry partnerships are encouraged and joint projects are established to address marine environment concerns, especially in relation to the paucity of data and the lack of quality studies.

Marine Conservation Projects: Public-Private Partnerships

A number of local marine conservation initiatives are being undertaken in Qatar. Many large-scale projects influencing the marine environment require environmental baseline surveys to be conducted and although these can be brief and selective they represent some of the few detailed studies that exist. Some of the highest profile conservation projects involve coral communities. Extensive mapping of the coral reefs between the east coast of Qatar and Abu Dhabi, massive coral relocation and various artificial reef projects have been carried out through MoE-industry partnerships (Box 3.8).

Box 3.8

Corporate Social Responsibility and the Marine Environment: Pioneering Innovative Technologies

To support marine ecosystems and minimise industrial process effects on the marine environment, Qatargas Operating Company Limited (Qatargas) and its sister company, RasGas Company Limited (RasGas), are pioneering natural resource conservation projects and award-winning innovative technologies:

Encouraging Biodiversity: Coral Relocation

This project is conducted in partnership with the MoE to preserve more than 4,500 coral colonies in an area that would otherwise have been adversely affected by the expansion of Qatargas installations. This programme provides protection from the future pipeline corridors and constitutes the largest coral protection effort conducted so far in the region. Periodic environmental monitoring surveys are carried out to determine the success of the programme.

In 2004, RasGas conducted a marine survey in coordination with Qatar University, deploying 150 different sizes of artificial reef structures to support the growth of additional ecological benthic communities. Recognising the importance of protecting endangered turtle species, RasGas is actively supporting MoE and Ras Laffan Industrial City's annual monitoring effort in Ras Laffan's northern beaches. In 2008, RasGas and Dolphin Energy Limited jointly conducted a five-month campaign during the nesting and hatching seasons.

Reducing Marine Impact: Pulse-Chlorination

Qatargas is the first company in the Indian Ocean region to research and introduce Pulse-Chlorination™ into its cooling seawater systems. This new technique allows Qatargas to control biological fouling (colonization of cooling water systems by mussels and oysters) while minimizing the amount of chlorine added into the cooling seawater by over 50 per cent. By adopting this new technique Qatargas significantly reduces the environmental footprint that cooling seawater has on the marine environment in and around its operations.

Protecting Biodiversity: Marine Reserve Area

A large area of the proposed Al Dhakhirah Nature Park has been declared a marine reserve. RasGas, supported by MoE, is leading the development of the park, which promises to attract eco-tourists with unique observation and educational facilities.

Other projects include the Qatar Dugong Conservation Initiative by the MoE and Dolphin Energy Limited to protect dugongs and their habitat and the Al Reem Biosphere Reserve, a biodiversity conservation project by the MoE, Shell GTL and the United Nations Educational, Scientific and Cultural Organisation. The Al Reem Biosphere Reserve, which covers around 10.4 per cent of Qatar's land area, functions as an outdoor learning laboratory for good environmental practices and serves as a model for sustainable human living and nature conservation.

Management and Conservation of Qatar's Marine Environment: A Shared Responsibility

Conservation of the marine environment within Qatar and the Gulf region needs to focus on maintaining and enhancing overall quality including a more strategic assessment of biodiversity, ecosystems and the use of natural resources. To achieve such an objective, radical changes from the current 'business as usual' scenario may be necessary rather than simply modifying existing controls and regulations.

Conservation of Qatar's marine environment require radical changes from the current 'business as usual' scenario

The main responses that Qatar can apply to regulate the interaction between marine environments and human activity can be broadly grouped into operational responses and specific responses (UNEP, 2006). Operational responses are important to consider for all policy options whereas specific responses relate to sectors.

Operational Responses: Getting the Foundations Right

Stakeholder Participation in Decision Making

Effective and broad stakeholder participation in decision making has in many cases been proven to improve the recovery of coastal ecosystems. This process is critical to promote ownership of marine-related policies, strategies and programmes. Stakeholders include ministries and agencies, the private sector and civil society. Key steps to improve participatory processes are to increase the transparency of information, improve the understanding of the issues, improve the representation of marginalised stakeholders, engage them in the establishment of policy objectives and priorities for the allocation of services, and create space for deliberation and learning, accommodating multiple perspectives (UNEP, 2006).

Civil society engagement in decision making is novel in Qatar, but increasingly being given emphasis, especially by the MoE. Open consultation with stakeholders is a key component of environmental impact assessments through the conduct of public hearings and the administering of questionnaires. Such consultations should consider how proposed policies, programmes and projects could affect various stakeholders. Task forces could be created to consider the major categories of concern (such as coastal flora, fisheries management and so on), covering all habitats and species. The formation of a marine environmental technical working group could facilitate the integration of the science into policy and explain science issues to affected stakeholders in order to achieve widespread participation, understanding and acceptance of adopted strategies and policies.

Capacity Development

Regional and global research and best practices may not be applicable for Qatar and the crossover potential is uncertain. Support for local research, monitoring and assessment is crucial to address the numerous gaps in knowledge, and for the success of policies, programmes and strategies on marine environments. Long-term capacity building efforts in policy formulation, implementation and enforcement is required, including the capacity to cope with the changing scientific advancements and take advantage of technological progress. Strategies adopted need to be measured and monitored to allow for a comprehensive evaluation of its impacts. Actions taken need to be reviewed periodically and revised in the light of new scientific information.

The establishment of the Qatar Science and Technology Park (QSTP) and the Qatar National Research Fund has partly addressed the need for greater scientific expertise and trained manpower in the area of marine research. For example, ExxonMobil Research Qatar, an anchor tenant at QSTP, focuses on the marine environment and seeks to scientifically understand the impacts that industrial activities might have on the quality of water off Qatar's coasts and the nearby marine ecosystems. (Box 3.9) The Environmental Studies Center at Qatar University also conducts research on the country's marine fauna and flora. Greater synergies could be achieved through closer collaboration and linkages between the various institutions, and between science and policy through greater accessibility of scientific data and information.

Support for local research, monitoring and assessment is crucial as is long-term capacity building efforts in policy formulation, implementation and enforcement

Box 3.9 Private Sector Participation in Environmental Management Research in Qatar

ExxonMobil Research Qatar (EMRQ) conducts research and development in the areas of environmental management and LNG safety. Some of the ongoing and planned initiatives include:

- The development of numerical models to predict the concentration of chlorine and chlorination by-products as LNG production increases;
- The evaluation of a new technology, Pulse Amplitude Modulation, in assessing the health of coral and seagrass beds in their natural environment. This study is conducted in cooperation with the Ministry of Environment (MoE);
- A study on the effect of residual chlorine on local marine species so that better and more relevant scientific data can be made available to the MoE as they review existing regulations; and
- Conduct multi-year ecological and water quality monitoring at selected important marine habitats, such as coral reefs and seagrass beds, to collect data to expand the baseline information on the state of Qatar's coastal marine environment. This study is conducted in partnership with the Environment Studies Center at Qatar University.

EMRQ is also investing in its scientific laboratories to improve established methodologies, reduce test times and reduce the number of test organisms required. Long-term monitoring of Qatar's marine ecosystems is essential to be able to differentiate natural and cyclical changes in ecosystem health from changes resulting from environmental disturbances associated with human activities. Such information is critical for the development of targeted and effective environmental protection and mitigation measures.

Communication, Education and Public Awareness

Communication, education and public awareness are important components of successful marine ecosystem management, ensuring that decision makers and other actors fully understand the background to and implications of their activities. An effective awareness programme will serve to strengthen benefits derived from stakeholder engagement initiatives. It will help develop an attitude of respect for the marine environment among both the local and expatriate populations. This is especially challenging for Qatar given the numerical dominance of the expatriate population and the lack of a common language.

Programmes can be incorporated at all levels of education to develop an appreciation for the marine environment and marine species diversity, emphasizing the country's marine heritage historically and culturally. Free access to maritime and marine career information and career-based strategies would promote interest in the marine environment amongst the growing young adult population.

Specific Responses: Building Blocks for Sustainable Development

National Marine Policy

It is essential for Qatar to concentrate initially on the immediate strengths, weaknesses, opportunities and threats to the marine environment. The creation of a national marine policy would help facilitate the sustainable use of resources for all future developments that influence the marine environment. Such a policy would highlight the need for basic research, baseline data collection for marine species, mapping, conservation and the wise use of resources within the marine environment.

A national marine policy is required to ensure the sustainable use and conservation of marine resources

For a robust marine policy, it is important not to focus solely on the species concept of management and the industry derived benchmarking of key performance indicators, but to adopt a more holistic approach of healthy ecosystem functionality that enables an assessment of the diversity and health of the marine environment. There should also be coherence and cross-sector linkages to other policies with direct or indirect implications on the marine environment such as water and waste management. This facilitates subsequent data interpretation and reporting to policy makers and the public.

In the initial phase of the development of a marine policy, clear synergies need to be recognised between biodiversity conservation and the interests of the maritime, land-based and fisheries industries. For example, a moderate reduction in fishing pressure will lead towards more sustainable and more profitable fisheries and improved conservation of biodiversity. By imposing limits for non-target species and protection of habitats, the fishing rates will not only adjust to the state of the target species but also be sensitive to the state of other species or habitats. This will lead to less exploitation, less fishing and reduced employment in the fishing sector. Similarly, due to the nature of the problems likely to be encountered, considerable conflicts will occur between objectives implicitly adopted in the industrial sectors and those imposed by the biodiversity concerns.

In practice a marine policy will be implemented by various action plans perhaps aimed at specific habitats. Generally these plans should lead to the application of the 'precautionary principle'. The application of the 'precautionary principle' refers to the cautious approach being adopted for living marine resource management. The avoidance of irreversible damage, such as reduced genetic variability in a population, is critical to these plans. Incomplete scientific knowledge should not be invoked to delay action deemed necessary where preliminary objective scientific evaluation indicates reasonable grounds for concern about potentially irreversible effects on the environment. This approach has gained widespread acceptance and there is now considerable experience that can be applied through regional research organisations to support the objectives of sustainable human development.

Integrated Maritime and Spatial Planning

Coordinating the science and knowledge-based management and subsequent zoning preferences for marine and coastal areas is a critical element in developing a policy for the marine environment. The aim for the management of the chosen zones is planned utilisation of its resources in an ecologically sensitive manner avoiding inappropriate developments whilst ensuring the full potential of the zone is realised.

Integrated Maritime Spatial Planning (IMSP) combines the tools and procedures of terrestrial spatial planning with the principles of the previously widely utilised Integrated Coastal Zone Management (ICZM) but extends the typically coastal focus to the open sea. It is the tool now being used to manage the seas within the European Union. Such planning accommodates land-based, maritime and fisheries components not fully addressed by marine biodiversity conservation or ICZM. It acknowledges that biodiversity extends beyond geopolitical borders. Such open borders introduce many complicating factors that require considerable commitment to overcome, including capacity building and institutional strengthening on local and regional scales. This will improve the conservation of natural resources by all stakeholders and ultimately the efforts to conserve marine biodiversity.

Marine zoning will need to encompass the three main characteristics of the marine environment's functional areas:

- Economic (for example, oil and gas fields and important fishery areas);
- Environmental (for example, ecosystems, species-specific habitats and genetically distinct populations); and
- Socio-economic (for example, administrative areas, recreational and urban areas and pearling beds).

IMSP will be successful if there is sufficient stakeholder engagement and involvement, and if the concepts are readily communicable to policy makers and the public through use of Geographical Information Systems. It is essential that IMSP should be utilised since there is an increasing number of competing demands on the use of this finite marine environment. IMSP allows for the management of land-based sources of pollution within Qatar that are due to its geography, to its rapidly developing oil and gas industry, and to its rapidly expanding population. Furthermore, not all the threats to Qatar's marine environment can be managed within the confines of the state's legal jurisdiction and IMSP can allow for a regional or even an international approach.

Coastal and Marine Ecosystem Surveys and Mapping

Marine research needs to be supported by an extensive biodiversity survey and mapping programme that provides ready access to, for example, an online specimen collection databank and map resources in collaboration with international museum and research institutions. Carrying out this process may be protracted due to the nature of the marine environment and difficulties in undertaking surveys because of weather conditions and availability of diving equipment. Currently, because of the short timeframes and small samples available, limited data are taken as representative of the entire ecosystem. Furthermore, the shifting baseline phenomenon requires surveying over several years in order to capture the variability in local marine species populations. Shifting baselines of ecosystem species dominance have only recently been acknowledged but have limitations as they constitute an observed ecosystem at just one point in time. This means that the observed species may be only one version of a number of possible alternative community assemblages capable of tolerating the given environmental conditions.

Internationally there is a growing trend for species conservation to be replaced by habitat or ecosystem conservation. Species conservation is popular because the public quickly develop an affinity with a particular species. However, while ensuring the conservation of a single species can be extremely difficult, the necessary components can more readily be incorporated into habitat management. Habitat management is also a more practical approach for the active involvement of regional bodies that can then take the lead in the creation of integrated coastal and marine policy and planning. Habitat management can also utilise many of the emerging remote sensing technologies, especially within the shallow water environment of coastal Qatar.

Sustainable Fisheries

Fisheries within Qatar are long established but face increasing pressure from the demand created by population increase, habitat degradation, pollution and global climate change. The main areas requiring action to facilitate the conservation of marine biodiversity are:

- Promotion of the conservation and sustainable use of fish stocks and feeding grounds through control of exploitation rates and the adoption of appropriate technical conservation measures. Measures available include fishing exclusion areas mainly for the protection of dense aggregations of juvenile fish; sustainable trap building material; and regulation and enforcement of net mesh sizes;
- Reduction in the impact of fishing and other human activities on non-target species and on marine and coastal ecosystems to achieve sustainable exploitation of marine and coastal biodiversity;
- Prohibition of aquaculture in sensitive localities such as mangroves and inter-tidal areas; avoidance of pollution by inputs and outputs from fish farms; and prevention of genetic contamination by releases or escapes of farmed species that may affect habitat conservation;
- Improved target species size selectivity with the aim of reducing harmful discards of juvenile fish and new or amended minimum landing sizes for target species;
- Temporal or spatial closures to enhance survival of juveniles or spawning concentrations, to maintain genetic diversity especially for species listed in environmental legislative instruments; and
- Introduction and promotion of fishing methods that have a reduced physical impact on the environment.

Marine Aquaculture

The continual rapid human population growth in Qatar is putting increasing strain on the local resources available to feed this population. Currently there is no aquaculture fishery but due to increasing human population pressure, habitat degradation and dwindling resources, the development of this option in the future needs serious consideration. Most such projects would probably entail introduction of non-native species or genetically modified species. A full assessment of the potential impacts would be required before the adoption of aquaculture strategies within a wider marine policy. These strategies would need to address the protection of Qatar's natural biodiversity in conjunction with development of any aquaculture ventures by encouraging responsible projects that help reduce demands on the natural genetic stock and alleviate pressure on Qatar's fisheries.

The positive impacts that aquaculture might have on conservation of aquatic genetic resources through relieving pressure on Qatar's fisheries needs to be considered. Reducing dependency on natural genetic material and the considered and careful introduction and movement of fish farm stocks would go a long way towards achieving the goal of sustainable development. Prior to implementation of such a scheme it would be important to undertake the cataloguing of the genetic structures of any commercially important marine species in Qatar's waters for which this has not already been done. Alternatively, as currently practised for terrestrial farming, it may be prudent to invest in the conservation of foreign marine biodiversity that provides feedstock for Qatar, or in areas currently fished for the Qatari market. Without adequate protection these areas may well face overexploitation and more severe pressure on a diminishing resource.

Biosafety is another area that needs to be fully investigated since the spread of marine species is generally more difficult to curtail than that of terrestrial species, and neighbouring states may not have strict aquaculture policies. This potential threat requires the development of adaptive biosafety management plans that are local, regional and international. Transboundary movement of genetic fisheries stock is difficult to monitor and requires close intergovernmental collaboration.

Marine Reserves and Restoration

Marine protected areas are essential components that help ensure the viability of marine resources. The creation and success of protected areas need to consider a number of elements including detailed site selection and adequate size; zoning requirements; inclusion of high ecological/ commercial value species; relevance at the regional level; establishment within a legal framework; enforcement, development and management by interaction with stakeholders; outreach and educational/ awareness programmes; explicit management plans; long term financial viability; and ongoing research that includes periodic reviews of these requirements.

Many of the partly functional reserves with either a marine component or a marine boundary, including Khor Al-Adaid (the largest natural marine reserve in Qatar), Al-Dhakhirah, Umm Tais and Al-Reem, have been made possible by private industry or development commitments to the MoE. Few if any of the protected areas have management plans and none of the related documents are readily available. Qatar has the opportunity to lead development and assessment of new technologies that make the design, monitoring and supervision of such reserves easier and more practical.

Marine ecosystem restoration is another potential area where Qatar could lead scientific investigation and development. In the last few decades many methods have been proposed to rehabilitate or restore mangrove forests, coral communities, sea grass beds, oyster beds, oil-impact beaches and their supporting biodiversity. Several artificial reefs have been deployed at locations around Qatar using differently shaped modules and construction materials. Given the financial support of the QNRF and the costly and time consuming nature of studies evaluating these systems and their potential benefits for the marine habitat and biodiversity rehabilitation, Qatar could provide a premier showcase of the region's marine biodiversity and concurrently develop attractions for eco-tourism.

