state of the environment report

IN STATE OF QATAR 2021

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“Qatar has made the Environmental Development as one of the four pillars of the Qatar National Vision 2030 which includes Human, Social, Economic and Environmental Development areas. The protection of the environment is one of the articles of the State of Qatar’s permanent constitution of the State of Qatar”

His Highness Sheikh

Tamim Bin Hamad Al-Thani

Emir of Qatar

His Highness the Father Emir Sheikh
Hamad Bin Khalifa Al Thani

Speech Of His Excellency
The Prime Minister And Minister Of Interior

Our step today towards realizing Qatar's vision 2030 and reaching the pertinent goals is extraordinary as it is incumbent upon every responsible member of our community. In order to fully achieve the four pillars of the vision and transform Qatar into an advanced nation, environmental integration should be sustainably considered beside socioeconomic developments.

Our target is to produce a significant shift towards environmental preservation and protection through monitoring and reporting the changes in the state of the environment regularly.

For the bright future of the State of Qatar, it is vital to ensure a high standard of living for its citizens and residents by 2030.

His Excellency Sheikh

Khalid bin Khalifa bin Abdulaziz Al-Thani

Prime Minister of Qatar and Minister of the Interior

Speech Of His Excellency
The Minister Of Municipality And Environment

Qatar has an environment that is unique, fragile and precious, It deserves a comprehensive assessment, encompassing the physical and biological elements and the ecosystems, along with social, cultural and educational aspects.

In this State of the Environment report for Qatar, serious efforts have been made for data collection and consolidation, and synthesis of credible information on matters that are pertinent to the environment., Due to of the interconnected nature of a wide range of issues, an understanding of how they relate to each other helps in making sense of the prevailing scenario.

Information contained in this report will contribute to promoting environmental awareness among the public and decision makers,; identifying knowledge gaps, and examining ways in which research could be pursued to achieve the national goals of evidence-based nature conservation and sustainable development.

The reporting system that this document establishes will enable our scholars to focus research on indicators that show changes and trends in the country's progress towards achieving the four goals of Qatar National Vision 2030, namely, Environmental, Social, Human and Economic development.

We believe that knowledge empowerment of the society is vitally important for environmental stewardship. In this context, the State of the Environment report is an important tool to spread the message that connects with all sections of the society and mobilizes them to contribute to the multiple dimensions of sustainable development.

HE Mr

Abdulla bin Abdulaziz bin Turki Al Subaie

Minister of Municipality and Environment

Speech Of The Assistant Undersecretary For Environmental Affairs

Engineer
Hassan Jumaa Boujumhour Al Mohannadi
Ministry Of Municipality And Environment - Doha - Qatar

PREFACE

Recent years have witnessed a growing interest in understanding and addressing environmental issues in Qatar, owing to the realization of their significance in sustainable development.

Efforts are being made for linking human development goals with the ability of natural systems to sustain the supply of resources and ecosystem services upon which the economy and society depend.

Obviously, it is pertinent to consolidate key information on the state of environment in terms of its prevailing condition, the pressures it is subjected to, drivers of those pressures, management response to address the environmental issues as holistically as possible and outcome of the initiatives taken. This is the reason for including in this report the assessments across the main biophysical and ecological elements of the environment, as well as social, cultural, economic and educational aspects that matter in practically feasible and knowledge-based environmental management.

In this report about the state of the environment some unique challenges facing Qatar (latitude: 24° 27› N, longitude: 50° 40› E) that constrain the sustainable development efforts deserve mentionioning.

It is a desert country in the form of a peninsula covering an area of 11,627.8 km2. Average summer temperatures are in the range 35 - 49 degrees Celsius and annual rainfall is one of the lowest in the world (about 75.2 millimeter). The entire landmass measures some 180 km in length and 85 km in width and is mostly surrounded by the Arabian Gulf waters except the 60 km of land border with the Kingdom of Saudi Arabia. The marine area (35,000 km2) of the country is almost three times the land area. Salinity of seawater can be as high as 60 – 70 ppt in some places and seasons. Obviously, such conditions require specific and locally relevant measures for environmental management and sustainable development of natural resources.

This report contains 8 chapters, 3 dealing with the core environmental domains - air, land and groundwater, and the sea, while the rest focuses on issues that are pertinent to environment and needed to be addressed for achieving the goals of sustainable development. In each of the themed chapters, wherever possible, the main elements of the state-pressure-response framework developed by the Organization for Economic Cooperation and Development have been elaborated in an extended form. The indicators selected are the ones used internationally. Besides, new indicators that evolved from the data can serve as a credible proxy for established indicators.

In this State of the Environment report, efforts have been made to follow a holistic and multi-sectoral approach towards management of environmental resources consistent with the Driver-Pressure-State-Impact-Response (DPSIR) framework.

In the context in which the issues have been highlighted in this report, DPSIR framework seems a practical tool that allows explaining the environmental problems by defining the nature and level of anthropogenic interaction.

This report contains a great deal of discussion of indicators and indexes, the DPSIR framework provides, thus, a structure for presenting the measures that reveals what is happening in the environment. This is needed to enable feedback to policy makers on environmental quality and the resulting impact of the policies and interventions made, or to be made in the future. The fact that the changes in environmental management systems have socio-economic implications, analysis of DPSIR components is important for the reviewing of government decisions in order to enhance the effectiveness of management decisions through the input of scientific advice.

This report will provide the public an access to professionally assessed conditions of the environment of Qatar and will motivate the various sections of the society to contribute to finding solutions.

In writing this report, efforts were made to highlight the implementation of Qatar National Vision 2030. The four pillars of this vision, namely, the economic, social, human and environmental development have been covered to varying degrees..

Contents of the report will also help in shaping up the priorities for environmental research in areas such as: accurate environmental monitoring systems, biodiversity, ecological tipping points, water security, seafood security, reducing carbon footprint of industries, renewable energy, and climate change impacts and adaptations.

The report will effectively inform the stakeholders that, in a long-term perspective, investing in environmental management now will be cheaper and a better option in the future.

The scientific evidences presented in the report hold out a strong possibility of Qatar emerging as an educational hub where mechanisms for climate change adaptation can be examined for gaining insights that are helpful for conservation of biological resources elsewhere. Qatar has a heritage that represents historic human interaction with nature in sustainable ways, and this could ignite new interest in blending of scientific knowledge with traditional knowledge and practices for developing adaptations to changing environment.

Some of the enduring questions related to Qatar's environment have been addressed together with analysis of how the available data could provide convincing explanations of environmental dynamics.

This document marks the beginning of what is envisioned to be a regular process of reporting, that sets benchmarks for assessment of the environmental condition of Qatar and measuring progress towards specific goals.

Hopefully, subsequent reports will build on the work done in this report by bridging the knowledge gaps and incorporating improved analysis of trends in the environment and assessment of the effectiveness of measures undertaken. In view of the complex nature of interactions between natural systems and human activities, future reports should ideally comprise a more interdisciplinary approach of analysis of geophysical, biological, geochemical and sociocultural interactions related to environment.

Table of Contents

Executive Summary

This report on the State of the Environment of Qatar is intended to present an authentic assessment of the condition of the country's environment to the community, decision-makers and global audience interested in knowing our environment, management efforts and outcomes.

The report lays a strong foundation for analysis of trends in the various environmental domains: air, land, groundwater and sea. Because of the inseparable and often intricate linkages of ecosystem health with human actions it was considered pertinent to include topics on education, society, culture, energy, industry and economy. This approach provides insights into what is at stake in environmental management and how to foresee problems for proactively implementing knowledge-based decisions. Topics such as biodiversity, pollution and climate change are explained as cross-domain themes in chapters where appropriate. The fact that Qatar's environmental management policy is oriented towards sustainable development, a major chapter focusing on environmental sustainability and its various links and implications, besides a roadmap for achieving long-term goals, was deemed necessary.

The State of the Environment report tries to cover most of the environmental issues concerning the country. Rather, it highlights only the major ones to draw the attention of the various stakeholders and raise the level of concern for the sake of individual or collective actions, with clear policy goals.

Human actions exert pressures on the environment directly as well as indirectly. It makes sense to examine what drives those pressures,its nature matters to the condition (state) of the environmental domain at a specific time, the impacts, initiatives and response. It is a structured procedure for sustainable development of the environment. Basically, this framework deals with human interaction with the environment and the management efforts. The natural s such as extreme weather conditions and human-induced climate change were given due consideration. However, there are intricate linkages between natural factors and environmental conditions resulting from anthropogenic interaction that have been highlighted wherever possible for appropriate response either by way of mitigation or adaptation.

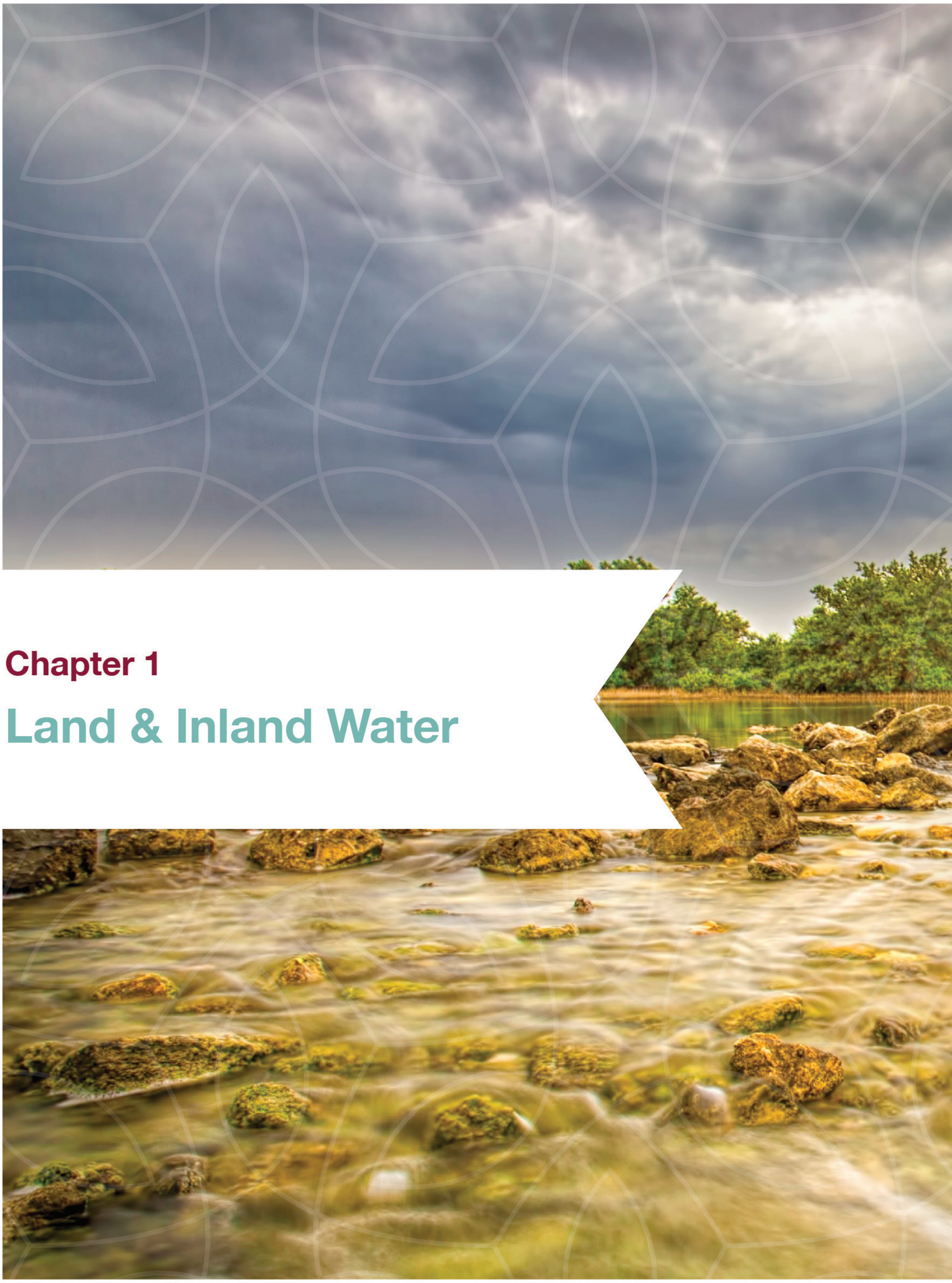
The environmental conditions linked to geography and climate of a country cannot be ignored in developing management systems that are appropriate and likely to yield desired outcomes. These geographical factors are necessary when formulating strategic environmental initiatives and prioritizing climate change adaptation measures in the related context . Qatar is a small country characterized by a desert climate: scanty rainfall, lack of permanent surface water body, little groundwater recharge, and summer temperatures so high that people are at risk of dehydration, strong winds that often turn into sandstorms and the hypersaline seawater. The changing climate is adding to these already difficult environmental conditions. The carbon sequestration resources that can reduce climate change effects are limited.

Although the rich energy reserves have provided means for decent living and coping with the stress of climatic origin, the living biological resources are vulnerable. It is difficult to assess their resilience and tipping points due to knowledge gaps. Investment in education, capacity development and healthcare are likely to help people cope with the vagaries of nature to a great extent. Institutions dealing with policies and governance are alert to the prevailing and anticipated environmental conditions. How effectively and wisely the rational programs are implemented will determine our success in sustainable management of the environment.

This report comprises of 8 chapters on the core environmental components and the relevant thematic topics. Each chapter includes introduction, objectives, indicators, condition of the environment, measures or governance and their effectiveness in addition to outlining the suggestions for addressing the issues and presenting the emerging as well as likely scenarios. It will also generate data that be helpful for informed decisions, bridging the knowledge gaps, and formulating strategies and action plans for improving sustainability.

While much of the contents of this report are technical, special efforts have been made to present synthesis of knowledge and interpretation of the data in ways that make it accessible to policy makers and to a wide audience. Key findings of all the chapters have been consolidated and summarized herein.

Chapter 1
Land and Inland Water



Chapter 1

Land & Inland Water

Chapter 1

Land and Inland Water

A considerable area of the country is barren, with dry sand, sand dunes and only scanty vegetation. There are two types of soils, namely Aridisol, which is mostly sandy to loamy, shallow and skeletal, and Entisol, which is mostly calcic and gypsic, lying beneath the topsoil. Land is quite heterogeneous, with distinct features: flat arid areas, sand dunes of land or marine origin, salt pans (sabkha), mangrove forest, intertidal and Rawda consists of fine soil and rain-washed litter. This is considered the best naturally occurring well-drained sandy-loamy soil in Qatar.

Building infrastructure for housing, industrial and commercial uses, farms and gardens measure about 6% of the country's land mass. The country's arable area is 65x103 ha and the cropped area is 13203.4 ha, with a fluctuating record of production that in 2018 stood at 736114.7 tons, contributing to less than 1% of the GDP.

Qatar has gazette several protected land areas. Mostly, these are ecologically sensitive habitats and are intensively used by the wildlife. This measure has helped in conservation of precious land, groundwater, desert vegetation and wildlife and offsetting desertification while enabling the country to fulfill its obligations towards biodiversity conservation. However, the prevailing governance mechanisms need to be reviewed and made effective through knowledge-based methods for better outcomes, especially with regard to terrestrial biodiversity.

Water security is a critical issue in Qatar. With very limited recharge and over-extraction of groundwater, the reserves are depleting, and intrusion of saltwater is increasing. The ongoing monitoring program that was initiated in 2014 provides evidence of increasing salinity and over-exploitation of the groundwater. the Government developed policies and invested heavily to ensure supply of safe drinking water to all its residents by massive desalination. Groundwater abstraction is being carried out mainly for agriculture. In terms of potable water supply and sanitation, Qatar has been able to meet the international indicators. With drinking water priority should be given to integrated water resources management. The country has a good record in efficient treatment and reuse of urban wastewater. The re-use of treated wastewater has already become an important alternative source of water for irrigation in agriculture, green spaces and district cooling systems. There is still considerable volume of wastewater that is left unused since the volume is beyond the capacity collection system and is, therefore, lost due to evaporation, leakage from networks and septic tanks seepage, or in other ways.

Public gardens receive special interest. As new gardens are being opened, the old ones are being renovated to increase the green spaces and aesthetic value. This has encouraged people to embrace healthy lifestyles and has also contributed to enhancing the quality of the environment.

Interest in public gardens, parks and green spaces is evident from the fact that these facilities numbered 116 in 2019, Qatar is going ahead with plans to extend green space, improve the park environment and modernize the management to increase their recreational value. Most of the parks and green spaces are irrigated using modern system devices and are being brought under radio control, although the traditional methods are still under operation. Flora used in public parks and gardens belongs to 5 categories: palm trees, ornamental trees, ornamental shrubs, fruitful trees and shrubs and native varieties.

Qatar National Vision 2030 recognizes the need to preserve and protect biological diversity and balancing development with environmental protection. Wild animals, especially Oryx, Falcon, Desert Hedgehog, Spiny-Tailed Agama, Pharaoh Eagle Owl, Horned Viper Snack, and the Repeal›s Fox are rare. The Government is working for their protection. For example, there is a program initiated for Arabian Oryx and it has seen a nearly 30% increase in its population of this animal from 1,136 to 1,537 between 2010 and 2014, while recently reach 1157 in 2019. Recognizing the significance of habitat in biodiversity conservation, Qatar has given due attention to demarcating protected areas. There are 11 protected area covering an area of 2,742.41 square kilometers, representing 23.59% of the total area of the state of Qatar.

Inhabited land 3%

1.1. Introduction

The State of Qatar is situated halfway along the western coast of the Arabian Gulf falling approximately between the latitudes 24° 27´ and 26° 10´ North and the longitudes 50° 40´ and 51° 40´ East. The Qatari peninsula extends northwards, covering approximately an area of 11,627.8 km2. The Qatari peninsula is about 185 km in length in North – South direction, while the maximum width East-West is about 85 km. The territorial waters of Qatar extend approximately 95 nautical miles east and around 51 nautical miles north into the Arabian Gulf. The only land border of about 86 km is shared with the Kingdom of Saudi Arabia. It includes a number of islands, reefs and shoals in the coastal waters of the peninsula. Halul, Shara'wah, Al Ashat and Al Bashiria are the known landmasses, Figure (1.1) presents Qatar's map. The marine area of Qatar is much higher than the terrestrial area.

Qatar has a warm desert climate with mild winters and hot summers, monthly temperatures range from 17°C in January to 48°C in August. The presence of the sea influences the climate by increasing the air humidity that is relatively high (relative humidity values are around 70%), however as in the rest of this region, rainfall is scanty. The annual rainfall is approximately 70 to 80 mm with rainfall confined to the months between October and May. Rainfall is very irregular and hence extremely unpredictable. Heavy localized rainfall on one day may account for more than the average annual rainfall. The morphology of the surface of Qatar is of low to moderate relief, with scattered depressions. Elevation of 50 m and more above mean sea level are limited and are in the southwest quarter of the peninsula (Figure 1.1).

Qatar's population has grown significantly in the past few years, from 744,029 in 2004 to 2,216,180 and 2,773,885 in 2014 and 2019, respectively. Thus, a rapid rising of the water, food and energy demands for domestic, industrial, and agriculture activities is noticed. In general, land and inland water underpin the provision of most goods and services that freshwater ecosystems provide to people. These are diverse and include not only direct use for drinking-water supply & sanitation, food, industry, fiber and medicines but also benefits such as decreasing pollution and nutrient absorption and recycling, flood management and mitigation against the impacts of natural catastrophes and climate change.

Repeated:

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1.2. Land Use

Life on land is the Goal No.15 of the UN Sustainable Development Goals (SDGs) and 2030 UN Agenda. It aims to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. This Goal focuses specifically on managing forests sustainably, restoring degraded lands and successfully combating desertification, reducing degraded natural habitats and ending biodiversity loss. In addition, both forests indictor and biodiversity and habitat indictor are two of the 9-environmental policies of Yale Center for global Environmental Performance Index (EPI).

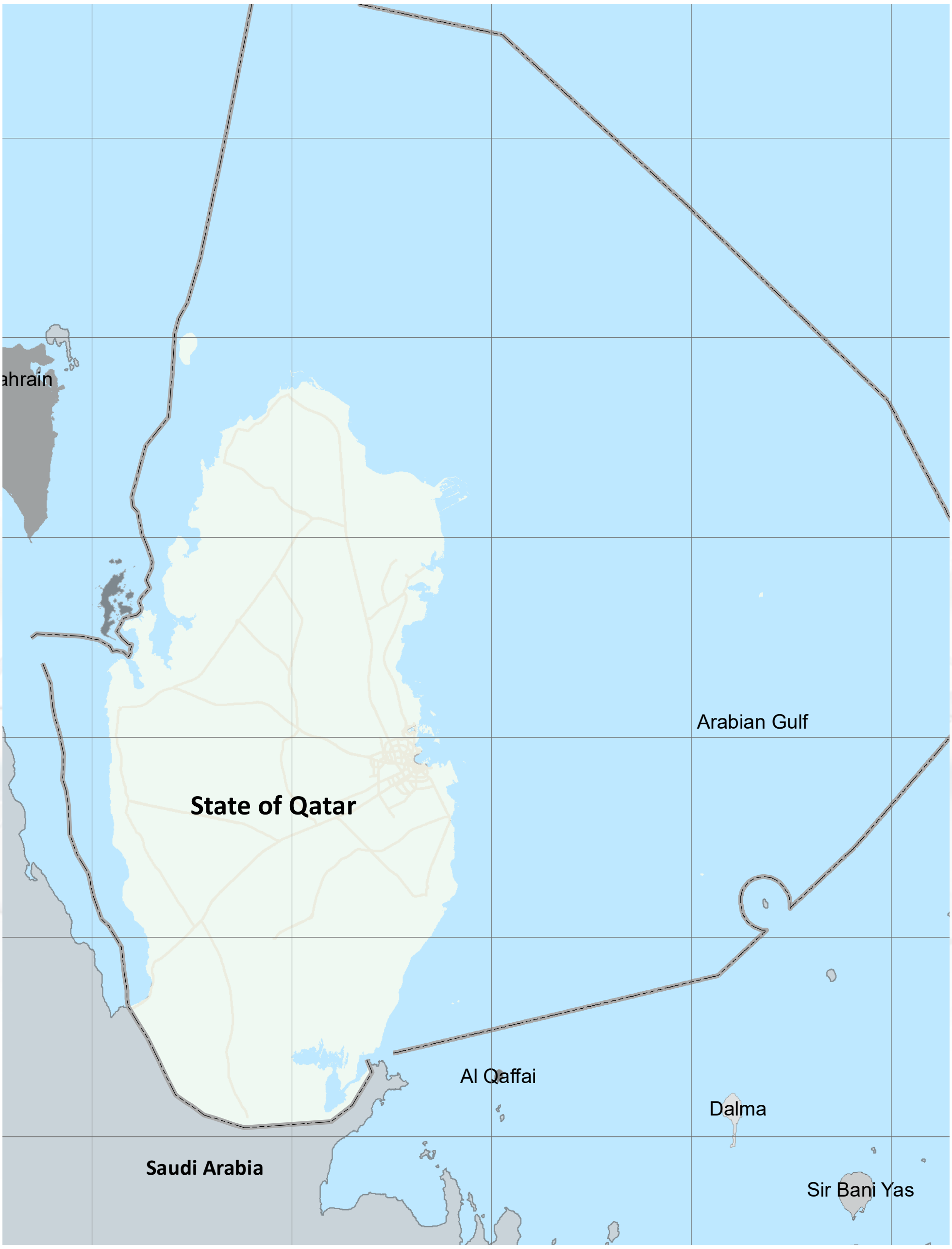


Figure 1.1. State of Qatar (Source: Qatar Atlas, 2013)

1.2.1. Built Environments and Urbanization

Land use and land cover of Qatar can be classified into three main categories:

- Soil Cover
- Human Activities
- Surface Water Bodies

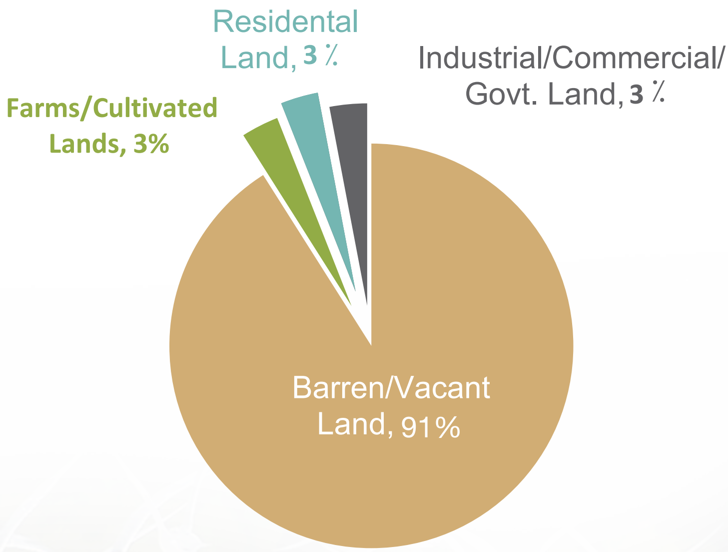
The majority of Qatar land is covered with soil. Human activities such as residential and industrial areas, infrastructures areas and other activities cover significant part of Qatari land. Farms, whci are places for agricultural activities, represent a percentage of land use and cover in Qatar. Surface water bodies include natural Sabkhas, which is natural wetlands and artificial lagoons. There are no rivers or natural lakes in Qatar (Figures 1.2 and 1.3). As a peninsula, Qatar is surrounded by the Arabian Gulf.

Vast area of the country still lies vacant with sand, sand dunes and scanty vegetation. The area under residential uses and that falling under industrial and commercial uses share about (3%) each of the total land area. The area belonging to farms and gardens share another (3%) of the total area of the country (Qatar

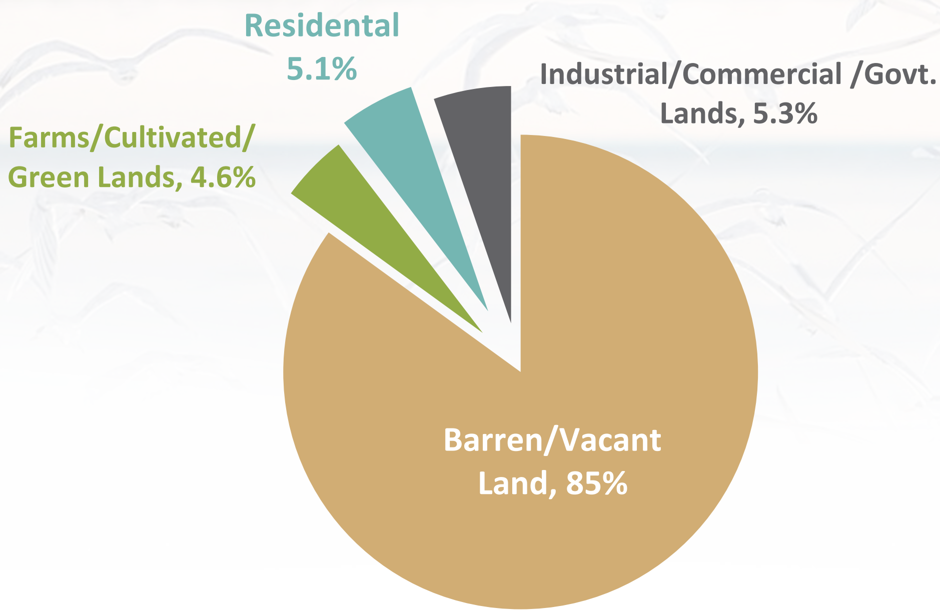
Atlas, 2013). Doha and Al Rayyan are the main areas developed for the residential purposes besides Umm Slal, Al Khor and Al Wakra areas. The industrial areas are well defined in Doha– Al Rayyan, Ras Laffan, Mesaieed and Dukhan, as seen over the map.

It is clear from figures 1.2 and 1.3 that the majority of Qatar is barren/ vacant land. It is more than 91% of the total land of Qatar in 2010 (Qatar Atlas, 2013). In 2015, there is an increasing in residential, farms, and industrial areas by almost 2% than 2010. Therefore, the vacant area has reduced from 91% in 2010 to 85% in 2015. However, distribution of used land among the main three categories of residential, farms/cultivated/green and industrial/commercial/governmental areas is almost the same for each category which is 5.1%, 4.6% and 5.3% of total area of Qatar, respectively. As for 2019 distribution of used land among the main three categories of residential, farms/cultivated/green and industrial/commercial/governmental areas is almost the same for each category which is 6.13%, 5.8% and 6.75% of total area of Qatar, respectively, the vacant area is reduced to 81.32%. (figures 1.2)

Land use for human activities includes urban areas or built environment. Two groups of cities/towns developed in the country can be clearly seen, one that belongs to ancient times and have grown with the development in infrastructure and socio-eco-



2013



2015

(Source: Qatar Atlas, 2013 and Department of Urban Planning, MME 2015) nomic development of the country and the others are industrial cities/towns developed by the government, with regards to special needs to the industries located there.

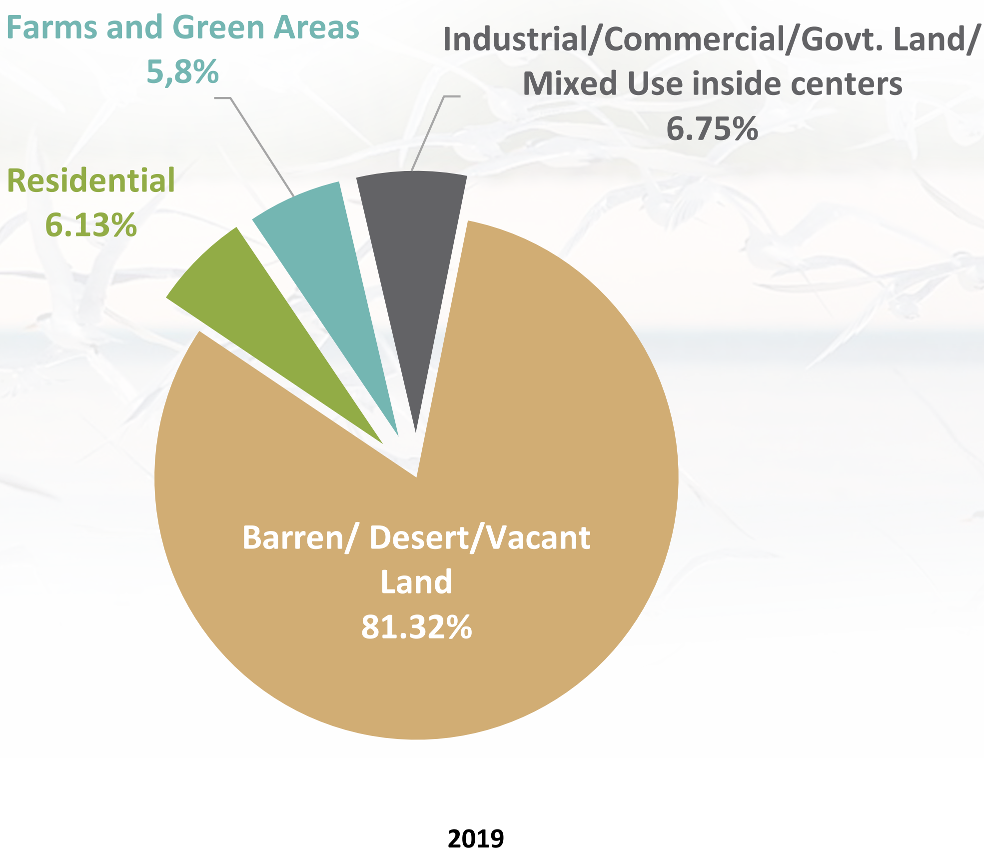


Figure 1.2. Land use and land cover.

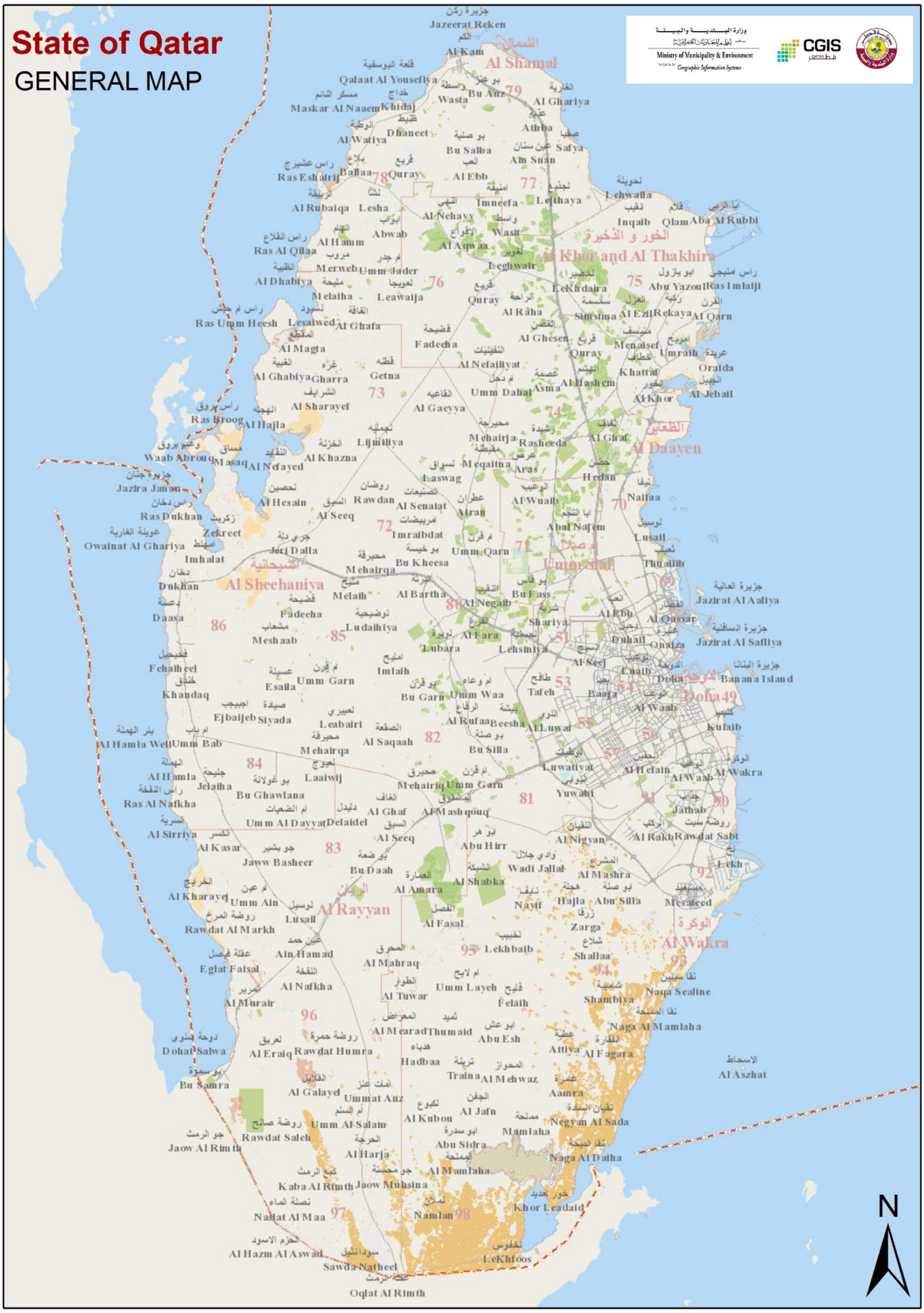


Figure 1.3a. Land distribution of Qatar. (Source: Qatar Atlas, 2013).