Public-Private Partnerships

An immediate opportunity for Qatar to champion marine policy and research would be to further exploit public-private partnerships to conserve marine environments. This is especially true given the size of the oil and gas industry in Qatar and the potential damage their operations can cause to marine environments through the wastes discharged or oil spills. This is also true for the construction industry through their manipulation of natural marine habitats.

An immediate opportunity for Qatar to champion marine policy and research would be to further exploit public-private partnerships to conserve marine environments

Successful examples include leadership in species-specific research (for example, Qatar Petroleum and sea turtles; and Dolphin Energy and dugongs) and the creation and management of marine reserves. Concentrating upon large or well known marine organisms serves a company's corporate image well whilst providing scientifically valuable information. Marine reserve development would require a longer-term commitment, but is a strategy that appeals to the public and contributes to the sustainable management of marine ecosystems.

Regional and International Cooperation

Qatar shares the features of the marine environment and its associated biodiversity with other countries located on the Arabian Gulf. The products derived from the sea and the anthropogenic pressures resulting from the regional drive for development are common to the whole region, and the quest for the conservation of marine environments necessitate regional cooperation in which Qatar can take a leading role.

Qatar is a geographically small nation with a relatively large marine environment under its stewardship. Given its strong financial situation, Qatar has the capability to support local environmental agencies and researchers by bringing in leading researchers and policy makers. Selected governmental and research partnerships with the international engineering and medical colleges in Qatar could be developed. The creation of a regional centre of maritime excellence could also play a role in informing and advising on strategies and policies and in evaluating planned policy interventions, through the observation, monitoring and data clearing of local marine biodiversity and environmental conditions.

Conclusion

Humankind depends on oceans and coasts and their resources for survival. Conservation of Qatar's marine environment requires changes from the current 'business as usual' scenario. A sound environmental management framework is essential for building a modern state and advancing sustainable development. With environmental concerns attracting global attention and people growing more worried about pollution, climate change and depletion of resources, Qatar's challenge is to marry its impressive economic progress with sustainable environmental policies. This approach will support sound national policies and enhance the quality of life for all Qataris.

A national marine policy is required to ensure the sustainable use and conservation of marine resources. Such a policy could be supported through a research organisation that addresses the numerous gaps in knowledge of marine environments and its conservation. Public-private partnerships could help champion marine policy and research.

Building and engaging Qatar's civil society are critical in the implementation of the national environmental vision. Stakeholder and communication campaigns targeting civil society can help make citizens aware of their responsibility towards the environment. This in turn can leverage the private sector to focus on its corporate social responsibilities and ensure that its actions are not detrimental to Qatari society. These measures can promote open dialogue on environmental topics. Media campaigns can also help promote appropriate patterns of behaviour on the part of the public, through highlighting the positive effect personal action can have on the environment.

Building and engaging Qatar's civil society are critical in the implementation of the national environmental vision

All of Qatar's marine conservation objectives cannot be achieved simultaneously. But some important improvements can be achieved quickly whilst a longer term adaptive strategy is being implemented. Further steps can be taken when the results from ongoing and proposed research become available.

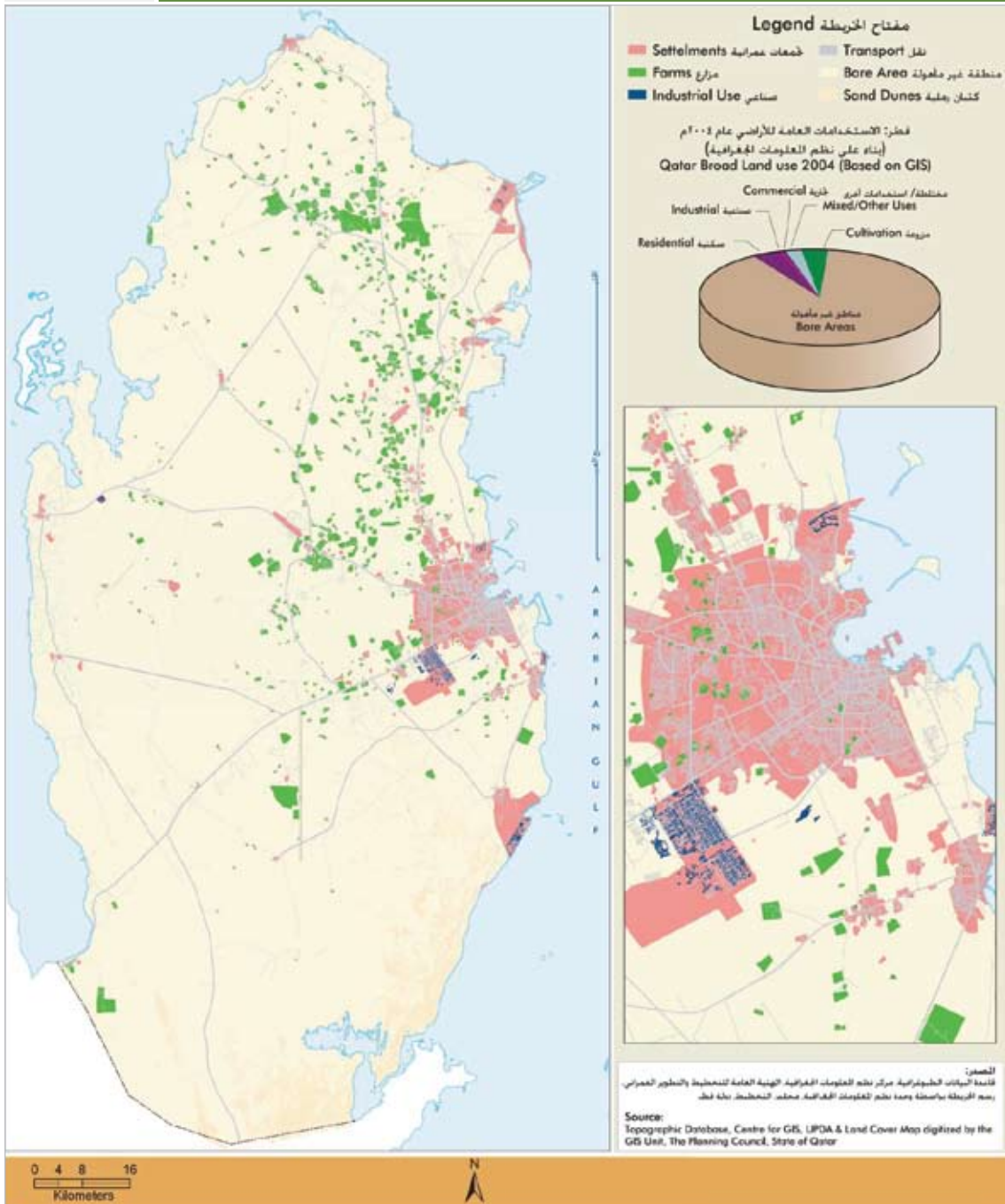
References

- Al Ansi, M. 2009.** "Marine Environment and Human Development in the State of Qatar: Problems, Challenges and Opportunities." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.
- DoF (Department of Fisheries, Ministry of Municipality and Urban Planning). 2008.** Qatar Fisheries Statistics Yearbook 2008. Doha.
- _____. **2007.** Qatar Fisheries Statistics Yearbook 2007. Doha.
- IPCC (Intergovernmental Panel on Climate Change). 2001.** *Climate Change 2001: Impacts, Adaptation, and Vulnerability. A Report of Working Group II of the Intergovernmental Panel on Climate Change*. (B. Metz, O. Davidson, R. Swart and J. Pan, eds.). Cambridge University Press, Cambridge.
- FAO (Food and Agriculture Organisation). 1997.** *Living Marine Resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar and the United Arab Emirates*. (K.E. Carpenter, F. Krupp, D.A. Jones and U. Zajonz, eds.). Rome.
- _____. **2003.** "Information on Fisheries Management in the State of Qatar." [<http://www.fao.org/fi/oldsite/FCP/en/QAT/body.htm>]. Accessed February 2009.
- _____. **2009.** *State of the World Fisheries and Aquaculture*. Rome.
- GSDP (General Secretariat for Development Planning). 2008.** *Qatar National Vision 2030*. Doha.
- Macdonald, I. A. 2009.** "Marine Biodiversity and Human Development: Patterns, Threats and Conservation Needs." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.
- MoE (Ministry of Environment). 2008.** Qatar Dugong Conservation Initiative. Final Report. Phase 1 Preliminary Assessment. Doha.
- QSA (Qatar Statistics Authority). 2005.** *Annual Statistical Abstract*. Doha.
- _____. **2006.** *Annual Statistical Abstract*. Doha.
- _____. **2007.** *Annual Statistical Abstract*. Doha.
- _____. **2008.** *Digital Atlas of Qatar*. Doha.
- State of Qatar. 2004.** National Biodiversity Strategy and Action Plan.
- _____. **2007.** "Third National Report On Implementation of the Convention on Biological Diversity". [<http://www.cbd.int/countries/?country=qa>]. Accessed February 2009.
- UNEP (United Nations Environment Programme). 1995.** "Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities." Adopted at the Intergovernmental Conference to Adopt a Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities. Washington D.C.
- [http://gpa.unep.org/documents/full_text_of_the_english.pdf]. Accessed February 2009.
- _____. **2002.** *Global Environment Outlook 3*. London.
- _____. **2006.** Marine and Coastal Ecosystems and Human Well-Being. A synthesis report based on the findings of the Millennium Ecosystem Assessment.
- UPDA (Urban Planning and Development Authority, Qatar) and PCI (Pacific Consultants International). 2008.** Qatar National Master Plan, Study Report 1 – Present Situation Analysis and Identification of Issues.

4

Climate Change and Human Development Interactions and Challenges

Map 4.1 Broad Land Use, Qatar



Source: QSA, 2008b

Climate Change and Human Development: Interactions and Challenges

Development patterns can, and often do, have negative effects on the natural environment. Environmental degradation can be reduced through investment in advanced technologies designed to minimise the damage caused by economic projects. It can also be reduced by avoiding rapid and unplanned growth. Even with Qatar's best efforts, it is impossible to entirely avoid harming the environment, given a development path that depends in its early stages on oil, gas, petrochemicals and heavy industries. Qatar has already committed to enforcing international standards for environmental protection when designing and implementing its industrial projects.

GSDP, 2008

Climate change, the long-term change in average weather conditions, is posing increasingly formidable challenges to all countries and to all humankind. Climate change has been identified as the most pressing global environmental problem with potentially catastrophic consequences for human development. The debate on whether climate change is taking place and whether it is human-induced is now obsolete. The Intergovernmental Panel on Climate Change (IPCC) has established an overwhelming scientific consensus that climate change is happening, that it is significant, and that it is clearly linked to human activity. Today, the focus is on strategies for mitigation and adaptation, involving national action and international cooperation.

The State of Qatar, through the environmental pillar of the Qatar National Vision 2030 (QNV 2030), acknowledges the need to address the challenges posed by climate change (Box 4.1). It is cognisant of the multidimensional nature of climate change, from the physical sciences to economics, from domestic politics to foreign policy and from environmental to social issues. It recognises that climate change should be viewed as part of the larger challenge of sustainable development.

Box 4.1 Towards Defining Climate Change

A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

United Nations Framework Convention on Climate Change (UNFCCC)

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Intergovernmental Panel on Climate Change (IPCC)

Climate Change is a Global Issue: Human Activity Poses the Biggest Threat

Climate change is a problem with unique characteristics. It is a global challenge which necessitates collective solutions. In an ecologically interdependent world, one country's emissions are another's climate change problem. Further, climate change is a long-term problem with cumulative outcomes. Once emitted, greenhouse gases (GHG) stay in the atmosphere for a long time, and the material effects from mitigation measures implemented today, no matter how stringent, will not be immediately felt. The current generation cannot solve the climate change problem alone but has the power to take urgent action now to ensure intergenerational justice.

While the scale and timing of the effects of climate change are still uncertain, warming of the climate system is unequivocal, as is now evident from observations of increase in global average air and ocean temperature, widespread melting of snow and ice and rising global average sea level (Box 4.2).

Box 4.2

Global Warming in Progress and Likely to Worsen

- Eleven out of the twelve years from 1995 to 2006 were amongst the twelve warmest years since records began in 1850. The linear warming trend over the 50 years from 1956 to 2005 was nearly twice that for the 100 years from 1906 to 2005.
- The temperature increase is widespread globally and is greater at higher northern latitudes. Land regions have warmed faster than the oceans. Global ocean temperature increases have been observed to a depth of at least 3,000 metres (m) resulting in sea level rises due to seawater expansion, as oceans have absorbed more than 80 per cent of the heat added to the climate system.
- There have been overall declines in mountain glaciers and snow cover in both hemispheres. Sea level rises have resulted from melting of glaciers and ice caps and very likely from melting of ice sheets in Greenland and Antarctica. The total 20th Century sea level rise is estimated to be 0.17m and was higher than the 19th Century rise.
- Since 1900, precipitation has significantly increased in eastern parts of North and South America, northern Europe and northern and central Asia. Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Heavy precipitation events have become more frequent over most land areas, whilst droughts have become more intense, longer and over wider areas, particularly in the tropics and subtropics.
- Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s.
- There is the general trend for cold days, cold nights and frost to occur less frequently, while hot days, hot nights and heat waves occur more frequently.

The Intergovernmental Panel on Climate Change (IPCC) predicts that changes in temperatures, sea levels and weather patterns are likely to deteriorate into the future. The degree of change will largely depend upon future human activity, that is, on the success of the global community to implement measures that enable stabilisation of the climate.

Simulation studies of a number of emission scenarios investigated by the IPCC predict average global temperature increases between 1.1 degrees Celsius (°C) (best case) and 6.4°C (worst case) with corresponding sea level rises of 0.18m to 0.59m by 2090 to 2099 relative to 1980 to 1999 levels. In the longer term, beyond 2100, the contraction of the Greenland Ice Sheet is projected to continue to contribute to sea level rise. A virtually complete elimination could result if average warming in excess of 1.9°C to 4.6°C over pre-industrial values is sustained for millennia, resulting in a maximum contribution to sea level rise of about 7m.

Source: Derived from IPCC, 2007a and 2007b

The emerging risks and vulnerabilities associated with climate change are the outcomes of physical processes and are primarily consequences of human actions and choices. The rapid rate at which atmospheric concentrations of carbon dioxide (CO₂) are increasing, accompanied by rising concentrations of other GHG, have resulted in global warming, with evidence that the process is accelerating.

The emerging risks and vulnerabilities associated with climate change are primarily consequences of human actions and choices

Considerable scientific progress has been made since the identification in the 19th Century of the 'greenhouse effect' and its influence on atmospheric temperature, enabling more accurate predictions of global temperature increases. The scientific consensus is that increases in GHG emissions are due to man-made contributions and the observed warming cannot be satisfactorily explained by natural causes (Box 4.3).

Box 4.3 Natural Causes Do Not Satisfactorily Explain Climate Change

Ocean circulation

The ocean interacts with the atmosphere through the exchange of heat, water and momentum. The atmospheric circulation and ocean currents carry heat from the tropics toward the poles. The ocean is also both a source and sink of greenhouse gases, thus playing an important role in determining the atmospheric concentration of carbon dioxide (CO₂). Changes in ocean circulation, chemistry and biology may affect climate change by slowly moving CO₂ into or out of the atmosphere.

Volcanic eruptions

Volcanic eruptions that add significant quantities of sulfur dioxide into the stratosphere lower global surface temperatures. Brief periods of global cooling have followed major volcanic eruptions, such as Mt. Pinatubo in 1991 (IPCC 2007a).

Solar variations

The energy output of the sun, which is converted to heat at the Earth's surface, is an integral part of shaping the Earth's climate. Physical changes within the Sun may alter the intensity or character of the incoming solar energy. However, while changes in solar activity over the longer term may impact climate change, solar variation has little effect in the shorter term.

Orbital variations

The effect of orbital variations on climate change is an extension of solar variability. Variations in the Earth's orbit and inclination toward the sun cause cyclical variations in solar energy received by the Earth and on the spatial distribution of solar energy on the Earth's surface.

Climate change can be traced back to two great transformations in energy use: (i) the harnessing of coal to new technologies that fuelled the industrial revolution in the 18th Century; and (ii) the harnessing of oil to the internal combustion engine in the early 20th Century, which fuelled the revolution in transport.

Today, the largest growth in GHG emissions has come from energy supply, transport and industry, while residential and commercial buildings, forestry (including deforestation) and agriculture sectors have been growing at a slower rate (Box 4.4).