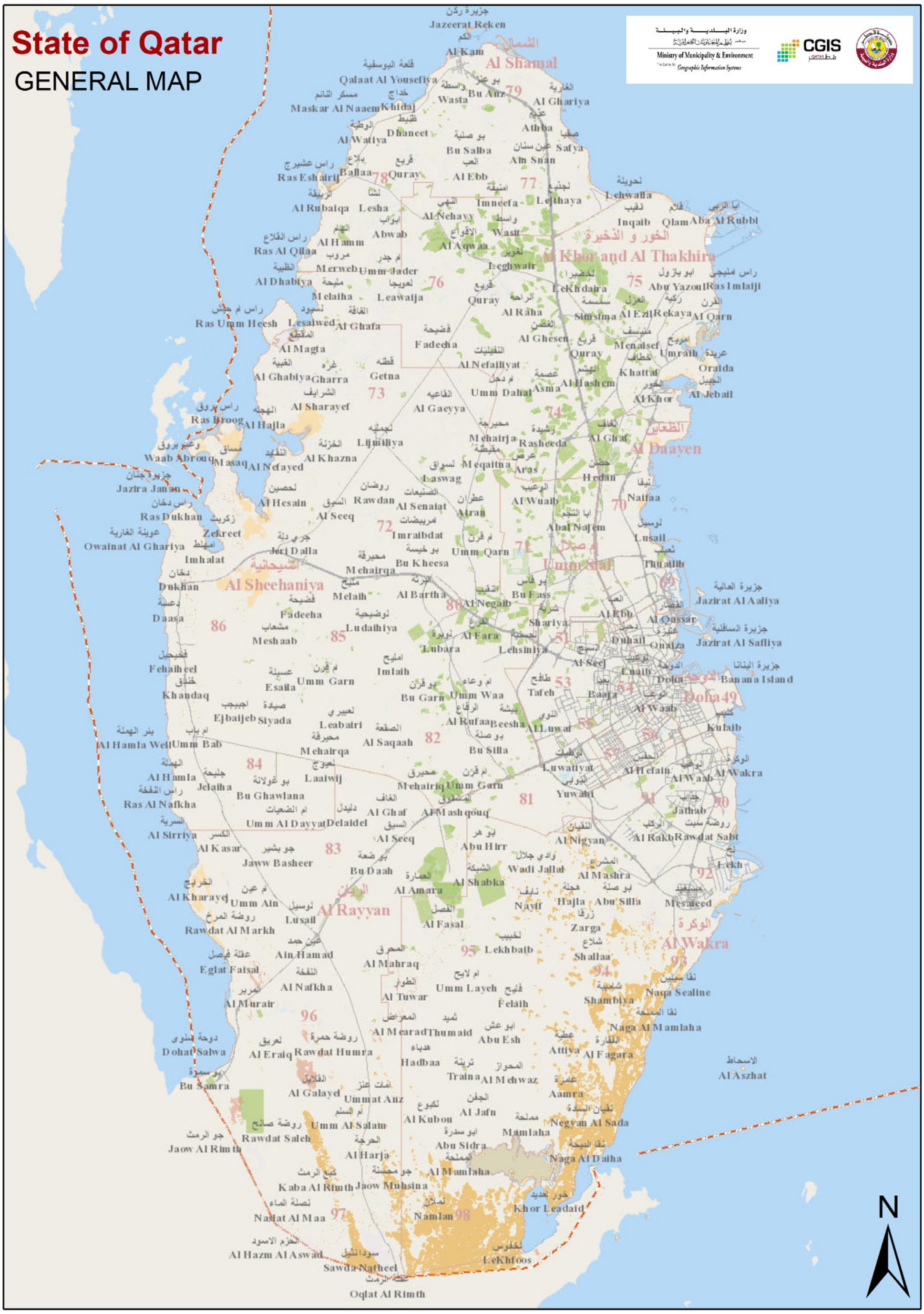


Figure 1.3b. Land distribution of Qatar (urban, roads, and agricultural farms). (Source: Qatar Atlas, 2013).

State of Qatar is divided into (8) Municipalities: Doha, Al-Rayyan, Al-Wakrah, Umm-Slal, Al-Khor and Dhekra, Al-Shamal, Al-Dayyen and Al-Sheehaniya (Figure 1.4). The main settlement is concentrated in Doha and Al Rayyan areas, which has fast extended towards outer areas including Al Wakra, Umm Slal, Al Dayyan and Al Khor areas. Doha city houses main government and semi-government establishments, educational and health institutions, traditional souqs (markets) and modern hyper-malls besides many other important establishments of national and international significance. Al Wakra is another old town reflecting traditional architecture. It is situated 15 km south from Doha. It has an important harbor for fishing boats. Madinat Al Shamal is situated in the extreme north of the country and is important for a number of fishing villages.

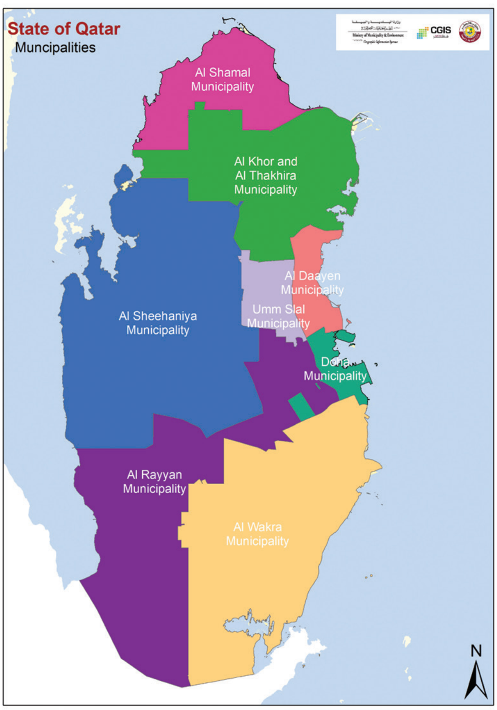


Figure 1.4. The eight Municipalities of the State of Qatar (Source: MME).

Among the industrial towns in the country, Dukhan and Mesaieed are the oldest ones whereas Ras Laffan is a newly created one. Al Khor town houses the employees from Ras Laffan industrial city. There are about (89) small villages scattered over the outside areas, most of these now have infrastructure developed as good as in towns. The settlement distribution has been primarily guided by the availability of infrastructure as developed by the government. The geographic factors seem to have been less effective in guiding the settlement pattern and distribution.

1.2.2. Land Altitude

Qatar overall has a flat rocky surface, rising to 102 m at its highest point. Figure 1.5 shows the distribution of Qatar land by elevation. About 60% of the land surface area falls under 10 m of height (above the mean sea level, msl /QNHD) whereas just only (1%) of the area has an elevation more than 50 m. This altitude is critical for climate change impact. A large part of the country has scrubby desert terrain, covered in sand and loose gravel. There are occasional low hills seen in Dukhan area in the west and Jabal Fuwairt in the northern part of the country. These are rocky limestone ridges having marked depressions with considerable Eolian sand accumulations. Shifting sand dunes ranging up to 40 m in height can be seen scattered over southeastern part and some along the northeastern coast near Ras Laffan.

More than 75% of the land surface is formed from the Tertiary sedimentary sequences and Quaternary deposits cover 25%. The Eolian sand deposits can be found in the southeastern and southwestern coastal parts of the peninsula. Occurrences of more or less unconsolidated material include gravel deposits of Young Tertiary age, and various sediments of Quaternary age. The largest part of country's flat surface belongs to the Lower to Middle Eocene beds (Upper Dammam formation) consisting of thick strata complex of terrigenous and marine deposits dipping very gently northeast and east. The oldest rocks exposed are the limestones of the RUS Formation of the Lower Eocene age, although the widest spread outcrops are the dolomites and the crystalline chalky limestones of the Upper Dammam formation of Middle Eocene age.

There are a number of surface depressions, which lie below the surrounding land surface at a depth ranging up to 20 m. The northern part is relatively lower in height, gradually increasing towards the west southwest. There are a number of islands, reefs and shoals scattered throughout the territorial waters and maritime boundary of the country. The Halul, Shira'wa, Al Ashat and Al Bashiria are the well known among these. The rocky land is cut by small channels of rainwater, which are dry throughout the year except during rains. The formation of pits in the cast topography is notable in the central part. These are believed to be a source of drinking water for the cattle herders.

1.2.3. Soil Types

Soil has an important direct and indirect impact on agricultural productivity, water quality, and the global climate. Soil makes it

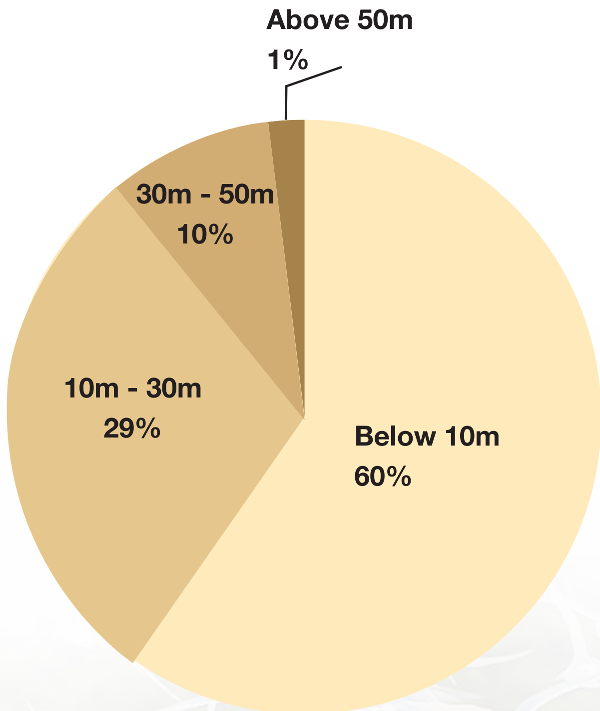


Figure 1.5. Land areas by altitudinal zone, m QNHD.
(Source: Qatar Atlas, 2013).

possible for plants to grow by facilitating the biological, chemical, and physical processes that supply plants with nutrients and water, which are a fundamental resource on which the productivities of agricultural and natural ecosystems depend. Hence, the soil is a key component in regulating and partitioning water flow through the environment. Almost 90% of Qatar land area is covered with soil. Overall, the country is covered by calcareous sandy loam-to-loam soils as well as small to large patches of rocky limestone outcrops are found scattered over the southwestern part of the country. Almost 50% of the soils in Qatar belong to Calcids group of soils while 29.3% falls under Gypsids soil group, as shown in figure 1.6.

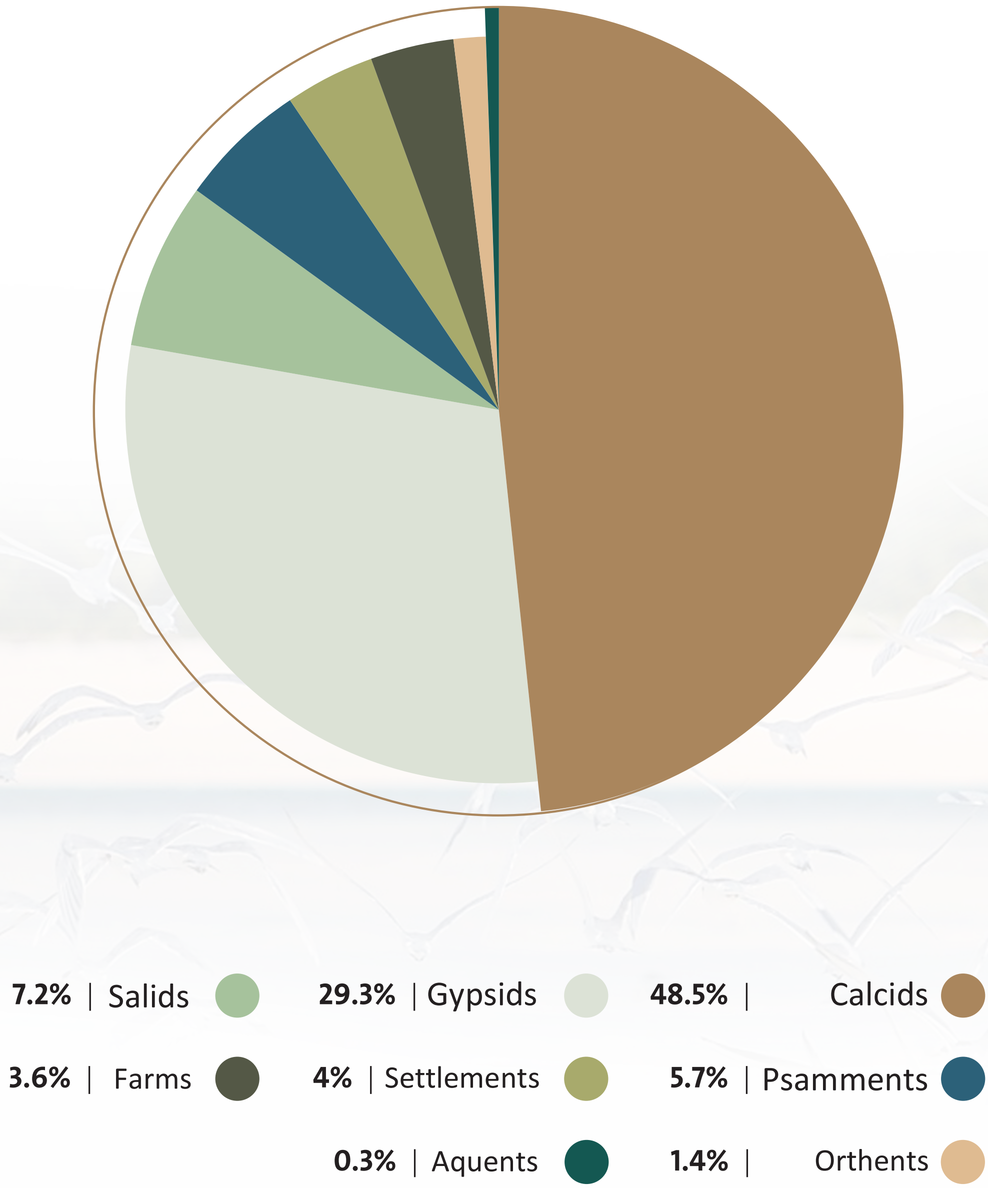


Figure 1.6. Soil classification areas %.
(Source: Qatar Atlas, 2013).

Soil in Qatar is generally classified into one of the following two categories (MoE, 2009):

- Aridsols: mostly sandy to loamy, shallow, skeletal and associated with flat to undulating topography. Most of the soils are light, thin and with very low organic content (10-30 cm deep).

- Entisols: mostly calcic and gypsic which lie beneath the top soil. It is characterized as undeveloped soil and is associated with rock outcrops.

There are some colluvial depressions (Rodah soils) found scattered at some places in the northern part which are considered to be fertile lands of the country. The depth of soil at places ranges from 30 to 150 cm. Some of the coastal areas have Sab

kha deposits, a highly saline depression soil intermixed with deep sand to sandy loam soils. The country also dotted with over 2000 depressions caused by shallow structural collapse in the underlying rocks that contain recent colluvial deposits. Features of soil characteristics in Qatar is shown in figure 1.7 Generally, five landforms and associated soils are recognized in Qatar:

Generally, five landforms and associated soils are recognized in Qatar:

1. Rocky Hammadas: much of the Northern and central area of Qatar is formed of a plateau of limestone and dolomite. The soils are dominantly (89%) lithosols, which are shallow soils of imperfectly weathered rock fragments.

2. Wadies: These fluvial channels contain fine sediments and found in the southwest areas of the country.

3. Depressions: are infilled with colluvial deposits that can be deep and fine textured calcareous loams, clay loam and sandy clay loam which is known as “Rawda” and they make up about 3% of soils in Qatar. After rainfall, the soils experience occasional saturation and result in the formation of clay minerals.

4. Sabkhas: these are inland consisting of silt and calcareous sands with high water and salt content.

5. Sand dunes: these are extensively found over the southeast part of Qatar and include desert sands.

The north of Qatar predominantly contains Rocky Hammadas and a number of depressions. The presence of clay loams (Rawda) within the depressions provides a higher organic carbon content and a better water holding capacity in these areas, which increase the potential for agricultural development.

1.2.4. Soil Quality

Soil quality is defined in relation to the functions that soils perform in natural and agricultural ecosystems. The quality of a soil is determined by a combination of physical, chemical, and biological properties such as texture, water-holding capacity and the content of organic matter.

The Environmental Monitoring and Laboratory Department implements a soil quality monitoring program in Qatar, which started in 2016 and has been revised and developed in 2018 to monitor (52) sites spread over different areas and covering the surrounding soil environment in the country. In the current program, 29 variables of soil quality are being measured, part of which (17) variables are of heavy metals. Soil samples are collected in two phases per year, where a shallow soil sample is collected at (15) cm depth from each monitoring site. The samples are preserved and delivered to the Environmental Laboratory to measure the required variables with methods that are adopted and quality assurance measures are applied. After the required measurements and analyses are made, the results are used to assess the state of the soil.

After successfully implementing and carrying out the soil quality monitoring program, the results and analysis yield to the following conclusions of the soil state in Qatar for the year of 2018:

1- Physio-Chemical

The soil physio-chemical properties consist of 3 parameters, soil acidity (PH), soil salinity (electrical conductivity “EC”), and calcium carbonate. Each is a measure of soil quality indicator. However, the results of the 2018 program showed that the majority of soil in Qatar is alkaline or basal (not acidic).Moreover, the average annual values of EC show that (62%) of soil samples contain less salt (with an electrical conductivity of less than 4 mSI/cm) and only about (25%) of soil samples (sabhas and near beaches) are highly saline soils, electric conductivity greater than 8 mSI/cm according to FAO classification. As for Calcium carbonate: the average annual values show that more than (40%) of soil samples were calcium soil (limestone)

2- Heavy metals:

The following Heavy metals were measured in soil samples; barium, boron, cobalt, copper, iron, manganese, molybdenum, zinc, aluminium, cadmium, chromium, nickel, lead, vanidium, selenium, arsenic and mercury. The annual results indicate that there is no contamination of the soil with these heavy metals.

3- Reciprocal ions:

The cation exchange capacity (CEC) is an important measure of soil quality as it affects soil structure stability and nutrient availability. The average annual values show that calcium is the main positive ion, followed by magnesium and potassium, which is in the normal position- place

4- Key nutrients (potassium, nitrogen, phosphorus):

Potassium (K), nitrogen (N) and phosphorus (P) are major nutrients for soil and crops. The average annual values show that nitrogen concentrations are lower than phosphorus concentrations in the top layer of soil of Qatar.

5- Abundance of total organic matter (OM):

Organic matter in the soil is essential for plants and is an indicator of nutrient availability in the soil. The average annual values ranged from 0.00 to 2.58%.

Soil type and soil classification according to the distribution of the size of the granules:

The average annual values show that the nature of the soil depending on the size of the granules were mainly sand ranging from (48.3 to 97.5%) followed by gravel and folding/clay for all surface soil samples.Soil quality is defined in relation to the functions that soils perform in natural and agricultural ecosystems. The quality of a soil is determined by a combination of physical, chemical, and biological properties such as texture, water-holding capacity and the content of organic matter.

1.2.5. Agriculture and Livestock

a- Cultivation and Food Crops

Zero Hunger is the Goal No. 2 of UN Sustainable Development Goals (SDGs) and 2030 UN Agenda. It aims to end hunger and all forms of malnutrition by 2030. It also commits to universal access to safe, nutritious and sufficient food at all times of the year. This will require sustainable food production systems and resilient agricultural practices, equal access to land, technology and markets and international cooperation on investments in infrastructure and technology to boost agricultural productivity. In addition, nitrogen indicator is one of the 9-environmental policies of Yale for global Environmental Performance Index (EPI).

Agriculture in Qatar is very limited due to the harsh climate,high temperature, limited freshwater resources and lack of arable fertile lands. Only about 65,000 ha of the land in Qatar is arable or suitable for use as pastureland (Table 1.1). The Government is developing this vital sector by offering technical assistance and material subsidies to the agricultural producers to provide a degree of self-sufficiency in food security for Qatar sustainability. Qataris a small state small yet a vital agricultural sector is made possible by modern greenhouses and modern irrigation systems. The arable land was only 8,312 ha in 1994 and became 30207.0 ha in 2018. The number of registered farms, for example, increased from 338 in 1975 to 891 in 1995 to be

1320 in 2018, as shown in Table 1.1. Only 942 farms were active in agricultural production in 2018. Most of the Qatari farms are located in the northern section, mainly due to the more advantageous hydrogeological conditions (i.e. relatively fresh groundwater and fertile lands) than those in the southern section of the country

Table 1.1. Agricultural land use during 2016 - 2018 Area : Hectare

	2013	2014	2015	2016	2017	2018
Total arable area	65000	65000	65000	65000	65000	65000
Number of the registered farmes	1340	1282	1290	1307	1306	1320
Total area of the registered farmes	47477.3	47116.4	47470	49877.7	49987.6	50346.0
Total arable area of the registered farmes	36122,5	35862.4	36631.3	29926.6	29992.3	30207.0
Numbre of active farms	839	872	910	902	916	942
Total arable area of active farms	28487.0	28269.8	2842	36426.2	36749.7	40690.0
Arable area of active farms	21673.5	21517.4	21978.8	21855.7	22049.8	24414.0
Cropped area for open field crops in the active farms	12473.0	11030.4	11570.1	10777.1	11339.5	12872.0
Total Cropped area in active farms	12608.5	11216.6	11804.6	11021.1	11589.2	13203.4
Crop intensity %	58.2	52.1	53.7	50.4	52.6	54.0

Source: Department of Agricultural Affairs, MME

Less than one-third of the current arable land is used to cultivate permanent crops, while the rest to cultivate seasonal or annual crops. Date palms were the most abundant permanent crop and it is one of the earliest crops to be cultivated in the peninsula. Agriculture production contains can be divided into four groups. The main production groups in Qatar are fodders, fruits, vegetables and cereals, respectively as shown in Table 1.2. Agricultural productions groups are as following:

- Vegetables include tomatoes, eggplant, squash, onion, cabbage and others.

- Cereals include wheat, barley, maize, and other cereals.

- Fruits include palm, citrus, almonds, fig, mulberry and other fruits.

- Fodders include alfalfa, Rhodes, and other species.

There is an increase in vegetables production and cropped area from 2013 to 2018. Nevertheless, the production and cropped area of cereals, fruits and green fodders decreased from 2013 to 2018. In addition, most of vegetables are cultivated in greenhouses. In some areas of the country, traditional open-field farming is used for vegetables such as onion, potato and carrot among others. Some farms also produce poultry, dairy products and honey.

Table 1.2. Total cropped area and production by group during 2013 - 2018

Crops		Vegetable group	Grain group	Fruit group	Green fodder group	Total
2019	Production	2832.2	153.3	2302.4	7620	12907.9
	Area	91470.3	1011	264007	619199	738081
2018	Production	74650.5	2309.3	29276.8	629878.1	736114.7
	Area	2778.7	266.7	2502.1	7655.9	13203.4
2017	Production	55578.8	1376.2	28974.7	534515	620444.7
	Area	2158.5	276.4	2571.3	6583	11589.2
2016	Production	53598.9	1377.2	29794.7	483210.5	567981.3
	Area	2140.5	293.5	2652.1	5935	11021.1
2015	Production	58077.2	1613.8	28339.8	541957.8	629988.6
	Area	2339	308	2491.7	6665.9	11804.6
2014	Production	51594	2455.6	28244.2	496136.3	578430.1
	المنطقة	2234.4	378.5	2495.4	6108.3	11216.6
2013	Production	43446.8	2259.6	32988.6	574206.7	652902
	Area	1972.3	394.9	3148.8	7092.6	12608.5

Includes the area and production of greenhouses
(Source: Department of Agricultural Affairs, MME)

Table 1.3 shows the total cropped area and total production in 2018 for both irrigation systems in Qatar, modern and traditional. Data indicate that modern irrigation systems are applied in more than 71% of total agricultural areas for all cultivated groups. Cereals are the only cropped group, which has modern irrigation less than traditional irrigation regarding the cropped area. This information is not pointed out in the table 1.3. Ac-

Table 1.3. Total cropped area and producyion by irrigation system and crop group for the agricultural season 2017 /2018

Area (Hecttar): Production (Ton)

Crops	Total Production (Ton))			Area(Hectare)ر		
	Total	Modern	Traditional	Total	Modern	Traditional
Vegetables group	40243.9	36257.6	3986.3	2312.2	2060.2	251.9
Cereals group	1011	627	384	143.3	72.5	80.9
Fruit group	26400.7	19393	7007.7	2302.4	1707.2	595.2
Green fod-ders group	619199	463168.7	156030.3	7620	5735.1	1884.9
Total	686854.7	519446.4	167408.3	12387.8	9574.9	2812.9

Includes the area and production from greenhouses (Source: Department of Agricultural Affairs, MME).

cording to 2018 data, more than 57% of the agricultural lands are used for green fodder cultivation. Areas used for fruits and vegetables are almost similar in size. Area used for cereals is limited to only 2.0 % of total cropped area in Qatar (Table 1.4, Figure 1.9). Recently, there is some interest in soil-less and hydroponics to overcome the limited arable lands.

Figure 1.8. Farm in Qatar (left, open area and right, greenhouse)

Table 1.4. Total cropped area and Production by group during 2013 - 2018. Area (A in Hectare): Production (P in Ton).						
Crops		Vegetables group	Cereals group	Fruit group	Green fodders group	Total
	A	2832	153	2302	7620	12908
	P	91470	1011	264007	619199	738081
Year 2018	A	74651	2309	29277	629878	736115
	P	2779	267	2502	7656	13203
Year 2017	A	55579	1376	28975	534515	620445
	P	2159	276	2571	6583	11589
Year 2016	A	53599	1377	29795	483211	567981
	P	2141	294	2652	5935	110.21.1
Year 2015	A	58077	1614	28340	541958	629989
	P	2339	308	2492	6666	11805
Year 2014	A	51594	2456	28244	496136	578430
	P	2234	379	2495	6108	11217
Year 2013	A	43447	2260	32989	574207	652902
	P	1972	395	3149	7093	12609

(Source: Department of Agricultural Affairs, MME)

In addition to the traditional agriculture, organic agriculture is growing in Qatar. (Agrico) Private company, has a cut through It challenged the environment, and started growing organic vegetables since 2012 all year long. Today Agrico is the largest vegetables producer in Qatar. In 2015 Qatar has five opertatingorganic farms.

Despite a noticeable increase in agricultural production in the course of the past 20 years, r, Qatar continues to rely on food imports, especially foodstuffs and live animals. despite all efforts to enhance agriculture production for Qatar food security, agricultural production currently plays only a minor role in the economy with less than 1% of Gross Domestic Product (GDP).

While essential to sustain human life, agriculture is one of the most environmentally harmful practices on the planet. It is a profound driver of deforestation, climate change, biodiversity loss, and freshwater degradation. The need to manage

resources sustainability is perhaps the most critical issue that crosscuts human life and the environment.

Currently, the main sourceof water supply for agriculture activities, is the deteriorated and depleted groundwater. The quality and quantity of ground water is degrading, due to its overuse. However, there is an increasing use of the highly ultrafiltration treated sewage effluent (TSE) for fodder cultivation. Areas useing modern irrigation methods is 71% of the total irrigation area in Qatar. In Qatar the strategy for agriculture and food securityis that there is a focus on the rational use of natural resources including water resources and another focus on enhancing the production efficiency of farms.

, International environmental indicators related to agricultural activities are the nitrogen indicator (as an indicator of chemical fertilizer use) and the indicator of pesticide use. Notably, a report of potential indicators to inform the post-2015 Sustainable Development Goals (SDG) agenda lists "crop per drop" as an indicator to be developed, suggesting FAO asthe potential leading agency for indicator development.

b- Agricultural Fertilizers and Pesticides

Use of agricultural fertilizers and pesticides per unit of area of land are among the significant influences of agriculture on environment. Environmental Performance Index (EPI) in 2014 used two indictors for agriculture, which are Agricultural Subsidies and Pesticide Regulation. Agricultural Subsidies is expressed in price of their product in the domestic market less its price at the border. Pesticide Regulation examines the adoption and legislative status of countries on one-landmark agreements on Persistent Organic Pollutants (POPs) usage, the Stockholm Convention, and scores the degree to which these countries have followed through on the objectives of the conventions by limiting or outlawing the use of certain toxic chemicals. In 2016 EPI, there is a change in indictors related to agriculture. The new EPI indicators related to agriculture are as following:

Nitrogen use efficiency (NUE) which measures the nitrogen inputs to outputs in crops.

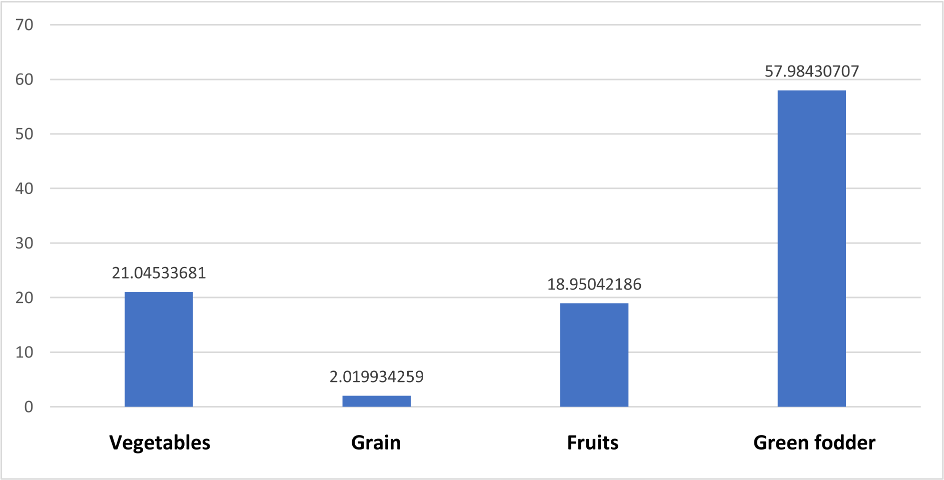


Figure 1.9. Percentage of cropped area by group during 2016 – 2018. (Source: Department of Agricultural Affairs, MME).

Nitrogen balance (NBALANCE) which measures excess nitrogen released to the environment because of fertilizer application (zero - 79 kg N/ha).

These two indicators help in measuring contribution of agricultural sector in affecting the ecological systems, through usage of different chemicals, in the shape of chemical fertilizers and pesticides, which contribute to contamination of soil type and groundwater. However, agricultural production currently plays only a minor role in the economy with less than 1% of Gross Domestic Product (GDP). EPI for 2014 did not consider the agriculture indicators for countries which agriculture is less than 5% of GDP. Agricultural chemical fertilizers and pesticides are given in Table 1.5 (MME). There is no clear trend in the chemical fertilizer in Qatar.

Table 1.5. The structure of imports for national agricultural production inputs 2016 - 2018 (Source: Department of Agricultural Affairs, MME).								
Commodities	2016		2017		2018		2019	
	quantity	Value	quantity	Value	quantity	Value	quantity	Value
Fertilizers	27090	19842	6498	17119	9066	18392	12344	31627
Pesticides and veterinary vaccines	2715	52431	405	13876	679	23417	2163	46059
Seeds	774	8299	541	8475	5141	21060	559	13729
Equipment and agricultural machinery	9668	171927	4067	74249	2981	55321	7753	206713
Total	40247	252499	11511	113719	17867	118190	22819	298128

Quantity: Ton. Value : Thousand Q.R
(Source: Department of Agricultural Affairs, MME).

There is an increaseing trend in imported chemical fertilizers for using in Qatar from 2016 to 2018. In addition, pesticides imported for using showed fluctuation during (2016-2018) as shown in the table 1.5 However, there is no accurate data of used chemical fertilizers and pesticides in Qatar due to the difficulties of records of actual use.

Here are further information that can be used as indicators of as internationally adapted for agriculture (2015):

Total water used for agriculture production: 294 Mm3/year (229 GW +65 TSE)

Crop yield: 629988.6 ton/year

Area of agricultural land: 11804.6 ha (total area of registered farms: 47470ha)

Imported fertilizers and pesticides for using: 4249 and 65 ton, respectively.

c- Livestock

According to 2018 data (MME), number of animals in Qatar in descending order are sheep, goats, cattle, camels, horses and others. Sheep ranks first among animals being bred in Qatar, it represents more than 60% of the total animlas.For livestockthe number in descending order is other animals like, poultry, broilers, layers and beehives. Table 1.6 shows the number of both animals and livestock in Qatar during the period of 2014-2018.

Table 1.6. Livestock numbers during the period 2014 - 2018.

Commodities	2014	2015	2016	2017	2018	2019
Cows	22277	17673	20138	24958	38198	43061
Camels	77417	84825	91182	105404	126378	131080
Sheep	545446	646408	784985	932471	994882	1009006
Goats	267202	320845	359885	382504	409911	441279
Horses	2006	8349	8697	7333	8325	9731
Poultry	8522231	9418905	8837004	10524315	10651577	654939
Other animals	19716	276	34008	26893	45402	28426

Source: Livestock Department. (MME).

There are other livestock farms called “Izbah” which is mainly for animals and livestock life. Usually Izbah is divided into two categories: complex that include group of Izbah and isolated/mobile Izbah. According to Census 2010, there are 2965 Izbah in the country. In 2014 and according to MME, number of Izbah increased to 3723 in 17 complexes plus 1433 scattered Izbah away from the complexes. This significant number of Izbah contains additional number of animals and livestock.

1.2.6. Public Parks and Green Spaces

Green spaces and parks are very important outlets for playing, sports, relaxation and social interaction. The public parks and green spaces are signs that the State of Qatar is paying considerable attention to the environment, to the general appearance and aesthetics and, above all, to the welfare of its residents. The administration responsible of managing parks and green spaces in Qatar is the Public Parks Department in the Ministry of Municipality and Environment.

1.2.6.1. Statistics of Public Parks and Green Spaces

Annual statistics of parks and green spaces in 2010 to 2015 show thatits total number in the country increased from 49 in 2010 to 86 in 2015 and increased to 116 in 2019 (Table 1.7). Table 1.8 and Appendix 1.1 provide names and photographs, respectively, of the green spaces and major parks in the country. However, the number did not increase between 2015 to 2019 because of the undergoing projects of different parks and gardent.

Table ١,٧. Number of gardens, parks and green spaces during the years 2010 to 2019 by municipalities.							
Municipality	2010	2011	2012	2013	2014	2015	Until 2019
Al-Doha	25	25	25	38	38	38	47
Al-Rayyan	11	14	14	22	22	22	20
Al-Khor and Al-Thakhira	2	3	3	5	6	6	20
Al-Daayen	2	2	2	5	5	5	8
Al-Wakrah	4	2	6	6	6	6	7
Um-Slal	1	4	2	4	4	4	6
Al-Shamal	3	1	2	4	5	5	5
Al-Shehania	-	3	-	-	-	-	3
Total	48	51	54	84	86	86	116

(Source: Public Parks Department, MME, 2016).

Public parks photos in Qatar by Municipality.

Al-Doha Parks

Al-Rayan Parks

Umm-Salal Parks

Al-Shamal Parks

Al-Khor Parks

Al-Wakra Parks

Al-Daayn Parks

Al- Shehania parks

(Source: Public Parks Department, MME, 2019)

1.2.6.2. Specifications for Public Parks Construction:

The Public Parks Department to Qatar Construction Specifications (QCS, 2014) which is the mandatory manual of construction projects in Qatar and prepared section 28 of the specifications, section 28 objectives are the organization and systematization of landscaping and greenery work in the stateThis section consists of two parts: the first part covers the landscaping work along with all technical data and practical details that meets the Qatari requirements and match with the international and regional standards as well, and the second one covers the irrigation system whereas all irrigation details including devices, requirements and calculations, this section is subjected to amendments and updating by the Public Parks Department every year to follow the latest updates in this field.

a- Irrigation Water Sources

Most public and family parks are irrigated with potable water. They are from the Qatar General Electricity and Water Corporation (KAHRAMAA) (except some large parks and some plaza are irrigated by TSE water). These parks have varying areas (large and small) and different types of plants. Gardens with large areas are Dahl Al Hamam, which requires irrigation water estimated at an area of 390 m3/day and is currently irrigated with both types of water (potable and TSE), and Al-Khour park ,and for example, those gardens with small areas like om Lkhbh, that require irrigation water estimated by 15 m3/ day.

All street farms, squares, and trees planted along the Corniche Road are irrigated by TSE. It is difficult to give an accurate figure for TSE consumption due to the constant pressure of difference in the distribution network, despite the presence of flow meters.

b- Irrigation Systems

Most of the streets (internal and external roads around the state) are currently irrigated by using modern computerized central Irrigation system (communication with the central system is done through radio) through which irrigation doses are controlled and managed, the system has devices and sensors for measuring flows, controlling quantities of the leaks that may occur, sensors to control pump pressure and measuring water level in the irrigation water reservoirs, sensors to stop irrigation during rains (the irrigation system is connected to the meteorological station) plus an alert system. All these devices and sensors are connected to a single control center in an office located in the Public Parks Department in the Ministry of Municipality and Environment, the system provides daily data along with alerts in case of defects, damages or system failure. However, there are still very few numbers of old streets' sides plantations that are irrigated using traditional methods (manually).

With the objective of water conservation, and in order to expand green spaces in Qatar, the Public Parks Department (MME) investigated through experiments (for the last two years) modernizing the irrigation system to supply each plant group with its exact daily water requirement without affecting its growth or the plants general condition. Experimentation Results have shown 50% reduction in the daily water need, which means the possibility to double the green areas with the same quantity of water and would very much enhance the status of landscaping and green covers in Qatar.

c- Irrigation Water Management

The Public Parks Department (MME) is using a number of irrigation devises that help in managing the irrigation water by helping to reduce the volume of irrigation water and minimizing its waste (by supplying the exact quantity of water to the exact area and spot). Irrigation devices used in Qatar are drip irrigation, sprinklers, bubbler, single drip, risers, root zone watering system and water distribution control adjusters as shown in Table 1.9 below.