Box 4.4**Climate Change is Primarily Driven by Human Activity**

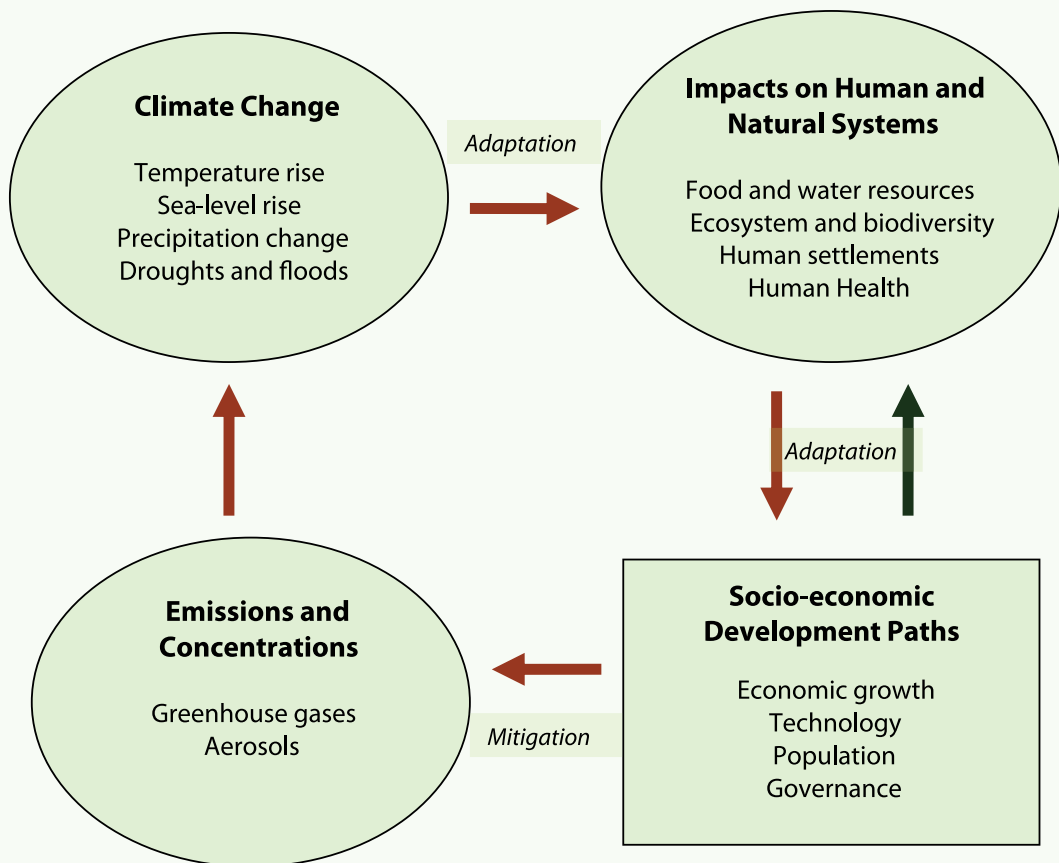
- The energy balance of the climate system is affected by atmospheric concentrations of greenhouse gases (primarily carbon dioxide, methane and nitrous oxides) and aerosols (primarily sulphate, organic carbon, black carbon, nitrate and dust), changes in solar radiation and in land surface properties.
- Human (industrial) activity has resulted in significant increases over pre-industrial values in atmospheric carbon dioxide, methane and nitrous oxide concentrations. Fossil fuel use and land-use change are the primary reasons for increases in carbon dioxide concentrations whereas increases in methane and nitrous oxide concentrations result mainly from agriculture.
- By 2005 the concentration of the most important anthropogenic greenhouse gas, carbon dioxide, had increased by 35 per cent over its pre-industrial value of about 280 parts-per-million (ppm). Over the same period, the methane concentration had increased from 715 parts-per-billion (ppb) to 1774 ppb. Carbon dioxide and methane concentrations now far exceed their natural ranges over the last 650,000 years. In addition, nitrous oxide concentrations have increased by about 20 per cent over their pre-industrial value to 319 ppb in 2005.
- The annual carbon dioxide concentration growth rate shows an accelerating trend. Annual fossil carbon dioxide emissions were around 26.4 gigatonnes of carbon dioxide (GtCO₂) per year in 2000–2005. Estimates of annual emission contributions due to land use change are estimated at 1.8 to 9.9 GtCO₂ over the 1990s.
- The increases in carbon dioxide, methane, and nitrous oxide have resulted in an estimated radiative forcing of +2.30 watts per square metre (W m⁻²). This implies that the increase in these gases have altered the balance of incoming and outgoing energy in the Earth-atmosphere system and warmed the surface. From 1995 to 2005, the carbon dioxide radiative forcing has seen the largest change for any decade in at least the last two centuries.
- Anthropogenic contributions to aerosols (primarily sulphate, organic carbon, black carbon, nitrate and dust) together produce a cooling effect. A mean effect of -1.2 W m⁻² has been stated.
- Because of the long time scales associated with the removal of carbon dioxide from the atmosphere, past and future emissions will cause further warming and sea level rises for more than a millennium.

Source: IPCC, 2007a

While fossil fuel burning accounts for the majority of CO₂ emissions from anthropogenic contributions, most of the rest is due to land use change, especially through agriculture, deforestation and urbanisation. Land use change results in changing the physical and biological properties of the land surface and thus the climate system.

Climate Change in the Context of Sustainable Development

There are strong linkages between climate change and sustainable development (Box 4.5). The impacts of climate change can hinder development progress and development choices will themselves influence the capacity to mitigate and adapt to climate change. The potential impacts and mitigation of climate change therefore need to be analysed within the context of sustainable development. Climate policies can be more effective when consistently embedded within broader strategies designed to make national development paths more sustainable.



Source: IPCC, 2001

Ecological Interdependence: Climate Change Knows No Borders

Addressing climate change is a cross-generational, cross-border exercise. Climate change challenges us to think about what it means to live as part of an ecologically interdependent community. Climate change will inevitably flow across national borders and inaction today will result in an accumulation of an unsustainable ecological debt that our future generations will inherit.

Addressing climate change is a cross-generational, cross-border exercise

For the Gulf Cooperation Council (GCC) countries, oil and gas revenues have led to high rates of economic growth which has enabled exceptional and accelerated development in all aspects of life. However, resource exploitation, urbanisation and increased consumption have led to increasing environmental challenges.

The GCC countries lack arable land and water resources for the development of carbon sinks, forests and green areas and are therefore vulnerable to climate change impacts (Raouf, 2008). If sea levels rise, coastlines and marine life will be affected, more land degradation will occur and freshwater levels will fall. If temperatures rise, water demand will increase but rising underground water salinity and falling freshwater levels will threaten water security and affect the efficiency of desalination plants that are the source of water for the region. Qatar and the United Arab Emirates (UAE) are among the top 10 countries in the world that would be most impacted by sea-level rise in terms of percentage land area and wetlands affected for Qatar and percentage of population and urban area affected for UAE (Dasgupta, et. al 2007).

Major GHG emitters in the region include Saudi Arabia, Kuwait and UAE (Table 4.1). The largest CO₂ emission growth rates due to fuel combustion are experienced in Qatar, Oman, Kuwait, and Iran (Raouf, 2008). Even though the GCC countries contribute only about 2.4 per cent of global GHG emissions, *per capita* emissions are high and climate change is of major concern.

Qatar's Carbon Footprint

Qatar has large energy-consuming industries to extract and process its vast oil and gas reserves. On a global scale, Qatar's total carbon dioxide emissions are relatively modest, a feature of many, though not all, high-income oil producing countries. Out of the total global carbon emissions, only about 0.2 per cent was attributed to Qatar in 2006 (CDIAC 2009a and 2009d). Some 59 other countries emitted greater quantities of carbon dioxide (Table 4.1).

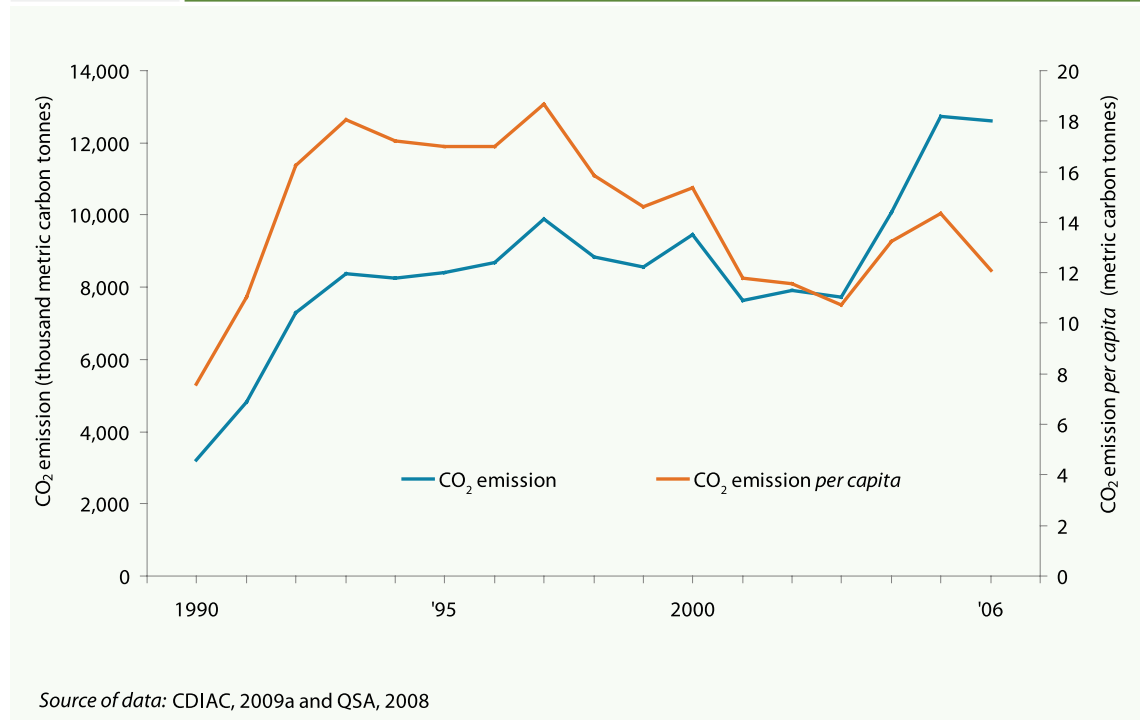
Table 4.1 Qatar Ranked 60th for Total Carbon Dioxide Emission in 2006 But Ranked 1st for *Per Capita* Emission Because of its Small Population

Country	Total CO ₂ Emission (thousands metric tonnes per year)	World Rank	<i>Per Capita</i> CO ₂ Emission (metric tonnes per year)	World Rank
Qatar	12,598	60	12.1	1
Kuwait	23,618	42	9.4	2
UAE	38,060	32	9.0	3
Bahrain	5,807	79	7.8	4
United States	1,568,806	2	5.2	9
Oman	11,285	66	4.4	13
Saudi Arabia	104,063	15	4.4	14
Brunei	1,612	111	4.2	15
Singapore	15,332	54	3.4	21

Source of data: CDIAC, 2009a; CDIAC, 2009b; QSA, 2008a

Qatar's total carbon emissions from fossil fuels recorded a substantial increase (Figure 4.1), with emissions more than tripling since 1990 due to rapid industrial expansion. *Per capita* emissions were somewhat more erratic, reflecting not only increased production but changes in population numbers as migrant labour was recruited in response to the needs of the expanding work force. Without direct action to ameliorate the rising trend in emissions, Qatar's carbon footprint can be expected to expand over the next decade.

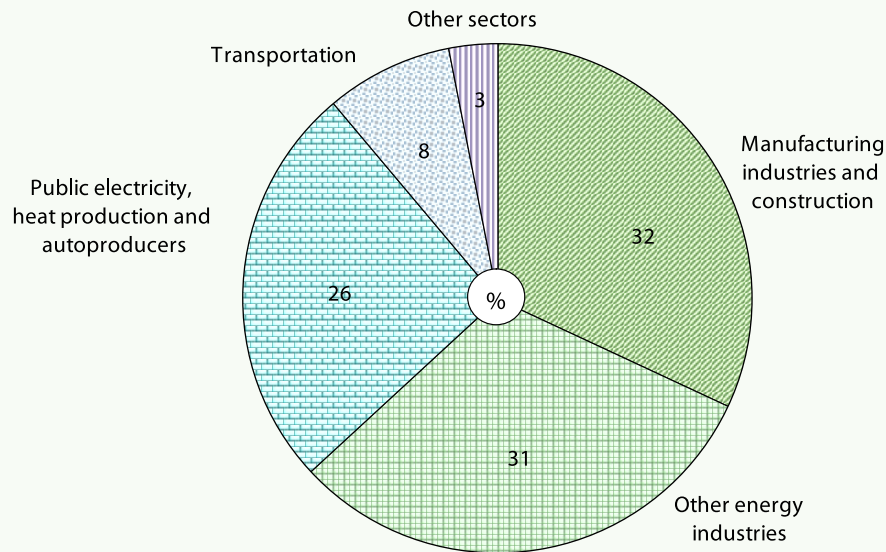
Figure 4.1 Continuing Substantial Carbon Dioxide Emissions But Declining Emissions *Per Capita*, Qatar



Without direct action to ameliorate the rising trend in emissions, Qatar's carbon footprint can be expected to expand over the next decade

According to the World Resources Institute (2006), the major contributors to Qatar's emissions in 1999 were energy and manufacturing industries and electricity and heat production for desalination, which together accounted for about 90 per cent of emissions (Figure 4.2). Transportation contributed 8 per cent of the emissions. Since then, the industrial share of emissions can be expected to have increased due to the rapid expansion of gas processing (liquefied natural gas (LNG) and gas to liquids (GTL)) and manufacturing (petrochemicals, cement, steel, aluminium) industries (Box 4.6).

Figure 4.2 Carbon Dioxide Emission by Sector, Qatar, 1999



Notes:

i Residential emission was zero in 1999

ii Other sectors include the commercial sector, agriculture, the public service sector and international bunkers

Source: WRI, 2006

Box 4.6 Major Features of GHG Emissions in Qatar, 2001 and 2006

- Total GHG emissions (carbon dioxide, methane, nitrous oxide) in CO₂ equivalent exceeded 59,700 kilotonnes in 2006. This was an increase of 47 per cent over 2001 (Table 4.2). Most of the GHG emissions are in the form of CO₂.
- This increase was mainly attributable to:
 - expansion of upstream oil and gas operations;
 - increased road transport and construction activities; and
 - accelerated growth in the electricity and water services sector;
- In 2006, the oil and gas industry accounted for about 70 per cent of the total national GHG emissions; about 60 percentage points are due to upstream operations and the remaining 10 percentage points are from downstream activities including the petrochemical industry, petroleum refining, and cement production;
- Overall emissions from the oil and gas sector have significantly increased (by 186 per cent, 2001-2006) despite reductions from flaring due to the sustained growth of the industry;
- Two other major sources of GHG emissions that are related to population growth, increase in construction and vehicle use were:
 - the electricity and water sector which significantly increased its contribution to the national total; and
 - the road transport and building and construction sector (about 10 per cent of the national total).

Source: Al Mulla et. al., 2009

Due to mitigation efforts by industry, emissions from flaring were substantially reduced from two-thirds of oil and gas industry emissions in 2001 to about one-quarter in 2006. Flaring comprised about 45 per cent of total national emissions in 2001, compared to less than 20 per cent of the national total in 2006 (Table 4.2). This progress can be expected to continue as, in May 2007, Qatar Petroleum successfully registered the first United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism project under the Kyoto Protocol in the Gulf region. The project is designed to decrease CO₂ emissions by further reducing flaring.

Table 4.2 Qatar's Sources of GHG Emissions; Flaring Has Declined While Oil and Gas Emission Has Increased

Sector	2001		2006		Percentage change 2001-2006
	Kilotonnes ¹	Per cent	Kilotonnes ¹	Per cent	
Energy and water productions	6,428	15.8	11,872	19.9	85
Transportation ²	2,584	6.4	6,008	10	133
Oil and gas	18,125	44.6	11,718	19.6	-35
Refining	241	0.6	383	0.6	59
Petrochemicals	4,737	11.7	5,736	9.6	21
Cement	252	0.6	258	0.4	2
Waste Management	na	na	315	0.5	na
Total³	40,597	..	59,789	..	47

Notes:

i CO₂ equivalent

ii 2006 data include construction projects

iii Total includes insignificant contribution from enteric fermentation and manure manufacture

na not available

Source: Al Mulla et. al., 2009

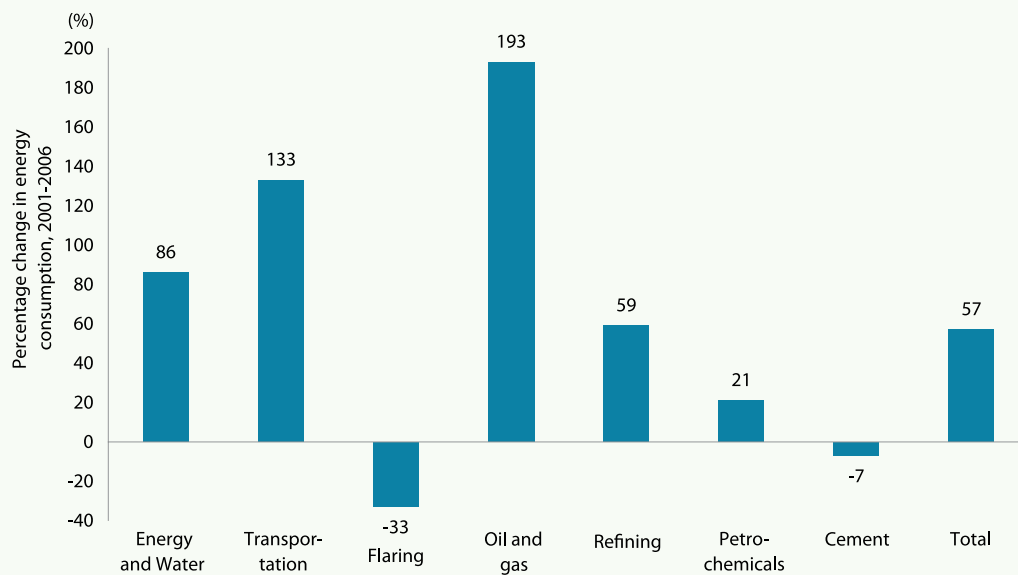
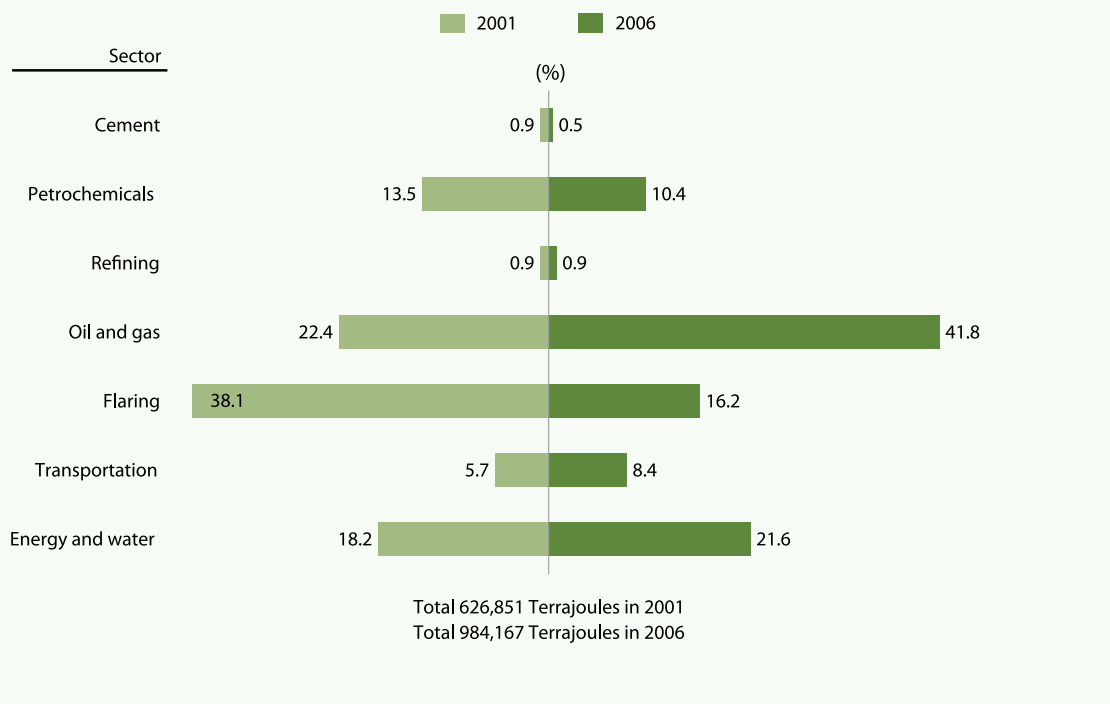
Significant reductions in GHG emissions are achievable given appropriate mitigation measures to address the major components of energy consumption (Box 4.7).

Box 4.7 Major Features of Energy Consumption in Qatar, 2001 and 2006

- Total energy consumption in Qatar in 2006 exceeded 984,100 Terrajoules. This was an increase of 57 per cent over 2001 (Figure 4.3).
- 90 per cent of 2006 consumption was in the form of natural gas.
- The remaining 10 per cent was gasoline and diesel.
- Domestic consumption of primary energy in 2001 and 2006 was estimated to be approximately 24 per cent of total energy production.

Source: Al Mulla et. al., 2009

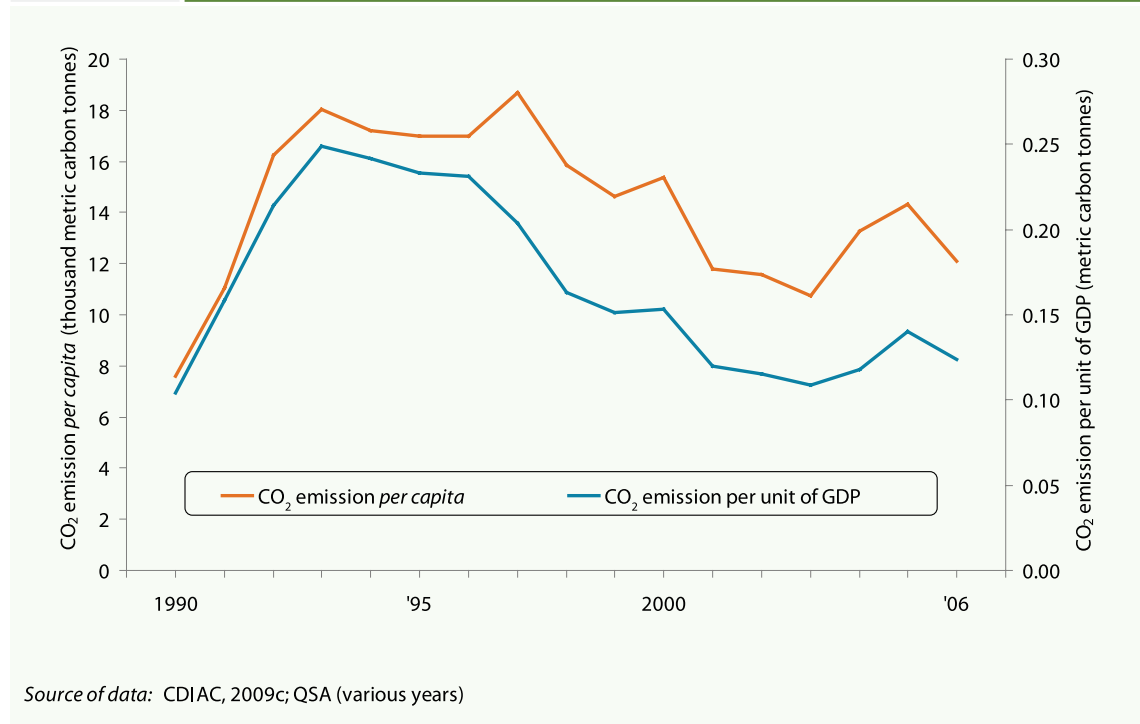
Figure 4.3 Oil and Gas, Flaring and Energy and Water- The Main Energy Consumers in Qatar; Importance of Flaring Declined While Consumption by Oil and Gas Increased



Note: Total includes small consumption by enteric fermentation and manure manufacture
Source of data: Qatar Petroleum

In recent years, CO₂ emission intensities per unit of GDP and *per capita* have decreased (Figure 4.4). The reduction in emission intensity *per capita* is largely the result of the sharp increase in migrant labour. The fall in emission intensities per unit of GDP reflects the extent to which CO₂ emissions are being managed within the country, through investment in cleaner technologies and other industrial processes with lower emissions.

Figure 4.4 Qatar's Carbon Dioxide Emission Intensities Reduced in Recent Years



Need for Fairer Measurement of Emissions

Qatar's standing as the world's number one *per capita* emitter of carbon dioxide is partly a function of the method of measurement together with its status as one of the world's major producers. The reported emissions data for Qatar employ a production-based emissions accounting methodology. That is, emissions associated with fossil fuels produced in and largely exported from Qatar are assigned to Qatar rather than to the countries importing and utilising the products.

Given its large production and small population, Qatar is disadvantaged when production-based emissions accounting is employed

Because of its large production and small population, Qatar's *per capita* carbon emissions are very high. Qatar is disadvantaged by having these production-based emissions attributed to it. Qatar's emissions data would be greatly reduced if a consumption-based accounting system was followed (Box 4.8).

Box 4.8**Emissions Accounting: Production or Consumption-Based?**

An important debate on emissions relate to the preservation of equity in emissions accounting. The choice of emissions accounting measure is critical for individual countries, especially those with large extractive industries. There are three possible methods of emissions accounting:

- Production-based accounting linked to geographical boundaries (greenhouse gas emissions occurring within national borders);
- Production-based accounting linked to economic system boundaries (greenhouse gas emissions from resident institutional units, analogous to gross domestic product); and
- Consumption-based accounting linked to input-output tables.

The contention is whether responsibility should be placed on the actor initiating the polluting process (consumer) or the actor producing the pollution (producer). Consumption-based measures favour developing countries while production-based measures favour richer countries. Countries with large extractive industries such as oil and gas and mining are heavily penalised with emissions accounting based on production vis-à-vis accounting based on consumption.

For Qatar, there are equity grounds for emissions to be assessed at the point of consumption. Qatar generates emissions to make products that are used elsewhere in the world and should not be made to carry the burden for those who receive the benefits from the emissions, or 'embedded carbon'.

However, while consumption-based accounting has attractive features, there are some obstacles to implementation. Data are generally easier to obtain for the production-based approach. The consumption-based approach is more complicated to compute as it relies on input-output tables, which includes all steps in production from raw material extraction through to final assembly and ultimately the final sale of the product.

Source: Derived from Peters and Hertwich, 2008 and Dervis, 2008

Emerging Risks and Vulnerabilities for Qatar: A Case for Action

The United Nations Development Programme (UNDP) identifies five key transmission mechanisms through which climate change could stall and then reverse human development, namely agricultural production and food security; water stress and water insecurity; rising sea levels and exposure to climatic disasters; ecosystems and biodiversity; and human health (Box 4.9).

- **Agricultural production and food security.** Changes in precipitation, temperature and water availability for agriculture will cause losses in agricultural production in vulnerable areas such as sub-Saharan Africa, Latin America and South Asia. As a result, 600 million additional people could be affected by malnutrition by 2080. Globally, the potential for food production is projected to increase with local average temperature rises over a range of 1 - 3°C over pre-industrial levels. Global food production potential will be reduced for temperature increases above this level. Climate change is expected to have negative effects on fisheries.
- **Water stress and water insecurity.** The 2007 HDR states that an additional 1.8 billion people could be living in water scarce areas by 2080. Significant reductions in water availability are expected for Central Asia, northern China and the northern part of South Asia, the Andean region in South America, and several countries in the Middle East. IPCC predictions for the 21st Century include increases in drought-affected areas and in the frequency and severity of heavy precipitation events leading to increased flood risk.
- **Rising sea levels and exposure to climatic disasters.** Rising sea levels could result in hundreds of millions of people being permanently or temporarily displaced through flooding, catastrophic damage to small islands in the Caribbean and the Pacific, hundreds of millions of people being exposed to heavy storms and cyclones, and in acute vulnerabilities of one billion people living in urban slums on fragile hillsides or flood-prone river banks.
- **Ecosystems and biodiversity.** Climate change has resulted in damage to ecological systems, including coral reef systems and ice-based ecologies. An increase in global average temperature exceeding 1.5°C to 2.5°C is predicted to result in 'major changes in ecosystem structure and function, species' ecological interactions, and species' geographical ranges, with predominantly negative consequences for biodiversity, and ecosystem goods and services, for example, water and food supply'.
- **Human health.** Negative impacts on the health status of millions of people are expected. People with low adaptive capacity are particularly vulnerable to increases in malnutrition, deaths, disease and injury due to heat waves, floods, storms, fires and droughts; the increased burden of diarrhoeal disease; cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change; and wider spreads of major killer diseases such as malaria or dengue fever

Source: Derived from UNDP 2007; IPCC, 2007a; IPCC 2007b

Risks and vulnerabilities to Qatar may arise due to changes in temperatures, precipitation levels and sea water levels in the Arabian Gulf. These include:

Flooding and loss of land area: Climate change is expected to lead to more frequent extreme weather events. Heavy rains may lead to local flooding causing damage and disruption. Sand storms may increase in frequency and severity and cause further disruption. In the longer term, the rising seawater level may lead to loss of land area by erosion of coastal areas. Significant long-term damage and loss of large land areas should be expected in case of dangerous climate change leading to drastic rises in sea water levels of several metres.

Damage to marine environment: Warming and acidification of the Arabian Gulf may lead to potential damage to the marine environment from corals to fish. Such warming may also impact on the ability to further heat seawater used as cooling water in industrial processes, power generation and desalination.

Water stress and water management: Rising seawater levels are expected to lead to seawater intrusion increasing the salinity of fresh water reserves in Qatar. There is no surface water available and ground water reserves in Qatar are already under severe pressure from agricultural demands. Negative environmental impacts from additional large-scale desalination facilities are the likely result.

Food security: Qatar imports 90 per cent of its food. With global agricultural productivity declining in the event of dangerous climate change and the global population on the increase, food shortages in exporting countries may lead to severe supply problems in the future. Increasing agricultural production would require significant land areas to be cultivated and would pose very high additional fresh water demands.

Strong dependency on the oil and gas sector: Qatar is a high income country, primarily due to exports of fuels and energy intensive products. With the world's use of energy sources shifting away from fossil fuels, a decline in income streams from energy exports is expected in the long term. Similarly, exports of carbon-intensive products from Qatar may be penalised by importing countries if border taxes for carbon intensive products are implemented (Jordan-Karte and Mildner, 2008) and production-based carbon accounting is maintained.

Inability to transform into a low carbon economy: Declining revenues from traditional industrial activity would require the identification and implementation of economic developments to replace them. Achieving such a major transformation in a dynamic global environment requires significant investments.

High cost of long-term adaptation: Infrastructure investments to adapt to the long-term impacts of climate change on the environment, economy and society are expected to be very high. The necessity for significant investments may coincide with declining revenue streams from economic activity, which could negatively impact human development.

Inappropriate education and training: A highly skilled and sizeable workforce would be required to plan, manage and execute the transition to a diversified and competitive economy away from oil and gas and to plan and implement climate change adaptation measures, as well as the corresponding transitions of infrastructures.

Health risks: Some health impacts would result from increases in climate extremes and weather disasters such as heat waves, floods, typhoon and droughts; some would be due to changes in the geographic distribution and biological behaviour of vector organisms of vector-borne infectious diseases such as malaria and dengue; and others may result from changes in the concentrations of local air pollutants and aeroallergens.

The monitoring of ambient air quality parameters, such as sulfur dioxide, nitrogen dioxide (NO₂), ground ozone (O₃), carbon monoxide, total hydrocarbons and methane, particulate matter (PM₁₀ – solid or liquid particles found in the air with a diameter of less than 10µm) and other meteorological parameters, is conducted in four stations in Doha and Al-Khor. In 2008, except for PM₁₀ and a few exceedences of O₃ and NO₂, all other parameters were below prescribed limits (MoE, 2008). The main health hazards arising from intensive exposure to PM₁₀ include respiratory morbidity, which is generally reflected in a rise in hospital admissions for respiratory illness.

Loss of habitat, food, water: Dangerous climate change in the long term could result in significant loss of Qatar's land to the sea. In addition, declining revenue streams could also negatively impact on the ability to import food and produce fresh water. Such changes could have detrimental health effects.

Managing Risks and Vulnerabilities: International Cooperation and National Action

Although climate change is a global problem, its impacts will be regional and local and will vary in different locations. Responses to climate change require progress in two directions. First balanced mitigation is required through global GHG emissions reductions in order to stop global warming and avoid the negative impacts of climate change. Mitigation requires local actions to be coordinated in global frameworks. Second, local adaptation is needed to enable societies to cope with the negative outcomes. Thus, policy and management responses to climate change require development and implementation of strategies for mitigation and adaptation.

Policy and management responses to climate change require development and implementation of strategies for mitigation and adaptation

Global Response to Climate Change

There is a general agreement among scientists and environmentalists for a threshold limit for dangerous climate change at 2°C above pre-industrial levels. This would require stabilising CO₂ equivalent concentrations at around 450 parts-per-million (ppm) by 2050 (UNDP, 2007). Global carbon emission reductions of 50 per cent over 1990 levels would be necessary to achieve this. The reduction over current emission levels would need to be significantly greater considering that CO₂ emissions increased by about 25 per cent between 1990 and 2004 (IEA, 2006).

According to estimates by UNDP (2007), developed countries would have to cut CO₂ emissions by at least 80 per cent, with cuts of 20 to 30 per cent by 2020. In the UNDP's stabilisation scenario, carbon emissions from developing countries will peak around 2020, with subsequent cuts of 20 per cent by 2050. These emission reductions will have to be achieved despite an increasing global energy demand forecast by the IEA (2007) to be in excess of 50 per cent between 2005 and 2030.

Achieving such drastic reductions in carbon emissions will require significant spending over the next few decades to realise the transition to a low-carbon regime. UNDP (2007) has estimated the annual cost of attaining the 450ppm CO₂ stabilisation target at 1.6 per cent of average global GDP until 2030, which is only about two-thirds of global military spending. The cost of stabilisation is significantly lower than the costs associated with inaction, which amount to 5 - 20 per cent of global GDP (Linke, 2009).

There is a general consensus within the scientific community that significant GHG emission reductions are needed, but the questions of how much and how fast remain open. Action to mitigate climate change must be undertaken: in view of the drastic reductions required to stabilise the climate, today's policies should already be aiming at achieving the challenging transition to low carbon societies.

International Agreements and Mechanisms to Mitigate Climate Change

The UNFCCC is an international environmental treaty which sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. Negotiated between 1990 and 1992, the UNFCCC was adopted in May 1992 and opened for signature a month later at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil.

The objective of the UNFCCC is 'to achieve stabilisation of GHG concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system'. Under the Convention, governments

- Gather and share information on GHG emissions, national policies and best practices;
- Launch national strategies for addressing GHG emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries; and
- Cooperate in preparing for adaptation to the impacts of climate change.

A total of 192 countries, including Qatar, have become members of the UNFCCC. Members are divided into three main groups according to their different commitments:

- Annex I (industrialised countries in the OECD and countries with economies in transition);
- Annex II (OECD countries); and
- Developing countries.