In order to preserve the precious potable water, the Public Parks Department is planning to use treated sewerage effluent (TSE) to irrigate areas/plants which are not in direct contact with public; like trees, shrubs, ground covers and seasonal flowers while the grass areas will continue to be irrigated with potable water. The plan will be applied as soon as the upgrading of TSE network and outlets for parks is finishedaccomplished.

As per the agreement between the Public Parks Department and the Public Work Authority in Qatar, the first connection to the upgraded TSE network is planned to be in 2018, moreover and as advance preparation the two authorities are working jointly to develop smart irrigation techniques that enable irrigating each plants category separately with different type of water

Irrigation Devices

Distribution tubes (single and multi)

Root zone watering system

Sprinklers

Micro-Sprinklers

Risers

Bubblers

Irrigation Devices

Distribution control adjuster

Riser and Adjuster

d- Fertilizers:

The Public Park Department is using different types of fertilizers in order to better manage plantation, and in order to meet the sustainability specs set by Qatar specifications agencies. Fertilizers applications vary according to the fertilizer formulation type and contents, while soil analysis is very important to determine the actual and exact quantity of fertilizers needed for different plants, and to avoid any unrequired additives to the soil. Fertilizers used by the Public Park Department are classified as organic and chemical fertilizers, and categorized as follows: Organic manure: regular animal fermented and heat-treated manure.

Organic fertilizers: fermented and treated plants residues, Qatar established the organic fertilizer factory in Messaied area to produce organic fertilizer from both plants and garbage residues.

Organic thermal treated sludge: a benign product of treated sewerage effluent, which is then thermally treated.

Chemical fertilizers: these are the urea and NPK, the urea manufactured in Qatar $(NH_2)_2CO$ is considered one of the best in the world.

1.2.6.3. Type of Trees in Public Parks

Part of the Public Parks Department's role is to import and plants that can tolerate the Qatari climate and that can be an addition to the Qatari flora. For the selection of the suitable plants the Public Parks Department specify the plants and review their biology in literatures or in climate zones, which are similar to Qatar, or by getting benefits from successful experiments in regional countries.

When plants are specified, the Department would check the plants sources in order to procure samples for experiments and to conduct intensive investigation for the plant›s suitability in terms of biological activities, adaptation ability, and tolerance for the Qatari climate, salinity and pests that might outbreak in Qatar. Plants under experiments would remain under monitoring for at least two years before giving the final recommendation on their suitability for the Qatari environment.

During the past years, the Public Parks Department managed to successfully import plant and adapt more than fifty species from different plants' categories. Appendix 1.2 presents a list of names of plants used by the Public Parks Department.

a- Plants used by the Public Parks Department:

The Public Gardens Department classified the plants they use into 13 groups, these are:

- Palms and Cycads (20 taxa);
- Large Evergreen Trees (30 taxa);
- Deciduous Trees (17 taxa);
- Medium Evergreen Trees (13 taxa);
- Small Trees or Large Shrubs (39 taxa);
- Shrubs (19 taxa);
- Conifers (01 taxa);

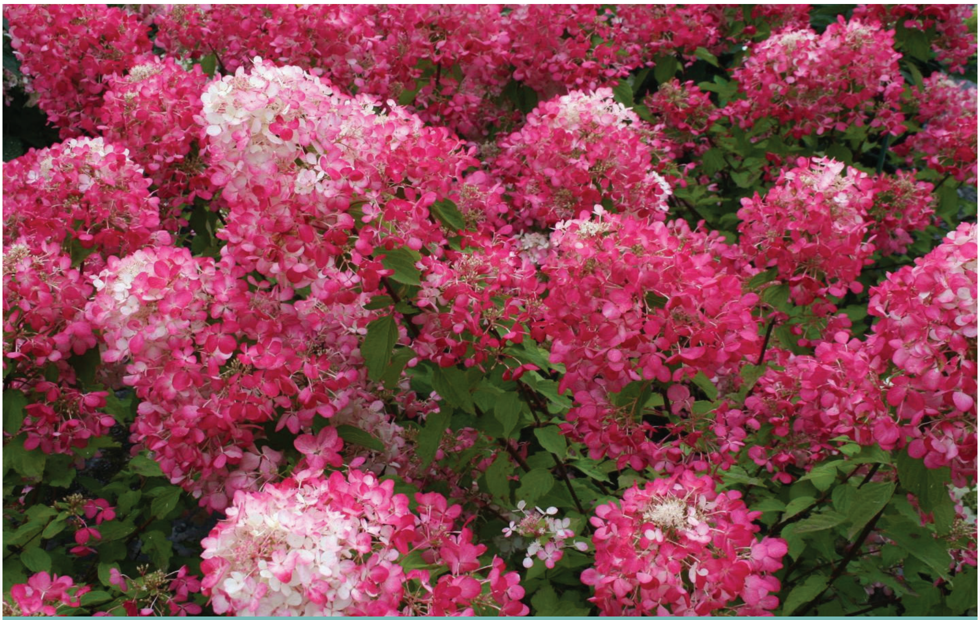
- Hedge (09 taxa);
- Succulents and Cactus (81 taxa);
- Vines (08 taxa);
- Ground Covers (35 taxa);
- Seasonals (32 taxa);
- Grass (03 taxa).

The Public Parks Department has published in 2015/2016 the book of “Qatar’s trees” which lists and documents different kinds of trees in Qatar, in which trees in Qatar are classified into five groups, these are; palm trees, ornamental trees, ornamental shrubs, fruit trees, and wildlife plants, Table 1.11 presents photos for plants by the classification presented in the book of “Qatar’s Trees”.

Plants and photos used by the Public Parks Department by the classification presented in the book of - Qatar's Trees

Palm Trees

Ornamental Trees



Ornamental Shrubs

Fruitful Trees

b- Plants that Public Parks Department are working to increase their use in ornamental plantation (Tables 1.12 and 1.13).

Palms:Table 1.12. Plants used by the Public Parks Department.

Table 1.12. Plants used by the Public Parks Department.

Species identified for increasing ornamental plantation			
Washingtonia Robusta	Phoenix Dactylifera	Copernicia Alba	Bismarkia Nobilis
Zamia Furfuracea	Phoenix Roebelenii	Cycas Revoluta	Chamaerops Humilis
	Phoenix Sylvestris	Livistonia Chinensis	Cocos Nucifera
	Washingtonia Filifera	Phoenix Canariensis	Cocos Plumosa

(Source: The book of “Qatar’s Trees” 2016)

Table 1.13. Trees and shrubs to be increased for ornamental plantation.

Trees and shrubs to be increased for ornamental plantation			
Peltophorum Inerme	Zizyphus Chinensis	Kigelia Pinnata	Brachychiton Populneus
Paulownia Tomentosa	Albizia Julibrissin	Moringa Oleifera	Casuarina Equisetifolia
Thespesia Populnea	Bauhinia Variegata	Parkinsonia Aculeata	Ficus Alii
Farnesiana Acacia	Delonix Elata	Prosopis Alba	Ficus Alii
Schinus Terebintifolius	Millingtonia Hortensis	Schinus Molle	Ficus Infectoria
Tabebuia Argentea	Melia Azedarach	Tamarindus Indica	Harpullia Pendula
Tabebuia Rosea	Zizyphus Chinensis	Taxodium Distichum	Khaya Senegalensis
Atriplex Halimus	Speciosa Lagerstroemia	Calotropis Procera	Aillanthus Altissima
Atriplex Lentiformis	Musa Paradisiaca	Carica Papaya	Alstonia Scholaris
Myrtus Communis	Polyalthia Longifolia	Cassia Javanica	Bucidia Buceras
	Sesbania Sesban	Cassia Nodosa	Bambusa Ventricosa
	Bougainvillea Torch Glow	Lagerstroemia Indica	Caesalpinia Gilliesii
	Bougainvillea Spectabilis	Lagerstroemia Loudonii	Calliandra Haematocephala

(Source: The book of “Qatar’s Trees” 2016)

c) The Public Parks Department is planting eco friendly trees such as Acacia nilotica and Ziziphus spina-christi and Prosopis cineraria around cities and at the entrances to villages. Until 2019, 41368 trees were planted by the Public Parks Department.

1.2.6.4. General Indicators of Public Parks and Green Spaces in the State

a) Area and number of public parks and green spaces

Number and area of gardens, parks and green spaces during the years 2010 to 2019 in the different municipalities, is an important indicator of the state vision for the distribution of gardens, parks and green spaces according to different aspects including environmental, social, demographic aspects and others.Table 1.14 (a-b) below presents the numbers and areas of public parks and green spaces during 2010 to 2019 by municipalities (Public Parks Department, MME, 2016).

The percentage of the increase in the numbers and areas of public parks in 2019 are nearly 136.73% and 59.35% of the number and area in the year 2010 respectively. Although the municipalities that have more increase in the number of parks are Al-Doha, Al-Khor and Al-Thakhira and Al-Rayyan,yet Um-Slal municipality has more increase in the percentage of added areas followed by Al-Daayen municipality.

Table 1.14a. Number and area (m^2) of the parks in Qatar by municipality (2010 – 2019).

Municipality	Parks (2010)		Parks (2015/2016)		Parks Until 2019		Added Parks 2010-2019		age of% increase (2010-2019)	
	m^2	No.	m^2	No.	m^2	No.	m^2	No.	m^2	No.
Al-Doha	646,612	25	715,489	38	952155	47	305543	22	47.25	88
Al-Rayyan	201,613	11	271,970	22	241125	20	39512	9	19.59	81.8
Al-Khor and Al-Thakhira	241,788	2	261,483	6	433824	20	192,036	15	79.42	1000
Al-Daayen	10,850	2	38,670	5	88997	8	78147	6	720	300
Al-Wakrah	59,150	5	64,303	6	64982	7	5832	5	9.85	40
Um-Slal	5,836	1	29,524	5	56652	6	50816	5	870	500
Al-Shamal	85,000	3	100,898	5	102385	5	17385	2	20	66.66
Al-Shehania	-	-	-	-	53131	3	53131	3	-	-
Total	1,250,849	49	1,482,337	87	1993251	116	742402	67	59.35	136.73

(Source: Public Parks Department, MME, 2016)

b) The per capita share in public parks and green spaces:

In the past few years, the Public Parks Department has rehabilitated and modernized several parks and green spaces. In addition, the Department has established new parks and green areas in various municipalities with the aim of increasing the total green areas in the country, as mentioned above.

Table 1.14b. Number and area of parks and green spaces (Streets and roundabouts) (m2) in Qatar by municipality (2010 – 2019)			
Municipal green spaces until 2019			
Municipality	Streets and roundabouts (m^2)	Parks (m^2)	Total green areas (m^2)
Al-Doha	1037230	952155	1989385
Al-Rayyan	1259830	241125	1500955
Al-Khor and Al-Thakhira	106759	433824	540583
Al-Daayen	34320	88997	123317
Al-Wakrah	41915	64982	106897
Um-Slal	45005	56652	101657
Al-Shamal	44135	102385	146520
Al-Shehania	-	53131	53131
Total	2569194	1993251	4562445

(Source: Public Parks Department, MME, 2016)

By increasing the number and area of parks and green areas from 2010 to 2019, the per capita total of the Green Zone increased from 0.74 m2/no to 1.90 m2 /no, as shown in (Table 1.15) below. We note that only the municipality of Al Wakra has reduced per capita from 0.41m2/no to 0.36m2/no due to the increase in the population.

Table 1.15. Population and area of parks per municipality, and the per capita share.						
Population and area of parks per municipality, and the per capita share						
Municipality	Areas (2010)	Population (2010)	Per capita share (2010)	Areas (2019)	Population (2015)	Per capita share (2019)
	m^2	No.	m^2/No.	m^2	No.	m^2/No.
Al-Doha	646,612	796,947	0.81	1989385	956,457	2.08
Al-Rayyan and Al-Shehania	201,613	455,623	0.44	1554086	793,283	1.95
Al-Wakrah	59,150	141,222	0.41	106897	299,037	0.36
Al-Khor and Al-Thakhira	241,788	193,983	1.24	540583	202,031	2.68
Al-Daayen	10,850	43,176	0.25	123317	54,339	2.3
Al-Shamal	85,000	7,975	10.65	146520	8,794	16.66
Um-Slal	5,836	60,509	0.096	101657	90,835	1.12
Total	1,250,849	1,699,435	0.74	4562445	2,404,776	1.90

Note: In Table 1.15 to calculate the per capita share of the green area, we adopt the last census for the year 2015 and therefore will be the municipalities of Rayyan and Shehania together in the calculation 2015. (Source: Public Parks Department, MME, 2016).

c) Other public green spaces in the country:

Different green areas are found distributed around Qatar (Table 1.16). The majority of these lands are found as Parks, while other lands are for example found in sports clubs and Souqs (open shopping area).

Table 1.16. Other public green spaces in the country								
N	Al-Doha m²		Al-Rayyan m²		Al-Wakrah m²		Um-Slal m²	
1	KAHRAMAA	21500	Al Rayyan Golf Club	3000000	Mesaieed Park	87557	Nursery Committee of Inheri-tance	880000
2	Doha Golf Club	1500000	Oxygen park	130000	East Traffic Park	27404	doha north sewage treatment	7520000
3	Lusail Park	275000	Aspire Park	880000	Altaeafi park	204915	-	-
4	Al Bidda Park	1700000	-	-	-	-	-	-
5	New Sheraton Park	76000	-	-	-	-	-	-
6	Islamic Muse-um Park	280000	-	-	-	-	-	-
7	Souq Waqif Park	39000	-	-	-	-	-	-
8	Katara	394200	-	-	-	-	-	-
9	Qatifiya area	175567	-	-	-	-	-	-
		4461267		4010000		319876		8400000
Total		**17191143 m²**						

If we add other green areas in the country to the green spaces, the per capita share of green areas increases from 1.90 m2 /no to 9.05 m2/no (Table 1.17) and this is a result of the great interest of all public and private bodies to preserve the environment of the country.

Table 1.17. Green area and parks.

N	Green area and parks (m2) (2019)		Population (2015)	Per capita share (2019)
	Green area and parks in municipality	Other public green area		
	4562445	17191143	2,404,776	9.05
Total	21753588			

1.2.6.5. Strategic Projects for Green Environment:

Ongoing Projects, the Urban Forest Projects:

The Urban Forest Projects are three joint projects between the Public Parks Department and the Public Work Authority in Qatar (one project is ongoing (Doha North), and two are ready for implementation in the near future (Umm-Birkah - 9,556,120 m2 and Al-Karaana – 3,132,588 m2). The projects were designed to be adjacent to urban areas, and near sewage treatment stations in order to use produced effluent water and sludge in the forests. This helps as a mechanism to claim the valuable resources of water and nutrients present in the sewage effluent, as well as to prevent the disposal of the treated effluent to the environment without control.

These urban forest projects won’t only improve the Qatari environmental conditions, mitigate the harsh climate or manage the problem of pollution, but, it will also strengthen the eco-system and solve other environmental issues including accommodating the huge quantities of produced thermal treated sludge and treated sewage effluent (TSE) water. Therefore, these projects are satisfying the needs of both society and government as well.

Moreover, this new habitat would offer shelters for animals and birds in Qatar. It can help stabilize the soil, and reduce any possible negative accumulative effect that might happen due to the use of chemicals and commercial pesticides or fertilizers. In general, urban forests can be a key method to control and manage negative impacts of greenhouse gasses emission in Qatar and can help build beautiful tourist areas in the suburbs, especially for those who are like watching and observing animals and birds.

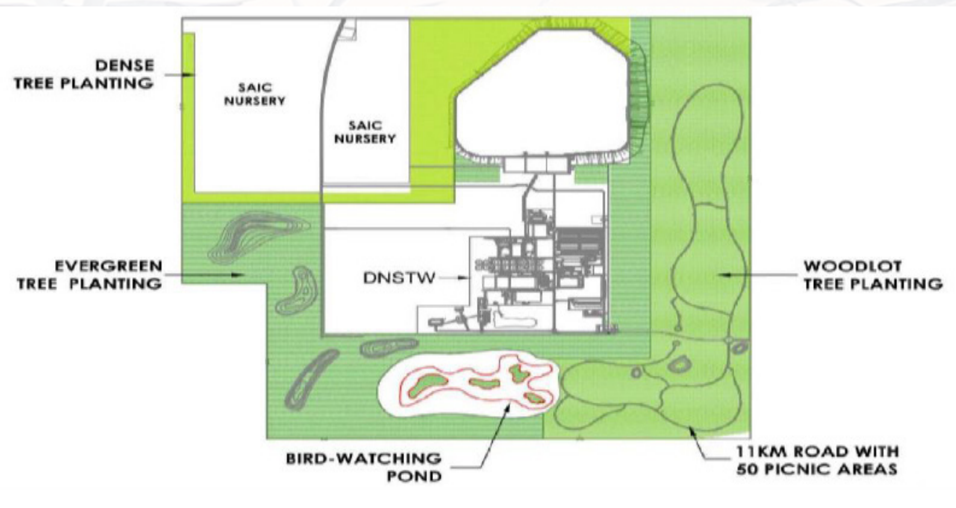


Figure 1.10. Design of Doha North urban forest. (Source: Public Parks Department, MME, 2016).

Figure 1.11. Photos of Doha North Urban Forest.
(Source: Public Parks Department, MME, 2016)

Proposed Strategic Projects:

There are several other projects proposed by the Public Parks Department that are ready for designing and future implementation. Below is a list of a few major proposed strategic projects:

- The traffic garden project.

- The project for constructing forests in Umm-Salal, Al-Mazruaa and Al Sailiya areas .

- The project of plantation establishment in Salwa Road for the production of environmental trees.

1.2.6.6. Challenges and Responses:

There are some challenges that face the department, regarding parks establishment and management, and regarding ornamental plants. The concerned administrative department manages to overcome these challenges by good governance and proper planning as explained below:

- The early coordination with government agencies to obtain permits before starting the implementation of the project's work.

- The early planning for obtaining the financial budget for the projects.

- Hiring highly skilled and experienced contractors who have good reputation to abide by the time schedule of the projects' implementation.

- The good planning and coordination with responsible authorities to allocate required irrigation water in terms of quantity and quality.

- The good planning and coordination with responsible authorities to allocate required lands for establishing parks in some areas.

- The appropriate selection of plants or conducting of necessary tests for their adaptability with the surrounding environment.

- Raising the awareness of residents of how to maintain landscapes and plants of different kinds.

- Conducting required investigations for parks' land and soil and taking necessary decisions like drilling and replacing them with agricultural soils that suit plants.

- Shortage of skilled and experienced labor sometimes.

- Fighting the spread of alien weeds in landscapes and the occurrence of some insect and/or fungal infections in some plants by applying the safest curative and preventive chemical pesticides.

1.3. Biodiversity:

What is Biodiversity or Biological Diversity ?Biological Diversity “refered to in this document as Biodiversity” indicates the variety of life on earth. As defined by the United Nations Convention on Biological Diversity (CBD), it includes diversity of ecosystems, species and genes, and the ecological processes that support them. Qatar’s ecosystem diversity results from the Country’s dramatic topographic and altitudinal diversity, combined with its location. The Qatar National Vision 2030 recognizes the need to preserve and protect biodiversity as part of balancing development with environmental protection. The approach used to classify the biota in the State of Qatar is that of the International Union for the Conservation of Nature (IUCN) (IUCN, 2016). The governmental administrations that are responsible of managing biodiversity in the State of Qatar are the Protection and Wildlife Department and the Natural Protected Areas Department, which are affiliated with the Ministry of Municipality and Environment according to the Emiri Decision (No.11/2019) for Organizational Structure & Departmental Mandates. Table 1.18 Species occurring in Qatar State with Extinction Risk Assessments published on The IUCN Red List (Version 2016-2) Red List categories: EX = Extinct; EW = Extinct in Wild; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient

Taxonomic Group	Total assessed species	Total known threatened species (CR, EN & VU)	EX & EW	CR	EN	VU	NT	LR/ Cd*	LC	DD
Vertebrates										
Amphibians	0	0	0	0	0	0	0	0	0	0
Reptiles	16	03	0	01	0	02	0	0	13	0
Mammals	19	04	0	0	01	3	0	0	12	03
Birds	233	09	0	01	01	07	10	0	214	0
Subtotal	268	16	0	02	02	12	10	0	239	03
Invertebrates										
Arachnids	0	0	0	0	0	0	0	0	0	0
Others	01	0	0	0	0	0	0	0	01	0
Crustaceans	02	0	0	0	0	0	0	0	02	0
Insects	15	0	0	0	0	0	0	0	14	01
Subtotal	18	0	0	0	0	0	0	0	17	01
Plants										
Ferns & Allies	0	0	0	0	0	0	0	0	0	0
Flowering Plants	21	0	0	0	0	0	0	0	21	0
Green Algae	0	0	0	0	0	0	0	0	0	0
Gymnosperms	01	0	0	0	0	0	0	0	01	0
Mosses	0	0	0	0	0	0	0	0	0	0
Subtotals	22	0	0	0	0	0	0	0	22	0
Fungi & Protista										
Lichens	0	0	0	0	0	0	0	0	0	0
Mushrooms	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0
TOTAL	308	16	0	02	02	12	10	0	278	04

1.3.1.1. Terrestrial Mammals:

Terrestrial mammals of Qatar were estimated to be 21 species. In addition, Arabian Oryx (Oryx leucoryx) and Arabian Gazelle – Gazella subgutturosa were both bred in captivity and are included in the group of mammals. In desert, Sand cats (Felis margarita) dwell and sometimes take over abandoned fox dens. Honey badgers – Mellivora capensis (also known as ratel) has been reported in the southwest of the peninsula. Golden jackals (Canis aureus) species was previously thought to be extinct in 1950s; but was discovered again in 2008 at Ras Albrouq. Bats were also recorded with a total of 2 species: Trident bat (Asellia tridens) and desert long-eared bat (Otonycteris hemprichii) which is more common in desert.

1.3.1.2. Avifauna:

Studies and field surveys on avifauna in Qatar, conducted by the Environment Centre (2010 – 2012), presented findings of 323 birds' species in Qatar which constitute an increase of 33% from the number registered in the fourth national report on the implementation of the Convention on Biological Diversity. The 323 species are grouped into five main groups plus others (resident breeders, migrants, vagrant, visitors' winter/summer, introduced and other birds in various statuses) as presented in Table 1.19

Table 1.19 Percentage of Qatari avifauna Populations' Dynamics per category		
Category/ies	Percentage (%)	Source
Passage Migrant + Rare Passage Migrants	80	(Basheer, 2015)
Passage Migrant + Winter Visitors	20	
Others (various status)	20	
Vagrants	19	
Resident Breeders	07	
Common (Throughout Seasons)	06	
Introduced or Escaped and Breeding Locally).	04	

1.3.1.3. Terrestrial Reptiles:

The occurrence of 21 lizard species in Qatar, from the 15-species indicated in the last biodiversity report conducted in 2004, has been updated during two field surveys in 2012 and 2013 (Castilla et al., 2014). The most abundant family found in Qatar is Gekkonidae with nine species (bunopus tuberculatus, cyrtopodion scabrum, hemidactylus robustus, hemidactylus flaviviridis, hemidactylus persicus, stenodactylus arabicus, stenodactylus slevini, stenodactylus doriae, pseudoceramodactylus khobarensis), followed by lacertidae with four species (acanthodactylus schmidti, acanthodactylus opheodurus, mesalina brevirostris, mesalina. adramitana), agamidae with three species trapelus flavimaculatus, uromastyx aegyptia, phrynocephalus arabicus), scincidae with two species (scincus mitranus, trachylepis septemtaeniata), varanidae (varanus griseus), sphaerodactylidae (pristurus rupestris) and trogonophidae (diplometopon zarudnyi) with one species each (Table 1.20). The species richness fluctuated largely across Qatar Environment between one and eleven species per grid square. The lizard fauna records in Qatar are still incomplete and additional studies are required.

Table 1.20. The Conservation Status of Lizard's Species Documented in Qatar State (20122013/)		
Family Name	Scientific Name/Names	IUCN Conservation Status
Gekkonidae	Cyrtopodion scabrum, Bunopus tuberculatus, Pseudoceramodactylus khobarensis, Hemidactylus persicus, Hemidactylus flavivridis, Hemidactylus robustus and Stenodactylus doriae.	Least concern
Lacertidae	Acanthodactylus schmidti, Acanthodactylus opheodurus and Mesalina brevirostris.	Least concern
Agamidae	Uromastyx aegyptica, Pharynocephalus arabicus and Trapelus falvimaculatus	Least concern
Scincidae	Trachylepis septemtaeniata and Scinus mitranus.	Least concern
Sphaerodactylidae	Pristurus rupestris	Least concern
Trogonophiidae	Diplometopon zarudnyi.	Least concern
Varanidae	Varanus griesus .	Least concern
Gekkonidae	Stenodactylus arabicus and Stenodactylus slini	Least concern
Lacertidae	Mesalina adramitana	Least concern

1.3.1.4. Terrestrial Invertebrates Fauna:

Five species of terrestrial snails, each belonging to a different genus, have been recorded in the country. The species belong to four families: subulinidae, with two genera, zootecus and allopeas; Polygyridae, with one genus; Hygromiidae, with one genus, Monacha; and Helicidae, with one genus, eobania. The most widespread is zootecus insularis (Al-Khayat, 2010). At least 170 species of insects belonging to 15 different orders exist in Qatar. These include thysanura, ephemeroptera, odonata, orthoptera, dermaptera, embioptera, isoptera, dictyoptera, anoplura, hemiptera, neuroptera, lepidoptera, diptera, coleoptera and hymenoptera (Abdu and Shaumar, 1985).

An investigative study, concerned with insect's Biodiversity (2013/2016), has been performed between the Ministry of Municipality and Environment in collaboration with the National French Institute of Agricultural Research. The study reported the presence of 10 species belonging to 6 families of the order Coleoptera; 5 species belong to 3 families of the order Diptera and 1 species for order hemiptera and lepidoptera, consecutively (Table 1.21).

Table 1.21 Biodiversity status of species reported.

Order	Family	Number of Species
	Tenebrionidae	5
Coleoptera	Staphylinidae	1
	Histeridae	1
	Elateridae	1
	Curculionidae	1
	Bubrestigae	1
Diptera	Agromyzidae	2
	Canacidae	2
	Scenopinidae	1
Hemiptera	Psyllidae	1
Lepidoptera	Pyralidae	1

1.3.1.5. Terrestrial Flora of Qatar:

Because of the dry warm climate in Qatar, the natural vegetation cover is reduced and mostly consists of small shrubs. But plant density increases in Rawdas where groups of some trees and shrubs grow separated by weed ephemeral soon after the rainy season (Abdel Bari, 2017). The flora of Qatar includes nearly 400 species and the flora native species (about 270 species) are well adapted to the desert environment (Norton et al., 2009). Over the years, several trees and shrubs have been introduced to Qatar, few of them have managed to adapt to the Qatari environment and have been planted in many roadside routes in Qatar. These include ziziphus sp., acacia nilotica subsp. indica, parkinsonia aculeate, acacia aphylla, melaleuca glauca, prosopis juliflora, pithecellobium dulce, and moringa oleifera. However, the spread of these trees and shrubs remained in urban areas most likely because of water seepage that helped to satisfy their needs and maintain them. However, two plant species (ziziphus and prosopis juliflora) invade places outside towns, especially prosopis juliflora which is now found in all habitats even in more remote desert localities and conceded as one of the most famous invasive species in Qatar. In contrast, the native ghaf (Ar.) plant prosopis cineraria became rare and, on the decline, (Norton et al., 2009; Abdel Bari, 2017).

Plants and Organisms in Qatar:

Wild organisms in Qatar were classified into (6) groups; these are fungi, mammals, amphibians, reptiles, birds, and invertebrates, excluding plants. The total number of wildlife species is 1152, out of which 730 organisms (grouped in six groups). While the total number of the kinds of wildlife plants is 422 species.

There is another classification for both wildlife plants and organisms, in terms of their exposure to the risk of extinction, to seven groups; These are least concern, near threatened, vulnerable, endangered, critically endangered, extinct in the wild and extinct. Table 1.23 below presents the plants and organism's species by their groups

.1.3.2 Analysis Driver Forces and Pressures Affecting Sustainable Management of Biodiversity:

- Unsustainable Management of Biodiversity Resources (Main Threat).
- Absence of Systematic Inventory and Documentation of Biodiversity Resources (Main Threat).
- Change or Loss of Natural Habitat including Urbanization, overgrazing, Agricultural Extension and Climate Change (Underlying causes).
- Invasive and Alien Species (Pet Animal Trade, Horticulture,etc) (main Threat).
- Pollution (Industrial, Argo-industrial and Domestic Waste) (Underlying causes).
- Overharvesting of Plants, Birds and Animals (Unsustainable) (Root causes).

1.3.2.1 Protected Areas:

Protected areas or national reserves are considered to be the most important and active measures that give indication of the attention governments pay to protect the environment and biodiversity of their countries. They preserve, protect and develop biodiversity if managed through scientific mechanisms, strategies, programs and activities. Good management of protected areas will lead to the preservation, protection and development of biodiversity existing and living in them. The State of Qatar turned great attention to wildlife, preserving and developing it to protect it from extinction. In 2004, Qatar issued an Emiri Decree approving Wildlife and Habitat Protection law

number (19). The State has established many nature reserves and conservation areas to protect and maintain ecological systems. The Environmental Protection and Natural Life Department in the Ministry of Municipality and Environment is in charge of preserving these nature reserves, maintaining their environmental components and proposing conservational policies, programs and activities. The number of protected areas in Qatar by the year 2018 is 11, with total areas equal to 2742.41 square kilometers (Km2) and that represents

23.59% of the total area of the State of Qatar (this percentage is among the highest around the world), these protected areas are Al-Uraiq, Al-Thakhira, Khor Al-Odaid, Al-Rafa, Um-Alamad, Um-Qarn, Sunai, Al-Reem, Shaahaneia, Al-Maszhabiya, and Lusail, (Planning and Statistics Authority, 2018).

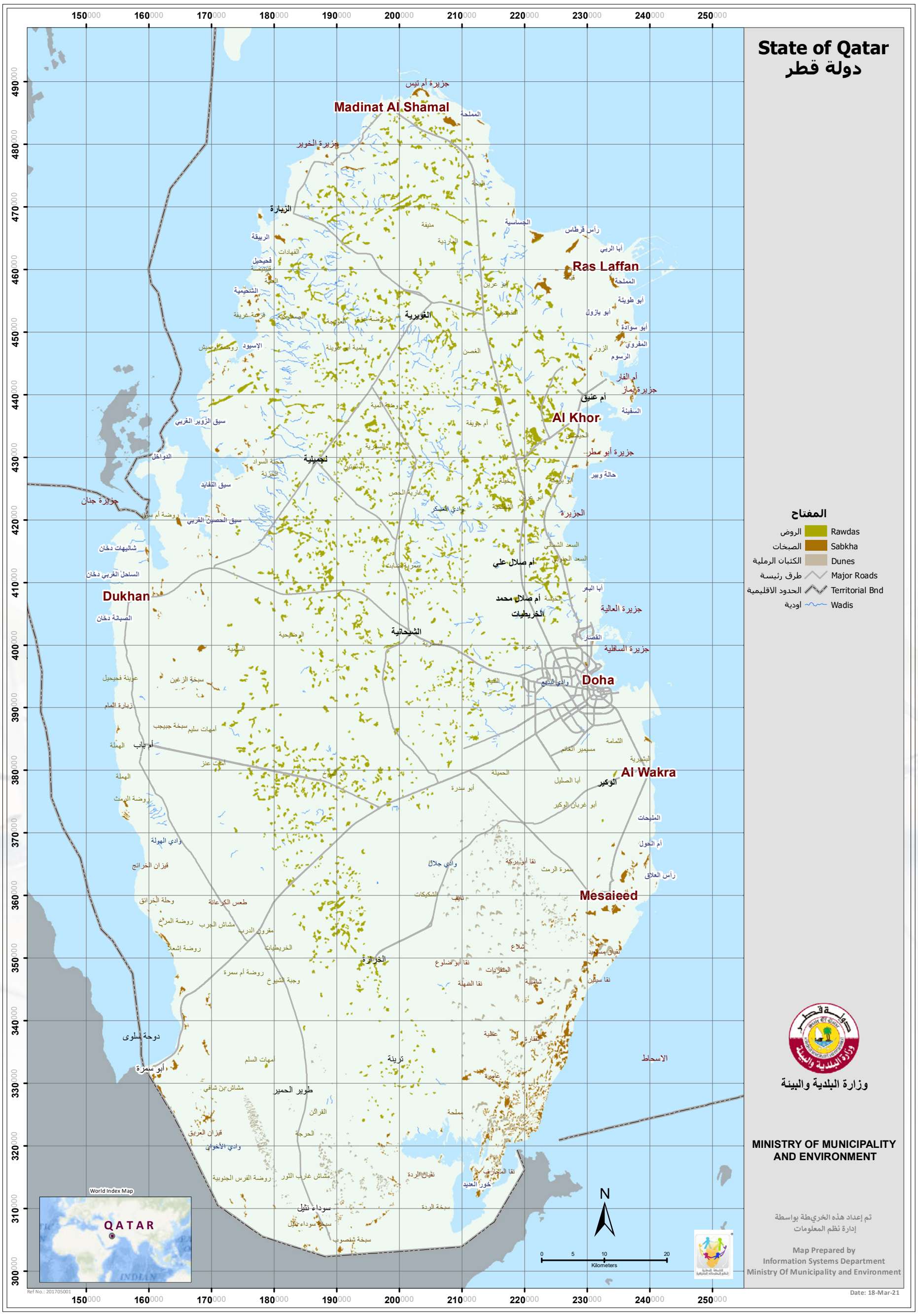


Figure 1.12a. Locations and approximate area of some Features in Qatar (Sand dunes, Rawda, Sabkha and Mangroves). (Source: Information Systems Department (MME 2016)).

Table 1.22a. Approximate area and percentage from the total land area for some Features in Qatar (Sand dunes, Rawda, Sabkha and Mangroves).		
Feature	Area (km^2)	Percentage from the total land area
Qatar's land total area	11,627.8	100
Sand dunes	59.29	0.51
Rawda	279.36	2.42
Sabkha	107.03	0.93
Mangroves	9.11	0.08

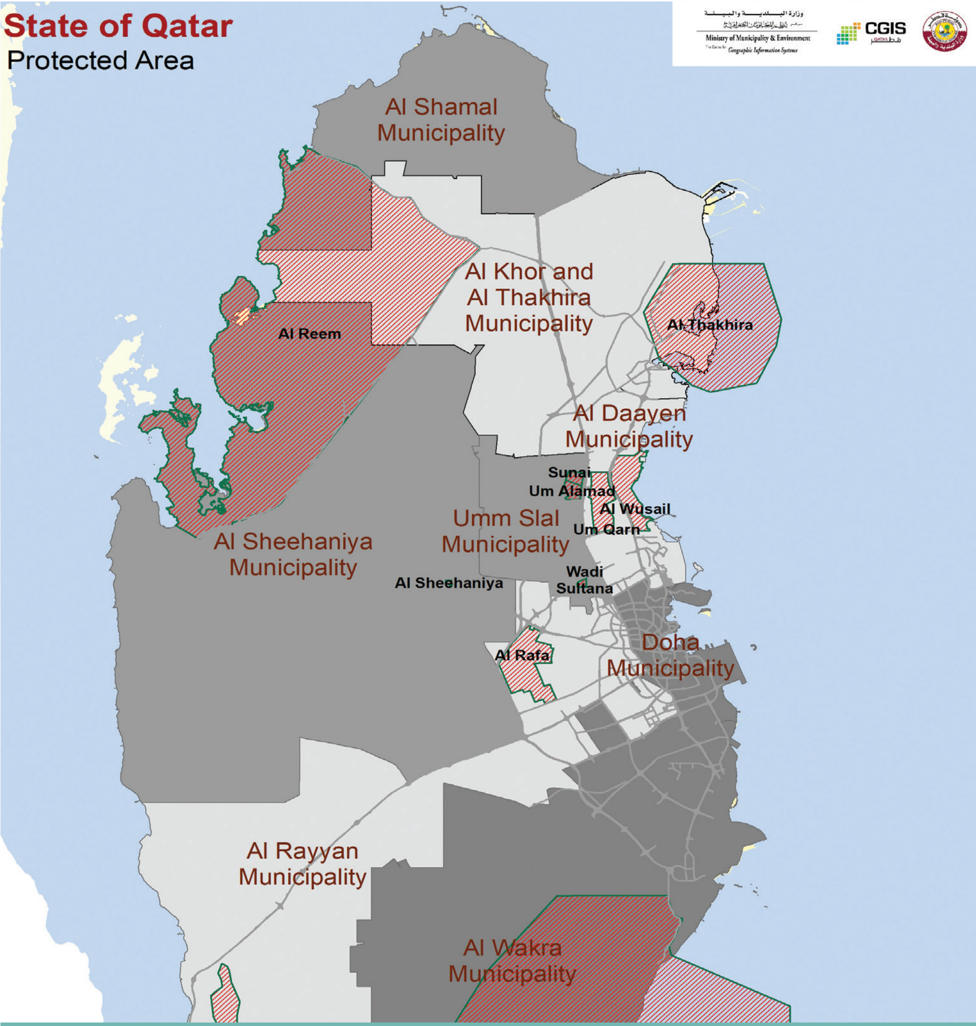


Figure 1.12b. Location of protected areas in Qatar. Source: Planning and Statistics Authority

Table 1.22b. Locations and percentage areas of the natural protected zones in the State of Qatar in the year 2018.		
Natural Terrestrial Protected Areas	Area (km2)	% from the total area of the State
Al-Uraiq	54.76	0.47%
Al-Thakhira	114.46	0.98%
Khor Al-Odaid	1,291.13	11.11%
Al-Rafa	53.33	0.46%
Um-Alamad	5.72	0.05%
Um-Qarn	24.71	0.21%
Sunai	3.92	0.03%
Al-Reem	1,154.10	9.93%
Shaahaneia	0.79	0.01%
Al-Maszhabiya	4.76	0.04%
Lusail	34.73	0.30%
Total Area of Protected Areas	2742.41	23.59%

Source: Planning and Statistics Authority

1.3.2.2. Wild Environment Tourism:

There are two seasons (winter and spring) in the year when Qataris camp in tents to enjoy the beauty of nature and the weather. Moreover, there are officially organized desert safaris for public. During camping, people of all ages search for the much loved nature's gifts, these are Faqaa (the desert truffles), Atar/Yarawa fruits (Glossonema varians) and the edible leaves of Huwa (Launaea capitata) and Malbo (Convolvulus prostratus)

Camping in North Qatar.