Annex I members have agreed to reduce their GHG emissions to specified targets. Annex II members are a sub-group of Annex I members that contribute to the GHG emissions reduction costs of developing countries. To avoid negative impact on their development, the developing countries are under no immediate GHG emissions restrictions. Within UNFCCC, these countries can benefit from income generation by exporting unused GHG emission credits and from attracting low-carbon investments from Annex II countries. Qatar is classified as a developing country for the purposes of the UNFCCC.

Linked to the UNFCCC is the Kyoto Protocol. The Protocol is an international agreement that sets binding targets for 37 industrialised countries and the European community for reducing GHG emissions, amounting to an average of 5 per cent against 1990 levels over the five-year period 2008-2012. The Kyoto Protocol came into force in 2005 and has been ratified by 183 countries, including Qatar. Some countries such as the United States of America are UNFCCC members but have not ratified the Kyoto Protocol.

The major distinction between the Kyoto Protocol and the UNFCCC is that while the Convention encouraged industrialised countries to stabilise GHG emissions, the Protocol commits them to do so. Based on the principle of common but differentiated responsibilities, the Kyoto Protocol places a heavier burden of historic responsibility on developed countries. The Kyoto Protocol introduces innovative market-based mechanisms that are available to Annex I Parties to help them meet their commitments. These mechanisms enable parties to achieve compliance through climate friendly investments in other countries and through emissions trading (Box 4.10).

Box 4.10 The Kyoto Mechanisms

Countries with commitments under the Kyoto Protocol (Annex I Parties) have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or 'assigned amounts' over the 2008-2012 commitment period. The Kyoto Protocol offers three market-based mechanisms for helping Annex I Parties achieve their emission reduction targets in the most cost-effective and efficient way.

- **Joint Implementation (Article 6):** Joint Implementation (JI) allows an Annex I country to earn emission reduction units (ERU) through investing in emission reduction projects in any other Annex 1 country as an alternative to reducing emissions domestically. The generation, transfer or acquisition of ERUs can only be supplemental and cannot be used as a substitution for domestic action. This mechanism offers countries a flexible and cost-efficient means of fulfilling a part of their Kyoto Protocol commitments, while the host country benefits from foreign investment and technology transfer. Most JI investments are expected to take place in 'economies-in-transition' where costs are lower.
- **Clean Development Mechanism (Article 12):** The Clean Development Mechanism (CDM) allows emission reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO₂. These CERs can be traded and sold, and used by industrialized countries to meet part of their emission reduction targets under the Kyoto Protocol. A share of the proceeds from the generation of CERs is forwarded to the Adaptation Fund to assist developing countries that are particularly vulnerable to climate change in meeting the costs of adaptation. This mechanism is overseen by an Executive Board and serves to stimulate sustainable development, technology transfer and emission reductions, while giving industrialised countries some flexibility in how they meet their emission reduction or limitation targets. CDM projects in the Gulf are being considered in various fields like renewable energy, gas flare reduction, energy efficiency, waste management, cement, and so on.
- **Emissions Trading (Article 17):** Emissions Trading (ET) allows Annex 1 countries to buy and sell their agreed allowances of GHG emissions. Highly polluting countries can buy unused 'credits' from those with excess capacity. Countries are also able to gain credits for activities which boost the environment's capacity to absorb carbon, such as tree planting and soil conversion. Since CO₂ is the principal GHG, carbon makes up the bulk of ET, resulting in a 'carbon market' where carbon is now tracked and traded like any other commodity. While the market for carbon trading is growing worldwide, it is still nascent in the Middle East.

Under the Kyoto Protocol, a country's actual emissions have to be monitored and precise records have to be kept. Registry systems track and record transactions by countries under the various mechanisms, and reporting is done by countries by way of submitting annual emission inventories and national reports at regular intervals.

Source: Derived from UNFCCC, 2009 [http://unfccc.int/kyoto_protocol/items/2830.php]

Qatar's Response to Climate Change

Qatar is actively working towards the management of risks associated with climate change. There are a number of significant and positive developments.

- The formulation and adoption of the QNV 2030, which demonstrates strong commitment at the highest levels of government to human, social, economic and environmental development. QNV 2030 provides a framework for managing present and emerging risks from climate change.
- Investments in research and development activities by Qatar Science and Technology Park (QSTP), Qatar National Research Fund (QNRF), and by private-public partnerships (for example, Qatar Petroleum, Shell, and Imperial College London) to create solutions for environmental problems with a focus on water, energy, and emissions, as well as promoting medical sciences and education.
- Active participation in the UNFCCC's CDM to reduce emissions and decarbonize energy intensive industries (Box 4.11).
- The formation of the National Committee for Climate Change (NCCC) under the auspices of the Ministry of Environment (MoE) and an investment of USD150 million to the Energy, Environment and Climate Change Research Fund launched by the Organisation of the Petroleum Exporting Countries (OPEC) in 2007.
- Continuous expansion of schools and universities to ensure access to high quality education at all levels in a variety of disciplines relevant to addressing climate change problems.
- The national plan to integrate all ambient air quality monitoring stations in Qatar which are currently managed separately by the MoE and the private sector. The nationwide network, which is targeted to be online by the end of 2010, will allow for continuous monitoring of ambient air quality and meteorological parameters and is the first such initiative among the GCC countries.
- The partnership between the MoE, the Ministry of Energy and Industry and Qatar Petroleum on continuous emission monitoring systems at the point of pollutant generation.

Box 4.11 Al Shaheen Oilfield Gas Recovery and Utilisation Project, Qatar

The Al Shaheen Oilfield Gas Recovery and Utilisation Project is the first of its kind in the region and the third Clean Development Mechanism (CDM) project in the petroleum industry worldwide. The purpose of the project is the recovery and utilisation of associated gas produced at the Al-Shaheen oilfield. Oil is recovered from the Al-Shaheen oilfield located about 90 kilometres off the coast of Qatar. The production at the field commenced in 1994. As part of the recent development of the oilfield, Maersk Oil Qatar has on the request of Qatar Petroleum installed facilities for the gathering and delivery of associated gas to Qatar Petroleum's North Field Alpha platform, and its subsequent transfer to the Mesaieed gas processing plant.

Prior to 2004, associated gas at the Al-Shaheen oilfield was primarily flared, with a small fraction of the remaining gas utilised for onsite consumption. This project captures and processes associated gas that previously was flared. As per its project design document version 02, the project aims to reduce GHG emissions by 2.49 million tonnes of CO₂ per year.

The project is comprised of three main components:

- Recovery of associated gas;
- Transmission of associated gas along a pipeline; and
- Utilisation of the associated gas at the gas processing plant.

Historically, the Al-Shaheen oilfield operations represented approximately 20 per cent of the Qatar's flaring. This project reduces flaring by approximately 80 per cent and is Qatar's largest project for reducing CO₂ emissions to date. Under the project activity, captured associated gas is injected into a gas pipeline for transport to the Mesaieed gas processing plant. The gas products include dry gas, LPG and condensate, which are utilised for generating electricity that is supplied to the national grid, for export and for local industry consumption.

Contribution to Sustainable Development

The project contributes to sustainable development in Qatar through the reduction of flaring, which in turn reduces local air pollution and other environmental impacts associated with the flaring of natural gas. Apart from emission reductions, the expected benefits from the project include socio-economic, environmental, and technological benefits:

- The project increases the national energy and electricity supply in Qatar without adding to existing levels of fossil fuel consumption, provides employment and transfers technical knowledge to the local industry.
- The multiplier effect of this investment lies in additional benefits such as the long-term sustainability of the oilfield and gas-processing plant, and thus local economic improvement.
- Demonstrates the use of a new mechanism for funding environmentally friendly technologies, in this case, a mechanism which reduces emissions of greenhouse gases.
- As the first registered CDM project in Qatar, the project will act as a clean technology demonstration project, encouraging development of similar projects throughout Qatar and the Middle East

Source: Al-Shaheen Oilfield Gas Recovery and Utilisation Project Design Document
[<http://cdm.unfccc.int/Projects/DB/DNV-CUK1162979371.3>]

The NCCC was established in 2007 to:

- develop a comprehensive national programme for climate change including policies to manage GHG emissions;
- ensure that the national climate change policies and measures required to implement the UNFCCC framework and its Kyoto Protocol are in line with national circumstances and sustainable development objectives;
- meet international commitments required by the UNFCCC convention and the Kyoto Protocol including preparation and publication of national communications relating to the UNFCCC;
- participate actively in climate change negotiations conducted by the UNFCCC, its Kyoto Protocol and their subsidiary bodies and *ad hoc* working groups;
- participate in other pertinent bilateral and regional meetings concerned with climate change and follow up recommendations resulting from such meetings;
- develop and coordinate climate change policy advice to ministries and industries, and ensure the integration and implementation of these policies within national development plans; and
- report periodically to the MoE on progress in the implementation of climate change policies within governmental and non-governmental bodies.

The NCCC is a necessary and important step to address the challenges of climate change in Qatar but it is too early to determine its impact.

At the regional level, Qatar is playing a proactive and significant role in assessing the impact of climate change and mitigating its negative impacts, especially on countries of the Gulf. In November 2007, GCC countries of the OPEC pledged a total of USD750 million to a new fund to tackle global warming through research for a clean environment. Kuwait, the UAE and Qatar pledged USD150 million each for the fund and Saudi Arabia will invest USD300 million in the fund, which is aimed at finding technological solutions to climate change, notably carbon capture and storage (Raouf, 2008).

Qatar, through the leadership role of Qatar Petroleum, is also the first GCC country to join the World Bank's Global Gas Flaring Reduction Partnership (GGFR). GGFR is a public-private partnership of governments, state-owned companies and major international oil companies committed to reducing flaring and venting worldwide. Under this initiative, Qatar has committed to achieve a target of zero-flaring by 2010 and utilise the gas currently being flared in economically beneficial ways.

Towards a Sustainable Climate Future: National Action to Meet a Global Challenge

In addressing climate change, Qatar needs to reconcile many priorities from economic growth to environmental management to human development and social development. As a consumer and key producer of fossil fuels, these priorities can at times be conflicting, especially against a backdrop of increasing local and global demand for energy. A holistic and integrated approach is essential to address the range of environmental, economic, social, educational, informational, gender, attitudinal and behavioural issues involved.

In fact, Qatar's robust oil and gas reserves offer a time-bound opportunity to diversify the national economy and to lower its carbon footprint. This can be achieved by instituting innovative economic and social policies and by increasingly adopting sound mitigation and adaptation strategies. Extensive participation by key stakeholders including civil society, academia and the private sector is critical.

Qatar's robust oil and gas reserves offer a time-bound opportunity to diversify the national economy and to lower its carbon footprint

Climate Change Mitigation and Adaptation Options: Energy Efficiency and New Technologies

Qatar can respond to climate change by adapting to its impacts and by reducing GHG emissions (mitigation), thereby reducing the rate and magnitude of change. Making the transition to a low carbon economy requires decarbonisation, which essentially involves efficiency improvements and structural changes in energy systems. While there is a wide variety of international best practices related to policies and instruments for mitigation action (Box 4.12), Qatar needs to evaluate and adopt those that are applicable to its national circumstances.

Making the transition to a low carbon economy requires decarbonisation, which essentially involves efficiency improvements and structural changes in energy systems

Qatar should consider a safe and stable target concentration level of GHG. The development of effective and economical emissions reduction strategies should follow a systems approach taking into account emissions and energy demands across industrial sectors, waste management, carbon capture and storage (CCS), land use change by agriculture, and alternative energy sources.

Energy efficiency and energy improvements offer many opportunities to save carbon. Decarbonization requires either CCS to collect and store carbon emissions from combustion processes, or changing energy use patterns. CCS has significant potential in Qatar given the concentration of emissions in only a few locations with high industrial intensity and the potential opportunity to use CO₂ for enhanced oil recovery. CO₂ emissions could be reduced by replacing carbon intensive fossil fuels with cleaner alternatives like nuclear energy or opting, where possible, for less harmful fossil fuels, like natural gas. Solar energy offers significant promise as an alternative energy source in Qatar for power generation using photovoltaics, the direct provision of heat to industrial processes including desalination, and the production of biomass from cultivating algae through carbon fixation.

GHG emission reductions can also be achieved by energy recovery between industries operating as industrial clusters to exploit synergies between energy and cooling requirements. Integration with fresh water production (desalination) facilities can be expected to further enhance energy recovery potentials. These reductions in emissions by energy savings can be attained by applying process integration technologies (Linke, 2009). Maximizing energy efficiency leads to minimum energy requirements being provided by fossil fuel combustion or alternative energy sources.

Box 4.12
Selected Examples of Key Sectoral Mitigation Technologies, Policies and Measures

Sector	Key Mitigation Technologies and Practices Currently Commercially Available	Policies, Measures and Instruments Shown to be Environmentally Effective
<i>Energy supply</i>	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, geothermal and bioenergy); combines heat and power; early applications of carbon dioxide capture and storage	<ul style="list-style-type: none"> ▪ Reduction of fossil fuel subsidies; taxes or carbon charges ▪ Feed-in tariffs for renewable energy technologies; renewable energy obligations; producer subsidies
<i>Transport</i>	More fuel-efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning	<ul style="list-style-type: none"> ▪ Mandatory fuel economy; biofuel blending and CO₂ standards for road transport ▪ Taxes on vehicle purchase, registration, use and motor fuels; road and parking pricing ▪ Influence mobility needs through land-use regulations and infrastructure planning; investment in attractive public transport facilities and non-motorised forms of transport
<i>Buildings</i>	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves; improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycling of fluorinated gases	<ul style="list-style-type: none"> ▪ Appliance standards and labeling ▪ Building codes and certification ▪ Demand-side management programmes ▪ Public sector leadership programmes, including procurement ▪ Incentives for energy service companies
<i>Industry</i>	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO ₂ gas emissions; and a wide array of process-specific technologies	<ul style="list-style-type: none"> ▪ Provision of benchmark information, performance standards ▪ Subsidies and/or tax credits ▪ Tradable permits ▪ Voluntary agreements
<i>Agriculture</i>	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce methane (CH ₄) emissions; improved nitrogen fertilizer application techniques to reduce nitrogen dioxide (NO ₂) emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency	<ul style="list-style-type: none"> ▪ Financial incentives and regulations for improved land management, maintaining soil carbon content, efficient use of fertilisers and irrigation
<i>Waste</i>	Landfill CH ₄ recovery; waste incineration with energy recovery; composting of organic waste; controlled wastewater treatment; recycling and waste minimization	<ul style="list-style-type: none"> ▪ Financial incentives for improved waste and wastewater management ▪ Renewable energy incentives or obligations ▪ Waste management regulations

Source: IPCC, 2007c

Given that more than 90 per cent of GHG emissions originate from the energy and manufacturing industries as well as from electricity generation and water desalination, Qatar has significant potential to reduce GHG emissions by targeting these sectors. GHG emissions can be reduced at low-cost through optimisation of industrial energy-use efficiency. For example, efforts to mitigate GHG emissions in the oil and gas sector should focus on the following areas:

- Integration of operations to improve energy efficiency along the supply chain. This could be achieved by developing energy management programmes that include upgrade of operating and maintenance procedures and practices;
- Investigation and implementation of cleaner fuel approaches during extraction, processing, distribution and use to reduce the burden on fossil fuels in meeting energy demands. This includes the use of advanced technology and cleaner production techniques;
- Reduction of venting and flaring of natural gas produced in association with crude oil;
- Reduction in oil, natural gas and refined products losses through leaks and spills in transportation and storage by use of leak-proof valves and vapour recovery systems; and
- Investigation and implementation of energy efficient technologies and/or renewable energy solutions.

There is further potential for reducing commercial and domestic-purpose related GHG emissions by improving desalinated water use efficiencies and power saving measures for air conditioning, appliances and lighting. To moderate the escalating needs for water and electricity and the subsequent GHG emissions, there is a need to formulate demand-side management schemes for the residential and commercial sectors through policies and programmes that promote and reward energy efficiency practices, use of renewable energy, green buildings, water conservation and conversion of waste to energy.

The Critical Role of Government Action: National Policies and Management Responses

Qatar, like other 'developing countries', has no emissions reduction obligation during the first commitment period of the Kyoto Protocol, but negotiations for the post-2012 climate regime, already being undertaken, are likely to lead to binding emission requirements on all signatory countries. For this reason, and to achieve the development outcomes of the QNV 2030, Qatar urgently requires a viable national policy to manage GHG emissions and the broader issues of climate change. Successful adaptation planning should be proactive and should take into account transboundary climate change impacts through regional cooperation.

Policies and management responses should aim at managing the economic, social, environmental and transition risks and vulnerabilities from climate change. A number of issues of national importance should be given due consideration including efficient and sustainable water provision and management, energy management and effective emissions reduction, sustainable agriculture for food security, economic diversification and education. These issues are not independent but strongly interconnected. A successful resolution of these challenges will depend upon careful and accurate problem definition in order to ensure all dimensions are covered and all stakeholders are appropriately represented.

Successful mitigation and adaptation ultimately requires behavioural change among consumers and producers towards supporting low-carbon energy sources. The government of Qatar has a critical role to play in encouraging such behavioural change through setting regulatory standards, encouraging research, development and the deployment of low-carbon technologies, providing information and where necessary, creating incentives for achieving low carbon emissions.

Successful mitigation and adaptation requires behavioural change among consumers and producers towards supporting low-carbon energy sources

With the natural depletion in hydrocarbon resources and the shift away from the use of fossil fuels, a decline in income streams from energy exports could be expected in the long term. Similarly, exports of carbon-intensive products from Qatar may be penalised by importing countries if border taxes for carbon intensive products are implemented and production-based carbon accounting is maintained. This calls for measures for the development of a diversified knowledge-based economy that gradually reduces dependence on hydrocarbon industries.

In order to manage the challenges of climate change and the transition to a low carbon economy, Qatar needs to further support human development through modern world-class educational systems. Education should prepare people to address complex climate change issues, which require collaboration with many institutions and stakeholders from a variety of backgrounds. The ability to function in multidisciplinary and multifaceted environments will be a vital ingredient for successful human development.

Qatar also needs to strengthen key features of its health systems to cope with the health risk from a changing climate. The detection and measurement of the health effects of climate change are necessary for the development of evidence-based health policies.

The development of strategies to address these issues requires 'big picture' thinking and intense stakeholder collaboration to avoid partial solutions designed to resolve local sub-problems that, taken together, turn out to be inadequate or incompatible. A necessary first step is the establishment of national task forces for priority areas such as energy provision, water management, emissions reduction, food security, education and economic transition.

These task forces should be responsible for quantifying risks, gathering data and information, defining problems and identifying sustainable solutions for climate change mitigation and adaptation. Members should consist of key stakeholders from government, the private sector and civil society. External experts should be recruited as and when necessary, particularly in areas where local expertise is lacking. Given that the area of environmental management is relatively new in Qatar and the complex nature of climate change, the planning phase is likely to span a longer time period. Supporting policies to enable efficient functioning of these tasks forces should therefore be implemented.

Filling the Gaps: Human Capital Development and Participatory Processes

To ensure the development of sustainable and integrated national policies and programmes for climate change, active stakeholder engagement and participation is a key institutional process. Besides ministries and agencies, the private sector and civil society have critical and catalytic roles to play. The

private sector can help accelerate the application of best available technology. A policy framework with the right incentives for a low-carbon future would provide the signal that industry needs to act. Voluntary agreements between industry and governments may also be politically attractive and will help raise awareness among stakeholders.

The private sector can help accelerate the application of best available technology

The response to climate change has to be knowledge-based, benefit from comprehensive analysis and be continuously updated by monitoring of data, trends and technologies. Qatar needs unbiased and technically sound data and information in order to target public investments and develop policies and strategies that can reduce its vulnerability to climate change.

Presently, the knowledge base in Qatar in the area of climate change and environmental management is rudimentary. Qatar needs to build, mobilise and enhance scientific and technical capacities in the form of expertise, institutions and appropriate national policies. National capacity to monitor, predict and evaluate climate impacts need to be strengthened through increased investment in scientific research and education. It will also be useful to develop networks of scientific data and information providers to improve synergies and support collaboration. Links between science and policy can be reinforced by improving the accessibility of information through the creation of a central depository for scientific data and information and active stakeholder consultations.

Taking the Lead: Regional and International Cooperation

In an interdependent world, climate change impacts will inevitably flow across national borders. Qatar's efforts alone in protecting the environment will not be sufficient. Qatar is a part of the Gulf Region, which forms one ecological system that is affected by the practices and activities of every country in the region. Many problems faced by Qatar will also confront other GCC countries and regional alliances should be continued and expanded to ensure success at the international level. It will be necessary to engage and to encourage all of the Gulf States to protect and conserve the environment.

At the international level, active participation in UNFCCC negotiations and Kyoto mechanisms should continue. Qatar should seek opportunities to support its transition to a low-carbon economy. This should range from screening beneficial CDM projects to be implemented in Qatar to ensuring national interests are considered in future negotiations.

Good global citizenship would also suggest active participation in technical cooperation initiatives to support adaptation capacity building in poor countries through increased financial and technological support for low-carbon power generation in poorer countries. Such initiatives have the potential to expand access to energy, lower carbon emissions and support poverty reduction efforts. It may also provide opportunities for Qatar to take leadership roles in emerging fields, in line with its interest to achieve suitable economic diversification as outlined in the Economic Development Pillar of the QNV 2030.

Conclusion

Climate change is a global, long-term challenge with potential to significantly affect human development in Qatar and derail the achievement of the QNV 2030. Human activities have led to the emergence of climate change. A people-centred, environmentally sustainable development approach will be instrumental in identifying and realising solutions to adapt to the effects of climate change, as well as to contain climate change by mitigation.

Qatar's abundant oil and gas reserves offer a window of opportunity to make the transition to a post-carbon economy, to help develop and exploit environmentally friendly and energy efficient technologies, and to invest in sustainable development. They also provide the means to improve human development, promote social justice and empower all its citizens.

All sectors of Qatari society, especially the private sector, have a role to play in the development and implementation of integrated national policies and programmes for climate change. The NCCC, the MoE, the General Secretariat for Development Planning and others need to play the leading role in coordinating the various stakeholders and ensuring the environmental goals of the QNV 2030 are incorporated into national development strategies.

Qatar has the will and great potential to take a leadership role in emerging fields, such as emission-reduction approaches and energy efficient technologies

Changes in global markets will open up new opportunities for Qatar in emerging fields, such as emission-reduction approaches, energy efficient technologies, green buildings, agricultural management in arid regions, innovative education, and financing of low carbon activities. Qatar has the will and great potential to take a leadership role in these fields, and it is starting to realize this potential through initiatives such as the GGFR and the QSTP.

The containment of climate change requires coordinated local, regional and global actions to reduce GHG emissions. Mitigation of climate change in Qatar will require continuing active participation in global initiatives to combat global warming. Adaptation to the consequences of climate change is complex and needs to be addressed at the national level, including the transformation into a sustainable low-carbon economy. This will require multi-stakeholder engagement, detailed risk assessment, significant research and development and the application of new technologies.

References

Al-Mulla, A. H., Yousuf, S. A. and Ahmed, A. F. M., 2009. "Climate Change and Human Development in Qatar: Issues, Challenges and Opportunities." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development*. Doha.

Al-Ramzani, A.F. 2008. Lessons Learned from Al-Shaheen (ALS) Oilfield Gas Recovery and Utilisation CDM Project. GPA GCC Chapter Technical Session on Environmental Challenges in Gas Processing, Doha. [<http://www.gpa-gcc-chapter.org/PDF/3rd/LESSONS-LEARNED.pdf>]

CDIAC (Carbon Dioxide Information Analysis Center). 2009a. Ranking of the World's Countries by 2006 Total CO₂ Emissions from Fossil-fuel Burning, Cement Production and Gas Flaring. (Boden, T., Marland, G. and B. Andres). Oak Ridge National Laboratory.

_____. **2009b.** Ranking of the World's Countries by 2006 Per Capita Fossil-fuel CO₂ Emission Rates. (Boden, T., Marland, G. and B. Andres). Oak Ridge National Laboratory.

_____. **2009c.** Qatar – National CO₂ Emissions from Fossil-fuel Burning, Cement Production and Gas Flaring: 1971-2006. (Boden, T., Marland, G. and B. Andres). Oak Ridge National Laboratory.

_____. **2009d.** Global CO₂ Emissions from Fossil-fuel Burning, Cement Production and Gas Flaring: 1971-2006. (Boden, T., Marland, G. and B. Andres). Oak Ridge National Laboratory.

Dasgupta, S., Laplante, B., Meisner, C., Wheeler, D. and Yan, J. 2007. "The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis". World Bank Policy Research Working Paper 4136

Dervis, K. 2008. *The Climate Change Challenge*. WIDER Annual Lecture 11. UNU World Institute for Development Economics Research. Helsinki.

GSDP (General Secretariat for Development Planning). 2008. *Qatar National Vision 2030*. Doha.

IEA (International Energy Agency). 2001. Dealing with Climate Change, Policies and Measures in IEA Member Countries. OECD (Organisation for Economic Cooperation and Development)/IEA, Paris.

_____. **2006.** CO₂ Emissions from Fuel Combustion 1971-2004. Paris.

_____. **2006.** CO₂ Emissions from Fuel Combustion: Highlights 1971-2004. OECD (Organisation for Economic Cooperation and Development)/IEA, Paris.

_____. **2007.** World Energy Outlook 2007: China and India Insights. Paris.

IPCC (Intergovernmental Panel on Climate Change). 1996. Guidelines for National GHG Emission Inventory. Volume 3. Institute for Global Environmental Strategies, Japan.

_____. **1999.** "Economic Impact of Mitigation Measures." In *Proceedings of IPCC Expert Meeting on Economic Impact of Mitigation Measures*. (J. Pan, N. Van Leeuwen, H. Timmer, R. Swart, eds.). The Hague.

_____. **2001.** *Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. (Bert Metz, Ogunlade Davidson, Rob Swart and Jiahua Pan, eds.). Cambridge University Press, Cambridge.

_____. **2006.** *IPCC 2006 Guidelines for National GHG Emission Inventory*. Volume 2. Institute for Global Environmental Strategies, Japan.

_____. **2007a.** *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds.). Cambridge University Press, Cambridge and New York.

- _____. **2007b.** *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, eds.). Cambridge University Press, Cambridge.
- _____. **2007c.** *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer, eds.), Cambridge University Press, Cambridge and New York.
- Linke, P. 2009.** "Climate Change and Human Development: Risks and Vulnerabilities of Climate Change in Qatar." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: *Advancing Sustainable Development.* Doha.
- Peters, G. P. and Hertwich, E. G. 2006.** "Post-Kyoto Greenhouse Gas Inventories: Production Versus Consumption." *Climatic Change* (2008) 86:51–66
- QSA (Qatar Statistics Authority). 1996.** Annual Statistical Abstract. Doha.
- _____. **2001.** *Annual Statistical Abstract.* Doha.
- _____. **2005.** *Annual Statistical Abstract.* Doha.
- _____. **2007.** *Annual Statistical Abstract.* Doha.
- _____. **2008a.** *Annual Statistical Abstract.* Doha.
- _____. **2008b.** *Digital Atlas of Qatar.* Doha.
- Raouf, M. A. 2008** "Climate Change Threats, Opportunities and the GCC Countries." Policy Brief 12. The Middle East Institute.
- UNDP (United Nations Development Programme). 2007.** *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World.* Palgrave Macmillan, New York.
- UNFCCC (United Nations Framework Convention on Climate Change). 1998.** "Kyoto Protocol to the United Nations Framework Convention on Climate Change." Climate Change Secretariat, Bonn. [<http://unfccc.int/resource/docs/convkp/kpeng.pdf>]
- _____. 2007. Decision 1/CP.13 (Bali Action Plan), FCCC/CP/2007/6/add.1. [<http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf#page=3>]. Accessed February 2009.
- WB (World Bank). 2008.** World Development Indicators Online Database. Washington DC.
- WHO (World Health Organisation). 2006.** WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide: Global Update 2005, Summary of Risk Assessment. Geneva.
- WRI (World Resources Institute). 2006.** Qatar Country Profile. [<http://earthtrends.wri.org/text/climate-atmosphere/country-profile-149.html>]. Accessed February 2009.

5

Advancing Sustainable Development

Conclusions and Recommendations

Map 5.1

Gulf Cooperation Council Countries



Source: QSA, 2009

Advancing Sustainable Development: Conclusions and Recommendations

Qatar's bountiful hydrocarbon resources can be leveraged to make sustainable development a reality for all its people. Converting these natural assets into financial wealth provides a means to invest in world-class infrastructure; build efficient delivery mechanisms for public services, create a highly skilled and productive labour force; and support the development of entrepreneurship and innovation capabilities

GSDP, 2008

The Qatar National Vision 2030 (QNV 2030) builds a bridge between the present and the future. Central to the QNV 2030 is a development path that is built on the tenets of sustainable development. The QNV 2030's four key pillars - human development, social development, economic development and environmental development - correspond with the interdependent and mutually reinforcing components of sustainable development. To achieve its ambitions, Qatar will take concrete actions and measures to integrate these pillars into its long-term development, balancing the needs of economic growth and social development with the conditions for environment protection.

Investing in Our Children's Future

Qatar seeks to build a safe, secure and stable society, providing its citizens with their basic needs and ensuring equal opportunity. For this, a vibrant economy is required to provide the foundation on which prosperity is sustained. Environmental degradation will affect livelihoods and health, and increase vulnerability to natural disasters, with the potential to stall or reverse the tremendous human development progress that Qatar has achieved. Yet, given a development pattern that depends in its early stages mainly on oil, gas, and petrochemicals, Qatar, even with its best efforts, will not be able to entirely avoid adverse effects on its environment.

The QNV 2030's environmental pillar will therefore be increasingly important as Qatar deals with local environmental issues such as pollution, diminishing water and hydrocarbon resources, loss of biodiversity, and environmental degradation, as well as international environmental issues such as the effects of climate change. These environmental concerns are a product of three factors: rapid population growth, increased consumption and production patterns, and technological change, especially in agriculture and energy use. The relative importance of each factor varies in time and space.

This Report identified three of Qatar's environmental stress points, namely water security, threats to marine environment and climate change, which are largely driven by human activities. Qatar has the financial resources and capability to resist and reverse many of the negative consequences from such stresses provided timely and constructive interventions are carried out. While the unfavourable effects have to be identified and addressed, the positive and constructive contributions have to be strengthened. Finding the right balance necessitates difficult policy choices with important political, regulatory, institutional and capacity implications.

Advancing sustainable development requires a strategic, systematic approach which has an underlying vision, is based on sound evidence, sets priorities, goals and direction, and a means of achieving them

Table 5.1 Recommendations for Advancing Sustainable Development in Qatar

Recommendations	Key Questions	Programme Options
Ensure an integrated and comprehensive policy framework for sustainable development	<p>Is there an agreed long term vision on sustainable development?</p> <p>Are there environmental policies and regulations that promote sustainable development? Are these integrated across sectors?</p> <p>Are Qatar’s national policies aligned with its regional and international commitments and obligations?</p>	<p>Review and align sustainable development policies, strategies and programmes with the QNV 2030 and the Qatar National Development Strategy. Identify and bridge gaps between policies and practice.</p> <p>Develop monitoring and evaluation mechanisms based on indicators and international benchmarks to track progress.</p> <p>Continue active participation in regional and global initiatives.</p>
Strengthen the institutional framework for sustainable development	<p>Are there established coordination mechanisms that provide leadership and integrated management of sustainable development strategies?</p>	<p>Establish high-level political leadership and commitment for sustainable development.</p> <p>Establish or strengthen an influential lead institution to champion sustainable development and ensure commitment and coordination across government.</p> <p>Engage with and leverage the capacity of the private sector and civil society as partners in achieving sustainable development.</p>
Develop credible and reliable data and information for evidence-based decision-making	<p>Are suitable data and information available on sustainable development?</p> <p>What are the main sources of these data and are they sufficiently reliable to provide the basis for informative analytical tools?</p>	<p>Support the establishment of a national database on sustainable development indicators.</p> <p>Improve access to data and information on sustainable development through networking and knowledge sharing, locally and internationally.</p> <p>Support studies and research in cutting edge technologies and knowledge on sustainable development.</p>
Build national capacity for developing, implementing, monitoring and evaluating environment-related policies and programmes	<p>Is local expertise available for pursuing sustainable development goals?</p> <p>Are there adequate institutions dedicated to science and technology development and research?</p>	<p>Provision of benchmark information, performance standards</p> <p>Support capacity building initiatives through formal training, knowledge sharing and networking.</p> <p>Support the establishment of scientific and technical research institutions and participation in national and international scientific networks.</p>

Promote effective participation and national ownership	<p>Is policy formulation and decision making participatory and inclusive?</p> <p>Are stakeholders aware of sustainable development issues and their implications for Qatar?</p> <p>Does civil society have a voice in the design and implementation of sustainable development policies and programmes?</p>	<p>Support broad stakeholder participation in policy formulation and decision making for greater national ownership.</p> <p>Raise and improve awareness of sustainable development issues to shape people's perceptions, attitudes and behaviour towards environment and human development.</p>
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Ensuring an Integrated and Comprehensive Policy Framework for Sustainable Development

Policies, strategies and programmes for sustainable development should be comprehensive and, where appropriate, integrate economic, social and environmental objectives. The pursuit of sustainable development requires policy changes in many sectors, and ensuring coherence between them. Unfortunately, sustainable development is commonly interpreted narrowly as an environmental issue with implications on a limited group of society. In many countries, the responsibility for sustainable development issues has been given to environmental ministries and departments which tend to be under-resourced and insufficiently influential in government, thus hindering the necessary process of cross-sectoral policy integration.

Qatar should avoid this pitfall. Environment should not be dealt with as a standalone sector. Environmental issues, including longer-term and global perspectives, need to be integrated into mainstream planning processes. And where integration cannot be achieved, trade-offs need to be negotiated based on a prioritisation of needs and objectives, taking cognisance of the impact of present decisions on future generations.

Qatar's long-term sustainable development objectives are in the QNV 2030. The QNV 2030 is a mandate that has evolved from national aspirations and reflects high-level political commitment towards building a sustainable future. Its goals will be operationalised through Qatar's first National Development Strategy, 2010-2015. By bringing existing and new initiatives together under the broad umbrella of the QNV 2030, Qatar is better able to institute a robust set of coordination mechanisms and processes to improve convergence between existing policies and strategies, avoid duplication and confusion, and relieve the burden on capacity and resources.