Desert Truffes

1.3.3 Protection and Conservation of Fauna and Flora:

Qatar signed the Convention on Biological Diversity (CBD), ratified in 1996 (90) and has taken noteworthy steps to promote fauna and flora conservation. MME developed in 2004 in partnership with International Union of Nature Conservation (IUCN), a National Biodiversity Strategy and Action Plan (NBSAP) and prepared a draft addendum to the strategy and action plan of 2005.

Regarding hunting, the Government imposed (but did not enforce) a total ban on hunting since 2002. Not only was enforcement ludicrous, but the government did very little to limit or restrict the import, the production and sale of hunting gear and ammunition, as well as game calls and other forms of luring devices.

1.3.4 General Indicators for Biodiversity Data:

1.3.4.1. Increase in National Reserves:

By the year of 2014 the total extent of land protected areas has reached 2744.41, which increased to 2742.41 in 2018. The Decrease was because of the removal of the Wadi Sultana protected area.

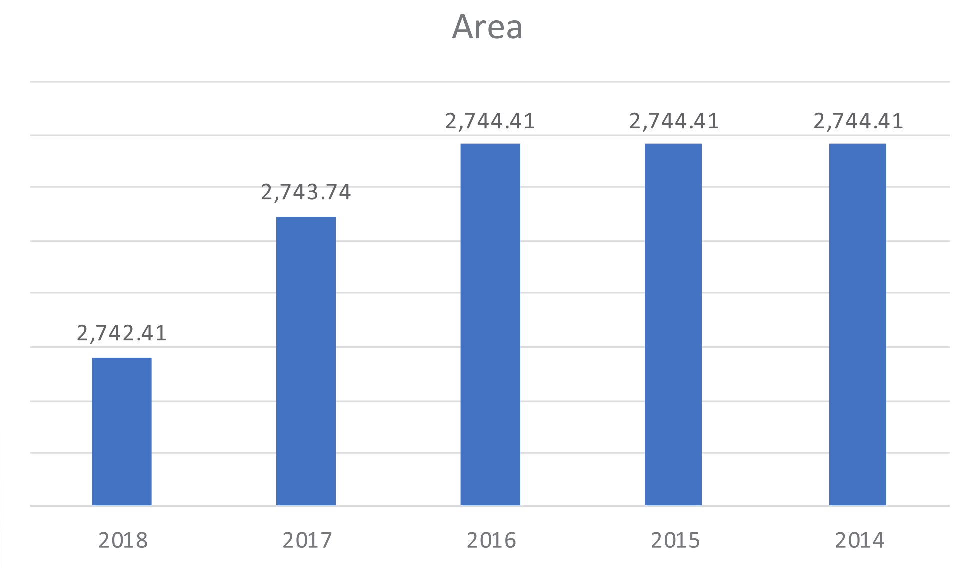


Figure 1.13. Areas of the national reserves in km2, 2014-2018. Source: Planning and Statistics Authority.

1.3.4.2. Number of Oryx in the Protected Areas:

There are national program run by responsible Qatari authorities to protect the Arabian oryx from extinction. The program focuses on oryx breeding in 11 protected areas around the State,these are Shahanyah, Mashabyah, Doha zoo (closed since 2012 for maintenance), Al Wajbah, Umm Thanytain, Umm Grebah, Umm Al Mawaqa, Ras Laffan, Sunai (added in the year 2014), Aushairj and Farm (279) (added in the year 2011) (Fandos and Castilla, 2015). Statistics show that the total number of oryx in the State is growing and steadily increasing, where numbers increased from 1136 to 1471 between the years 2010 and 2014, an increase of nearly 30% of the oryx number in the year 2014. The Arabian oryx species is now only categorized as vulnerable, which is a great achievement after facing near extinction, though it will still need time until it is not endangered at all. However, a drop in the number of oryx in 2019 occurred because of the relocation of some of the oryxes to private protected areas (Table 1.24, Figure 1.14).

Table 1.23. The number of Arabian oryx in the various protected areas for the years 2010–2014 & 2019.

Protected Areas	2010	2011	2012	2013	2014	2019
Shahanyah	324	326	343	361	357	290
Mashabyah	649	705	752	786	763	699
Doha zoo	25	30	35	–	0	–
Al Wajbah	96	99	122	138	161	–
Umm Thanytain	4	4	4	4	4	–
Umm Grebah	23	28	27	27	27	–
Umm Al Mawaqa	11	19	21	19	21	–
Ras Laffan	4	4	4	4	4	–
Sunai	–	–	–	–	29	–
Aushairj	–	–	–	–	–	168
Farm No.)279)	–	147	146	132	171	–
Total	1,136	1,362	1,454	1,471	1,537	1157

Source: Planning and Statistics Authority

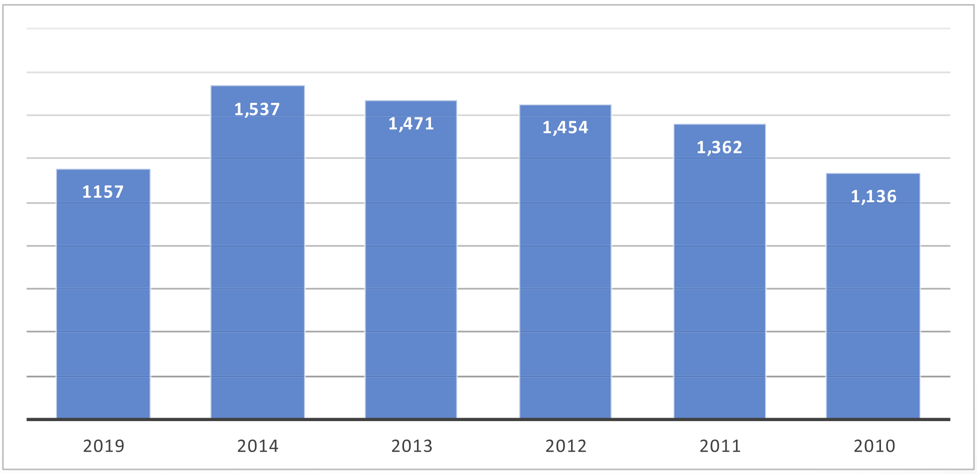


Figure 1.14: The total number of Arabian Oryx in Qatar in the years 2010 to 2014 & 2019

1.3.5. Challenges and Response:

Although the percentage of protected areas in the State is very good (23% of the total area of the country), there are still very limited environmental indicators for the current protection status, and on the efficiency and perfection of the management of these protected areas. Through these indicators we will be able to judge the wellbeing of the biosafety of these protected lands.

1.3.5.1. Challenges Facing Wildlife:

Human activities are the main reason that negatively affects environmental and ecological systems, either through increasing the urban expansion and taking-over natural spaces, or through the direct human impact like camping, trips, cutting trees and hunting. - Overgrazing that destroy wildlife habitat. - Climate change and the increase in temperature, especially in the summer season, and the decrease in quantity of rainfall.

1.3.5.2. Protection: Response & action:

The State's stakeholders are currently implementing (among the stakeholders themselves for some of the projects and in coordination with third parties for other projects) several projects for the protection of wild flora and fauna and their environment in the State. The Emiri Decree approved Wildlife and Habitat Protection through law number (19) of the year 2004. By this law, the Ministry of Environment, at this time, was assigned the

responsibility of the rehabilitation of the Qatari mainland. Accordingly, a decision was made by the Minister of Environment (resolution number. 95 for the year 2011) to ban grazing camels in Qatar. The implementation of the resolution left apositive impact on the Qatari wild plants, and that encouraged the Ministry of Environment to study the benefits of this decision to improve the Qatari environment by starting a project for the rehabilitation of the Qatari mainland.

The project focuses on the rehabilitation of the rawdas, especially those with historical and social significance, by planting and seedling only Qatar wild trees and shrubs. This project aims to:

- Make use of treated water for irrigation.

- Combat desertification, sand dune stabilization and reduction of soil erosion caused by wind and rain.

- Develop rawdahs, pastureland and the country mainland in general, stop the deterioration in the remainder of the Qatari rawdahs, and raise the regenerative ability of the land.

- Contribute to raising environmental awareness of the importance and role of the tree.

- Cooperate and coordinate with local and foreign authorities in the field of management of afforestation and rehabilitation projects of lands, and develop pastoral natural resource.

The implementation of the project started in the spring of 2014 by rehabilitating three rawdas (Al-Ghafat, Al-Wakra, and Simaysma), 4 rawdas were rehabilitated in the years 2015 & 2016 (Bu-Salyla and Al-Basier in 2015) and (Asa-Alraee and UM-Juweifa in 2016).

Location of rehabilitated rawdas

Ghaf trees

a) Ongoing Projects:

- The preparation of the integrated administration plan for Al-Reem protected area 2016 – 2017, in accordance to the highest standards approved by the UNESCO and the international union for conserving nature. - The project of restricting the spread of the Guweif plant all around the State. The first phase from 2016 to 2017.

- The project of protecting the Ghaf plant in the Ghafat Rawda in Al-Shamal municipality. The first phase from 2015 to 2018.

- The project of the preparation of the inventory, assembly, characterization and conservation of wild plants in Qatar. The first phase from 2012 to 2016.

b) Future Projects:

- The project of the preparation of the inventory, assembly, characterization and conservation of wild plants in Qatar. The second phase of the project from 2017 to 2022.

- Project of enriching genetic diversity and conservation of genetic resources of plants in the State using nuclear techniques and related technologies. The first phase from 2017 to 2020. - The Documented guide of local genetic resources.

1.3.5.3 Conventions Related to Wildlife:

- The Biodiversity Convention for the State and the oCuntries of the Region (1996), and protocols following this convention: o Cartagena Protocol on Biosafety signed in Colombia (2007). o Nagoya protocol for sharing the benefits of genetic resources, signed in Japan (2010).

- The Convention of Regulating the Trade in Endangered Wild Species and their Products (2002). - The United Nations Convention to Combat Desertification. Qatar joined the agreement in (1999). - The Convention of Protecting Wildlife and their Habitats in GCC Countries (2004).

1.3.6 Multilateral Environmental Conventions and Protocols Related to Biodiversity and Ratified by Qatar:

1. Convention of Biological Diversity (CBD).
2. UNESCO World Heritage Convention.
3. United Nations Framework Convention on Climate Change (UNFCCC).
4. United Nations Convention to Combat Desertification (UNCCD).
5. Convention on International Trade in Endangered Species (CITES).
6. International Treaty for Plant Genetic Resources (ITPGRA).
7. Protocol of Cartagena/Biosafety.
8. Nagoya Protocol on Access and Benefit Sharing of Genetic Resources.
9. Convention of Wildlife and Their Habitat in the Gulf Region.

1.3.7 Selected Responses to Biodiversity Management in Qatar:

1.3.7.1 Rawdas Vegetation Cover Restoration:

Rawdas' vegetation cover has recently undergone significant losses and dieback primarily because of habitat change or conversion into croplands, and chaotic clearing of rawdas for urban expansion. The ecosystem resilience of some rawdas is being compromised. In response to these problems, MME has initiated and is implementing several programs to restore rawdas and/or halt the degradation through fencing and plantation programs.

Because of the dry warm climate in Qatar, the natural vegetation cover is very little and mostly consists of small shrubs. But plants density increases in rawdas that form in the lowlands, where groups of some trees and shrubs grow separated by weed ephemeral soon after the rainy season Most rawdas spread in the northern part of the State, where many of them are converted to farms (Source: Plants life in Qatar, Environmental Studies Center – University of Qatar). Over the years, a number of trees and shrubs have been introduced to Qatar, a few of them have managed to adapt to the Qatari environment and have been planted in many roadside routes in Qatar. These include ziziphus pp., acacia nilotica subsp. indica, parkinsonia aculeate, acacia ophylla, lelauca glauca, prosopis juliflora, pithecellobium dulce, and moringa oleifera. However, the spread of these trees and shrubs remained in urban areas (mainly residential areas) most likely because of water seepage that helped to satisfy their needs and maintain them. However, two plant species (ziziphus and prosopis juliflora) have managed to establish places for them outside towns at roadsides of highways, specially prosopis juliflora which is now found in all habitats. In addition, it has conceded one of the most famous invasive species in Qatar. The plants of Qatar were grouped into two groups (according to studies conducted by the Scientific and Applied Research Center of Qatar University). The groups are saline plants and non-saline plants.

The flora of Qatar includes more than 371 species of wild plants belonging to 236 genera in 61 families and the flora native species (about 270 species) are well adapted to the desert environment (Qatar Biodiversity Inventory 2003). The total number of species included in the checklist is nearly 400 of which about 270 are likely to be truly native. In Qatar, and elsewhere in the Gulf, one tree, the mesquite prosopis juliflora, originally from central America, has now become an undesirable invasive species. Although primarily found in and around inhabited areas, it is increasingly seen growing in more remote desert localities. In contrast, the native prosopis cineraria or ghaf, which is on the edge of its range in Qatar, is undergoing a serious decline. The vast majority of the naturalised species included in this checklist are annual or perennial 'mesophytic' plants that are dependent on artificial irrigation. Many, however, are also found in the numerous natural depressions in Qatar, particularly after winter rains, when soils may remain damp for a considerable time. It is prudent to monitor such species to see if they are having any impact on the native flora, which also abound in these depressions.

1.3.7.2 Wider Responses:

Several other and wider responses also have positive implications for Qatar's biodiversity including:

• The ratification of Environment Law (30/2000) and the arrangement that running in the Physical Planning department of national land Use Master Plan.

• The Development of NIAP (National Ivory Action Plan, 2018)

• A defined National Strategy and Action for Controlling Invasive and Alien Species (A running initiative has been performed in the department of Wildlife and Protection concerned with Controlling Population Dynamics of Myna Birds (Acridotheres tristis – 2019) in the country.

• The preparation of the draft law regulating the access to genetically modified organisms (GMOs) was developed based on the national Biosafety Framework (2018).

• A law of regulating the acquisition of predators and dangerous creatures (10/2019) has been endorsed since April 2019.

• An initiative proposal concerning "Knowledge Status, Documentation, Species Conservation Management Plans for Fauna Population" (2019) has been submitted for

approval and inclusion within the framework of the Strategic Plan for the Environmental Sector (2018 – 2022) of MME.

1.3.8 Emerging Issues and Outlook:

1.3.8.1 Conserving and Protecting Species:

It is necessary to improve and update the knowledge about species biodiversity and threat level. For example, a NATIONAL RED LIST would help keep decision makers and managers informed about natural resources to act appropriately to conserve and maintain species. All recent species studies are either in the form of checklists limited to protected areas or specific studies conducted in some sites by single researchers. Qatar has yet to develop its first SPECIES ACTION PLAN.

1.3.8.2 Upscaling Ecotourism and Other Forms of Low Impact Recreation:

Nature and culture tourism are important activities and sources of income to municipalities near protected areas (PAs). Because these sectors are growing and gaining recognition among municipalities and tour operators, it is important to develop environmental business guidelines for responsible tourism. Residents should participate in the provision of ecotourism services (guides, rangers, natural foods and cottage products, guesthouse accommodation, festivals, etc.). Fair and responsible tourism provides many opportunities for balancing income-generating activities with natural resource management and biodiversity conservation.

1.4 Water Resources, Supply and Sanitation:

Clean water and sanitation, are Goal 6 of the Sustainable Development Goals (SDGs) and 2030 UN Agenda that aims to end hunger and all forms of malnutrition by 2030. Water and sanitation are at the very core of sustainable development, critical to the survival of people and the planet. Goal 6 not only addresses the issues relating to drinking water, sanitation and hygiene, but also the quality and sustainability of water resources worldwide. Holistic management of the water cycle considering "water stress" and integrated water resources management (IWRM) are among the follow-up actions of the implementation plan of the UN agenda. In addition, water and sanitation indicator is one of the 9-environmental policies of Yale for global Environmental Performance Index (EPI).

1.4.1 Water Resources Status in Qatar:

Freshwater resources are very limited in Qatar and the main available groundwater resource is known by its deterioration and depletion. The country has very low precipitations and high evapotranspiration with no natural surface freshwater like rivers or lakes. The only traditional freshwater resource in Qatar is groundwater, which is recharged mainly from precipitations. The non-traditional fresh water resources in Qatar are desalinated water and treated sewage effluent (TSE). In Qatar, there are another two additional non-traditional water resources which are the collected surficial/ groundwater (SGW) and the associated water to gas and oil production, known as produced water. Until 1953, the population of Qatar was entirely reliant on groundwater for its potable and agricultural water. This water, which was brackish in places, was pumped from shallow aquifers in the central and northern areas of the State. In 1953, the first desalination plant was commissioned, and the country's desalination capacity has been increased over the years. In 2017, almost 100% of water for potable water supply is produced by desalination plants (606 Mm3 (Kahramaa, 2017). In the last years, Qatar's population, about 744,029 in 2004, has grown significantly with high rates to be 2,773,885 in 2019. Thus, a rapid rising of the water, food and energy demands for domestic, industrial, and agriculture activities are associated. According to 2017 data, the total supply from desalination & groundwater is about 606,250 Mm3/year respectively and according to 2018 data TSE is about 257.8 Mm3/year, (Kahramaa, 2017; Ashghal 2018). In the same time, there is a surplus for TSE, which is not reused. Therefore, the estimated total used water in Qatar is 1087.5 Mm3/year according to 2017 data (excluding industrial cities). In addition, the collected surface/ groundwater in urban areas is discharged into sea without any reuse of it (it is equal to 100 Mm3/ year in 2018). The groundwater abstraction is about 41% of the total annual water supply according to 2017 data. Almost all the groundwater abstracted in Qatar is used for agricultural irrigation. Currently, desalination plants installed on the Arabian Gulf supply all drinking water in Qatar. However, the industrial water in major industrial cities in Qatar, including associated water of Gas-to-Liquid (GTL) and other associated water with industry, and oil & gas sectors, are not considered in the national budget and integrated management, which should be.

1.4.2 Aquifers and Groundwater Use:

1.4.2.1 Geology: The Qatar Peninsula is situated on the stable Eastern Arabian Shelf of the Arabian Plate, as a wide anticlinal dome that is trending to the north direction, and protruding north south into the Arabian Gulf, forming what is known as the Qatar Arch. The dome then flattens but re-emerges offshore forming the North Dome. In the Central Dome area, uplifts and erosions have resulted in the exposure of the oldest rocks that occur in Qatar, which belongs to the Rus Formation. This basin is mainly composed of extensive carbonate sediments with different ages overlying the basement rocks and may reach up to 10 km in thickness. The outcropping rocks in Qatar are mainly of the Quaternary and Tertiary Ages, except Halul and Shara'wah islands. Simsima limestone, part of the Upper Dammam Formation, forms more than 75% of land surface with up to 30 m thick in the extreme north of Qatar. Upper Dammam formation consists of thick strata complex of terrigenous and marine deposits. However, its detailed stratigraphy and lithology are not well known. Quaternary deposits cover the rest of surface area less than 25%. Over the southern half of Qatar, the lowermost member of the Dammam Formation – comprises the attapulgite shells of midra shale and fahahil velates member. A general transgression at the beginning of the midra eocene results in a return to shallow marine deposition across the whole of Qatar and the formation of Simsima limestone. Occurrences of unconsolidated material include gravel deposits of Young Tertiary age, and various sediments of Quaternary age (MoE, 2009 and MME internal reports). Older Mesozoic-age rocks have been found in boreholes and include the Upper Jurassic-age carbonate sequence of the Arab Formation which form the oil reservoir of the Dukhan anticline, and which are in turn overlain by an 800m thick, Cretaceous-age sequence dominated by calcarenite, limestone and sandstone. There are overlying Tertiary-age sequences which dominate outcrops in Qatar. The recent post-Cretaceous geologic succession of Qatar is a sequence of shallow water marine limestone along with occasional shales and evaporites. Shales are accumulated in a low energy environment, while evaporites represent the precipitation of anhydrite and gypsum in still and shallow basins. The manifestation of the deeper geology on the surface is mainly through karst processes, which is the key component in the formation of depressions (MoE, 2009). The main lithological units, which outcrop or occur at shallow depth in Qatar, are summarized in Table 1.24. The only important deep formation is aruma, which is about 550 m below the surface Regarding the seismicity of Qatar, the tectonic style of the Qatar peninsula is essentially gentle and quite simple. Nevertheless, the Qatar Peninsula is located within the Arabian Plate, which is characterized by active seismic edges. It is located southwest of the active collision plate boundary between the Arabian and Asian (Iranian) Plates (Zagros Fold Belt).

Table 1.24. Summary of the Geologic Succession of Qatar

Age	Epoch	Formation	Member	Lithology
Quaternary	Holocene Pleistocene			Sand dunes, beach sediments, sabkhas.
Tertiary	Pliocene Miocene	Upper Dam	-	Residual gravel.
Tertiary	Pliocene Miocene	Lower Dam	-	Sandstone, clay and gypsum (up to 30 m thikness).
Tertiary	Eocene	Upper Dammam	Abarug	Dolomitic limestone
Tertiary	Eocene	Upper Dammam	Abarug	Marl.
Tertiary	Eocene	Upper Dammam	Simsima	Dolomite and limestone (up to 30 m thickness).
Tertiary	(Middle)	Lower Dammam	Alveolina	Limestone
Tertiary	(Middle)	Lower Dammam	Midra & Saila	Shale with thin argillaceous limestone.
Tertiary	(Middle)	Lower Dammam	Fhaihil Velates	Limestone.
Tertiary	(Lower)	Rus Chalk (Upper & Lower)	-Khor limestone -Carbonate facies -Sulphate facies	Chalky limestone with intercalations (up to 4m thick common) of marl and gypsum with minor anhydrite. Outcrops in the core of the central arch and the gypsum is typically absent in the Northern Province of Qatar.
Tertiary	Paleocene	Umm Er-Radhuma		Dolomite with intercalations of chert, marl, shale and anhydrite over calcareous shale at the base.
Tertiary	Paleocene	Aruma		Shale and marl.

1.4.2.2 Aquifer Units and Hydrogeology:

In Qatar, there are two main aquifer units that were used to provide fresh groundwater: The uppermost is Eocene-age a chalky limestone referred to as the Rus aquifer, comprising the Rus and Dammam formations (30 – 50 m thickness). This overlies the second important unit, Paleocene-age Umm Er Radhuma (UER) aquifer that comprises the UER formation only. It is the major and regional aquifer throughout the Gulf region (270 – 370m thickness). UER

presents at higher elevations up to 1.8m (QNHD: Qatar National Height Data) in the center of the arch whereas to the east and west it occurs at depths below -120m. The groundwater salinity level of these two aquifers in northern and central Qatar varies spatially and temporally and increases towards the sea reaching high saline water near coasts. In the extreme southwestern region of Qatar, near Abu Samra, the Abarug/Alat member of the Upper Dammam Formation creates an artesian aquifer. The aquifer is of limited extent with an average thickness of 15m. The Aruma aquifer, in southwest Qatar, comprises approximately 130 meters of granular limestone belonging to the Aruma Formation. The drilling data of exploratory and production wells indicate the occurrence of relatively brackish quality water (with a salinity level of about 4000mg/L) at depths of 450–650 m in southwest Qatar. A key characteristic of the near surface aquifers of Qatar is karst. The surface expression of karst in the form of sinkholes and depressions has already been discussed in detail in reports of MoE study in 2009. Table 1.25 shows the aquifer units in Qatar.

Table 1.25. Description of Aquifer Units in Qatar		
From Surface	Lithostratigraphic Units	Description
1	Quaternary deposits	Limited outcrops.
2	Dammam Formation	Limestone and dolomite (30 – 50 m thickness).
3	Midra Shale	Aquitard extent limited to southern part of project area.
4	Upper Rus (carbonate)	Fractured/karstic limestone (20 – 120 m thickness).
5	Lower Rus (Gypsum)	Aquitard, mainly very low permeability gypsum, extent limited to southern part of project area.
6	Umm Er Radhuma (Upper and Lower)	Deep strata, fractured/karstic carbonate aquifer, most probably unconnected to the shallow groundwater system in the south. Limit of interest defined at the upper surface of the chert layer that is found in this formation (270 – 370 m thickness).

1.4.3 Groundwater Provinces:

Conventionally, the aerial extent of the aquifers of Qatar has been subdivided into two main hydrologic provinces: Northern and Southern groundwater basins. The boundary between the two provinces coincides closely with the Northern limit of the Lower Dammam Midra Shale member and Lowe Rus Gypsum member. In the southern province, the UER is confined at its top by massive gypsum of the lower Rus Formation. In the Northern Province, the lower Rus Formation gypsum unit is generally absent. These two basins are different in the

hydrochemistry of the groundwater, with a less saline groundwater being present in the northern zone, which largely reflects the generally higher incidence of rainfall occuring in this region. Smaller groundwater provinces have subsequently been added to this conceptual framework, Figure, 1.17.

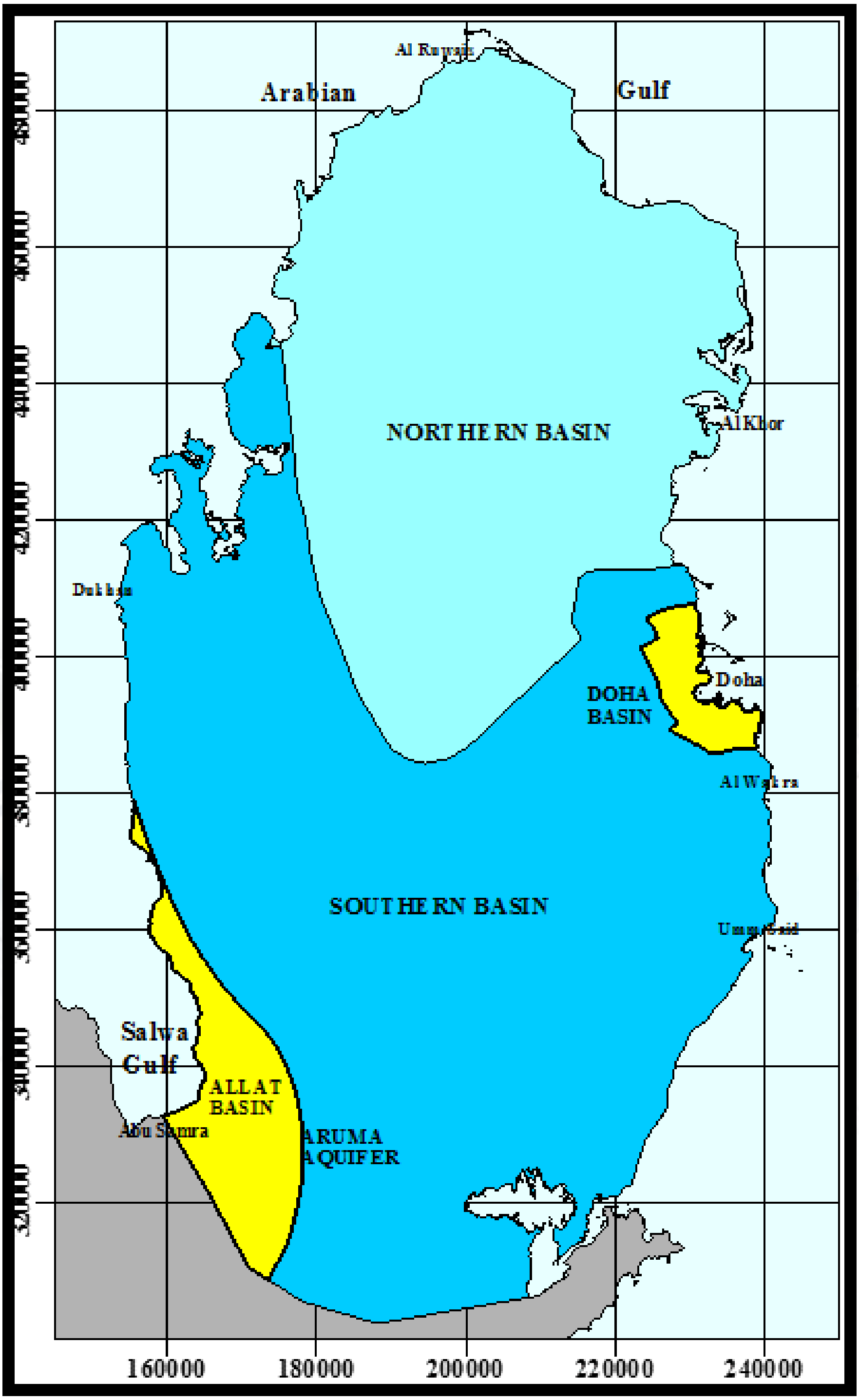
- Northern Province, where available data indicates that massive gypsum beds are generally absent, and the aquifers are less hydraulically separated. With Rus and upper UER it is considered as an unconfined aquifer.

- Southern province, where the shallow Rus and deep UER aquifers are generally hydraulically separated by a thick sequence of gypsum confining bed with low permeability (UER is confined),

- Abu Samra province or southwestern province,

- Doha province.

Another deep basin, which is Aruma deep groundwater basin, can be considered another groundwater province. The division of the Qatar area into Groundwater Provinces in previous work highlights natural differences between the south and the north, as well as differences between urban areas and the remainder of the country. These provinces are defined based on geological, geomorphological, hydrogeological evidences and on the configuration of the Rus lithofacies, forming the V-shape boundary between the depositional carbonate facies in the north and the depositional sulphate facies in the south. Comprehensive conceptual explanations of the hydrogeological processes (i.e. vadose zone flow, groundwater levels and flow, groundwater abstractions, hydrochemistry and groundwater balances) and analyses of observations are presented in previous comprehensive studies carried out in Qatar (MoE, 2009; Ashghal, 2013; Kahramaa, 2014).



Source: Environmental Protection, Reserves and Wildlife Department (MME).

a- Northern Groundwater Province:

Qatar's fresh groundwater reserves have historically occurred predominantly in the Northern groundwater province, although these reserves have been depleted over time as discussed below. The Northern Province covers an area of Qatar where evaporite deposits (i.e. gypsum: calcium sulfate dihydrate $CaSO_4.2H_2O$ and anhydrite: anhydrous calcium sulfate $CaSO_4$ are limited due to both syndepositional control and post-depositional dissolution. The presence or absence of the midra shale member is believed to be a controlling factor in the dissolution of the underlying evaporites. The midra shale, where present, is considered to retard downward percolating groundwater, thus also retarding dissolution. The dissolution of the evaporite unit within the Rus Formation has led to enhanced recharge and in the development of a complex freshwater lens sitting on top of deeper saline/brackish water over the area. Northern groundwater province, the Dammam and Rus are considered as a single, continuous unconfined aquifer system due to the absence of the shale.

b- Southern Groundwater Province:

The southern province occurs beneath more than one half of Qatar and encompasses the central and southern areas. It is characterized by the existence of a basal unit of evaporites in the rus formation. The basal gypsum-rich interval of the Rus Formation is considered an aquitard, whereas the overlying dolomitic limestone is considered an aquifer. Midra shale member of the Dammam Formation overlies Rus Formation dolomite in this province, probably retarding the dissolution of the gypsum. Throughout much of the Southern province the Rus formation is considered to be an aquitard because the gypsum has low permeability. In the Southern groundwater province, the Dammam and Rus formations are separated by the midra shale aquitard. The shale reduces hydraulic connectivity between the Rus and the Dammam formations, leading to semi-confined conditions in the Rus. The Rus and Dammam formations are considered separate aquifers in these areas. Where the midra shale is present, it refers that the perched aquifer in the Dammam formation has been as the "Surficial Aquifer". Although considered an aquitard, flow through the midra shale member may occur in areas where collapse structures have compromised its structure.

c- Doha and Southwestern Groundwater Provinces:

These two zones have been defined by literature studies to reflect the enhanced recharge, which occurs due to anthropogenic processes in the Doha urban area and aquifer members of Abu Samra in the southwestern area of Qatar.

1.4.4 Groundwater Abstraction and Use:

Groundwater abstraction has increased from 160 Mm3 in 1993 to be 250 Mm3 in 2009, and until 2018 without significant change. The total production wells for all purposes including agriculture, domestic, and industrial is about 4205 wells, according to 2009 records (MoE 2009). Currently Kahramaa is doing an extensive inventory regarding all wells located on the State of QATAR. Table (1.26) shows the groundwater use for each sector according to MoE data of 2009 and Kahramaa data of 2018. Furthermore, groundwater is almost the only source for irrigation in Qatar, with the exception of few farms, which are using treated sewage effluent (TSE) for producing fodder crops. This increasing abstraction can be compared with semi-constant annual fresh replenishment by infiltration recharge. This increasing groundwater abstraction than the natural replenishment caused the salt-water intrusion which makes most groundwaters to be brackish.

According to MoE data up to 2014 & Kahramaa water Balance 2018, groundwater use for agricultural activities is 230 Mm3/year and for domestic / industrial activates is about 20 Mm3/year with total of 250 Mm3/year. Almost all groundwater is used for irrigation. Currently, some farms in Qatar are using desalination units to desalinate the high salty groundwater to be suitable for crops and livestock. There is negligible groundwater usage for industrial and domestic purposes. For domestic use, only Abu Samra RO small plant is using groundwater for potable water supply for residents, less than 0.3 Mm3/year according to Kahramaa (2018). There are five well fields for potable water supply only in emergency. Table (1.27) shows the total abstraction from each province of the 4-groundwater provinces in Qatar according to MoE (2009). Figure 1.17 shows the spatial distribution of abstraction wells in the 4-groundwater provinces of Qatar and according to their depths in the aquifers. Data indicate that about 80% of groundwater use is in the Northern Province.