By bringing existing and new initiatives together under the broad umbrella of the QNV 2030, Qatar is better able to institute a robust set of coordination mechanisms and processes for advancing sustainable development

In the shorter term, Qatar needs to review the immediate strengths, weaknesses, opportunities and threats to its environment, and identify key policy issues to be strengthened or introduced. Policy making should be proactive and evidence-based, avoiding *ad hoc* reactive decision-making.

Key policy gaps identified here relate to the lack of comprehensive, long-term national policies for the regulation and management of Qatar's scarce water resources, threatened marine environment and climate change implications. Being able to afford 'the best' and being able to pay for responses to 'solve' problems in the short-term is not the same as investing in optimal and sustainable policies that provide a coherent, strategic long-term vision in line with the QNV 2030.

Existing water policies and strategies are supply-driven, ignoring the critical role of demand management in promoting water security. Addressing the trade-offs between human activities and marine environments is impeded by the lack of understanding of the interactions and the non-existence of a national marine policy. And the promotion of energy efficiency practices and renewable energy obligations is ineffectual if not supported by a national policy regulating energy use and promoting investments in new technology. Further, these policies should be synchronised, noting their reciprocal relationship with economic and social policies and strategies.

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Policies and programmes must be supported by monitoring and evaluation systems. There must be an agreed plan of action identifying goals, objectives, expected outputs, delineating what should be monitored, by whom and when. This is crucial to track progress, capture key lessons and change strategic directions where necessary. It is also important to promote transparency and accountability. Here, civil society has a key supplementary role given people's local grassroots networks.

Policy options and institutional reforms should identify links between national and global concerns. Qatar's efforts alone in protecting the environment will not be sufficient. Many problems faced by Qatar will also confront other countries. Regional and international alliances should be continued and expanded. Qatar has the capacity and resources to take a leadership role in spearheading best practices in sustainable development.

Strengthening the Institutional Framework for Sustainable Development

International experience shows that when lead responsibility for a sustainable development strategy lies within a single line ministry, this creates a perception that the strategy is a project of that ministry, or a narrowly sectoral matter, resulting in limited involvement and cooperation from other ministries (OECD, 2001). To ensure commitment across government agencies and overcome institutional rivalry and inertia, there must be high-level political commitment.

It is preferable for the coordination of sustainable development to be the responsibility of the office of the Prime Minister, or a ministry with considerable authority so that its policies are taken seriously by all sectors, and so that it can resolve policy conflicts between line ministries. In the United Kingdom, sustainable development policy is coordinated by the Cabinet Committee on the Environment, and each department designates a Green Minister to sit on a sub-committee which ensures that environmental and sustainable development considerations are integrated into their departmental strategies. In other countries, such as New Zealand and Canada, long-term commitment to sustainable development is achieved by linking strategies to the regular government budget processes.

Qatar should identify the stakeholders necessary for an integrated sustainable development strategy, and outline their responsibilities, rights and relations. Broad participation from the private sector and civil society are important to leverage on the comparative advantage of each agency and ensure shared ownership towards a common goal of sustainable development. While public-private partnerships are growing, particularly in the energy sector, civil society presence is limited. Sustainable development policies and programmes should consider the critical role of the private sector and civil society, and measures need to be taken to create an enabling environment for growth in this area.

To ensure an integrated institutional framework, Qatar should consider the establishment or enhancement of a high-level interdepartmental sustainable development task force, with powers and resources to coordinate policies and strategies. This task force will be responsible for the promotion of cross-sectoral approaches in policy and strategy formulation; coordination, implementation and enforcements of laws and regulations; and monitoring and reporting on progress. For greater impact, this task force could be chaired by Qatar's Higher Authorities, with General Secretariat for Development Planning serving as Secretariat.

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Developing Credible and Reliable Data and Information for Evidence-Based Decision-Making

Policies, strategies and programmes for sustainable development should be built on a comprehensive analysis of key issues and challenges, their underlying causes, and the actual or forecast trends and risks. External pressures resulting from globalisation and global climate change need to be considered. Such analysis requires credible and reliable data and information on changing environmental, social and economic conditions, and their correlations with sustainable development objectives. Without a solid evidence base, strategies and programmes often have shallow foundations.

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Further, it has been internationally recognised that existing sustainable development indicators do not provide a sufficient or adequate basis for tracking national progress in sustainable development. The concepts involved are generally difficult to measure because they are abstract and multidimensional in nature. Countries have been encouraged to tailor sustainable development indicators to their country-specific context in order to have more realistic targets and improved sustainability of long term development strategies.

In order to identify policy options and monitor outcomes of sustainable development initiatives, Qatar needs to develop an integrated set of indicators. Changes in environmental, social and economic conditions have to be statistically measured, including an analysis of the links between national and global concerns. However, baseline data on sustainable development in Qatar remain partial and weak, especially on environmental issues. The necessary technical skills and capacities are in short supply, and those which exist are often already heavily committed or overstretched.

Much more work is required to close existing data gaps, improve their timeliness and to develop indicators that better reflect the situation in Qatar. Qatar needs to mobilise and enhance technical capacities in the form of expertise, institutions and appropriate national policies for improved quantity, quality, useability and accessibility of data. It will be useful to develop a network of scientific data and information providers to improve synergies and support collaboration. Links between science and policy can be further reinforced by improving the accessibility of information through the creation of a central depository for scientific data and information.

As a first step, Qatar could establish a high-level technical working group under the task force on sustainable development, comprising data experts from relevant ministries and agencies, including private sector entities. This technical working group could discuss and address the data challenges faced in quantifying the progress towards sustainable development, with the aim to develop and monitor an integrated set of sustainable development indicators. This is important to support an analysis of the inherent trade-offs and interlinkages between economic, social and environmental dimensions of sustainable development, and to inform policies and programmes. In doing so, Qatar could draw on the many international best practices and guidelines (UN DESA 2007, Esty et. al., 2005), adapting where appropriate to the national context.

Building National Capacity for Developing, Implementing, Monitoring and Evaluating Sustainable Development Policies and Programmes

For effective implementation of sustainable development policies and programmes, Qatar needs to first identify what skills/capacities will be needed, what exists, what can be achieved using them and finally what training options are available to fill capacity gaps. Given that development took place at an unprecedented rate, Qatar lacks the capacity in regulatory bodies and management agencies for successful implementation of policies and programmes. Scientific expertise and trained manpower are also in the early stages of development.

Qatar needs to continue to build its scientific and technical capacity through investments in people, research institutions and its overall science and technology context

Yet, in addressing environmental problems such as loss of biodiversity, climate change, water scarcity and land degradation, science and technology play a major role. Qatar needs to continue to build its scientific and technical capacity through investments in people, research institutions and its overall science and technology context including infrastructure, regulations and national policies. The establishment of the Qatar Science and Technology Park (QSTP) and the Qatar National Research Fund are key milestones for capacity enhancement in Qatar. Scientific and technical expertise also exists within Qatar University and the international universities under the purview of Qatar Foundation. Such local expertise needs to be mobilised and optimised to address environmental challenges facing Qatar. Capacity enhancements and synergies could be further achieved through knowledge sharing and networking among practitioners at the national, regional and international levels.

Promoting Effective Participation and National Ownership

Broad, effective participation is essential for ensuring commitment to sustainable development in Qatar. This requires a long-term perspective and emphasises a multi-stakeholder approach to policy making and implementation, mobilising public and private resources for development and making use of the knowledge, skills and energy of all social groups concerned with Qatar's future. The extent of participation in a strategy process defines the ownership of the strategy.

In advancing its sustainable development objectives, Qatar should promote public participation in policy formulation and decision making, including the active participation of women. Participation should take place throughout the entire process in defining objectives, analysing problems, implementing programmes and evaluating outcomes. Indeed, many civil society organisations are often better aware than government ministries and agencies of the social, economic and environmental consequences of decisions, and thus serve as useful watchdogs (OECD, 2001). Public-private partnerships can facilitate

access to broader financing options, assist skill and knowledge development, and make possible sustainable delivery of basic services, particularly energy and water.

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Building trust among all stakeholders is fundamental to the participation process. This depends to a large extent on their understanding of the complex development issues affecting sustainable development. Therefore, Qatar needs to invest in long-term engagement with stakeholders and incorporate communications strategies into policies and programmes to bring about a shared understanding of sustainable development and its implications. This can be achieved through information campaigns and the media, and supporting mechanism which ensure good dialogue between policy makers and the public.

Nevertheless, very extensive participation is not always possible, cost-effective nor desirable. There should be a balance between top-down and bottom-up approaches depending on the extent of the issues, the need for broad-based consensus and the capabilities of those leading the process. Stakeholder analysis is therefore important at an early stage to provide information on motivations and interests of stakeholders, the means used to secure interest, pressures for change and constraints to making change.

Advancing Sustainable Development: Towards a New Horizon

Maintaining Qatar's advances in human development necessitates addressing the sustainable development challenges identified here. Qatar's rich endowment of natural resources must remain as a blessing for the well-being of society. A neglect of sustainable development issues has the potential to halt or reverse the significant progress that the nation has achieved. The recommendations from this second National Human Development Report will be further reviewed and developed by key stakeholders, and, as appropriate, will serve as inputs to Qatar's first National Development Strategy, 2010 - 2015.

References

Esty, D. C., Levy, M., Srebotnjak, T. and de Sherbinin, A. 2005. *2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*. Yale Center for Environmental Law and Policy, New Haven.

GSDP (General Secretariat for Development Planning). 2008. *Qatar National Vision 2030*. Doha.

OECD (Organisation for Economic Co-operation and Development). 2001. *The DAC Guidelines. Strategies for Sustainable Development: Guidance for Development Co-operation*. Paris.

QSA (Qatar Statistics Authority). 2008. Map of Gulf Cooperation Countries. GIS Section.

UN DESA (United Nations Department of Economic and Social Affairs). 2007. *Indicators of Sustainable Development: Guidelines and Methodologies*. New York.

Annex 1: Biogeophysical Setting of Qatar¹

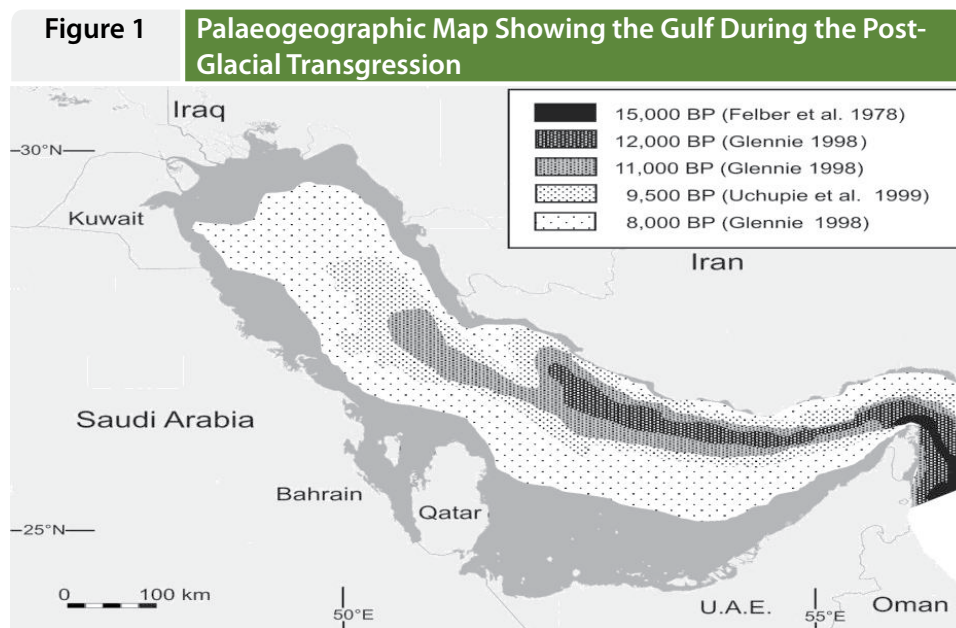
The Gulf is a semi-enclosed sea, 240,000 square kilometres (km²) in size, with low precipitation, high aridity, and evaporation rates of more than 2000 millimetres per year. It is a shallow sedimentary basin, about 1,000 kilometres (km) long and between 200 and 330km wide, with an average depth of 35 metres (m). The deepest areas are off the Iranian coast and at the entrance to the Strait of Hormuz, reaching 60-100m respectively. The Arabian side displays a gradual slope with a wide intertidal zone and a steep, narrow shoreline at the Iranian side.

Geology of the Gulf Region

The geological situation of the Gulf region is basically the result of continuous sediment accumulation. The present structure was established during major tectonic processes. The Arabian Peninsula was originally attached to the African Shield. It split away from the African Shield along the large rift system which extends from the Gulf of Aqaba and the Dead Sea rift in the north to the Afar triangle in Ethiopia. There it diverges through the Gulf of Aden into the Arabian Sea and down the African mainland as the large African Rift Valley System in the south. The current widening of the Red Sea rift is estimated to be 2-3 centimetres each year.

Sea Level Changes

Considerable changes in sea levels of the Gulf occurred about 15 thousand years before present (ka BP), with values between 120m and 150m below present sea level. This implies that the Gulf was completely dry during that period. After that the global surface temperatures increased, which led to a rise in sea level to near present levels at about 6.0ka BP (Figure 1), with the highest sea level between 2.5m and 3.5m above the actual level.



Source: Barth and Khan, 2008

¹ Based on Barth, H. J. and N. Khan. 2008. "Biogeophysical setting of the Gulf." In *Protecting the Gulf's Marine Environment from Pollution*. (A. Abuzinada, H.J. Barth, F. Krupp, B. Böer and T. Al Abdessalaam, eds.) Birkhäuser, Switzerland., with the generous permission of Birkhäuser Verlag/Switzerland. Additional information more specific to Qatar has been included.

General Climate Pattern

The climate of the Gulf region is a typical desert and semi-desert climate, with high summer temperatures and aridity throughout the year, due to its geographical situation. Rain normally occurs between October and April. Although it is difficult to detect, there is evidence of climate change in the Arabian Peninsula based on climatic recording in the region.

Hydrographical Influences

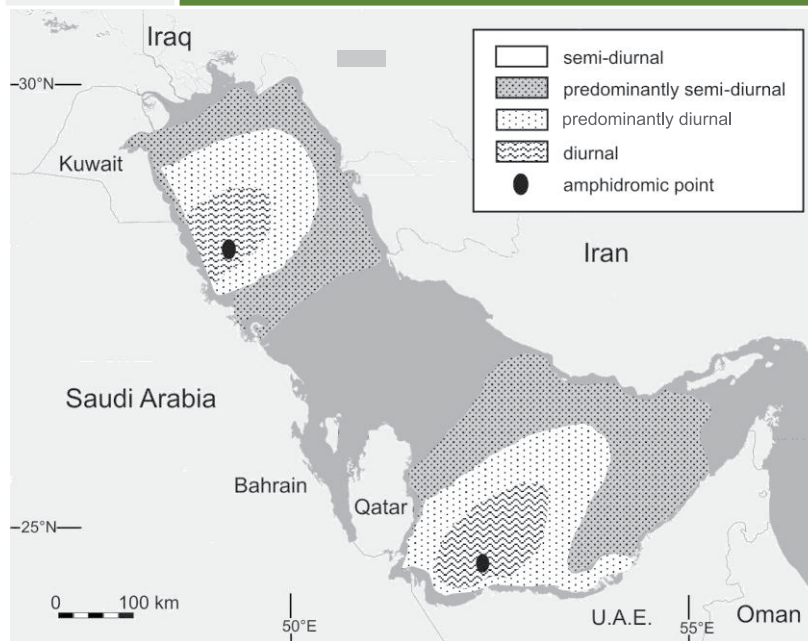
Due to the high evaporation rates there is a net loss of water in the Gulf. This creates a density dependent estuarine reverse flow. Sea water enters the Gulf through the Strait of Hormuz at a salinity of 36.5-37 parts-per-thousand (ppt) and circulates in a general counter-clockwise direction with northward currents along the Iranian shores and southward currents along the Saudi Arabian shores. With increasing distance from the Strait of Hormuz, there is a general decrease in nutrients and increase in salinity because of excess of evaporation over fresh sea water input.

In the northern Gulf the diluting influence of the Shatt al Arab at the northwest corner of the Gulf is evident throughout the year, especially in winter when the flow is greater. The dense saline water of the Western Gulf (now 40ppt) sinks towards the trough along the Iranian coast and is returned southward in greater depths. The total exchange rate of the Gulf water is estimated from 3 to 5 years.

Going southward along the coast of Saudi Arabia, the salinity increases dramatically south from Al-Khobar where restricted water exchange in the Gulf of Salwa, due to the Peninsula of Qatar, promotes highly saline conditions. Salinities range between 38-42ppt in the region north of Al-Khobar and 52-59ppt in the open waters of the Gulf of Salwa. Because salinity is a controlling factor for occurrence and abundance of organisms, the waters south of Al-Khobar display a less diverse plant and animal life. Reef corals and many other major taxonomic groups are not found south of Tarut Bay, and number of species and individuals of benthic infaunal organisms and zooplankton decrease significantly with increasing salinity. However, seagrass and macro-algal productivity remains high.

In the Gulf, the tidal pattern is complex and does not correlate with the tides of the Indian Ocean (Figure 2). There are two amphidromic points where tidal range is zero (and around which tidal waves rotate). One is off the northern Saudi Arabian coast and the second off the United Arab Emirates (UAE) coast. The tidal regime in the central part is complex and mostly semi diurnal, and in some areas it is only diurnal. The tidal range is 0.6–2.0m. Off Kuwait, spring tidal range reaches 4m in the north. Because of the barrier effect from a shallow reef complex between Qatar and Bahrain, the water in the Gulf of Salwa is restricted with tidal ranges of 0.5 – 1.2m.