Table 1.26. Groundwater abstraction wells for each use (Source: MoE, 2009)

Use	Farms	Household	Municipal (government)	Industrial	Total
Abstracti n (Mm^3/year)	226	9.9	9.3	3.4	248.7
Use percent %	90.9	4	3.7	1.4	100
Number of wells	3532 (84%)	505 (12%)	147 (3.5%)	21 (0.5%)	4205

Table 1.27. Groundwater abstraction wells from each province (Source: MoE, 2009)

Zone	Northern	Southern	Abu Samra	Doha	Total
Abstraction (Mm^3/year)	198.6	47.1	2.2	0.7	248.7
Use percent %	79.9	19	0.9	0.3	100

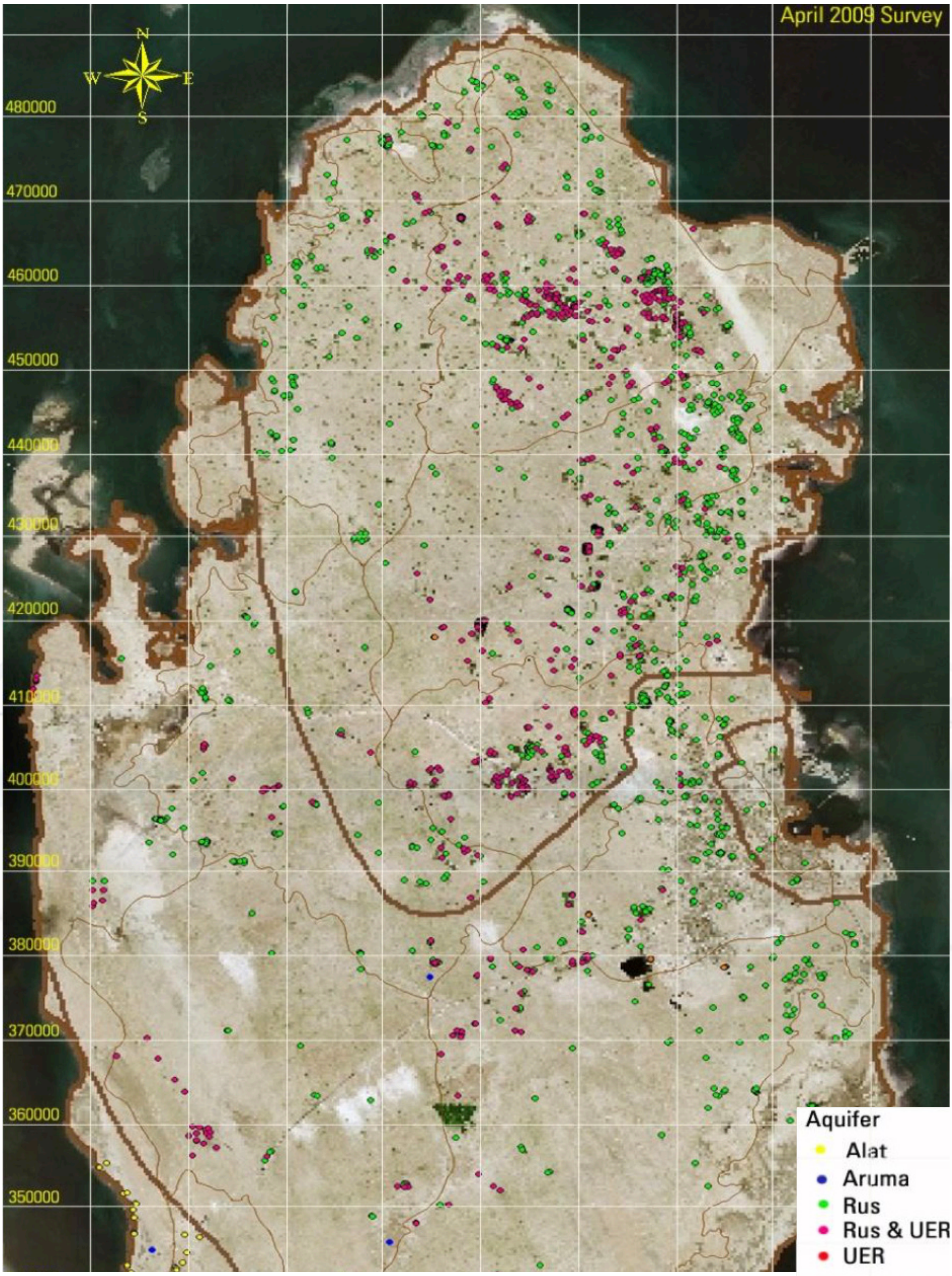


Figure 1.17. Spatial distribution of abstraction wells according to the four-groundwater provinces and the aquifers (Source: MoE, 2009).

1.4.5 Groundwater Recharge: Recharge to the aquifers in Qatar takes place through :

- Infiltration from rainfalls or lagoons through open karst and collapse structures;

- Irrigation/urban returns, and leakage and injection; - Marine intrusion;

- Upward flow from lower aquifers, especially where confining beds have been affected by structures/dissolution/subsidence. The infiltration via open karst and collapse structures is considered to be the most important form of recharge, given that they are widely distributed throughout Qatar, they cover a large area and provide a mechanism for rainwater (the primary source of fresh water) to infiltrate and recharge the aquifers. In urban areas, five main types of recharge can be defined:

1. Direct or diffuse recharge from widespread infiltration of rainwater at or near to the point where rain falls.

2. Localized recharge (also called indirect or focused recharge) where surface waters run-off and accumulates in localized depressions with no surface water outlet and through recharge wells.

3. Indirect recharge from leaking water, potable water network, TSE and sewage systems, and on-site water lagoons disposal systems.

4. Artificial recharge from soakaways and injection wells.

5. Irrigation return flows from irrigation of parks, landscaping along roads, house yards, and gardens. a- Natural Infiltration from Rainfall: There are different types of natural groundwater mechanism process-

es, which are generally recognized to be operating in Qatar:

- Direct or diffuse recharge from widespread infiltration of rainwater at the point where rain falls

- Localized or focused recharge where surface water run off occurs into local depressions with no surface water outlet and through recharge wells The direct or diffuse one, resulting from rainfall over extensive areas of litho-sols and bare outcrop and from accumulation in small hollows where soil depth is minimal; and secondly, by an indirect process via surface water runoff accumulation and subsequent infiltration through the colluvial soils of the numerous depressions in Qatar. A preliminary, semi-quantitative assessment maybe undertaken to determine the potential for localized recharge Direct and indirect recharge of groundwater from rainwater forms the main natural internal water resource. This estimated every year according to rainfall quantity and infiltration rate into groundwater table. In last years, rainfall quantity over Qatar was estimated according to 18-rainfall stations allover Qatar. Average rainfall from this data was about 69.3 mm/year. To estimate annual recharge from rainfall, Qatar was divided into 11 catchment areas to calculate the recharge in each one and to calculate the total recharge. Figures 1.18 and 1.19 show the distributions of average rainfalls allover Qatar since 1988. Some significant areas in Qatar are Sabkha which is operating as evaporation process not infiltration process (Figure 1.20) .

The average annual groundwater recharge from rainfall for the period 1990-2018 is estimated according to MoE and Kahramaa data to be equal to 68.5 million m3/year (Mm3/year). This was estimated annually using empirical infiltration rate from rainfalls over northern and southern groundwater zones using the 11 catchments areas.

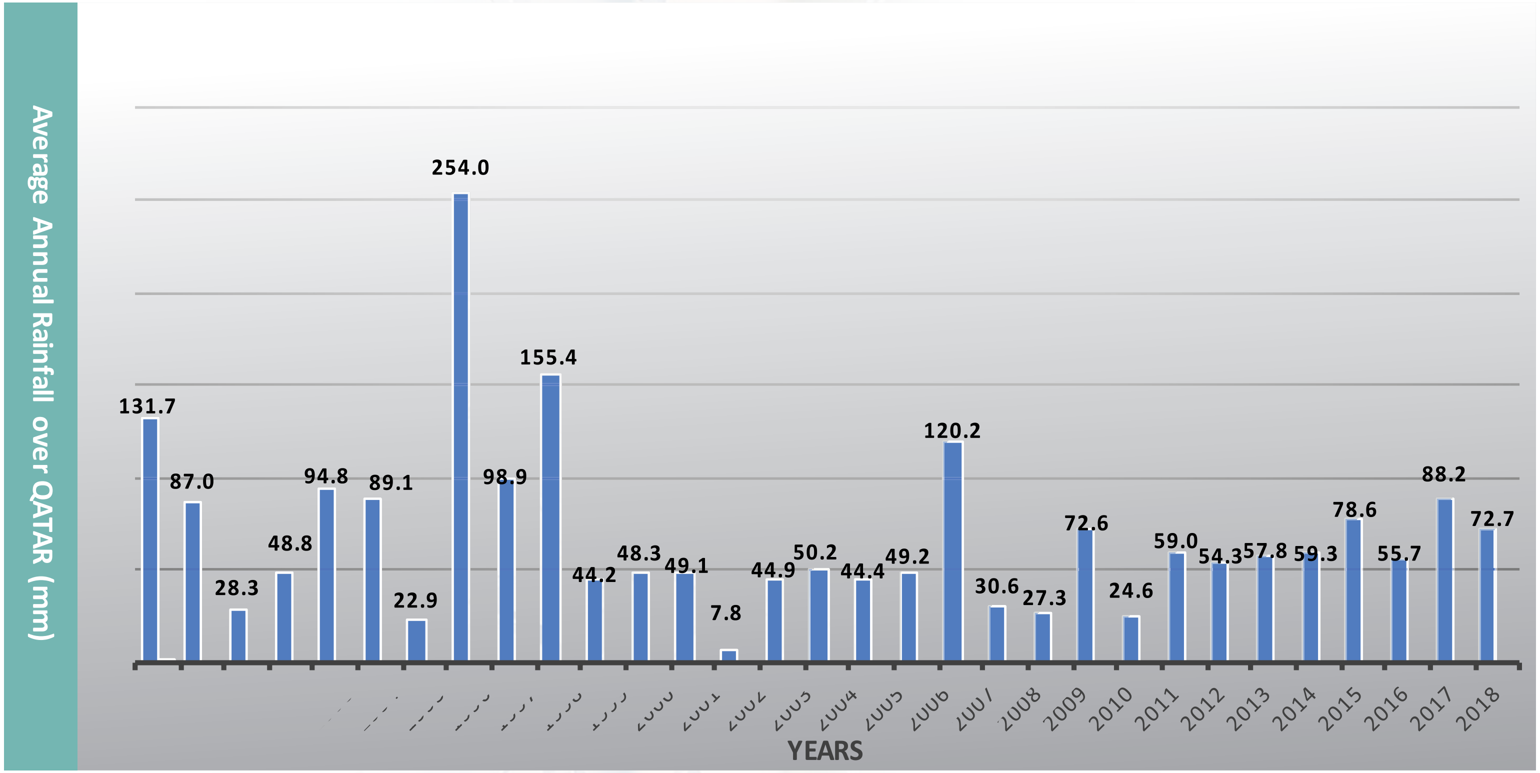


Figure 1.18. Average annual rainfall in Qatar from 1988 to 2018 (QCCA 2018).

To enhance the focused rainfall recharge into groundwater in Qatar, a number of recharge wells were constructed. Recharge wells are normally located in the lowest topographical point in depressions and along the trajectory of shallow Wadi systems. There are total of 313 recharge wells were installed in Qatar; 166 of these are located within depressions and 147 are located outside of topographical depressions. Recharge wells are 'passive' gravity recharge wells in which no active injection is undertaken. Rainfall water, that enters the recharge well, infiltrates into the aquifer under the force of gravity. The construction details of a typical example of a recharge well in Qatar are presented in Figure 1.21 a and b. The majority of recharge wells are concentrated in the northern part of Qatar. The estimated average recharge through those recharge wells is 10.6 Mm3/year (MoE, 2009).

Figure 1.19. Contour map of the average annual total rainfall from 1988 to 2018 (Source: QCCA, 2018)

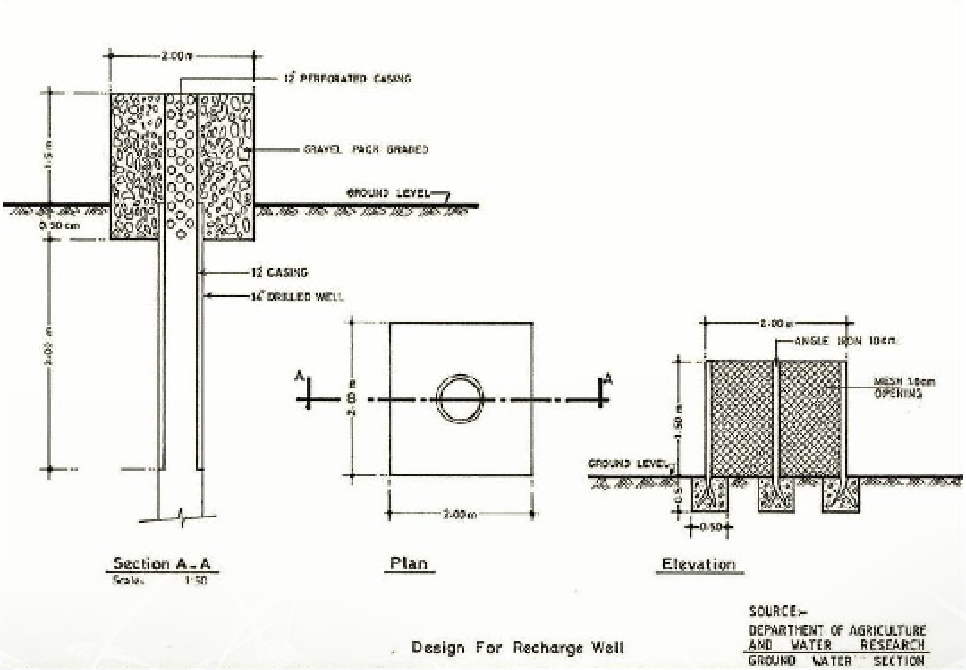


Figure 1.21b. Design for a typical rainfall recharge well in Qatar (Source: MoE, 2009)

b- Other Recharges into Aquifers:

In addition, there are three other types of groundwater recharge in Qatar. Groundwater recharge will also be contributed to from irrigational returns. Returns from agricultural irrigation are estimated to be around 20% to 25% of the total abstracted water for irrigation. Based on the extraction of 230 Mm3 for the year 2018, the recharge from irrigation returns using 20% is calculated to be about 46 Mm3/year. In Qatar, TSE is used to irrigate fodder farms, which is equal to 79.7 Mm3/year in 2018. This means 16 Mm3/year is return into groundwater from TSE irrigation. Also, another recharge type is the inflow of groundwater from trans-boundary aquifers. This was estimated to 2.2 Mm3/year. This makes the total recharge of Qatar groundwater by the three previous natural sources to be about 64.2 Mm3/year. In urban areas (i.e. Doha groundwater zone), there are other recharge sources into groundwater in Qatar. TSE for green space irrigation & injection of excess treated sewage effluent (TSE) which is applied in Qatar since 2009 as a feasibility project. A number of deep injection wells (400m deep) were installed to TSE disposal into UER aquifer. A numbers of shallow and deep monitoring wells were also installed. The average injection TSE from 2010 till 2018 is 45.6 Mm3/year and the average irrigation return using TSE for green spaces from 2010 to 2018 is 7.1 Mm3/year. Figure 1.22 shows the schematic diagram of TSE deep injection that is applied

in Doha. In addition, a few other injection wells were installed for the disposal of dewatering and collected surficial groundwater in Doha. All injection wells are boreholes into UER aquifer only. Recharge from artificial lagoons such as Abu-Nakhla TSE lagoon is another recharge. Leakage from water supply and TSE networks and leakage from septic tanks are other recharge sources in urban areas of Qatar (i.e. Doha). It is estimated that the total leakage from the potable water distribution network is about 3.01% of supplied water in 2017 (Kahramaa, 2017). This 3.01% leakage rate equates to a potential recharge contribution of 18.2 Mm3 in Doha for 2017. In Doha, there is a combined engineering system (network, pump stations, outfalls) to collect both surficial groundwater and storm water and to discharge both into sea. The quantity discharged into the sea in 2018 according to received data from Ashghal is about 0.55 Mm3/year

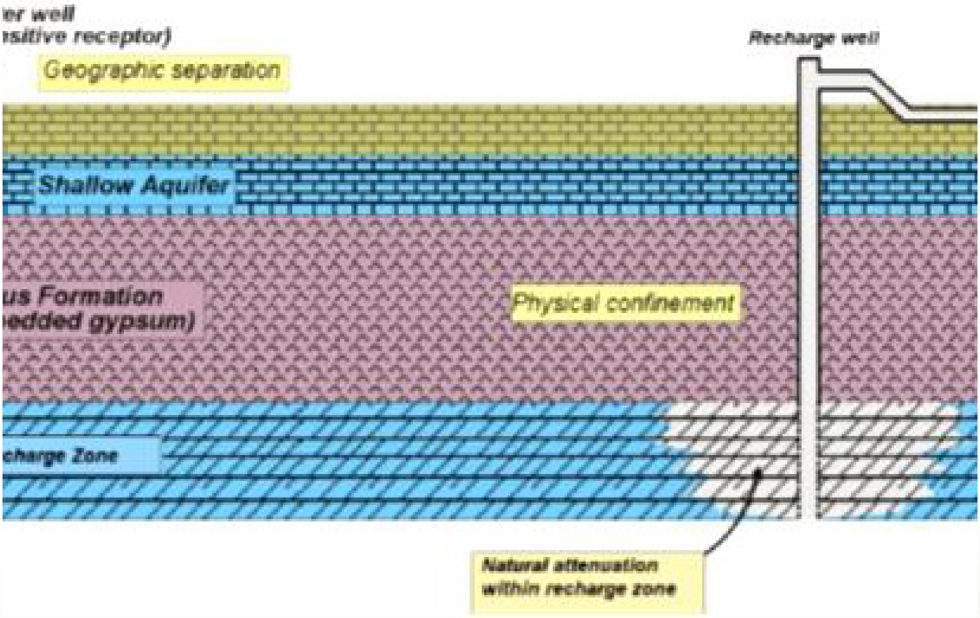


Figure 1.22. Schematic diagram of deep TSE recharge borehole illustrating the multiple barriers between a recharge well in UER and a sensitive receptor (water well). (Source: MoE, 2009).

From previous discussions of recharge and discharge from groundwater aquifers in Qatar, the difference between recharge and discharge can be estimated. Urban Doha basin is excluded from calculation because it has complex conditions. According to MoE and Kahramaa data from 1990 to 2018, The estimated average significant recharge and discharge of aquifer's

groundwater in Qatar indicates that the groundwater abstraction is about two times its balanced recharge (Table 1.28). This situation caused a remarkable depletion and deterioration of groundwater resources in Qatar. However, the equilibrium abstraction from groundwater aquifers in Qatar can be estimated using a simple equation of recharge –discharge as follows: Recharge – Discharge =0 It means: Rainfall recharge + irrigation return + lateral inflow = well abstraction + lateral outflow Equilibrium abstraction which is in balance with recharges and do not cause groundwater degradation can be estimated considering the average annual recharge quantities in Table 1.28 and applying the previous equation. Note that irrigation return is function of groundwater discharge for irrigation. Thus, equilibrium abstraction is equal to about 125 Mm3/year. If TSE injection is to be added as a recharge item, then the estimated balanced abstraction is about 145 Mm3/year. This is the safe abstraction using simple calculation. Accurate safe abstraction is to be calculated using a regional 3D groundwater calibrated model for all of Qatar.

Table 1.28. Average groundwater recharge-discharge balance, 1990-2018

Balance Component	Discharge Mm3/year	Replenishment Mm3/year
Recharge from rainfall		68.5
Recharge from recharge rainfall wells		10.6
Recharge from groundwater irrigation return		46.0
Recharge from TSE irrigation (fodder farms+ landscape)		19.7
Recharge from lateral trans-boundary aquifers		2.2
Discharge by pumping irrigation wells	227	
Discharge by industrial, household, municipal wells	9.40	
Discharge by lateral vertical and horizontal seeping	18.0	
Total (average 1990-2018)	254.4	147

1.4.6 Groundwater Deterioration and Threats:

One of the key concerns of water management in Qatar is the ongoing depletion of groundwater aquifers due to over-abstraction. In the last years, groundwater water resources in Qatar have

been used extensively for irrigation and other activities. The total number of working farms has increased from 259 in 1976 to 910 in 2015. Abstraction from groundwater was 1-2 times more than the balanced recharge-discharge. Desalination is used to provide potable and industrial water demands. Currently, groundwater is mainly for irrigation demand. Nevertheless, groundwater use for irrigation is much more than its replenishment. The groundwater depletion can be monitored by changes of groundwater table and changes of water quality. Overexploitation of groundwater can lead to intrusion of seawater and deep saline groundwater into freshwater aquifers and thus increase the salinity and concentration of total dissolved solids (TDS). High concentrations of salinity and dissolved solids can make the water unusable for drinking and agricultural purposes. Figure 1.23 shows the degradation of groundwater quality using total dissolved solids as an indicator (MoE, 2009). According to the World Health Organization (WHO, 2006), TDS limit for drinking water is 1000 mg/L. Comparing two groundwater maps of TDS for 1971 and 2009 indicates the significant deterioration of groundwater quality. Almost and only 2% of the total area of Qatar is under TDS of 1000 mg/L in 2009. This fresh water is only in the northern groundwater province. The northern groundwater province, where groundwater occurs as freshwater ‹floating lenses› on brackish and saline water and the southern one where no such lenses exist and where water quality is generally brackish with only a thin veneer of freshwater at the top of the water table. This over-abstraction resulted in a decline in water level together with an associated deterioration of water quality. Saline intrusion from the coast and underlying aquifers, have been the main causes of deteriorating groundwater quality. Water from irrigation returns into groundwater carrying a high dissolved load, precipitated by the remaining 75% of irrigation water, which evaporates and includes elevated concentrations of sodium, chloride, nitrate and others. Thus, this high TDS causes increasing groundwater salinity. According to MoE (2009) study, the deterioration of water quality has led to no drinking suitability, the abandonment of farms, particularly in the coastal areas, and finally the salinization of soils.

Figure 1.24 shows the area of TDS less than 1000, 2000, and 3000 mg/L. From 1971 to 2009,

areas of TDS of 1000 mg/L decreased significantly from 1683 km2 to 275 km2 (80% shrinkage

in the fresh water area) and the same shrinkage for TDS of 2000 and 3000 mg/L. However,

groundwater reserves are still being overexploited which will lead to lower groundwater levels

and higher salinity. This makes it difficult to use groundwater for irrigation and drinking water

supply in the future without further treatment.

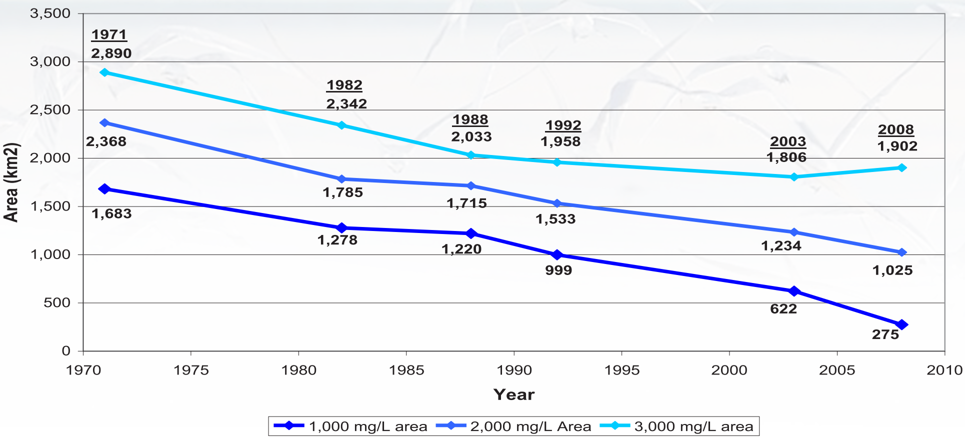


Figure 1.24. Graph showing areas of TDS less than 1000, 2000, and 3000 mg/L, as fresh and brackish groundwater in the northern groundwater province of Qatar, 1971 - 2009 (Source: MoE, 2009).

1.4.7 Monitoring of Groundwater Quality:

The State of Qatar has a continuous groundwater quality-monitoring program that started in 1971 and is administrated by the Water Department at the Ministry of Environment until 2015. This monitoring program has moved from MoE to Kahramaa in 2015. It has a total of 100 annual monitored wells (with an overall of 344 wells since starting) distributed all over the country with the majority in the northern zone. Those 100 monitored include observation wells and production wells in farms. All wells are monitored twice per year, in May and in September (before and after the rainfall season in Qatar). The monitoring program of those 100 wells includes measuring the groundwater table, samples collection and analysis. Detailed analysis of the main quality parameters, namely pH and electrical conductivity (EC), along with analysis for the major cations: Ca++, Mg++, Na+, and K+; anions: HCO3-, CI-, and SO4--, in addition to SiO2 in some years (MoE, 2014). In 2009, MoE has conducted a comprehensive groundwater study, which included a detailed groundwater analysis in its three phases. Results from this 2009 comprehensive study indicated no serious problems with pollutants including petroleum hydrocarbon, heavy metals and microbial items. Data of MoE in 2014 of this groundwater-monitoring program was used to assess the latest status of groundwater quality in Qatar. TDS is selected as indictor of groundwater quality. TDS limit for drinking water according to Qatar standards and WHO guidelines is 1000 mg/L. In addition, Qatari standards for TDS in water for irrigation purposes is 2000 mg/L. FAO has another useful classification of TDS for water different purposes.

Table (1.29) shows TDS limits for different purposes. Table 1.29. Classification of water according to its TDS

Table 1.29. Classification of water according to its TDS			
	Qatar or (WHO)	TDS (mg/L)	Type of water
	Qatar or (WHO)	FAO	Water class
Drinking and irrigation water	1000>	500>	Non-saline
Irrigation water (fresh-brackish)	2000>	1,500 – 500	Slightly saline
Primary drainage water and groundwater (brackish)	4000 >	7,000 – 1,500	Moderately saline
Secondary drainage water and groundwater (brackish–saline)	-	35,000 – 15,000	Highly saline
Very saline groundwater	-	35,000 – 15,000	Very highly saline
Seawater	-	45,000<	Brine

Northern Province:

Figure 1.25 shows the TDS values of groundwater in Northern Province in Qatar according to 2014 MoE data of monitoring wells. It is clear that almost all monitored wells are above TDS drinking limit of 1000 mg/L. Only two wells off 59 wells have TDS less than 1000 mg/L, fresh water. Only 12 and 34 of monitored wells have less than 2000 and 4000 mg TDS/L and might be used for irrigation and drainage water, respectively. The rest of monitored wells (11 wells), have TDS more than 4000 mg/L and up to 45,000 mg/L which is not suitable for irrigation or drinking, classified as moderately to brine water.

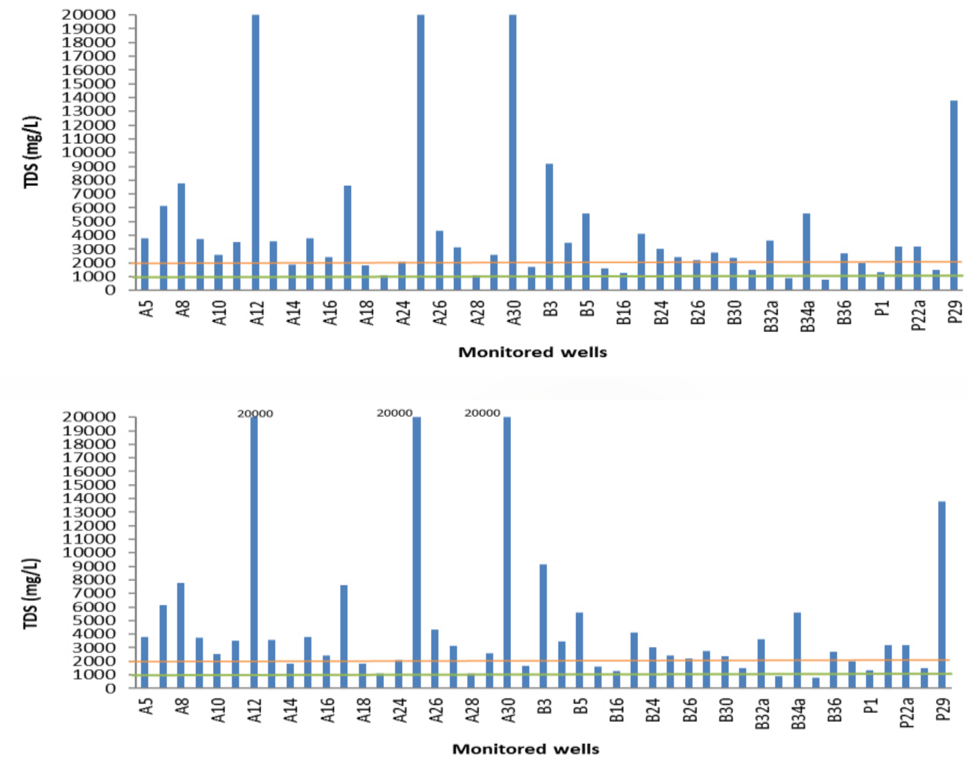


Figure 1.25. TDS of groundwater wells in the Northern Province (Source: MoE, 2014).

Southern Province:

Figure 1.26 shows the TDS values of groundwater in Southern Province in Qatar according to 2014 MoE data of monitoring wells. Almost all monitoring wells are above TDS drinking limit of 1000 mg/L. Only three wells of 37 wells have TDS less than 1000mg/L, fresh water. Only 6 and 18 of monitoring wells have TDS less than 2000 and 4000 mg/L, irrigation and drainage water, respectively. The rest of monitored wells (8 wells) have TDS more than 4000 mg/L which is not suitable for irrigation or drinking, classified as moderately to brine water.

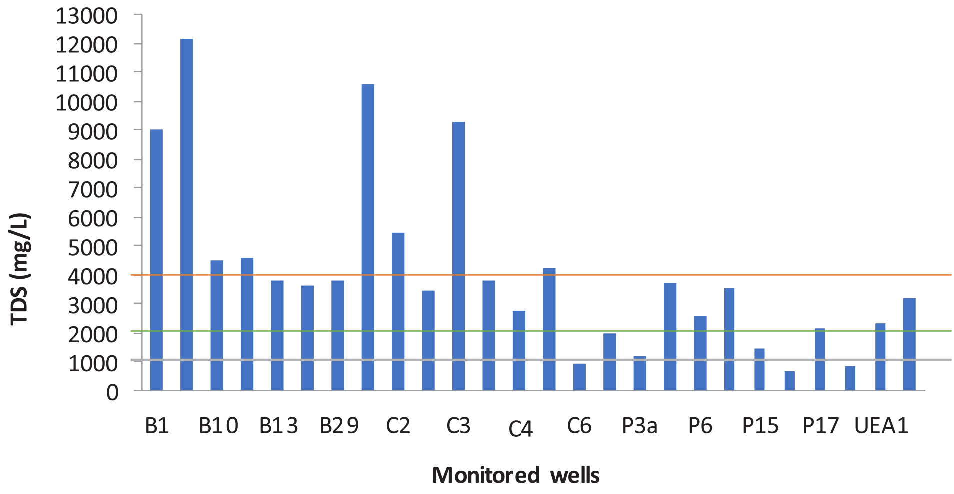


Figure 1.27. TDS of groundwater wells in Abu Samra province (Source: MoE, 2014).

Southwestern (Abu Samra) Province:

Figure 1.27 shows the TDS values of groundwater in Southwestern Province in Qatar according to 2014 MoE data of monitoring wells. All monitoring wells (18 wells) are above TDS drinking limit of 1000 mg/L, and only 6 of monitoring wells have TDS less than 4000 and no wells measured less than 2000mg/L. The rest of monitoring wells, (12 wells) have TDS more than 4000 mg/L which is not suitable for irrigation or drinking, classified moderately to brine water.

Doha Province:

MoE monitoring wells include nine wells for Doha province. In 2014, only two wells were available for sampling. Almost all Doha province is considered now as an urban area and there are other monitoring projects, which are operated by Ashghal to monitor the shallow and deep groundwater of this basin.

1.4.8 Regulations for Groundwater Protection and Replenishment:

Due to the observed and recognized depletion and degradation of groundwater quality in Qatar, the government of Qatar adopted some regulations to protect and replenish this vital source. About 313 natural recharge wells were installed to enhance the recharge from rainfalls in Qatar. However, the total required number of recharge wells according MoE 2009 study is about 1500 recharge wells. Injection of good quality water such as TSE and desalinated water is under experimental investigation to augment groundwater aquifers in Qatar.

Thus, there are some important aspects, which are open to better regulate and manage this depleting resource in Qatar.

The important adopted regulations to protect groundwater in Qatar are:

- Law no (1) of 1988 for wells drilling and its amendments;
- Environmental protection law no (30) of 2002 and its executive by-law no (4) for 2005;
- Minster law no (20) for 2007 to rationalize groundwater use and prevent its degradation (no new wells are allowed unless it is of public benefits)
- Cabinet decision no (1) for 1971 to prevent drilling of artesian wells;
- New National Water Act as a national development project 2011-2016.

To better regulate groundwater resources in Qatar, comprehensive studies are needed to accurately reflect the groundwater situation. Accurate calculations of recharges and discharges (i.e. wells abstraction) are important. Using 3D groundwater models for Qatar is a useful tool using accurate inputs and acceptable calibration. Good, accurate and updated data is needed to feed this model. Mapping groundwater systems using satellite and Deep Penetrating Radar are powerful tools that are used. This will help to regulate and manage the groundwater in Qatar in an accurate way.

1.4.9 Water Supply and Sanitation:

The Sustainable Development Goals (SDGs), which replace the expired Millennium Development Goals (MDGs), include targets "universal access to safe and affordable drinking water" and "adequate and equitable sanitation". These new goals align with the United Nations' (UN) formal acknowledgement that clean drinking water and sanitation are encompassed in the realization of human rights. Access to safe drinking water is critical for promoting human health, socioeconomic development, and individual wellbeing. Enhanced access to safe drinking water is widely considered one of the great successes of the MDGs eighth international development goals between 1990 and 2015. In addition, the Environmental Performance Index (EPI) by Yale Center for Environmental Law and Policy (YCELP) is a global ranking of how well countries perform on a defined set of environmental policy issues, from 2006 to the present. The index is released every two years. The 2014 EPI measures national environmental performance in 2 objectives, 9 policy issues, and 20 indicators. One of its 9 policy issues is "water and sanitation".

1.4.9.1 Water Supply:

The State of Qatar's rapidly growing economy and population (mainly immigrants) caused a big increase in the water supply and demand that is mainly desalinated seawater from the Arabian Gulf. Desalination plants are operated by a semi-governmental company, QWEC and water distributed by governmental corporation, Kahramaa. In

2017, there are three main desalination plants, Ras Abu Funtas (RAF), Ras Laffan (RL) and Umm Al Houl. RAF has 5 internal desalination sub-plants. RL has 3 desalination sub-plants. The total distributed potable water is 368 and 588 Mm3/year in 2011 and 2017. Therefore, the average consumption based on authorized consumption of system input volume including losses per capita is equal to 610 and 594 L/capita per day in 2011 and 2017, respectively. Figure 1.28 shows the total volume of produced and distributed desalinated water supply in the year 2011 to 2017.

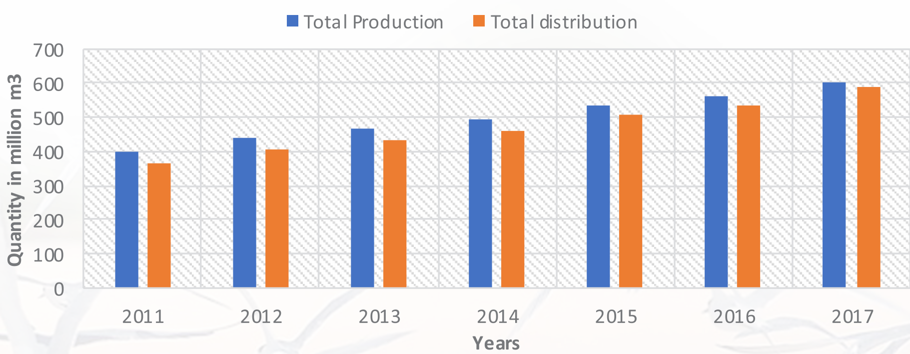


Figure 1.28. Total production and drinking desalinated water supply in Qatar (Source: Kahramaa, 2017).

Produced desalinated quality potable water is distributed through distribution network that includes pipelines and storage tanks. Almost all populations in Qatar are provided with safe drinking water through this distribution network (Figure 1.29), except very small remote households that are supplied by safe drinking water through registered tankers. All served drinking water is disinfected to the required level using disinfection advanced methods. Number of water customers was raised from 221,423 in 2011 to 317,215 in 2017. In 2010, 3.42% of total buildings in Qatar were not connected to drinking pipeline network. In 2014 and 2015, almost 100% of population has access to improved and safe water supply all days.

Figure 1.29. Map of drinking water distribution system and main desalinating plants (Source: Kahramaa, 2016).

The most important challenging issues facing water supply in Qatar (efforts and plans are in place to deal with them) are:

- High level of per capita drinking water consumption.

- Water supply during for emergency can only last a few days which will be mitigated by the new Mega Reservoir project. - Impact of disposing brine water from desalination plants on marine and groundwater aquifers environment.

- The high consumption rate of fossil fuel for operating the desalination plants.

1.4.9.2 Sanitation:

Sanitation is vital for maintaining healthy/hygenic drinking water supplies, minimizing contact with dangerious pollutants, and minimizing environmental threats associated with improper liquid waste management. In the State of Qatar —since it is an arid country—treated urban wastewater is a very important source of water for the purposes of irrigation, cooling and recharging the deep groundwater aquifers. On the other hand, reusing treated wastewater helps to protect the environment from adverse impacts of water-borne pollution. Access to proper sanitation is a very important environmental performance indicator. The State of Qatar is currently implementing a major infrastructure project which is an intigrated wastewater treatment system (covers the measures of the SDG and EPI as mentioned above), this is essential to provide appropriate sanitation services for all individuals throughout the State. With one of the world's lowest levels of rainfall and shifting towards integrated water resources management (IWRM), treated wastewater (treated sewage effluent—TSE) is an important source for water, that helps releasing desalinated water to be utilized for uses that require higher water quality (like domestic water uses) and to minimize abstraction of fresh groundwater resources which is already depleating. Use of TSE is an important measure to achieve the country's water resources sustainability. The sanitation indicator is the percentage of population with access to improved sanitation to the total population. The system is considered improved if it hygienically separates human excreta from contacting human, the living organizns and the environment. Improved sanitation includes connection to public sewers (private or shared) network, to septic tanks, or connection to simple latrines. According to Qatar Atlas (2015) which has data of 2010, the number of buildings which are connected to sewer network is 98,515 out of total buildings of 128,074, with a percentage of 77%. The rest of the buildings that are not connected to sewer are already connected to septic tanks. Wastewaters in septic tanks are pumped and transported by tankers to wastewater treatment plants and a temporary sewage lagoon. This means that the percentage of population with access to improved sanitation is 100%, this puts Qatar in the highest rank of the international ranking of the countries having proper access to sanitation.

1.4.9.3 Wastewater Treatment:

In Qatar, expansion of the sewage collection network has not always kept coincide with that of water supply network. There is a time lag between both systems. Since 2004 the capacity for treatment of urban wastewater increased from 54,000 m3/day up to 965,000 m3/

day in 2018, with significat increase of plants capacity. The current number of treatment plants are eight main wastewater treatment plants (WWTPs) as follows:

- Doha South WWTP (tertiary treatment with ultrafiltration and (disinfection)

- Doha West WWTP old plant (tertiary treatment with disinfection)

- Doha West WWTP (tertiary treatment with N&P removal, ultrafiltration and disinfection)

- Industrial Area WWTP (tertiary treatment with disinfection)

- Lusail WWTP (tertiary treatment with N&P removal, ultrafiltration and disinfection)

- North Doha WWTP (tertiary treatment with N&P removal, ultrafiltration and disinfection)

- Barwa City WWTP (tertiary treatment with disinfection)

- Al-Khor WWTP (tertiary treatment with disinfection)

- 14 Package Treatment Plants (PTP) distributed in spesific areas as needed

Table 1.30. Treatment capacity, collected and treated sewage and TSE usage (Ashghal, 2018)								
Data per year								
2010	2011	2012	2013	2014	2015	2016	2017	2018
(Treatment capacity (1,000 m3/day								
260	323	391	695	705	809	827	828	965
Wastewater received (1,000 m3/year) - excluding Slaughter House PTP								
101,653	123,887	142,339	158,792	173،933	197,492	209,518	231,473	275,829
Wastewater after treatment TSE (1,000 m3/year) (excludes slaughter house PTP, because it goes to (Doha South								
102،839	108،759	129،212	151،883	168،949	193،854	204،392	228،668	256،467
Of which reused in agriculture - 1,000 m3/year								
32،275	41،979	58،707	55،233	64،920	66،289	61،699	69،508	79،669
(Of which reused in agriculture (1,000 m3/year								
18،630	21،657	19،915	24،670	29،096	31،088	42،480	61،029	71،208
Of which for deep injection into aquifers - 1,000 m3/year								
26،240	26,212	30,854	35,599	43,465	57,291	60,364	63,859	66,892
(Of which discharged to lagoons (1,000 m3/year								
23,878	18,760	13,474	35,391	31,109	38,845	39,168	33,817	38,161
Of which discharged to the sea - 1,000 m3/year								
141	268	293	234	358	350	681	455	546

All existing wastewater treatment plants (WWTPs) are now treating wastwater to tertiary level. PTP treatment level up to secondary level. As presented above, for the main WWTPs are upgraded or equiped with nitrogen and phosphorus removal units. Most of WWTPs are located in Doha. Before operation of Doha North and Lusail WWTPs, tankers collect raw sewage from various locations and discharge it to WWTPs and into an open lagoon at Al Karaana. According to 2015 data, the amount of collected sewage by tankers from septic tanks or from other activities is 1.7 Mm3/year which is discharged into Al Karaana lagoon. Thus the percentage of collected wastewater for treatment is nearly 100% considering those raw sewage tankers from septic tanks. Al Karaana lagoon was closed for rehabilitation and soil remediation, it was officially opened back on November 2019 to accept TSE only.

Table 1.30 shows the data of wastewater, treatments and Treated Sewage Effluents (TSE) and its usage in different purposes. According to this data, all collected wastewater is treated to tertiary level except a small number of PTPs. The collected wastewater and the TSE are 258 and 256.5 Mm3/year, in 2018. The capacity of WWTPs start to be higher than the collected wastewater since 2013. In 2018, the capacity is 352 Mm3/year which is higher than the collected wastewater (257.82 Mm3/year) by about 27%. However, It is noted that the collected wastewater in 2017 is only 231.5 Mm3/year from the distributed drinking water which is 606 Mm3/year in 2017. This is a very low percentage which is only 38.2%. However, the difference between supplied water and collected wastewater might be going to septic tanks, landscape and yards irrigation, percolation, evapotranspiration, leakage, and other purposes.

1.4.9.4 Treated Sewage Effluent (TSE):

Treated sewage effluent (TSE) is an important non-conventional water resource in Qatar. It is considered as Environmental Performance Indicator (EPI) by Yale Center. It measures the percentage of collected wastewater that is treated. According to table 1.30, the quantity of TSE has been increased from 102.8 Mm3/year in 2010 to 256.5 Mm3/year in 2018. Almost all collected wastewater is treated to high quality tertiary level with disinfection. N and P are removed in TSE in most cases. Therefore, TSE quality is high according to local and international standards. It is worth mentioning that in 2018, the percentage of collected wastewater that is treated was almost 99%.

The usage of TSE is indicated in table 1.30. TSE usage in Qatar is for fodder irrigation, green spaces irrigation, cooling plants, injection to deep UER aquifer (between 100–400 m), discharge into engineered or natural lagoons, and discharge into the sea. Figure (1.31) shows the percentage of TSE usage in Qatar in 2018. Major TSE use.

is for irrigation of fodder and green spaces with total percent of 58.8% of total TSE use. However, there are TSE amounts, which are not re-used, and just discharge into lagoons (14.88%) and sea (0.21%). The rest of the percentage of TSE, which is 29.5%, is injected into deep UER aquifer between 100–400m deep. This injected TSE is not very useful for reuse, since the injection take place in urban areas away from areas in need for fresh water (i.e. farms with abstraction wells) and because of the high salinity of deep groundwater aquifers.

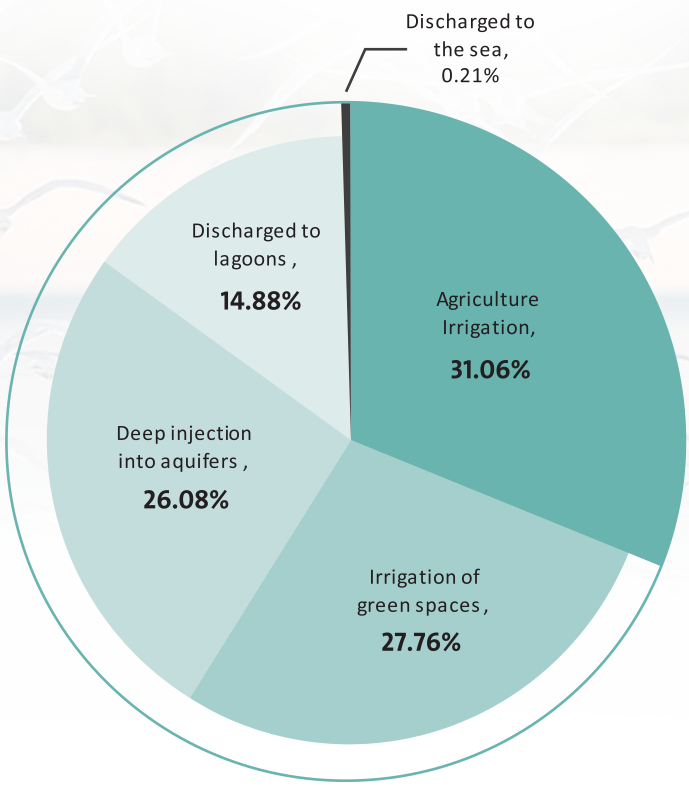


Figure 1.31. TSE usage in Qatar in 2018 (Ashghal, 2018).

1.4.9.5 Wastewater Sludge:

Treatment of wastewater generates liquid Treated Sewage Effluent (TSE) and sludge. This sludge is then dried in the WWTPs plants. With the increase in treatment plants capacities, the generation of sewage sludge has increased. In 2018, the generated sludge in dry solids was 37,688 ton/year (about 80% of the liquid sludge is water) (Table 1.31). This generated dewatered sludge was disposed into the land-fill area of Domestic Solid Waste Management Center in Masaieed which was opened in October 2011. Currently after 2015, significant amounts of this dewatered sludge are treated and completely dried using centrifugation and thermal methods in new North Doha Waste-water Treatment Plant. This dried sludge is being reused in useful healthy and environmentally friendly purposes (i.e. as soil conditioner for landscaping and as fertilizer for animal fodder).

Table 1.31. Sewage sludge generation (Source: Ashghal data)

Data per year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sewage sludge generation (ton dry solids/year)	11,870	20,443	21,572	27,575	32,352	40,099	41,551	41,554	37,688
Sewage sludge generation (1,000 m3/ year)	104	263	372	303	250	224	197	224	202

1.4.9.6 Surface Groundwater (SGW) System:

In Doha, there is a sewer system that collects only wastewater to be treated in the WWTPs. However, there is another separate combined collection system to collect both storm-water and surficial groundwater from several areas in Doha and to discharge this collected water into the Arabian Gulf via outfalls. This system is called surface groundwater (SGW) system and is only in Doha urban area. Surface/groundwater drainage systems were installed as early as the 1980's, and plans continue to cover many of the roads in the residential areas. This SGW is collected using about (8) main pumping stations. These pumping stations (PS) discharge the collected SGW into the sea through (5) outfalls: SGW-PS1 (Wadi Mushaireb), SGW-PS3 (Qatar Sports Club), SGW-PS4 (New District of Doha, Onaiza), SGW-PS8 (West Bay, Diplomatic Area) and Al Rayyan PS outfalls. Table 1.32 shows the quantity of collected storm water and surficial groundwater in Doha which is discharged into the sea. The discharged amounts decreased after 2011 but again increased in

2015. The amount of discharged water into the sea in 2018 is 100.9 Mm3/year according to Ashghal data. This is a significant amount of water resource and further action is needed to reuse this water instead of discharging it into the sea. In the last three years, Doha was suffering —during the rainy season— from many storm-water floods in different areas. However, Ashghal has a master plan and this SGW will be transferred into the two main WWTM plants in north and south to treat it using RO and reuse it as recycled water after mixing with TSE.

(Table 1.32. Quantity of Surface Ground Water discharged to the sea (Ashghal, 2018									
Data per year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Surface Ground Water dis-charged to the sea (million m3/ (year	-	76.3	68.7	64.3	63.0	75.7	89.7	95.4	100.9

1.4.10 Environmental Conservation Projects - Land and Inland Water :

Qatar's National Development Strategy (NDS) 2011-2016 has 14 sectors, including two sectors of environmental sustainability and natural resources. This national development strategy includes important national outcomes and projects related to Land's Environment and Groundwater such as:

- National Water Law. - Urban Water Table Mitigation Project.
- Solid Waste Management Project.
- National Biodiversity Database.
- Functional Green Spaces.
- Limitation of Groundwater Discharge according to Natural Recharge.

- Decrease Leakage from Water Supply Network.

- Decrease Per Capita Water Consumption.

- Increasing the use of TSE in Additional Purposes.

- Sectorial master plans and strategies for water supply and wastewater

In addition to those projects on the national level, there are other projects in the internal strategy of the Ministry of Environment before merging it with the Ministry of Municipality in 2016.

1.4.11 Water Security in Qatar:

Water security and sustainability in Qatar is a critical issue. All drinking water is depending on desalination of seawater from the Arabian Gulf. The storage capacity for emergency use in case of desalination plants shutdown is only for 3 days. There are two major projects to increase this reserve of supply storage to cover 7 days and 90 days using mega reservoirs, Aquifer Storage, and Recovery (ASR), respectively. In addition, there are a few well fields for emergency water supply. However, depending on groundwater desalination in case of emergency is a useful and practical source. In Qatar, there is excess TSE water, which is not reused, almost 40% of total TSE. In addition to significant surface/groundwater (SGW) quantity which is discharging into sea without reuse until now. There is a master plan, Qatar Integrated Drainage Master Plan (QIDMP) within Ashghal to reuse this SGW in the long term after Reverse Osmosis (RO) treatment and merging in the recycled water network. The industrial water (associated and processed) in industrial cities is not considered at the national level. It is only managed locally within the industrial cities in Qatar. Groundwater depletion and deterioration is a critical issue in Qatar. Without proper management using accurate calculations, understanding the dynamics of the aquifers, protecting measures of well drilling and withdrawal, this will not be solved in the short term. The abstraction from Rus and UER groundwater aquifers is about 2, the safe equilibrium recharge. Therefore, a continuous trend of depletion and deterioration is expected. National strategies and master plans in national or sectorial dimension are underway in Qatar. However, implementation and using accurate tools is vital in this regard. Integrated Water Resources Management (IWRM) must be the umbrella for all those national strategies and master plans supported by legal and enforcement frameworks. Three major aspects of IWRM should be considered for secure and sustainable water management in Qatar. Those three aspects are enabling environment, management instruments, and institutional framework.

1.5 Summary:

Status of the environment related to land and in-land water was presented in this chapter. Driving force, pressure, status, impact, and response were presented and discussed. Indicators considering Sustainable Development Goals (SDGs) and Environmental Performance Index (EPI) by Yale Center for Environmental Law and Policy (YCELP) were given. The environmental status of land and inland water can be summarized as following:

Land Use: Vast area of the country still lies barren/vacant with sand, sand dunes and scanty vegetation. The vacant area is reduced from 91% in 2010 to 85% in 2015. The used land area rose to a total of 15% of the total area in 2015. The distribution of used land among the main three categories of residential, farms/cultivated/green and industrial/commercial/governmental areas is almost the same for each of the categories which are 5.1%, 4.6% and 5.3% of total area of Qatar, respectively (2015 data).

Soil: Soil in Qatar can be classified into two types i) Aridsols which mostly sandy to loamy, shallow, and skeletal and ii) Entisols which mostly calcic and gypsic which underlain the top soil. These soils are commonly associated with rock outcrops. Soil quality according to monitoring program of 2012 is of no contamination of total petroleum hydrocarbons (TPHs) and heavy metals in the soil according to 2012 monitoring data.

Agriculture: Total arable area is 65x103 ha and the cropped area is 11216.6 ha with total production of 630x103 ton in 2015, which is low self-sufficiency. There is a fluctuation in annual agriculture production and cropped areas from 2012 to 2015 with no clear trend of increase or decrease in both. The number of registered farms increased from 891 in 1995 to be 1290 in 2015 with an area of 4% of the total country area. The percentage of the area that uses modern irrigation systems of the total area of farms is 72%, which indicates more water use efficiency. Two international indictors are considered for agriculture, which are nitrogen use efficiency and nitrogen balance. Used fertilizers and pesticides in Qatar are fluctuating from year to another. In 2015, imported fertilizers and pesticides to be used are 4249 and 65 ton, respectively with no data of actual annual use. However, agriculture has low outputs in Qatar with less than 1% of GDP. More accurate data was needed to calculate the new two 2016 EPI indictors of agriculture using nitrogen indicators. Four critical issues, which are related to the environment of land and inland water, were presented. Those critical issues include land degradation, contamination, saltwater intrusion and climate change adaptation.

Public gardens and green spaces: The Qatari governments believe in the importance of the wellbeing and good living of the nationals and residents. The Public Gardens Department is working hard to achieve the government's vision by increasing areas for the public for recreation. The Public Gardens Department opens new public gardens and green spaces and rehabilitates the old ones to accommodate increasing public use. Moreover, the department pays respected effort to improve and modernize the parks and green spaces in line with the aspirations of the public and to keep up with international standards.

Terrestrial Biodiversity: The majority of the protected areas (23.6% of total area of Qatar) are wild locations aimed to protect wild habitats of sensitive desert areas from overgrazing, overhunting, the loss of genetic resources, and desertification. But because of the shortage in human resources and financial support in the first place, the majority of these protected areas are suffering from:

- The absence of an effective management.

- The absence of monitoring in these areas in order to evaluate the efficiency and the performance in these protected areas,

- The absence of plans for the development of education and communication in order to raise the awareness on the importance, aims, gains and values of these habitats and the unique species and biodiversity they embrace.

However, there is currently little information available on the situation of these habitats and their species, as well as the situation of their management. This will be one of the most important challenges on National Development Strategies (2017-2022), which will be:

- The study of the current situation for these protected areas and their biodiversity.

- Developing programs for monitoring and preserving the protected areas.

- Make those protected areas a place for increasing awareness, education and change people's perception of the status and importance of biodiversity, this could be by the support and participation of all active sectors of the society.

Conservation of Biodiversity and maintaining a healthy ecosystem has global as well as local benefits. The State of Qatar play a role in the protection of some of the world's most critically endangered species, and supports many uniquely adapted organisms, some of which may still be unknown to science. However, these species and the habitats that support them are at risk from current developments. Coastal development is particularly damaging to marine species

and may threaten commercial fishing. This, combined with other factors such as desertification and soil salination due to water over-exploitation, demands a response. While the State of Qatar has moved quickly to ratify international conventions and to establish regulatory and managerial bodies, the implementation has been slow. This is in part due to a lack of trained labor and a dearth of scientific expertise in the country. Yet, development of industrial and residential areas continues unabated. Therefore, the development of an effective conservation program that is strictly implemented lags industrial and economic development. Much of the environmentally related work has been supported or lead by industry. A concerted effort lead by the government, combining financial and scientific support, and a multi-year comprehensive terrestrial and marine survey, could greatly strengthen conservation efforts. Only then will we know what Qatar must conserve, before it is too late.

Water and sanitation: Important successes of Qatari water policies are the supply of safe drinking water to all of its residents, and the reduction of water losses to a minimum. Qatar's main source of water is desalination of seawater for drinking water supply and groundwater abstraction for agricultural purposes. In 2017, the distributed drinking water is 606 Mm3/year and collected treated wastewater is 231.5 Mm3/year (i.e. only 38.2% of the distributed drinking water). The capacity of WWTPs starts to be higher than the collected wastewater since 2010. In 2018, the capacity is 352 Mm3/year which is about 27% higher than the collected wastewater of 94.9Mm3/year in 2010. Percentage of population with access to improved safe drinking and improved sanitation is almost 100% for each. Thus, the two international indicators of EPI for water and sanitation are 100% fulfilled for each one.

Water resources: Qatar's fresh groundwater reserves are still being overexploited which leads to low groundwater levels and increased salinity. The average safe abstraction from groundwater was estimated in this report to be about 125Mm3/year. Results of quality monitoring of 2014 shows more depletion and salinity increasing in the four-groundwater provinces in Qatar. This makes the use of groundwater for irrigation and drinking water supply impossible without further treatment in most of the areas. There is no serious groundwater pollution by major pollutants, according to a 2009 study. There is a remarkable achievement in the treatment of urban wastewater to a high level and also to re-use great proportions of the treated wastewater. The percentage of wastewater that receives treatment weighted by connection to wastewater treatment rate is 100% (or 99% if we consider those raw sewage tankers from septic tanks). This is the only EPI indicator for water resources.Water resources: Qatar’s fresh groundwater reserves are still being overexploited which leads to low groundwater levels and increased salinity. The average safe abstraction from groundwater was estimated in this report to be about 125Mm3/year. Results of quality monitoring of 2014 shows more depletion and salinity increasing in the four-groundwater provinces in Qatar. This makes the use of groundwater for irrigation and drinking water supply impossible without further treatment in most of the areas. There is no serious groundwater pollution by major pollutants, according to a 2009 study. There is a remarkable achievement in the treatment of urban wastewater to a high level and also to re-use great proportions of the treated wastewater. The percentage of wastewater that receives treatment weighted by connection to wastewater treatment rate is 100% (or 99% if we consider those raw sewage tankers from septic tanks). This is the only EPI indicator for water resources.

1.6 Appendix:

Annex 1.1. Names of major parks and green spaces in the State’s municipalities in 2019.

Shehania parks :

Al-Jamilah Park - Shehania Desert Park - Shehania Park

Al-Doha Park :

Linear Park - Al-Daffnah - Dahl Al-Hamam - Al-Khalifat Park - The Museum Park - Al-Ghanim Al-Atieq - Sharq - Uniezah - Al-Mamurah - Al-Gharieah - North Khalifa City - Al-Hueilah -Khaliefah South City- New Al-Salta - Fariej Al-Ali - Nueijah Park - Al-Muronah

Al-Rayyan Parks :

Al-Luqtah Park - Green Carpet - Bu-Hamour Park - Al-Gharafa Park - Mueizir Park - New Rayyan Park - Al-Selia - Azaghoy - New Gharafa - Manaseer Park - Mueizir 1 - Al-Rayyan 11 - Al Rayyan Park 4 - Azizia Park - Al Waab Park - Ain Khaled Park - Sudan Park - Abu Sidra Park - Al Sailiya Park Abu Nakhla - Al Rayyan Family Park

Al-Wakrah Parks :

Al-Uweinah Park - Al-Wakrah Public Park - Al-Juw Park - Ghasham Park - Al Wakra Plaza - Al Wakra Beach Park - Al-Hala Park

Al-Khor Parks :

Al-Khour Park - Al-Khour Corniche - Al-Zakhierah - Al-Kaaban City Park - Al-karem Park - Al-Gulta Park - Kremh Beach Park - Al- Ghuwairiya Park - Tawasol Park - Al-Zakhierah East Park - Al-Khour Park Plaza - Shuaa Protected Area - Triangle Park - Ein Hlaytan Park - Hzem Alhole Park- Dallah Park - Al-Musnad Park - Fardet Alkhor Park - Safa al Touk Beach Park -Municipal

The North Parks :

Aein Sinan Park - Aba Dhulof Park - New North Park -North City Park

Al-Dhaaien Parks :

Al-Ubeib Park - Al-Kheisah Yard for Occasions - Simaisma Olympic Park - Simaisma Family Park - Al-Ubb Park - Al-Sakhama North Park - Al-Sakhama South Park - Sumaysima Beach for Families

Um-Salaal Parks :

Al Kharaitiyat Family Park - Al Kharaitiyat Plaza - Abdullah Bin Nasser Park
Mohammed Bin Jassim Park - Ali Bin Jassim Park - Barzan Olympic Park

Annex 1.1. Names of major parks and green spaces in the State's mu-.nicipalities in 2019

Al-Doha Parks		Al-Khor Parks
Linear Park	Freej Bin Dirham	Al-Khour Park
Al-Daffnah	Helal Park	Al-Khour Corniche
Dahl Al-Hamam	Freej Al Ali Park West	Al-Zakhierah
Al-Khalifat Park	Yusufiyah Park	Al-Kaaban City Park
The Museum Park	South Khalifa City Plaza	Al-karem Park
Al-Ghanim Al-Atieq	Jeryan Nujema Park	Al-Gulta Park
Sharq	Freej Al Ali Park East	Kremh Beach Park
Uniezah	Um Al Khaba Park	Al- Ghuwairiya Park
Al-Mamurah	North Nuaija Park	Tawasol Park
Al-Gharieah	south Nuaija Park	Al-Zakhierah East Park
North Khalifa City	Al Thumam	Al-Khour Park Plaza
Al-Hueilah		Shuaa Protected Area
Khaliefah South City		Triangle Park
New Al-Salta		Ein Hlaytan Park
Fariej Al-Ali		Hzem Alhole Park
Nueijah Park		Dallah Park
Al-Muronah		Al-Musnad Park
		Fardet Alkhor Park
		Safa al Touk Beach Park
		Municipal Park

(Source: Public Parks Department, MME).

Appendix 1.2. Plants names by the classification of the Public Gardens Department. Appendix 1.2a. Palms and Cycads:

Botanical Name	Common Name	Botanical Name	Common Name
Bismarckia nobilis	Bismarckia palm	Livistona chinensis	Chinese fan palm
Brahea armata	Blue hesper Palm	Phoenix canariensis	Island Date palm
Butia capitata	Pindo palm	Phoenix dactylifera	Date palm
Chamaerops humilis	European fan palm	Phoenix roebelenii	Pygmy date palm
Cocos nucifera	Coconut palm	Phoenix sylvestris	Silver date palm tree
Cocos plumosa	Coconut palm	Roystonea regia	Cuban Royal Palm
Copernicia alba	Wax Palm	Sabal domingensis	Hispaniola palmetto
Cycas circinalis	Queen Sago	Washingtonia filifera	California fan palm
Cycas revoluta	Sago palm	Washingtonia robusta	Washingtonia palm
Elaeis oleifera	American oil palm	Zamia furfuracea	Cardboard Palm

Appendix 1.2b. Large Evergreen Trees

Brachychiton populneus	Bottle tree	Ficus salicifolia	Willow leaved fig	Schinus molle	Pink pepper, peruvian pepper
Brachychiton populneus	Bottle tree	Ficus salicifolia	Willow leaved fig	Schinus molle	Pink pepper, peruvian pepper
Casuarina equisetifolia	Horsetail tree, Australian pine	Ficus syco-morus	sycamore fig	schinus terebin-thifolius	Brazilian pep-per tree
Chorisia speciosa	Bottle tree	Harpullia pen-dula	tulip lancewood	Tamarindus indica	Tamarind
Ficus alii	Amstel king	Khaya senega-lensis	African mahogany	Taxodium dis-tichum	bald cypress
Ficus alii	Amstel queen	Kigelia pinnata	Sausage tree	Terminalia arjuna	Arjun tree
Ficus altis-sima	Council tree	Moringa oleifera (pterygosperma)	Horse rad-ish tree	Terminalia bellirica	Bastard myro-balan
Ficus bengal-ensis	Banyan tree	Parkinsonia aculeata	Jerusalem thorn	Terminalia cattapa	
Ficus infec-toria	White-Fruited Wavy Leaf Fig	Pithecelobium dulce	Manila tamarird	Zizyphus chin-ensis	jujuba tree
Ficus panda	indian ficus panda	Prosopis alba	White car-ob tree	Zizyphus jujuba	Chinese date
Ficus religiosa	Scacred ficus	Prosopis juli-flora	Honey mesquite	Zizyphus spina - christi	Christ Thorn

Appendix 1.2c. Deciduous Trees

Botanical Name	Common Name	Botanical Name	Common Name
Albizia julibrissin	Silk tree	Millingtonia hortensis	Indian Cork Tree
Albizia saman	Rain tree	Melia azedarach	China berry
Albizia lebbeck	Women's tongue	Morus alba	Fruitless mulberry
Azadirachta indica	Neem tree	Morus nigra	Black mulberry
Bauhinia varie-gata	Orchid tree	peltophorum inerme	yellow ponciana
Coccoloba uvifera	Seagrape tree	Paulownia tomentosa	Princess Tree
cochlospermum religiosum	Silk-Cotton Tree	Peltophoroum inerme	Yellow poinsiana
Delonix elata	Royal poinsiana, flame tree	Thespesia populnea	Portia tree
Delonix regia	Flame of forest		

Appendix 1.2d. Medium Evergreen Trees

Botanical Name	Common Name	Botanical Name	Common Name
Acacia arabica	Arabian acacia	Schinus terebintifolius	Brazilian pepper tree
Acacia ehrenber-giana	Salam	Tipuana tipu	Rosewood
Acacia farnesiana	yellow mimosa	Tabebuia argentea	Silver Trumpet Tree
Acacia nilotica	Garat	Tabebuia impetiginosa	Pink Lapacho
Cordia myxa	Bambaar	Tabebuia rosea	White trumpet tree
Dalbergia sisso	Indian rosewood	Xanthorrhea sp.	Grass Tree
Hibiscus tiliaceus	sea hibiscus		

Appendix 1.2e. Small Trees or Large Shrubs

Botanical Name	Common Name	Botanical Name	Common Name	Botanical Name	Common Name
Aillanthus altissima	Tree of heaven	Cassia bake-riana	Pink Shower	Malvaviscus arboreus pendi-luflorus	Sleepy hibiscus
Alstonia schol-aris	Devil tree	Cassia glauca	Cassia glauca	Musa paradisi-aca	Banana
Bauhinia black-nea	Orchid tree	Cassia javanica	apple blossom tree	Nerium oleander	Oleander
bauhinia pur-purea	orchid tree	Cassia nodosa	Pink and white shower	parmentiera edulis	Candle Tree
bauhinia varie-gate	orchid tree	Cordia sebeste-na	Scarlet cordia, aloe wood	Plumeria obtusa	Temple tree
Bucidia buceras	Black Olive tree	Dodonaea viscosa	Hopseed bush	Plumeria rubra acutifolia	Temple tree Red flower)
Bambusa ven-tricosa -Thick stem	Buddha's Bel-ly Bamboo	Hibiscus ro-sa-sinensis	China rose	Polyalthia lon-gifolia	Ashoka tree
Caesalpinia gilliesii	Bird of paradise bush (yellow flowers)	Jatropha inte-gerrima	Peregrina	Punica grana-tum	Pomegran-ate
calliandra hae-matocephala	Red Powder Puff	khaya senega-lensis	African ma-hogany	Sesbania ses-ban	Sesban
Callistemon viminalis	Weeping bottle brush	Lagerstroemia indica	Crape myrtle	Tamarix sp.	Athel tree
Calotropis procera	Dead sea apple	Lagerstroemia loudonii	Thai Bungor	Tecoma stans	Yellow bells
Carica papaya	Papaya	Lagerstroemia speciosa	Pride of India	Thevetia peruvi-ana nereifolia	Yellow oleander
Cassia fistula	Golden show-er tree	Leucophylum frutescens	Texas ranger	Vitex agnus castus	Hemp tree

Appendix 1.2f. Shrubs			
Botanical Name	Common Name	Botanical Name	Common Name
Acalypha wilkesiana	Irish Petticoat	Jasminum sambac	Arabian jasmine
Bougainvillea glabra	Paper flowers	Ixora chinensis	Flame of the woods
Bougainvillea torch glow	Torch Glow	Ixora coccinea	Flame of the woods
Bougainvillea spectabilis	Bougainvillea	Ixora javanica	jungle geranium
Caesalpinia pulcherrima	Barbados pride (orange-red flowers)	Lantana camara	Lantana
Carissia grandiflora	Natal plum	Lantana montevidensis	Lantana
Cassia alata	the Candle Bush	Nandina domestica	Sacred bambo
Cassia bicapsularis	Senna	Tabernaemontana corymbosa	Great Rosebay
Cestrum diurnum	Day jasmine	Tabernaemontana divaricata	crepe jasmine
Cestrum nocturnum	Night jasmine		

Appendix 1.2g. Conifers	
Botanical Name	Common Name
Cupressus sempervirens	Italian cypress

Appendix 1.2h. Hedge			
Botanical Name	Common Name	Botanical Name	Common Name
Atriplex halimus	Salt bush-high salt tolerant	Myrtus communis	Myrtle
Atriplex lentiformis	Salt bush	Nerium oleander	oleander
Clerodendron inerme	Wild jasmine	Ruellia tuberosa	Ruellia
Dodonaea viscosa	Hopseed bush	Vitex agnus castus	Hemp tree
Leucophylum frutescens	Texas ranger		

Botanical Name	Common Name	Botanical Name	Common Name	Botanical Name	Common Name	Botanical Name	Common Name
Adenium obesum	Desert rose	Aloe arborescens	candelabra Aloe	Austrocephalocereus dybowskii	Cereus dybowskii	Euphorbia lactea	brain plant
Agave americana	Century Plant	Aloe clavifolia	Aanteelaalwyn	Austrocephalocereus estevesii	Thumbnail	Euphorbia milli	Christ plant
Agave angustifolia variegata	Caribbean Agave	Aloe dichothoma	quiver tree	Aylostera archibuininguiana		Euphorbia tirucallii	pencil tree
Agave attenuata	lion's tail	Aloe littoralis	on the coast	Carnegiea gigantea	saguaro cactus	Euphorbia stenoclada	Euphorbia insulae-europae
Agave elegans	Salm-Dyck	Aloe eru vicornuta		cephalocereus senilis	Old Man Cactus	Cereus sp.	Lady of the night cactus
Agave filifera	thread agave	Aloe excelsa	Zimbabwe Aloe	Cleistocactus braunii	climbing cactus	Echinocactus grussonii	Golden barrel
Agave geminiflora	Twin-flowered Agave	Aloe humilis	Spider Aloe	Cleistocactus jujuyensis	argentina cactus	Euophorbia lactea	Mottled Spurge
Agave lechugilla	lechuguilla	Aloe maculata	Zebra Aloe	Cleistocactus strausii	silver torch	Echinopsis hauscha	Red torch cactus
Agave macroacantha	Black-spined Agave	Aloe marlothii	Mountain Aloe	Copiapoa cinerea	chalky/ white stems	Ferocactus sp.	Desert Barrel
Agave nigra	sharkskin agave	Aloe melanacantha	Black-spined Aloe	Copiapoa haseltoniana	chille cactus	Furcraea gigantea	boojum tree
Agave potatorum verscafeltii	Dwarf Butterfly Agave	Aloe pelegrae	Pauline	Crassula	baby jade	Cephalocerus seniies	Old Man Cactus
Agave pygmaea	Dragon Toes	Aloe ramosissima	Maiden's Quiver Tree	Cylindropuntia bigelowi		Carnegia giganta cactus	saguaro cactus
Agave stricta	A young specimen	Aloe mitriformis	Gold Tooth	Didierea madagascariensis	Didierea	Mamelaria elongata	Monstrous Lady Fingers
Agave titanotta	Rancho Tambor	Aloe squarrosa	Yemen Aloe	Discocactus		Melocactus	Melon cactus
Agave verschaffeltii	Blue Agave	Aloe striata	coral aloe	Dyckia	brazilian cactus	Pachypodium Lamerei	Madagascar Palm
Agave victoria regina	Queen Victoria agave	Aloe tharskii	the Dune Aloe	Euphorbia alba		Portulacaria afra	elephant bush
Aloe vera (Berbadensis)	Medical plant	Aloe tomentosa	Hairy Green Aloe	Euphorbia canariensis	Canary Island spurge	Sansevieria trifasciata	bird's nest snake plant
Agave america mediopicta	Agave mediopicta	Aloe vaombe	Malagasy Tree Aloe	Euphobia enopla		Sansevieria hahnii	baseball bat
Agave victoria regina	Queen Victoria Agave	Aloe vera (Berbadensis)	Aloe indica royle	Euphorbia erythraea		Yucca elephantips	soft-tip yucca
Agave zebra	Zebra Agave	Aloe zebrina	Zebra Leaf Aloe	Euphorbia ingens	Euphorbia candelabrum	Yucca filamentosa	Adam's needle
Alluaudia procera	Madagascan Ocotillo						

Appendix 1.2j. Succulents and Aloe Vera							
Aloe vera (Barbadensis)	medicinal plant	Aloe vera tomentosa	Hairy green cactus	Euphorbia canariesis	Canary Island Spurge	Sansevieria Trevaciata	Bird's nest snake plant
Agave Americana Mediopecta	Mediopecta cactus	Cactus fombie	Malagasy cactus	Euphorbia anopla		Sansevieria hani	Baseball Bat
Agave Victoria Regina	Queen Victo-ria's cactus	Aloe vera (Barbadensis)	Aloe Indica Royal	Euphorbia Arrythria		Yucca Elephantps	Soft yucca tip
Agave Zebra	Zebra cactus	Aloe vera Zebrina	Aloe vera zebra plant	Euphorbia Engens	Candlestick Ephropion	Yucca velamentosa	Rangoon creeper
Aluidia Procera	Octolio Madagascar						

Appendix 1.2j. Vines			
Botanical Name	Common Name	Botanical Name	Common Name
Rail crawler	Ipomoea palmata	Coral vine	Antigonon leptobus
Yasmine Al-Shaer	Jasmine officinal Grandiflorum	Bougainvillea	Bougainvillea
Trumpet vine	Lonicera semperverin	Wild jasmine	Clerodendron Enrme
Rangoon Creeper	Quesqualis indica	Morning Glory Beach	Ipomoia Peace Capri

Appendix 1.2I. Seasonals

Botanical Name	Common Name	Botanical Name	Common Name	Botanical Name	Common Name
Ageratum mexicanum	Floss flower	Chryanthemum morifolium	Florist's mum	Pellionia pulchra	Training begoria
Amaranthus tricolor	Joseph's coat	Cosmos bipinnatus	Mexican aster	Petunia x hybrida	Petunia hybrid
Antirrhinum majus	Floral snapdragon	Dianthus barbatus	Sweet william	Polianthes tuberosa	The pearl
Asclepias curassvica	Blood flower	Dianthus chinensis	Chinese pink	Portulaca graniflora var. Corniche	Moss rose, sun plant
Calendula officinalis	Port marigold	Gaillardia pulchela	Blanket flower	Salvia splendens	Scarlet sage
Callistephus chinesis	China aster	Gazania splendens	Gazania	Senecio cineraria	Dusty miller
Catharanthus roseus	Madagasar periwinkle	Gomphrena globosa	Globe amaranth (red)	Tagetes	Marigold
Celosia cristata	Fair fountains	Kochia scoparia	Summer cypresus	Verbena peruviana	Aztec queen
Celosia cristata var.nana	Cockscomb	Lobularia maritima	Sweet alysum	Viola tricolour	Kiss-me-love
Celosia plumosa	Burut plume	Mathilola incana	stock	Zinnia sp.	Zinnia
Chrysanthemum carinatum	Monarch court	Pelargonium x hybrida	Garden Geranium		

Appendix 1.2m. Grass	
Botanical Name	Common Name
Cynodon dactylon	Bermuda grass-High salt tolerant
Paspalum vaginatum (notatum)	Bahia grass- seashore paspalum
Zoysia japonica	Japanese grass

Source: Public Parks Department (MME).