Figure 2 Tides in the Gulf



Source: Barth and Khan, 2008

The high temperature amplitudes are another controlling factor regarding the distribution of fauna and flora in the Gulf, particularly at nearshore areas, with annual fluctuations of temperature exceed 20°C (16-36°C; compared to 17-34°C in open Gulf waters).

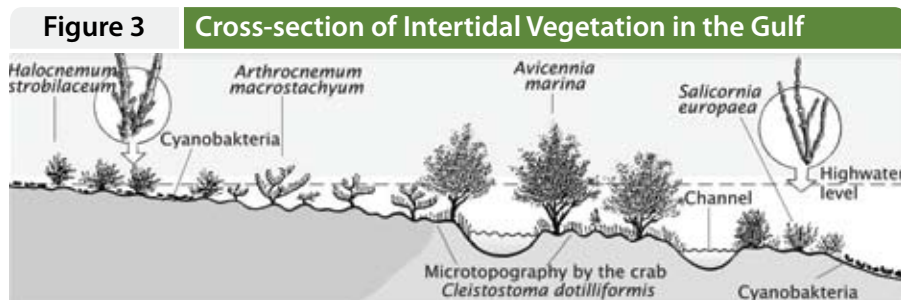
Habitats

The terrestrial area of Qatar is 11,437 km² in size, with its highest point of elevation being just 103m above sea level. Most of Qatar consists of undulating gravel sheets, dominated by small trees of *Acacia tortilis* and *Lycium shawii* shrubs, and heavily overgrazed by camel, goats, and sheep. In the south of the country there is a mosaic pattern of large sand dunes with *Seidlitzia rosmarinus*, *Cornulaca monacantha*, and *Cyperus conglomerates*, interspersed with barren sabkha.

The coastal sediments in the Gulf support highly productive habitats, such as extensive intertidal mudflats, seagrass and algal beds, mangroves, and coral reefs. These productive habitats are limited to waters less than 10-12m deep which are closest to the anthropogenic activities and are, as such, vulnerable to the adverse effects of pollutants deposited in sediments, as well as coastal development. Some of these habitats are critical for endangered species such as the green turtles and dugong and serve as nursery grounds for shrimp and commercial fish. The taxonomic work of the last 20 years revealed that the biodiversity is far richer than previously thought, in the marine, coastal, and terrestrial ecosystems.

The coastal wetlands include salt marshes, mangroves, sabkha, sandy, and rocky beaches. The salt marshes and mud-flats are among important types of intertidal systems, together with the mangroves. They contain halophytic plants, such as *Avicennia marina*, *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, as well as members of the *Zygophyllaceae*, *Chenopodiaceae*, and *Poaceae*. The typical vegetation zones controlled by tidal inundation, soil and groundwater salinity - are the cyanobacteria zone, the *Salicornia* zone, *Arthrocnemum* zone, *Halocnemum* zone,

and landward of the littoral fringe follows the *Limonium* – *Suaeda* – *Seidlitzia* – *Halopeplis* zone. Figure 3 shows a typical cross-section of a vegetation zonation of low energy shores in the Gulf.



Source: Barth and Khan, 2008

The most common invertebrates of the salt marshes include the crab *Nasima dotilliformis* dominant in the upper eulittoral. This crab excavates burrows in the mud, and piles up the excavated material around the entrance, thus forming a distinctive mound or turret. These burrows occur at high densities of up to 40 per square metres (m²). Another crab that occurs the intertidal, *Metopograbsus messor*, does not build burrows, but seeks shelter in open burrows of other crabs. Cyanobacteria is distributed almost everywhere below the high water spring line, where bioturbation by crabs is limited. A variety of microscopic animals inhabit the cyanobacterial mats including gastropods, ostracods, nematodes, flatworms, copepods, and oligochaete worms. Larger animal life is usually absent where cyanobacterial mats are well established. Normal populations of the crab *Macrophthalmus depressus* and gastropods such as *Cerithium scabridum* and *Pirinella conica* keep the substrate constantly bioturbated and the mud surface churned up, preventing the cyanobacteria from forming a mat.

Mangroves, currently represented by a single species, *Avicennia marina*, are salt-tolerant trees found from the mean high tide level down to the mid eulittoral. There is limited evidence, and limited efforts to re-introduce another mangrove species believed to have occurred in the Gulf, namely *Rhizophora mucronata*. A small number of specimens have been re-introduced, mainly into marine areas of Abu Dhabi. The mangroves in the Gulf are decreasing in growth height gradually from Ras al Khaimah towards Khafji, probably based on decreasing winter temperatures. North of Khafji mangroves are completely replaced by salt marsh vegetation. The same is true for Ras Mohammed in the Red Sea. Mangroves provide food and shelter to many invertebrates, as well as shrimp and young fish. The mangrove stands occur only patchy at sheltered sites of low energy beaches and lagoons. Even though mangroves are protected by law in Qatar, their obvious destruction seems to be tolerated. This is very different in comparison to Abu Dhabi, which is one of the few places globally where mangrove stands have increased in size over the last few years.

Mangroves are highly important, especially in desert countries, where the terrestrial vegetation cover is 0-2 per cent, and mangroves reach values of up to above 100 per cent. The importance of mangroves in Qatar does not only come from primary productivity, providing habitat structure for numerous marine and bird creatures, but also is it based on their capacity for greenification based on seawater irrigation, as well as the potential for agricultural fodder crop production for camels, goats, and sheep.

Sabkha are areas with high salt concentrations which renders them unsuitable for growth of halophyte plants. Coastal *sabkha* are a common feature along the Gulf coast. Sand beaches begin in the supratidal zone which is composed of beach dunes mostly vegetated by Halophytes such as *Suaeda maritima* or *Seidlitzia rosmarinus* and the beachgrass *Halophyrum mucronatum*. At higher energy sand shores, the ocypodid ghost crab, *Ocyrode rodundata*, occurs frequently near the littoral fringe.

It is especially conspicuous because of the large conical towers that form the entrances to its burrows. Lower down the beach there are few signs of visible life. But beneath the sand, over 200 species of macroscopic animals have been recorded. On mixed sand-rock or sand-mudflats this number is even higher. Marine snails are the dominant group with 48 recorded species. Secondary there are pelecypods (clams and cockles), polychaete worms, peracaridans (isopods and amphipods such as sandhoppers), and decapod Crustacea. Sand flats in Qatar occur in various locations around the peninsula, and especially in the southeastern part, known as Khor al Udayd. The small deposit-feeding crab, *Scopimera crabicauda*, particularly its burrows (often greater than 100 per m² with typical feeding trench and piles of sand pellets), is a conspicuous feature on the sand flats. Gastropods commonly found on sand flats include: *Cerithium scabridum*, *Cerithidea cingulata*, *Mitrella blanda*, and *Nassarius plicatus*. Other important invertebrates are polychaetae that occur beneath the intertidal sand. The lower tidal level is characterised by polychaetes and shells.

Rocky shores consist principally of flat beachrock in sheets, often with a thin veneer of sand or sandy mud. They are not as productive as the other ecosystem types. The main reason is the heat and desiccation during low tide in summer which limits the growth of algae. Therefore the fauna is limited to animals which inhabit crevices, rock pools, holes, and the underside of boulders, or else are mobile forms capable of retreating to suitable shelter when tide is low. Permanently attached, sessile animals such as the barnacles (for example, *Euraphia sp.*, *Balanus amphitrite*), tube dwelling serpulid polychaetes (for example, *Pomatoleios kraussii*) and bivalves (for example, *Isogomon legumen*, *Brachidontes sp.*) mostly are plankton feeders and occur along the rocky shores, usually in crevices and on the underside of pieces of rock. They are either cemented to the rock, attached by a bundle of threads, or they live wedged into crevices in the rock. Some mussels even bore into the rock (for example, *Lithophaga*). Tube worms and barnacles are usually found in dense clusters covering large parts of the rock where conditions are favourable. In contrast to the sessile forms are vagile animals, able to move about freely on the rock surface. The most important group in this category are the gastropods or snails. A majority of them are herbivorous and graze on algae and cyanobacteria.

Although six species of seagrasses have been reported from the Gulf, the seagrass assemblages are generally dominated by *Halodule univervis*. Seagrass habitats are highly productive ecosystems and are of critical importance, both directly and indirectly, to the marine fauna. This applies in particular to flagship conservation species, foremost dugong and marine turtles, as well as numerous fish and species of commercial interest. Subtidal rock substrates are limited and are often covered with calcareous sand. Coral reefs in the Gulf are not well developed as a result of extreme environmental conditions and are represented by only 62 coral species. Along the coast where temperature and salinity variations are highest only poorly developed fringing reefs occur, displaying a drastically reduced number of species. Dominant reef builders here are usually *Porites compressa*. The best developed and most diverse reefs in the Gulf are located around some offshore islands and dominated by *Acropora clathrata*. The high diversity of the coral reefs provides a wide range of habitats for other reef species.

Annex 2: Qatar's Human Development Indicators, 1990 to 2007

Human Development Index and its Component Indices ¹					
	1990	2000	2005	2006	2007
Human Development Index (value)	0.802	0.803	0.875	0.899	na
Life expectancy index	na	0.740	0.834	0.838	na
Education index	na	0.790	0.852	0.857	na
GDP index	na	0.870	0.938	1.000	na

Components of the Human Development Index					
	1990	2000	2005	2006	2007
Life expectancy at birth (years)	69.2	69.6	75.0	75.3	na
Adult literacy rate (% , ages 15 and above)	79.4	87.8	90.6	90.8	93.1
Combined gross enrollment ratio for primary, secondary and tertiary schools (%)	72.9	80.7	91.1	93.9	95.9
GDP <i>per capita</i> (PPP US\$)	15,004	27,214	49,228	57,330	61,528

Demographic Trends					
	1990	2000	2005	2006	2007
Total population (millions)	0.4	0.6	0.9	1.0	1.2
Annual population growth rate (%)	3.2	5.1	15.5	15.9	16.3
Total fertility rate (births per woman) Qatari	5.7	4.2	4.2	4.2	4.4

Commitment to Health: Resources, Access and Services						
	1990	2000	2005	2006	2007	
Health expenditure	Public (% of GDP)	2.40	1.31	2.28	1.83	1.81
	Private (% of GDP)	0.04	0.08	0.08	0.14	0.15
One-year olds, fully immunised	Against tuberculosis (%)	96	100	100	100	96
	Against measles (%)	79	91	100	99	92
Births attended by skilled health personnel (%)	99.5	100	100	100	100	
Physicians (per 100,000 people)	179	220	350	276	208	
Population with sustainable access to affordable essential drugs (%)	100	100	100	100	100	

Water, Sanitation and Nutritional Status					
	1990	2000	2005	2006	2007
Population with sustainable access to improved sanitation (%)	100	100	100	100	100
Population with sustainable access to an improved water source (%)	100	100	100	100	100
Percentage of families with access to electric power	100	100	100	100	100
Percentage of population with access to primary healthcare facilities	100	100	100	100	100
Children underweight for age (%)	--	10.4	6.0	12.6	12.6
Infants with low birth weight (%)	7.9	8.8	8.5	8.8	8.3

¹ Source: UNDP Human Development Indices: A Statistical Update 2008 [<http://hdr.undp.org/en/media/HDI2008Tables.xls>]. Accessed February 2009

Leading Global Health Crises and Risks		1990	2000	2005	2006	2007
Condom use at last high-risk sex (%)	Women	--	48	48	20	20
Malaria cases (per 100,000 people)		28.0	24.0	21.1	23.6	15.9
Tuberculosis cases	Per 100,000 people	25.0	20.3	20.3	21.7	15.6
	Detected under DOTS (%)	--	48.0	40.8	40.4	22.5
	Cured under DOTS (%)	--	7.30	11.6	13.7	--

Survival: Progress and Setbacks		1990	2000	2005	2006	2007
Life expectancy at birth (years)		69.2	69.6	75.0	75.3	na
Infant mortality rate (per 1,000 live births)		13.50	11.70	8.21	8.10	7.46
Under-five mortality rate (per 1,000 live births)		16.60	13.10	10.45	10.69	9.10
Maternal mortality	Ratio reported (per 100,000 live births)	--	8.3	22.4	7.1	31.8
	Ratio adjusted (per 100,000 live births)	--	8.3	22.4	7.1	31.9

Commitment to Education: Spending		1990	2000	2005	2006	2007
Public expenditure on education	As % GDP	4.24	2.98	3.49	2.30	3.24
	As % of total government expenditure	10.18	9.41	12.71	8.04	11.23

Literacy and Enrolment		1990	2000	2005	2006	2007
Adult literacy rate (% ages 15 and above)		79.4	87.8	90.6	90.8	93.0
Youth literacy rate (% ages 15-24)		96.5	98.0	98.9	99.0	99.1
Net primary enrolment ratio (%)		91.5	96.9	96.0	97.6	92.5
Net secondary enrolment ratio (%)		54.1	75.0	89.2	92.5	92.5

Technology: Diffusion and Creation		1990	2000	2005	2006	2007
Telephone main lines (per 1,000 people)		218	260	258	219	196
Cellular subscribers (per 1,000 people)		0	194	900	883	1,002

Economic Performance		1990	2000	2005	2006	2007
GDP	US\$ billion	7.4	17.8	42.5	56.8	71.0
GDP <i>per capita</i>	USD\$	17,426	28,797	47,794	54,496	57,936
GDP <i>per capita</i> annual growth rate (%)		9.93	36.23	17.20	16.50	7.30
Average annual change in consumer price index (%)		3.0	1.65	8.8	11.8	13.8

Structure of Trade					
	1990	2000	2005	2006	2007
Imports of goods and services (% of GDP)	23.0	22.3	31.1	38.3	38.2
Exports of goods and services (% of GDP)	52.9	67.3	68.3	67.4	64.2
Primary exports (% of merchandise exports)	49.47	65.28	50.1	47.1	45.9
Semi-manufactured exports (% of merchandise exports)	0.79	23.34	38.8	44.3	46.2
Manufactured exports (% of merchandise exports)	10.74	4.74	11.1	8.6	7.9

Priorities in Public Spending					
	1990	2000	2005	2006	2007
Public expenditure on education (% of GDP)	4.24	2.98	3.49	2.30	3.24
Public expenditure on health (% of GDP)	2.45	1.39	2.36	1.97	1.96

Energy and the Environment					
	1990	2000	2005	2006	2007
Electricity consumption <i>per capita</i> (kilowatt-hours)	12,082	14,944	16,316	14,383	14,201
Ratio of the protected area to the total area	0.17	0.17	11.12	12.46	21.72

Components of Gender-Related Development Index						
		1990	2000	2005	2006	2007
Life expectancy at birth (years)	Female	na	71.3	75.8	76.1	na
	Male	na	68.7	74.6	74.9	na
Adult literacy rate (% age 15 and above)	Female	73.0	84.2	87.5	87.8	90.4
	Male	85.7	91.3	93.6	93.7	93.8
Combined gross enrollment ratio for primary, secondary and tertiary level schools (%)	Female	80.3	84.1	95.4	95.4	99.6
	Male	65.4	77.2	87.0	92.4	94.3

Components of Gender Empowerment Measure					
	1990	2000	2005	2006	2007
Seats in parliament held by women (% of total seats)	0	0	3.4	3.4	3.4
Female legislators, senior officials and managers (% of total)	0.9	6.6	8.1	7.2	6.8
Female professionals and technical workers (% of total)	26.8	25.9	24.5	25.0	19.6

Gender Inequality in Education		1990	2000	2005	2006	2007
Adult literacy	Female rate (% age 15 and above)	73.0	84.2	87.5	87.8	90.4
	Female rate as % of male rate	85.2	92.2	93.5	93.7	96.4
Youth literacy	Female rate (% age 15-24)	95.0	97.3	98.4	98.6	99.0
	Female rate as % of male rate	96.8	98.5	99.2	99.3	99.1
Net primary enrolment	Female ratio (%)	90.8	97.3	95.3	97.3	97.8
	Ratio of female to male	0.98	1.01	0.99	0.99	1.01
Net secondary enrolment	Female ratio (%)	55.7	77.3	92.6	94.3	94.2
	Ratio of female to male	1.07	1.07	1.08	1.04	1.04
Gross tertiary enrolment	Female ratio (%)	66.8	74.2	66.6	66.3	62.7
	Ratio of female to male	2.50	2.46	2.09	1.94	1.99

Gender Inequality in Economic Activity		1990	2000	2005	2006	2007	
Female economic activity rate (age 15 and above)	Rate (%)	27.5	35.2	40.6	45.4	49.3	
	As % of male rate	29.6	38.7	44.3	44.8	51.9	
Employment by economic activity (% distribution)	Agriculture	Female	0.0	0.0	0.1	0.1	0.0
		Male	3.5	4.3	3.2	3.2	2.7
	Industry	Female	1.5	1.9	3.1	3.1	4.8
		Male	35.5	38.0	47.6	47.6	58.4
	Services	Female	98.5	98.1	96.8	96.8	95.2
		Male	61.0	57.7	49.2	48.2	39.0

Note: na signifies the data are not readily available

Source of data: Based on Al Mahdi, N. 2009. "Qatar's Sustainable Development Indicators." Background paper for GSDP and UNDP, Qatar's Second Human Development Report: Advancing Sustainable Development. Doha., and QSA (various years)