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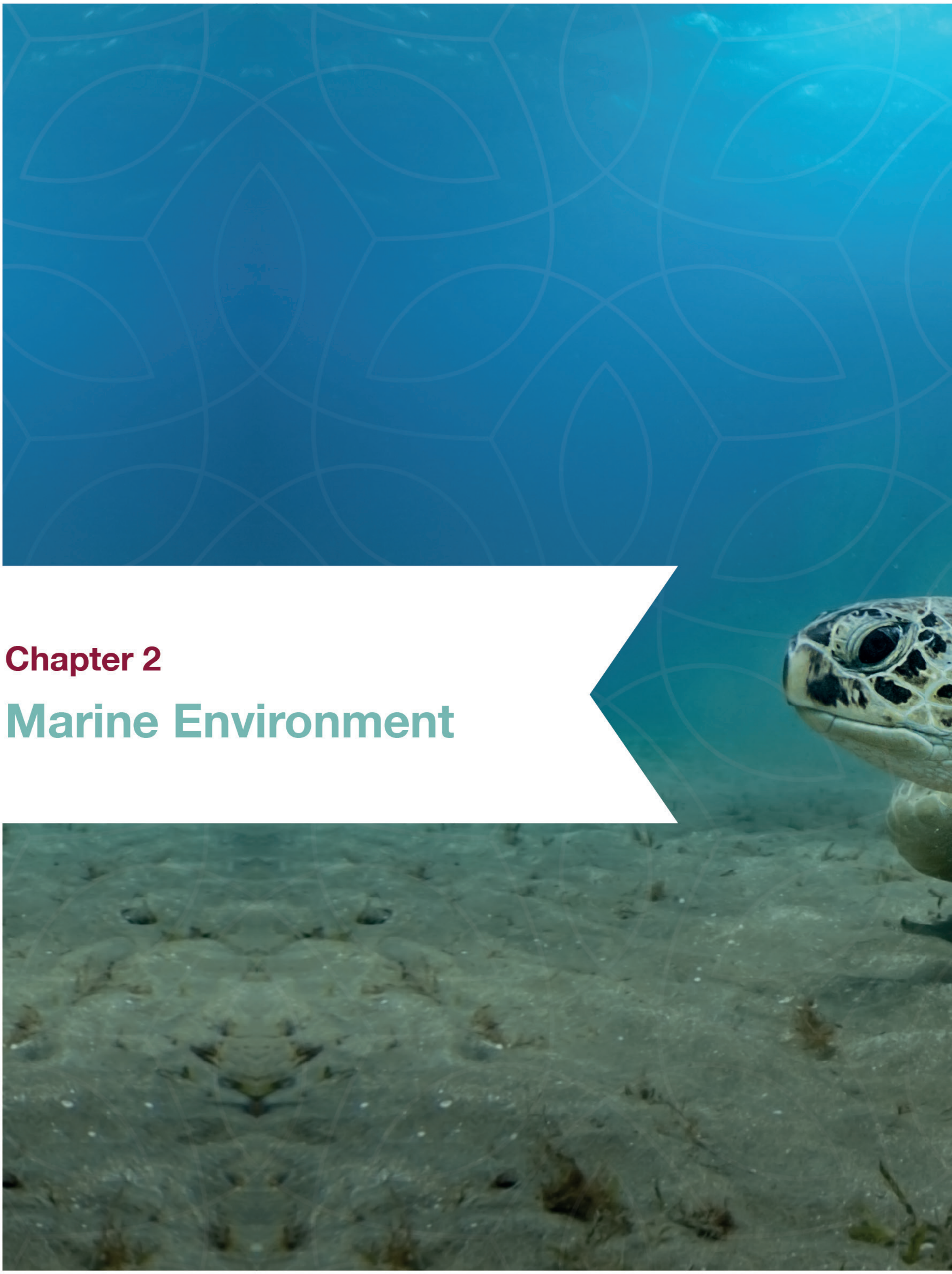
Chapter 2

Marine Environement



Chapter 2

Marine Environment

Chapter 2:
Marine

Marine environment of Qatar supports biodiversity, fisheries, trade, transport, recreation, and oil and gas industries. The marine area is three times the country's land area and the increasingly important ecosystem services,so there is much at stake in protection of this vast resource. A healthy marine ecosystem supports biodiversity, cultural and social values, and economy. It is a matter of concern that pressures on this precious resource are increasing. Among the more visible impacts could be loss of marine biodiversity and sustainability of fish populations. Marine environment is also adversely affected indirectly by climate change driven by human actions and which is causing acidification and warming of seawater besides other modifications. Dealing with these mounting pressures is challenging, requiring more knowledge that can contribute to improved governance. It stands to reason that any future direction for ocean governance and management must be knowledge-based and informed by the best scientific understanding. Since science is not static, it would require a continued

investment in knowing the anonymous and a quest for seeking explanation on the processes that take place in the sea. It could be that over a period of time the present-day solutions might need transformation or fine-tuning by increasing knowledge and societal concerns. From ecological and economic perspectives, monitoring the health of our marine resources is important for understanding the impacts and devising effective response. While there are on-going marine monitoring programs in Qatar, but especially structured research programs will be needed to transform the current efforts into investigative research. Such dedicated studies that will facilitate the development of a baseline information will also help in establishing the cause-and-effect relationships. Importance of baseline data can

not be overemphasized since the evaluation of environmental change depends on this information.

Enormity and complexity of marine ecosystem make it difficult to monitor its every aspect and, therefore, some indicators that reflect the overall state of the environment have been used. The criteria guiding their selection are relevance, interpretability, data availability, accuracy and consistency. Selected for this report biodiversity indicators, fisheries indicators and water quality indicators. Their rationale in describing the quality of marine environment has been elaborated in detail.

Education plays a vital role in environmental management. While Qatar has a good record of budgetary allocation for education, but the marine research deserves a better share through earmarked grants. Progress on this topic will generate information that will help in public awareness, worthwhile knowledge-generation and smart decisions vis-à-vis management of marine ecosystem. It will also assist in reducing the vulnerability to extreme events, rehabilitation of degraded resources, developing offset solutions and enhancing adaptation to changing climate. Mechanisms need to be institutionalized for prioritizing knowledge gaps, removing management barriers that impede action over the short term, and for promoting multi-sectoral approach to action.

An outlook for improving governance of marine environment in Qatar is greater emphasis on conserving marine natural resources. These nature-based solutions can be applied without delay and are cost-effective besides having many other advantages accruing from improved resilience of the vast marine ecosystem. A healthy ocean ecosystem of Qatar is a very important asset for meeting the challenge posed by climate change. Given the desert landscape of the country, the blue carbon stocks in the form of mangroves and seagrasses and other marine critical habitats deserve priority. Ecosystem approach to managing marine environment is the most rational way forward in terms of sustainability of services we derive from it for the welfare of society.

2.1 Introduction

The sea plays an important role in the lives of the people of Qatar. The relationship of the indigenous communities with the sea is historic and has evolved in important ways that have shaped the country's socio-economic development. This also reflects the seriousness with which the marine natural heritage is valued in Qatar. The cultural tradition of open access to the sea for transportation and fishing has been a unifying element in different sections of the society in the country. Pearl oysters and dried fish were the important commodities traded for a long period. Oil and gas reserves in the sea discovered in the recent past have contributed a great deal to changing the cultural and socio-economic landscape of Qatar, and enabled the country to emerge as an important player at the world stage. Primitive methods of catching fish and shellfish have given way to mechanized commercial harvesting. Trends of seafood consumption, navigation and other forms of interaction with the sea have undergone changes.

The increasing use of sea and effects of climate change have brought significant impacts to bear on the marine ecosystem. Some of these pressures have been examined and measures taken to address them. However, much more work is needed for understanding and mitigating pressures for a knowledge-based response to ensure protection of vital marine ecological processes and heritage. Marine environment of Qatar is a cradle for a diverse range of marine organisms. A healthy marine environment supports food supply, social well-being, and cultural activities and values. Benefits provided by the sea can be divided into 4 categories (Figure 2.1).

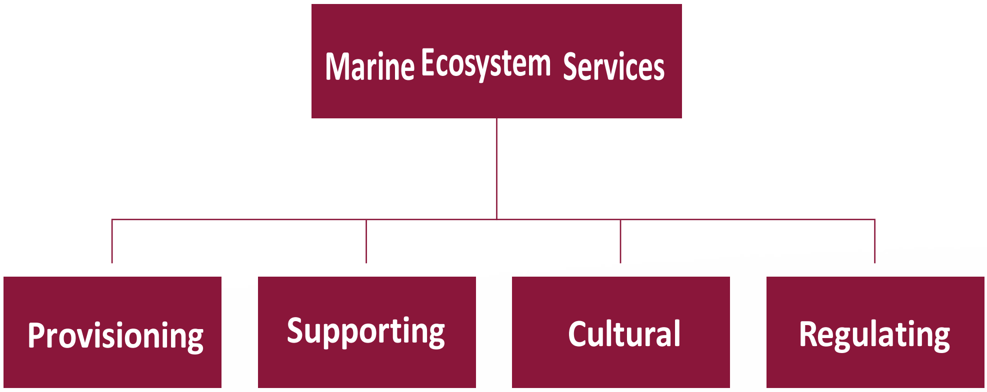


Figure 2.1. Marine ecosystem services.

Provisioning Services :

Seafood, fuel and water. Qatar meets most of its seafood requirements from capture fisheries. This industry provides employment to a large number of people. Qatar is now the biggest producer of natural gas in the world. Massive volumes of seawater are desalinated to meet the demands for human consumption. This is considered a critical water security program. The marine ecosystem of Qatar is home to a wide variety of organisms which can be a rich source of biopharmaceuticals, nutraceuticals and products of cosmetic importance. However, considerable R & D investment will be required for generating basic information and commercial extraction of these products. Many marine natural products have been used in traditional medicine in the country. Another area of interest could be renewable energy, which is a topic of growing interest.

Regulating Services : Regulation of weather and climate, water quality, carbon cycle and storage. Due to the regulatory role of the sea, Qatar is habitable despite the extremely hot and humid conditions that prevail in the summer months.

Cultural Services : Recreational and aesthetic benefits. There is a growing interest in coastal tourism. Scuba diving and other nature-based tourism in coral reef areas are limited activities. Cultures and traditions of many coastal communities are linked to the marine ecosystem.

Supporting Services : Nutrient cycling, photosynthesis, generation of oxygen that take place in the sea support organic productivity, and provide many goods and services used by humans. Marine critical habitats such as seagrass, mangrove and coral reefs are important breeding grounds and nursery areas for young stages of fish and invertebrates that support commercial and recreational fisheries. Mangrove and seagrass beds also stabilize sediments and reduce turbidity.

In view of these significant roles of the sea, it is necessary to assess the state of its environment and explain the deliberative processes and mechanisms to develop knowledge-based strategies for sustainable development.

The objectives of this chapter are:

a) To provide an authentic assessment of the state of marine environment of Qatar.

b) To examine the main pressures on the marine ecosystem and response mechanisms.

c) To identify some indicators that can be used to assess the environmental conditions and their changes.

d) To review the governance issues and their effectiveness, and project an outlook.

This chapter has been structured in a logical sequence that reflects connectivity among the topics covered. The introductory section that elaborates the significance of marine environment of Qatar provides a justification for giving it due attention. Structural components that define the focused topics are outlined under the objectives that are consistent with the essential goals of this state of the marine environment chapter. Coastal marine environmental profile comprising the key oceanographic features, including those unique to the marine environment of Qatar, islands and habitats provides an idea of the environment we are dealing with. Certain indicators of the state of marine environment (marine biodiversity, fish and fisheries and water quality) have been selected for their relevance and availability of scientific data for evidence. Pressures on the marine environment and response to mitigation measures for sustainable management have been detailed. The last section deals with the governance in view of the importance of this topic for the future of the marine ecosystem and its ability to continue to provide services to the society. It embodies discussion of the institutionalized arrangements, governance indicators and the future outlook.

Considerable scientific data had to be consolidated for synthesizing information of relevance. Existing data reflected the fragmented way in which studies were carried out. This initiative for producing the state of the marine environment chapter is an attempt to regularize a process of assessment of marine environment. Hopefully, the knowledge gaps as identified in this chapter will be filled up by research and data integration programs. Follow-up reports will be able to document our increasing efforts and their outcomes for the marine environment covering the three pillars of sustainable development (environmental, economic and social aspects) commensurate with our stewardship of the marine ecosystem.

2.2 Coastal Marine Environmental Profile:
2.2.1 Oceanographic Features:

Qatar is a peninsular country in the Arabian Gulf, located between 24o27' and 26o 10' N latitudes, and 50o 45' and 51o and 40' E longitudes. Maximum length of the country is 200 km approximately along the north-south axis and east-west width at its widest point is less than 100 km. The country is surrounded by the Arabian Gulf from all sides except the south where it joins the eastern province of Saudi Arabia with a land boundary of 60 km (Figure 2.2).

Climate is a typical arid desert type, characterized by low rainfall with an annual average of about 80mm, high temperature that generally ranges from 40 – 45oC during peak summer.

months, high evaporation (annual average =2200 mm), high relative humidity and strong winds. There is no permanent surface water in Qatar. Temperature of the upper layers of the coastal sea varies widely, depending on season.

In winter, the temperature reaches 12oC and exceeds > 38.6oC in summer. A strong sea breeze prevails along the coastline and is caused by significant difference in temperature between land and seawater.

As the sea breeze circulates, it adds a landward push to the winds. The Arabian Gulf is about 1,000 kilometers in length and 200-300 kilometers in width.

Depth of the water column averages 35 meters. However, along the coast of Qatar, the depth of sea is approximately 20 meters. Bathymetric data shows a depth varying from an intertidal zone of <0.5 m to a maximum of 30 m.

The deepest point is 75 meters near Al Shaheen. The seabed is heterogeneous in substrate features- pure sandy substrate, silty, sandy-stony substrate or a hard-rocky bed of coral rubble. Water movement is driven by tides, winds and density difference.

Currents due to tides follow a tidal pattern, and thus change in a matter of hours. Wind-driven currents develop and fluctuate with the duration and intensity of winds.

Density-driven currents take several weeks to change in response to seasonal forcing. Tides, winds, currents and waves are strong enough to cause turbulence and mixing of water columns. Tides are complex, varying from semi-diurnal to diurnal. Generally, tides are >1 meter (mostly 1.4 meter). Current movement is in southern direction. The wave height is 30 – 120cm but can reach 450 cm during extreme events (Sivasubramaniam and Ibrahim, 1984).

The average sea temperature varies from 18.7o to 32oC (Al-Maslamani et al., 2009).

Decline of temperature in winter increases the density of surface water while warming in summer produces a reverse effect.

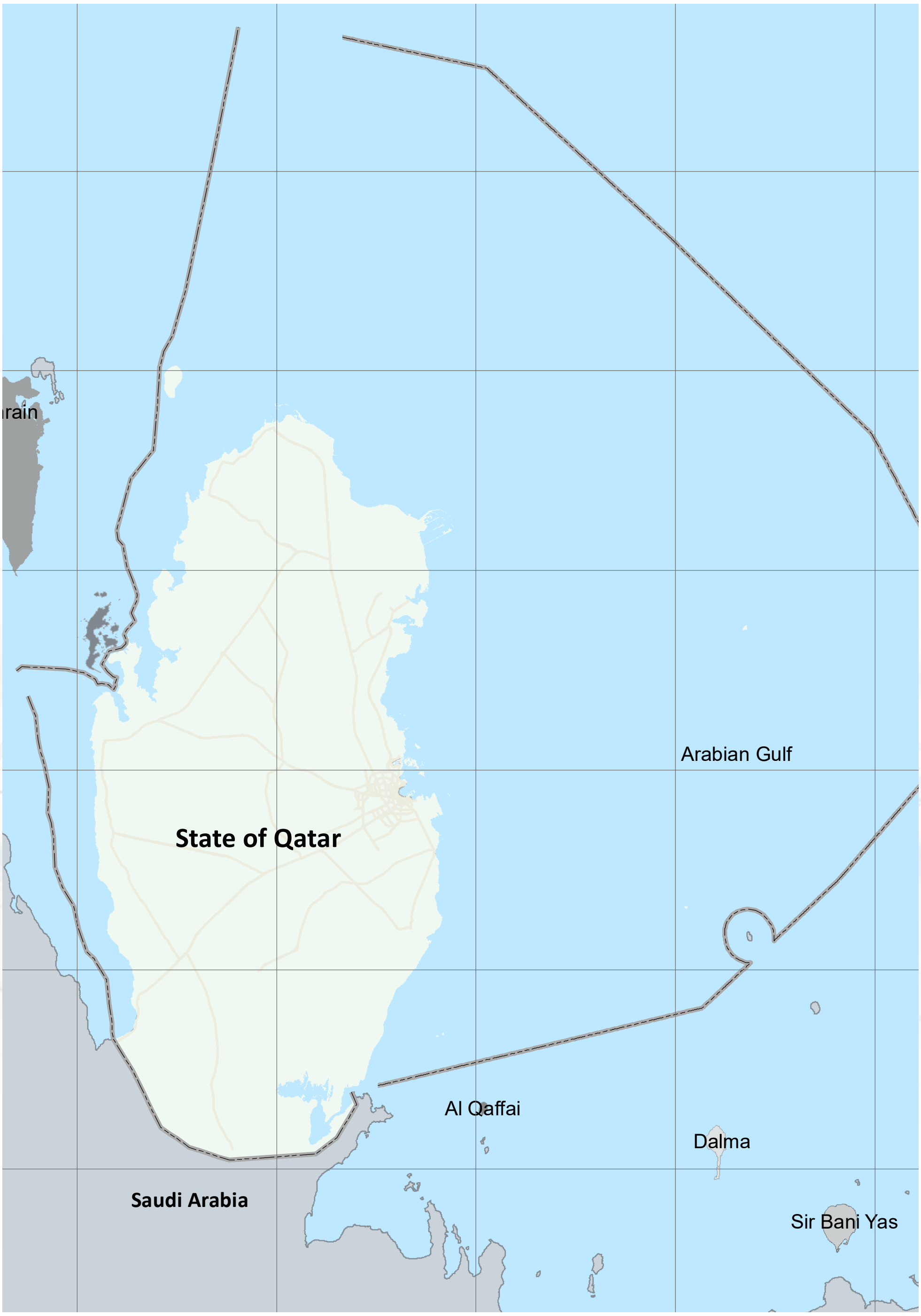


Figure 2.2. Location of Qatar in the Arabian Gulf.

The density gradient plays a significant role in water circulation, which is generally counter clockwise. Density of water in the shallow region near the shore increases during winter because of the cooling of hyper saline seawater. Evaporation also contributes to increase in the salinity and density of surface water. Salinity is high, 35.5 – 44.5 ppt (Al-Maslamani et al., 2009), and in localized areas the value can go up to 60 ppt (Khawr Al Udayd) and 70 ppt in Gulf of Salwa (UN, 1997).

Strong winds that prevail in Qatar not only help in mixing water but also prevents thermal stratification that tends to develop in summer. Strong tidal currents are effective in flushing, which contributes, among other factors to oxygenation of water. Mixing and flushing of water also tend to offset nutrient accumulation. Surface waters are nearly saturated with dissolved oxygen. Whenever upwelling happens, it can result in elevated levels of nitrate and phosphate. The country experiences a regional wind pattern called 'Shamal' that blows in the north-west direction and can happen any time during the year. Shamal has a significant impact on the oceanography of the area as it brings large amounts of sand and dust that are deposited in coastal waters and contribute to high turbidity. At the same time, the strong winds so produced increase the mixing in the water column. Marine domain of Qatar stretches from the seashore to the outer limits of the exclusive economic zone. The marine area measures some 35,000 km2 which is almost three times the land area of the country. Length of the coastline is 563 km (Smyth et al., 2016) which is subjected to a southeasterly surface circulation (Kampf and Sadrinasab, 2006).

2.2.2 Islands:

Qatar has several islands; most of them are close to the shore while

No	Island Name	Qatar National Grid	WGS84		
		Easting	Northing	Latitude (N)	Longitude (E)
1	Al Aszhat Island	241676	334036	24.75739	51.62794
2	Al Beshairiya Island	238528	381862	25.18922	51.59814
3	Al Jazira Island	227719	421104	25.5437	51.4917
4	Banana Island	243279.3	393925.725	25.298	51.64566
5	Haloul Island	320010.6	436098.868	25.67443	52.41128
6	Reken Island	200071.4	491104.127	26.17582	51.2166
7	Umm Tais Island	204451	489810	26.16413	51.2604
8	Janan Island	151762.9	422777.673	25.55828	50.73586
9	Abu Matar Island	233747.5	431005.527	25.63296	51.55194
10	Al Aaliya Island	235467	405812	25.4055	51.56839
11	Al Khuwair Island	186870	480143	26.07682	51.08465
12	Al Nakheel Island	231380	394684	25.30514	51.52752
13	Al Safliya Island	236338	399442	25.34798	51.57688
14	Bin Ghannam Island	233485.5	437622.274	25.69269	51.54949
15	Yemaz Island	238184.8	440854.127	25.72175	51.5964
16	Sheraouh Island	302357.3	364680.932	25.03116	52.23008
17	Umm Al Far Island	236245	442823	25.73957	51.57713
18	Al Besheriya Island	240758.5	357311.678	24.96754	51.61954

Table 2.1 (Cont.): Islands in Qatar territorial waters and their respective coordinates in Qatar National Grid.

2.2.2.1 Halul Island:

Halul Island is situated about 90 km east of Al Khor city. It is an oceanic island measuring 2 km along the north-south axis and 1.2 km east to west. Halul Island is composed of compac of the area has not been ignored. Marine turtles use the island for nesting. That area has been demarcated for preserving its pristine status as far as possible to allow unfettered access to turtles and unhindered incubation and hatching of their eggs. Halul, by virtue of most diverse coral formations in Qatar, with its high fish diversity and use by turtles for breeding (CREOCEAN, 2009, 2011) is of very high ecological sensitivity. of the area has not been ignored. Marine turtles use the island for nesting. That area has been demarcated for preserving its pristine status as far as possible to allow unfettered access to turtles and unhindered incubation and hatching of their eggs. Halul, by virtue of most diverse coral formations in Qatar, with its high fish diversity and use by turtles for breeding (CREOCEAN, 2009, 2011) is of very high ecological sensitivity.

2.2.2.2 Al Aaliya Island:

Lies at a distance of 7 km east of Doha. Covers an area of 1.8 km2. Topography is flat. Surface layer is made up of sand and limestone. Rocky projections are seen in some places.

2.2.2.3 Al Safliya Island:

Situated 5 km from the mainland, this island covers an area of 1 km2. A layer of sand covers the rocky base. The island offers stunning skyline, especially during sunset.

2.2.2.4 Sheraouh Island:

Located about 63 km from the coastline. Covers an area of 1 km2. Fringing reefs are found on one side of the island. Its sandy beach attracts marine turtles. It is a favorite spot for sea birds.

2.2.2.5 Al Aszhat Island:

About 10 km from the mainland, this island covers an area of 6 km2. Consists of 3 islets bordered by cliffs, and has detached rocks.

2.2.2.6 Al Besheriya Island:

Just about 1.5 km from the coast, this island is spread over 5 km2.

2.2.2.7 Reken Island:

Located near the mainland at a distance of 2 km and covers an area of 1.4 km2. A small growth of mangrove is seen on the southern side. Other small islands in Qatar are ecologically important. It is beyond the scope of this chapter to cover their details.

2.2.3 Coastal Marine Habitats:

Marine environment of Qatar is home to many different organisms ranging from microscopic planktonic forms to large whale shark and marine mammals. Their interactions with the hypersaline environment define the uniqueness of the country's marine ecosystem. Habitats that make up this system range from the productive nearshore regions to the open sea and sea bed. Temperature, salinity, tides, wave action, currents, light and substrate are among the physical factors that influence the diversity and functioning of these habitats. Discussion in this chapter pertains to habitats found in the area that extends from the shoreline to nearshore region on the continental shelf. Coastal marine habitats in Qatar have been structured by both non-living and

living components. While the former comprises the geological structures such as intertidal rocks and sub-tidal substrates among others, the latter include living or dead organisms. Some of these are in the form of plants (ex. mangrove and seagrass). Others are of animal origin, such as coral reefs or shell deposits.

Water is a critical non-living element of the habitat. Its various attributes, especially salinity, determine the habitat suitability of many marine species. Some marine animals (for example, corals) and plants (for example, mangrove and seagrass) act as ecosystem engineers that shape the areas of their occurrence in the marine environment to create habitats for other organisms. Mangrove and seagrass habitats also protect the coastline from wave action and erosion in addition to capturing sediment to improve the living space for corals and other forms of marine life.

2.2.3.1 Coastal Sabkha:

Sabkha is an onshore salt marsh in the form of a flat lowland close to the highest tidemark and is often flooded with seawater during high tides. Generally, made up of sand or silt, these are very saline coastal areas characterized by unconsolidated carbonate or siliciclastic sediments, minerals and sedimentary deposits. When evaporation is high, a thin layer of salt and gypsum forms in shallower areas. Close proximity of Sabkha with the seawater prevents blowing of sand during strong winds. Sabkha may be associated with coastal sand dunes, the most prominent being around Khawr Al Udayd where a spectacular interface develops between landscape and seascape. Sand dunes may be mobile, or somewhat stable. The latter supports only specialized species of vegetation, particularly beach grass or plants that withstand extremely dry sand (xerophytes) and some animals. Sand dunes are the work of the wind. Wind blows sand into a sheltered area, and over a period, the accumulated sand takes the form of a dune, which has a windward side and a slip face. Sand dunes protect the land from waves and force of the seawater surge during strong winds. Because environmental conditions at the seafront are harsh, the biodiversity is low. Only halophytes adapted to tolerate high salinity grow in some areas in the regions of Sabkha in addition to salt-tolerant bacteria and some blue-green algae. Other likely organisms are algal mats consisting of cyanophytes, diatoms and bacteria. These are efficient in fixing nitrogen. Sabkha provides habitat to many benthic species. The diversity of species and their stock strength decrease with increasing distance from the sea.

2.2.3.2 Intertidal Areas:

There is a vast area of seashore in Qatar that is submerged under water at high tide and exposed to air at low tide. These intertidal areas are dynamic environments where conditions keep

changing. Many species of invertebrates are distributed in the entire range of the area between the tidemarks. These include molluscs, crustaceans and annelids. Annelid worms burrow in the soft land. Small crabs make burrows where they take shelter during low tide to prevent desiccation. Snails close their shell with the operculum when water recedes and open it when high tide covers the habitat.

Three distinct intertidal areas include mud flat, rocky shore and sand bank. Mud flat is formed where energy is low, allowing clay particles to settle down. Some species of birds are attracted to mud flats for feeding purposes. Rocky shores are evident as hard cliffs projecting from the shoreline and reaching a height of up to 15 meters and are prominent in Fuwayrit. Intertidal sand bank is an area on tidal beaches containing higher proportion of sand that has substantial quantities of silt and calcareous matter unlike clay-rich mud flats. Intertidal sand bank is the most prominent type of intertidal area that forms the tidal beach along the coastline of Qatar. It consists of calcareous sand mixed with silt. It provides habitat for benthos. Many species of benthic animals inhabit this area, subsisting on organic matter in the sediment. Marine worms, mollusks and small crustaceans occupy the

intertidal sand bank. Small crustaceans make burrows where they recede during low tide to avoid desiccation of their bodies. Some birds make nest in sand banks. Many bird species visit this habitat for gathering food.

2.2.3.3 Sub-Tidal Sand Beds:

Qatar has a vast subtidal area below the low tide mark. It is submerged most of the time. Some sand bears are away from the shore and perpetually submerged under water. Sand and gravel form the substrate of this area. However, rocks and coral deposits also occur there. This habitat is less disturbed by wave action and, therefore, provides a stable condition for many species of marine animals, including polychaetes, mollusks, shrimp and crab.

2.2.3.4 Mangrove:

Mangroves are salt- tolerant trees usually found in association with mudflats. Due to the severe climatic condition, only one eurythermal & euryhaline species Avicennia marina (Figure 2.3) grows in Qatar. Although the species diversity of mangrove is limited to only this single species, but this species is remarkably well-adapted to very high salinity, temperature and evaporation. This would be possible with a rich genetic diversity due to which it has adaptable genotypes.

Figure 2.3. Mangrove - a precious coastal vegetation

It grows up to a height of 5 meters and is found mostly in higher intertidal regions. This mangrove excretes salts through its leaves to maintain internal balance. Even when temperature exceeds 45oC and strong winds blow across the coast, the mangrove remains green and healthy. It reproduces from April to October (outside winter season) although proliferation by vegetative means occurs throughout the year. Mangrove has been reported to cover an area of 5 km2 (= 500 ha). There has been no change in this area since 1990 until 2005 (UNEP, 1999) and until 2010 (FAO, 2010). Although there is no published record for recent years, if this coastal vegetation has been preserved due to increasingly stringent conservation measures, it would reflect the success of conservation measures. For a country like Qatar with small land area and high rates of coastal erosion, the role of mangrove ranging from stabilizing the coastal areas by controlling erosion, buffering the action of currents and controlling seawater intrusion is important. Furthermore, the mangrove vegetation also supports fisheries by providing a habitat for larval stages of many commercially important species, increasing their chances of survival, growth and recruitment. In arid condition where green carbon stocks are very limited, mangrove provides a resource for blue carbon sequestration.

2.2.3.5 Seagrass Meadows:

Seagrass beds (Figure 2.4) develop on unconsolidated and stable substrates that allow penetration of roots. Seagrasses are flowering plants. They require light to carry out photosynthesis and are, therefore, limited in their distribution to shallow water depths. They provide a mostly indirect food source and habitat for both resident fauna and some crustaceans. There are mainly three species of seagrasses found in Qatar, including halodule uninervis, halophila ovalis and halophila stipulacea. The most common among these species is Halodule

uninervis. None of these species can grow in very turbid water and where salinity is extremely high (60-70 psu) that happens in some areas of Qatar.

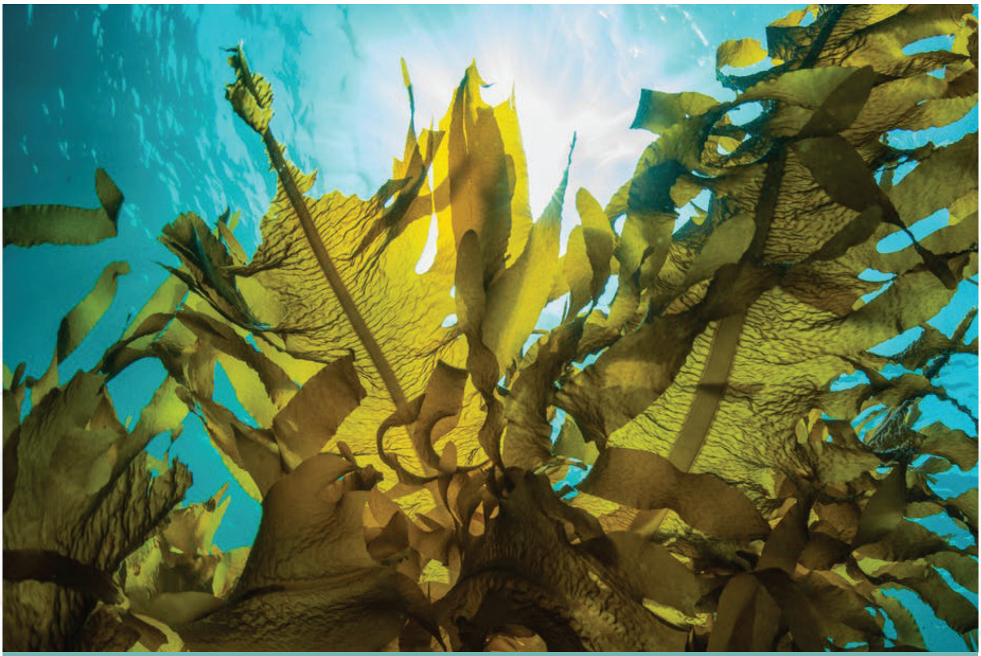


Figure 2.4. seagrass bed - a valuable natural resource in Qatar

Many species of fish, green turtle and dugong consume seagrasses. They provide nursery ground and shelter to larval stages of several species of finfish, shrimp and molluscs. Seagrasses also filter the sand and allow cleaner water to move towards coral reefs. By mitigating the force of currents, seagrasses protect the shore. Due to these roles seagrass beds are considered to have high ecological importance.

2.2.3.6 Coral Reefs:

Water around Qatar is generally shallow which present major constraints against reef development. The west of the country borders the Gulf of Salwa where salinities are double that of oceanic water and thus, coral reef are absent. On the northern and eastern coasts, salinities are less elevated and there is extensive coral growth. Coral reefs are shallow and are low in diversity but are well developed along the east coast. There are 10 different genera of corals belonging to 4 families (siderastreidae, portitidae, faviidae and dendrophylliidae) known to be distributed in Qatar (CREOCEAN, 2009). These are among the most diversified of the marine critical habitats in the country. Due to difficult environmental conditions and anthropogenic factors, coral bleaching is common. Corals are particularly vulnerable to ocean hotspots that often develop during peak summer season from July–August.

Coral reefs (Figure 2.5) are repository of marine biodiversity. There are many species of fish and invertebrates that use coral reefs for feeding, breeding and shelter. Some species, especially groupers, are closely tied to coral reefs. The connectivity of coral reefs with seagrass beds is evident from dependence of various stages of life of certain marine animals in these critical habitats. The species diversity and ecological roles performed by coral reefs make them a highly sensitive habitat.

Figure 2.5. Coral reefs of Qatar are home to diverse types of marine animals despite some extreme environmental conditions. Source: M. Al-Jaidah.

2.2.3.7 Macroalgal Beds:

Marine macroalgae (seaweeds) are plant-like organisms belonging to the kingdom protista. They are not true plants. They lack a vascular system in the form of roots, stems and leaves for transport of liquid and nutrients. Seaweeds also do not produce flowers, seeds, and embryos. These organisms are placed under a separate phylum 'protista'. They possess chlorophyll for photosynthesis and some species have other light-absorbing pigments. There are three types of seaweeds, namely green, brown and red macroalgae. In the coastal water of Qatar, as many as 13 species of seaweeds have been documented (Heiba et al., 1997; CREOCEAN, 2009; 2011). They are often encountered on the beaches or seen floating on the surface. Sunlight is the limiting factor in their distribution. Seaweeds can be used in biomonitoring of coastal marine waters due to significant correlation between seawater and metal concentration in their tissues. In this connection, it is worth mentioning that a species of seaweed (Cystoseira trinodis) found in Qatar can be considered as a suitable bio-indicator of metal pollution. Use of this species in biomonitoring the Mediterranean Sea has been reported earlier (Khalid et al., 2014). A regular program of monitoring of metal concentration in this alga can help in detecting metal contamination of seawater due to anthropogenic activities anywhere along the coastline.

Seaweeds have important ecological roles. They are a source of food for marine animals such as sea urchins, fish and even turtles. Seaweeds provide shelter to fish and invertebrates, and serve as nurseries for many animals. Habitats described above differ in ecological sensitivity (Table 2.2). This is based on their role in the ecosystem, especially in biodiversity, and that defines their conservation significance in coastal zone management. Marine habitats are variable and support a large variety of productive marine ecosystem and biodiversity. Protecting them is essential for preserving biodiversity in the sea. Migratory species tend to inhabit more than one natural habitat, and this requires protection of not only those habitats but also the migratory routes for reasons of ecological connectivity. There are conflicting reports on the number of marine species known to occur in Qatar. This chapter takes into account the species that are specifically mentioned in the Qatar Marine Environment Monitoring Program (QMEMP) 2018 report in addition to the published record available to date. There are as many as 899 species of marine organisms and an additional 24 species of seashore birds listed in this chapter. This matter is discussed in the forthcoming sections.

Table 2.2. Coastal marine habitats in Qatar	
Coastal habitats	**Ecological sensitivity**
Coastal sabkha	Low
Intertidal habitat Mudflat Rocky shore Sand bank	Medium Medium Low
Sub-tidal sand bank	Medium
Seagrass meadow	High
Mangrove	High
Coral reef	High
Macroalgal (seaweed) bed	Low

(Source: Heiba et al., 1997; CREOCEAN, 2009; 2011).

2.3 Indictors of Coastal Marine Environment:

Marine ecosystem is complex, and no single indicator can adequately describe its overall condition or all aspects of its functional dynamics. The indicator performance may differ with the nature of marine ecosystem of a particular area, trend of exploitation and pressures such as pollution and habitat degradation (Cury and Christensen, 2005). Accepting the criteria outlined by FAO (1999) for an indicator as a variable pointer or index whose fluctuations reveal the key elements of the system, marine environmental indicators in this report selected from three thematic areas are:

a) Biodiversity indicators

b) Fisheries indicators

c) Water quality indicator

Selection of these indicators is based on their ecological value, data availability and practicality for assessment and management decisions. Given the ground realities in Qatar, these indicators are appropriate for monitoring and reporting progress towards sustainable development. Because marine biodiversity and conservation-based indicators are complementary to ecological indicators of fishing pressure, they can be useful in providing information relevant to evaluation of the impacts on exploited marine ecosystems (Coll et al., 2016). These indicators can reflect health and functional integrity of marine ecosystem, rather than the quality of a specific aspect of the environment (for example, level of nitrate and phosphate pollution). Efforts have been made to present information on each indicator with respect to: issue, which the indicator is intended to highlight, policy objective, which it is intended to inform, and the explanation covering the process of assessment for reporting the indicator's status or trend and related information.

2.3.1 Marine Biodiversity-related Indicators :

These indicators could be related to species, habitats and community structure. The main issue is the pressure on marine environment that requires action to reduce further degradation of any of the environmental components, and where possible to mitigate the condition. The policy objective is fulfillment of aims of the Convention on Biological Diversity signed and ratified by the Government of Qatar. Explanation includes the assessment methods or action plans followed for biodiversity conservation backed up by an illustrated presentation of status or trend.

Some of the important marine biodiversity indicators are as follows :

a) Marine biodiversity profile (or biodiversity inventory)

b) Change in the status of threatened species

c) Coverage of marine protected areas

d) Marine trophic index

e) Population of seashore birds

2.3.1.1 Marine Biodiversity Inventory:

Marine biodiversity has assumed importance in Qatar especially after the country signed and ratified the Convention on Biological Diversity. Of the three levels of marine biodiversity – genetic, species and ecosystem, the focus of attention in Qatar has been mainly on the species level. This is not to suggest that species diversity is more important than the other two aspects, but because it is more practical and convenient to work on species inventory at least in the initial phase of the work on as complex and as comprehensive a topic as marine biodiversity. Interest is catching up in genetic diversity. A beginning has been made for DNA barcoding on hawksbill turtle. Using mitochondrial cytochrome C oxidase gene, the DNA barcode has been compared with the gene bank database. The results suggesting 94-95% homology in the population sample (Environmental Science Center, 2016) are of conservation importance.

Qatar is uniquely placed for investigating genetic diversity because of low species diversity in some groups. For example, only one species (avicennia marina) represents the entire mangrove flora in Qatar, and its survival under a wide range of environmental variability, particularly summer temperature, and extremely high salinity and evaporation requires considerable genetic variability. A high genetic diversity implies a greater number of genes in the population that could translate into the ability of some individuals of the species by virtue of their more resilient genes to adapt to the environmental extremes and continue to evolve with time. Although genetic data on this mangrove species is not available, it can be presumed that the high DNA diversity has helped it evolve the necessary adaptations to survive in difficult environments, especially about temperature, salinity and oxygen levels. It makes sense to protect their number (population) as a strategy to conserving the variability. Any significant reduction in the number of individuals deletes the genotype variability.

There should be interspecific differences in the genetic variability across the populations of individual species of flora and fauna. An in-depth understanding of this variability and the complexity of the processes governing adaptation to extreme environment will throw light on the nature and scale of the needed conservation intervention to manage the marine biological resources. This important topic requires a long-term study.

Marine organisms in this area are believably living close to the limits of their tolerance to physical environment (Price et al., 1993). These organisms could provide unique opportunities for research into adaptable genotypes and for developing models for climate change

adaptations. Understanding of the natural mechanisms that marine life of the Gulf uses might help in possible application of the information for conservation of marine biodiversity in other places as well.

Not all species will have as high a level of genetic variation as the mangrove to allow them to evolve rapidly with the help of adaptable gene complexes. For this reason, studies on genomes of wild populations of marine organisms in Qatar deserve priority.

Qatar has started developing a comprehensive marine biodiversity inventory through the Qatar Marine Environment Monitoring Program (QMEMP) which assists in narrowing the knowledge gap in the field of Qatar's marine biodiversity and generate information on the role of environmental heterogeneity and variables in driving the patterns of biodiversity composition. Undoubtedly, the marine environment is quite diverse, exceeding the arid terrestrial ecosystem in terms of the variety of habitats and number of species, necessitating a regular updating of the inventory with progress in research.

The information retrieved from QMEMP & many other sources is presented here to give an idea of the country's marine biodiversity heritage. The few available reports suggest different numbers of marine species known to exist in Qatar, as an attempt to provide a validated inventory of marine species.

According to the annual report of QMEMP for 2018, the average number of phytoplankton species recorded was 102 species, and represented mainly by diatoms, followed by dinoflagellates, and only one species represents blue green algae cyanophyta.

While this program mentioned that the average number of zooplankton species is 43 species and represented by holoplanktonic (permanent members) and meroplanktonic (temporary larval members) forms of protozoa, cnidaria, chaetognatha, annelida, arthropoda (especially copepoda), mollusca, echinodermata, appendicularia, fish eggs and larvae. Of all these species, copepods were the most abundant as a group and the most varied in number of species (18 species).

In addition to the previous information regarding QMEPM report, other documented information was reviewed and this has enabled listing of as many as 899 species in the inventory (Table 2.3). Additionally, there are 24 species of seashore birds (Table 2.4) closely associated with the marine ecosystem and are of great importance in the ecology of coastal zone of Qatar. It is evident from the data presented here that plankton (phytoplankton, zooplankton), porifera, cnidaria, annelida, sipuncula, arthropoda, mollusca, echinodermata and chordata constituted 11.35%, 4.78%, 1.33%, 5.01%, 0.67%, 0.11%, 2.56%, 41.16%, 3.67% and 26.92%, respectively to the total number of recorded species of the marine fauna. Marine flora was limited in species number, with only one species (avicennia marina) representing the mangrove (0.11%) and 3 species (halodule uninervis, halophila ovalis, halophila stipulacea) of sea grasses (0.33%). Under IUCN Red List, all these marine plants are in the category of 'Least Concern'. While there is no recent data on their coverage in Qatar, the global trend for this species of mangrove is declining and is stable for seagrasses. The generic threats are coastal infrastructure development, pollution, resource use, extreme weather conditions and climate change. Planktons are key components of marine ecosystem, forming the base of most marine food webs. Among the protists, foraminifera is an important part of the marine food chain and seaweeds are of ecological and economic importance. Sponges, marine polychaete worms, unsegmented marine worms, cnidarians and echinoderms play vital ecological roles at different levels. Marine crustaceans and molluscs are commercially, as well as ecologically, significant groups of marine invertebrates. Mollusca is the most diverse group, occurring on a wide variety of substrates such as sandy beaches, rocky shores and mud flats, and occupying many habitats in the sea. For example, members such as cuttlefish are active swimmers and predatory while others such as giant clams live a sedentary life. Except for fish, the other chordates were limited in terms of species diversity. Fish outnumbered all the other marine chordates, constituting 91.73% of the total marine chordates. Their role in ecosystem functioning and economy of scale cannot be overemphasized. Other classes comprising tunicates, reptiles and mammals are prominent representatives of marine fauna of great value.

Table 2.3. Marine biodiversity inventory.

Taxonomic group	Number of species	Proportion (%)
PHYTOPLANKTON	102	11.35
ZOOPLANKTON	43	4.78
Foraminifera Seaweed	3 15	2.00
PORIFERA (sponges)	12	1.33
cNIDARIA (corals & sea anemones)	45	5.01
ANNELIDA (segmented marine ploychaete worms)	6	0.67
SIPUNCULA (unsegmented marine worms)	1	0.11
ARTHROPODA (crustacea: shrimp, crab, lobster)	23	2.56
MOLLUSCA (gastropods, bivalves)	370	41.16
ECHINODERMATA	33	3.67
CHORDATA Tunicates Fish Sea turtles Sea snakes Marine mammals	242 4 222 5 5 6	26.92
Halophytes MANGROVE	1	0.11
Angiosperms SEAGRASSES	3	0.33
TOTAL	899	100

Table 2.4: Seashore birds in Qatar.				
No	Species	Common name	Status in IUCN Red List of Threatened Species	Global trend
1	Alcedo atthis	Kingfisher	Least concern	Unknown
2	Ardea cinerea	Grey heron	Least concern	Unknown
3	Ardea purpurea	Purple heron	Least concern	Decreasing
4	Calidris alpina	Dunlin	Least concern	Decreasing
5	Charadrius leschenaultia	Greater sand plover	Not assessed	Unknown
6	Charadrius mongolus	Lesser sand plover	Least concern	Unknown
7	Cursorius cursor	cream coloured courser	Least concern	Stable
8	Egretta garzetta	Little egret	Least concern	Increasing
9	Egretta gularis	Western reef heron	Least concern	Stable
10	Eremopterix nigriceps	black-crowned sparrow lark	Least concern	Increasing
11	Falco tinnunculus	Common kestrel	Least concern	Decreasing
12	Haematopus ostralegus	Eurasian Oyster catcher	Near threatened	Decreasing
13	Larus cachinnans	Yellow-legged gul	Least concern	Stable
14	Larus fuscus	Lesser black-backed gull	Least concern	Increasing
15	Larus genei	Slender billed gull	Least concern	Increasing
16	Larus hemprichii	Sooty gull	Least concern	Decreasing
17	Merops apiaster	European beef eater	Least concern	Stable
18	Numenius phaeopus	Whimbrel	Least concern	Decreasing
19	Pandion haliaetus	Osprey	Least concern	Increasing
20	Phalacrocorax nigrogu-laris	Socotra cormorant	Vulnerable	Decreasing
21	Phoenicopterus ruber	Greater flamingo	Least concern	Increasing
22	Sterna (Thalasseus) bengalensis	Lesser crested tern	Least concern	Stable
23	Sterna repressa	White-cheeked tern	Least concern	Decreasing
24	Tringa nebularia	Common green shank	Least concern	Stable

(Source: RLIC, 1999).

Presence of Non-native Species:

Three non-native species of marine animals reported to occur in Qatar include: cuttlefish (Sepia pharaonis), blue swimming crab (Portunus pelagicus) and flathead locust lobster (Thenus orientalis). There is no record to suggest that they were deliberately released into the local environment by permission of the government. It could be that these species were introduced elsewhere and then expanded the geographical coverage to enter Qatar's marine environment. Their regular occurrence in the catch (Department of Fisheries, 2013) suggests that they have established populations in the wild. It is difficult to confirm if there are other exotic species, especially the microscopic ones, due to limited nature of marine monitoring program and a lack of baseline data for comparison. However, considering the scale of shipping for trade, it is expected that large volume of ballast water is discharged in and around marine zone of Qatar. This could have introduced exotic organisms. There is no commercial aquaculture in Qatar, so it is unlikely to be the source of non-native species. While ballast brings planktonic organisms, but many marine animals have a planktonic stage in their early life cycle, and if they happen to enter the ballast water and survive until discharged then the larvae can develop into adults. Such exotic forms may be fish, barnacles, jellyfish, molluscs, and possibly others. The extreme environmental conditions, especially very high salinity, might offer some natural protection against alien species, but it depends on the origin of ballast, time of the year it is discharged, and resilience of the species to survive the transport period before discharge and their survival in the new environment. We cannot, however, rest assured that natural conditions will take care of the problem. When logistical arrangements are in place Qatar will be able to enforce the ballast management regulations. As far as deliberate introduction of alien species is concerned, the government policy is not to allow it for protecting the marine biodiversity consistent with the recommendations of the Convention on Biological Diversity.

2.3.1.2 Status of Threatened Species:

This section covers those species which are considered charismatic megafauna and described as 'Critically Endangered', 'Endangered' and 'Vulnerable' under the IUCN Red List of Threatened Species for 2016. These are large-sized marine animals with widespread interest and are often given special consideration in marine conservation. Marine environment of Qatar is bestowed with charismatic species of whale shark, sea turtles and marine mammals (Table 2.5). Species reported to occur in Qatar are whale shark (1), sea turtles (5) and marine mammals (6). Some species of marine mammals have not been identified but it is believed that the number is much higher. The cultural traditions in Qatar deserve mention from a conservation perspective. There is no practice of consuming whale shark, sea turtles and marine mammals in the country. This is unlike many other places in the world, especially Asia, where these animals are hunted for their meat. In addition, there is no particular interest in consuming turtle eggs or organizing any trade involving them. There could be isolated cases of humans consuming turtle eggs, but that number is far too small. There is not a single report at least over the last 5 years of any of these animals being lost because of by-catch in commercial fishing. Also, there has been no stranding event in Qatar for several years. Probably, this could be due to the topographic features of the area or other factors.

Table 2.5. Charismatic species of marine megafauna in Qatar and their conservation status.				
Group	Species	Common name	Status in IUCN Red List	Global trend
Fish	Rhincodon typus	Whale shark	Endangered	Decreasing
Sea turtles	Caretta caretta	Loggerhead turtle	Vulnerable	Decreasing
	Chelonia mydas	Green turtle	Endangered	Decreasing
	Dermochelys coriacea	Leatherback turtle	Vulnerable	Decreasing
	Eretmochelys imbricata	Hawksbill turtle	Critically endangered	Decreasing
	Lepidochelys olivacea	Olive Ridley	Vulnerable	Decreasing
Marine mammals	Dugong dugon	Sea cow	Vulnerable to extinction	Decreasing
	Tursiops truncates	Bottlenose dol-phin	Not assessed for IUCN Red List	Unknown
	Steno bredanensis	4-rough-toothed dolphin	Least concern	Unknown
	Stenella sp	Spotted dolphin	Least concern/ Data deficient (depending on species)	Unknown
	Delphinus spp (species 7)	Depending on species	Least concern, Data deficient (depending on species)	Unknown
	Balaenoptera spp (species 4)	Baleen whale	Endangered/Least concern/ Data deficient (depending on species)	Stable/ unknown Depending on species

2.3.1.2.1 Whale Shark:

Whale shark (Rhincodontypus) (Figure 2.6a, b) is harmless and is the largest fish in the world. Because it is highly migratory, international efforts are needed for its protection. Unfortunately, targeted exploitation in certain countries has led to decline in their stocks, prompting

IUCN to raise the threat level by changing the Red List categorization of this fish from 'Vulnerable' until 2015 to 'Endangered' in 2016.

Figure 2.6: Whale shark – a large number of whale shark specimens visit marine area of Qatar. (Source: M. Al-Jaidah (personal communication).

There is a paucity of data on population dynamics, migratory routes and critical habitats for different stages of life of the whale shark. Data on these aspects will greatly aid in knowledge-based management. In Qatar, whale sharks received considerable research interest. The Arabian Gulf is host to a large population of whale sharks. Boat surveys and public sightings during the period from 2011 to 2014 have resulted in photo-identification of 422 individuals of this species

from the Arabian Gulf and the Gulf of Oman (Robinson et al., 2016). This study yielded biologically useful information, which is outlined here. Most of the sightings occurred at the Al Shaheen area of Qatar. Their average estimated length was 6.90 ±1.24 meters. At this population hotspot, sex ratio was skewed in favor of males. Only two females were observed in pregnant condition. During the period 2011 – 2014, the number of whale shark specimens identified at Al Shaheen is shown in Figure 2.7. Prebble et al (2018), has reported some demographic characteristics of whale sharks in the Qatari Sea Area, as indicated in the Table 2.6.

Research in Al Shaheen began comparatively recently, and has already documented high abundance, long residency time (about 6 months) and philopatric behavior to the site. The reason for the unique adult male bias observed on Al Shaheen feeding aggregation has not been identified, but the sex and size-based aggregation inherent in whale shark aggregations globally makes this an interesting topic to investigate (Robinson et al, 2016). To commensurate with the Qatar National Biodiversity and Action Plan, the Ministry of Municipality and Environment has signed a Memorandum of Understanding (MOU) with North Petroleum Company with the purpose of conservation and sustainable utilization of whale shark, in June 2019. There is a high level of connectivity in the whale shark stock in the Arabian Gulf and Gulf of Oman as reflected by resighting of whale shark individuals across this area that is reported to host a population of 2,837 individuals. Aggregations are common during summer months of April–October during which time the seawater temperature of up to 10 meter depth often exceeds 33oC. Outside this season (November–March) the shark is seen as single individuals. At Al Shaheen, the aggregation coincides with the spawning of mackerel tuna, euthynnus affinis, obviously to feed on the spawn of this teleosteon fish.

Table 2.6. Number of identified individuals in the Qatari Sea Area over the study period (Aug 2007 – Dec 2015) (Source: Prebble et al., 2018)

Demographic Characteristics	
Encountered Number of Individuals watched	870
Identified Number of individuals	437
Percentage of Male Individuals (%)	55.8
Percentage of Female Individuals (%)	25.2
Individual size Range (cm)	400-900
Mean individual size (cm)± standard deviation	641± 124

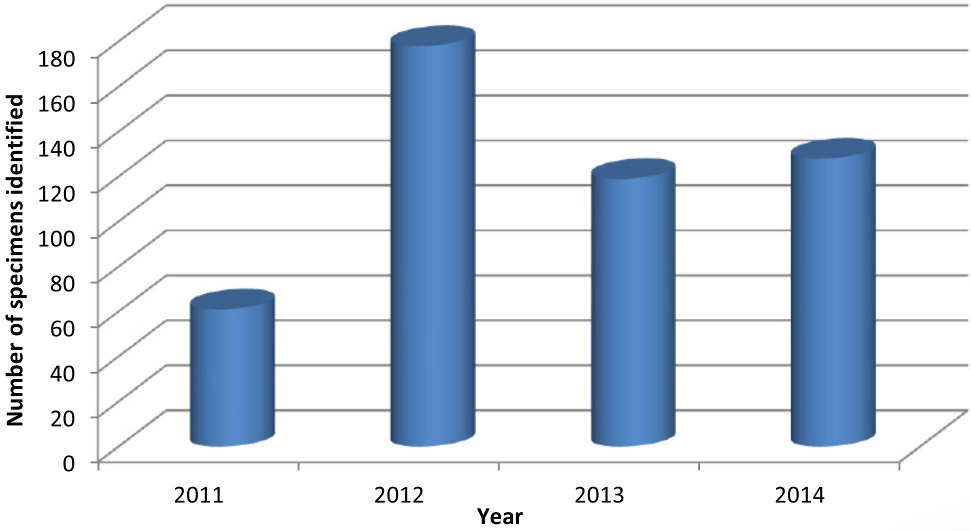


Figure 2.7: Whale shark specimens identified at Al Shaheen in Qatar between 2011-2014. (Source: Robinson et al., 2016).

2.3.1.2.2 Sea Turtles

Five species of turtles, namely loggerhead turtle (caretta caretta), green turtle (Cheloniamydas), leatherback turtle (dermochelys coriacea), hawksbill turtle (eretmochelys imbricata) and olive ridley (lepidochelys olivacea) are represented in the marine zone of the country. However, only hawksbill turtle nests in Qatar. The turtles play vital roles in maintaining health of the marine ecosystem. The significance of sea turtles (Figure 2.8) is in protecting the productivity of coral reefs and seagrasses, controlling the population of jelly fish, and transporting essential nutrients from the sea to the beaches enabling nutrient-deficient sand dunes to be well-established. The fear of loss of biodiversity prompted many marine conservationists worldwide to seek means to help evade extinction in particular those that already are on the Red List of the IUCN and the marine turtles are among this list. Qatar is a county where marine turtle's visit and one species nests on Qatar shorelines on sandy beaches.

Figure 2.8: Sea turtle- Qatar is home to this remarkable 'living fossil'.

Hawksbill Turtle, eretmochelys imbricata, with high nesting density, nests along the northeastern coastline of Qatar at Ras Laffan and Fuwairit and the sandy beach of Jazirat Halul is equally an important nesting location. Meanwhile, the collaboration of the Ministry of Municipality and Environment (MME), Oatar Petroleum (QP) and Environmental Science Centre (ESC) for Qatar University (QU) contribute to the protection of these endangered species during the turtle nesting seasons demonstrated that Qatar State is taking a positive step and contributing to the World effort to conserve the endangered species. Studies now include not only the study of the female turtles, nests and hatchlings but also tracking them by satellite and testing for the DNA fingerprinting to search for origin of local nesting population. Marine turtle conservation is now a priority for both the government and private sector.

DNA barcoding sequence using (COI) marker were carefully determined for 10 samples of Qatari hawksbill turtles, with 99% maximum identity for the turtle strains sequence generated by National Centre of Biotechnology & Informatics, (NCBI-USA). Out of these five species, the hawksbill turtle nests in the beaches in Qatar. Adult hawksbill mainly resides in the clear offshore water and around shelves of islands in the open sea, primarily associated with coral reefs. While their diet predominantly comprises sponges, other items consumed are crustaceans, cnidarians, prey fish and algae. Hawksbill mates biannually. After mating the females move towards the beaches during the night, clear the area of debris and dig a nesting hole using their flippers.

Once the nest is ready, the female lays clutches of eggs and covers them with sand. The female then returns to the sea. After about 2 months of incubation, the baby turtles hatch out at night and instinctively move towards the sea unless disoriented by artificial light or other obstructing factors.

Those, which fail to make it to the sea during the night, can become easy prey for shore birds, crabs and other predators that actively start foraging by daybreak. If nest is in shaded area with lower heat exposure, incubation is longer and hatchling population comprises more males.

As many as 8 turtle nesting sites, namely Halul, RasLaffan, Fuwairit, Ras Rakkan, Umm Tais, Sheraouh, Al Ghariya and Al Maroona were identified in the latest survey carried since 2007 to 2017 by Environmental Science Center and MME ranger teams under the sponsorship of Qatar Petroleum Company (QPC). The mentoring of nesting and hatchlings trends throughout the period of 2007 to 2017 is represented in Table 2.7.

The first three being the most important sites in terms of the nesting numbers accounting for 87.4% of the total nests, with Halul on the top with 43.3%, Ras Laffan 30.3% and Fuwairit 13.8%. Historic data provided by Environmental Science Center and MME ranger team (2016) shows yearly fluctuations at both these nesting grounds for unknown reasons but unlikely to be related to anthropogenic impacts

Table 2.7. Number of Nests per Habitat for Hawksbill Population in Qatar State (Environmental Science Center, 2016)										
Year	Coastal Beaches Habitat				Cumula-tive total Nests/ year	Island Habitat				Cum-mu-lative Nests/ year
	Ras Laf-fan	Fuwairit	Al-Ghariya	Al-Maroona		Ras-Rakkan	Umm-tais	Halul	Sheraouh	
2007	76	51	8	NA	135	24	19	57	22	122
2009	72	33	8	NA	113	20	21	70	8	119
2010	124	55	7	NA	186	30	31	78	7	146
2011	75	29	8	NA	112	19	20	71	9	119
2012	109	19	10	NA	138	22	21	73	10	126
2013	54	15	7	NA	76	13	16	54	8	91
2014	147	25	19	NA	191	27	29	92	6	154
2015	68	31	3	2	104	10	7	97	6	120
2016	42	32	4	0	78	7	10	61	8	86
2017	42	52	0	4	98	43	24	40	3	110
Total Nests/ site	809	342	74	6	1231	215	198	693	87	1193

Table 2.8 shows a decrease in hatching numbers. In 2014, the number of hatchlings was 16120 which was reduced to 13304 in 2017. Accordingly, the number of rescued turtles decreased from 2011 to 2016 with a total of 531 individual rescued among the 6 years. Hawksbill

.Table 2.8. Estimated Total Hatchling individuals of Hawksbill Turtle Nesting in Qatar				
Years	2014	2015	2016	2017
Hatchlings Number	16,120	14,455	10,498	13,304

Table 2.9. Number of Rescued Green, Hawksbill and loggerhead Turtle individuals in Qatar State.

Total/Year	Loggerhead Turtle	Hawksbill Turtle	Green Turtle	Year
2011	16	91	NA	107
2012	44	114	NA	158
2013	13	24	NA	37
2014	30	38	NA	68
2015	18	120	1	139
2016	9	12	1	22
Total/Species	130	399	2	531

Turtles face threats from natural as well as anthropogenic factors. Foraging on newly emerging turtle hatchlings by predators (ghost crab, birds and foxes) decreases the turtle population. Erosion of sand dunes at the shore areas has reduced the land elevation and increased the risk of tidal flooding of nesting grounds. This is evident at Fuwairit nesting ground where many turtle eggs have been lost to flooding due to tidal surge. Human activities causing habitat degradation are responsible for this situation.

Turtle conservation has received a great deal of attention in Qatar with cultural values favoring conservation. Barring some people who may occasionally consume turtle eggs, there is no niche market for either turtle meat or eggs. Besides, specific measures have been taken for conservation.

Ras Laffan City Conservation Project implements sea turtle conservation. Main activities being carried out are: Protection of nesting ground, clearing of debris from nesting areas and removing any obstacles in the path of females seeking access to the beach for nest construction or their return to the sea post-egg laying, fencing of the nest areas for protection of eggs undergoing incubation and removing the fence before emergence of hatchlings, counting the number of hatchlings and documenting the process by video recording. Closure of Fuwairit beach to the public throughout the egg-laying season offers an environment favorable for nesting. Habitat restoration will further facilitate the nesting and successful hatching of the eggs. A restored habitat should be able to control erosion and flooding of the nesting grounds. Regulating the vehicular movement and visitors will also minimize change in sand compaction, which is vital for erosion control and preserving the nature of sandy substrate suitable for nesting and emergence of hatchlings.

Research: Through structured research projects studies are being carried out on nesting sites, hatching rates, tagging and satellite tracking, population, genetic characterization, monitoring of substrate at nesting sites especially temperature, sediment composition, morphometric measurements of turtles, tagging, observations on visible characteristics of eggs, external observations on hatchlings, DNA characterization using tissue samples extracted from dead hatchlings and development of database on biology. In a recent publication, Pilcher et al. (2015); reported the results of their investigations on population structure of marine turtles in coastal waters of Qatar. The data pointed to the need for the protection of seagrass beds, effective mitigation measures for dealing with the problem of sedimentation from coastal developments and rehabilitation of coral reef resources.

Inception of Turtle Information Centre at Fuwairit: This is open to public for generating information on the ecological importance of turtles, threats facing these reptiles, conservation measures being taken, and cooperation of society in protecting this biological resource. This is being done through interactive programs including poster displays, lectures and video presentations. The Centre encourages students to undertake their research projects and learn techniques of tracking turtles.

DPSIR Framework for Sea Turtles:

Driving forces-Pressures-State-Impacts-Responses (DPSIR) framework is used to assess and manage environmental problems, and for reporting state of the environment. Drivers are the socio-economic and socio-cultural forces behind the human activities. A driving force can be a need for land, raw material or other resources. These human activities exert ‘pressures’ (or stress) on the environment which affects its ‘state’ (condition). Changes in the state may have

‘impacts’ on the ecological processes leading to environmental degradation that requires ‘response’ to deal with the situation. DPSIR represents a systems analysis view that flows in a logical sequence: social and economic developments exerting pressure on the environment and, consequently, resulting in a change in the state of the environment. All the components of the framework are typically represented by indicators to assess and explain change in a situation, or the progress in implementing a program. It is an approach developed by the Organization for Economic Co-operation and Development (OECD) and has since gained widespread acceptance. The European Environmental Agency adopted the DPSIR model in state of the environment reports to provide a basis for analyzing the interrelated factors that can affect environment, and the role and effectiveness of laws and regulations (EEA, 2005). UNESCO (2006) has recommended using DPSIR framework to analyze linkages among socioeconomic trends, ecological phenomena and institutional responses. In this report, the DPSIR model has been further elaborated to include analysis of the effect of management response on the state of the environmental component in the form of an 'outcome'. The fact that this model is adaptive to requirements and developments (Burkhard and Müller, 2008), the additional step provides a feedback loop to gauge the practical importance of applied measures as a management response. This model can be applied at various levels to integrated coastal and marine management or to address some fundamental issues such as fisheries management or conservation intervention. DPSIR model specifically developed for conservation of marine turtles (Figure 2.9) that are categorized as 'Endangered' and 'Critically Endangered' in the IUCN Red List for threatened species is presented here to explain the basic nature of the framework approach to assessment and management.

DRIVER (D)	•Increasing use of coastal zones for a variety of purposes (D_1)
PRESSURES (P)	•Degradation of habitat or shrinking of turtle nesting sites due to multiple causes, including direct anthropogenic interaction and increasing extreme events causing erosion and tidal surges (P_1) •Predators eating eggs undergoing incubation and foraging on newly emerged hatchlings (P_2)
STATE (S)	•Nesting attempts by turtles (S_1) •Hatching rate (S_2) •Survival of hatchlings (S_3) •Size of beach available for nesting (S_4) •Change in sand compaction (S_5)
IMPACT (I)	•Reduced recruitment to population (I_1) •Alteration in marine ecosystem (examples, increase in jellyfish population, weakening of resilience of seagrass meadows and coral reefs), decline in enrichment of nutrient-deficient sand dunes (I_2)
RESPONSE (R)	•Legislation prohibiting collection of turtle eggs from nesting grounds (Law no. 4, Section 47, 1983) (R_1) •Ministerial decision no. 2, 1985, to reinforce turtle conservation measures (R_2) •Compliance with international agreements ratified including Convention on Biological Biodiversity (CBD) and Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora (R_3) •Research oriented towards knowledge-based conservation of turtle resources (R_4) •Public awareness programs (R_5) •Marine protected areas. (R_6) •Closure of Fuwairit beach to public during nesting season that resulted in increased level of nesting activity, with highest number of nests recorded in 5 years) (R_7)
OUTCOME (O)	•Stabilization or increase of nesting activity (224 nests in 2015, comparable to previous years in a trend). This was observed during study tour but the number will be higher if recorded in a regular monitoring program (O_1) •Return of tagged turtles to marine water of Qatar (a scientific indicator of success of tagging program) (O_2)

Figure 2.9: DPSIR model specifically developed for conservation of marine turtles.

This DPSIR- Framework can be represented as:

DPSIRO = (D1), (P1+P2), (S1+S2+S3+S4+S5), (I1+I2), (R1+R2+R3+R4+R5+R6+R7), (O1+O2 = Positive).

2.3.1.2.3 Marine Mammals

The Arabian Gulf provides habitat conditions suitable for marine mammals. Whales (toothed whale, delphinus sp. and baleen whale, balaenoptera sp.) are occasionally sighted. Bottlenose dolphin (tursiops truncatus), 4-rough-toothed dolphin (steno bredanensis), spotted dolphin (stenella sp.) and Indo-Pacific humpback dolphin (sousa chinensis) are encountered across the Gulf, including marine waters of Qatar.

The sea cow (dugong dugon) occurs in significant numbers. Its population has been reported as large enough to be considered only next to Australia (Preen, 1989). Subsequently, after a gap of 10 years there was no change in this population status according to Marsh (1999). Five years later, observations published by Preen (2004) suggested that the dugong population in the Gulf to be 5,800. Interestingly, the estimates of dugong population were not significantly different in a span of 13 years (1986–1999) and this could imply stability in the population. There are no published reports in recent years. However, going by the past trend, with no significant additional impacts and given the more conservation awareness, extension of this trend would mean that the Gulf retains its status as an important habitat zone for the dugongs.

The regions between Qatar and Bahrain and between Qatar and the UAE are among the most important sites for dugong in the Gulf (Preen, 1989), especially for the purpose of aggregating in the winter season. Seagrass beds are the hotspots of dugong occurrence.

Beyond occasional sightings, not much has been done on the biology of dugong in Qatar. There could be some interesting adaptive features of the indigenous population of this marine mammal due to survival in extreme environmental conditions, even to the extent of divergence in morphometric, genotypic and physiological features from populations elsewhere in the world. Structured studies on a long-term basis on sightings, habitat preferences and migration pattern in addition to those aspects that do not require sacrificing the animal will be helpful in knowledge-based management of this interesting marine mammal, which is the only surviving species of the family dugongdae.

There is a paucity of information about other marine mammals in the Gulf except for the occasionally reported sightings. The bottlenose dolphin is believed to be the most common representative of the cetacean group, followed by the Indo-Pacific humpback dolphin.

2.3.1.3 Coverage of Marine Protected Areas and Critical Habitats:

Progress has been made in implementing the various provisions of the Convention on Biological Diversity. Qatar signed the Convention on Biological Diversity on 11 June 1992, became a party to the Convention on 21 August 1996, and followed up the agreement by drafting a National Biodiversity Strategy and Action Plan to guide national efforts to achieve the outcomes.

Biodiversity Indicators Partnership (BIP) was accepted as an important initiative to assist in the delivery of biodiversity indicators in support of the Convention on Biological Diversity, specifically the Strategic Goal C "To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity". However, the target 11 set for 2020 by bringing 10% of coastal and marine areas under protection will require more investment in research to fill the knowledge gaps in marine biodiversity hotspot areas and ecoregions as well as a clearly defined policy direction.

Two ecologically important areas in Khawr Al Udayd and Al-Dhakhira covering 721 km2 have been gazetted for marine protected area (MPA) status (ESAR, 2013). Considering the fact that marine area of Qatar is 35,000 km2, the MPA amounts to 2.06%. Currently, only 2.1% of the world's oceans are protected, and only 1.0% is effectively protected in no-take marine reserves (IUCN-UNEP, 2010). Efforts being made in Qatar for effective enforcement of 2.06% of marine area are in a way higher than the global average.

MPAs have provided a healing touch to the marine ecosystem as they generally do, and they could have contributed to sustainability of capture fisheries in addition to a better environment for resident or transient populations of marine animals. The fact that charismatic species such as turtles continue to breed, and marine mammals and whale sharks continue to appear with undiminished frequency could be positive indicators of this conservation intervention. Marine critical habitats, particularly mangroves, seagrasses and coral reefs that are located in the marine protected areas are well conserved. However, critical habitats are also distributed outside the marine parks. While the environmental impact assessment takes care of their protection from anthropogenic impacts when projects are planned in designated areas but they remain vulnerable outside these areas. There has been no thorough study in recent years on health and extent of marine critical habitats in Qatar. For mangrove, the published data suggests no change from the coverage of 5 km2 (500 ha) from 1990 (UNEP, 1999) and in subsequent years until 2010 (FAO, 2010). A change in the status will be indicator of the success or otherwise of the conservation intervention and state of the marine ecosystem. Recent studies undertaken by Smyth et al. (2016) provide valuable data that suggests that importance of monitoring of oysters and associated organisms for gauging the change in the marine environment.

2.3.1.4 Marine Trophic Index:

Marine Trophic Index (MTI) refers to trophic level (position of an organism in the food chain) of fisheries. It can be used as an indicator of marine ecosystem integrity and sustainability of fisheries.

MTI is particularly useful in understanding the structural changes in the marine ecosystem caused by fisheries exploitation (Cury et al., 2005). For example, a pattern of decline in the prey species upon which the higher trophic level species depend (bottom-up control) can lead to decline in the harvest or else a geographic shift in the predatory species. In either case, the decreasing fish biomass would affect the functioning of marine ecosystem. Analysis of the distribution of species according to their position in the food chain (trophic level) and number of trophic links in the sample are among the parameters that form the metrics which can be used to characterize indicators. In Qatar, only two broad categories of trophic levels are represented in the catch comprising 31 species: herbivorous and carnivorous in the ratio 1: 30. Only blue-barred parrot fish is herbivorous while the rest are carnivorous. MTI based on the species caught in Qatar varies from 2.0 to 4.7. This is consistent with the trophic levels suggested by Froese et al. (2004) and Karpouzi (2005) with a value of 2.0 for herbivores and detritivores, and 4.7 for piscivorous fish. There are so far no international targets for this indicator.

The fact that the CPUE does not show any significant decline in stock strength, it implies that all these species have so far been recruiting to the population, using ecosystem resources, particularly prey organisms, for all these predatory species. However, the absence of prey species from the catch demonstrates the limitation of the capture fisheries data in establishing the trophodynamic links that characterize the marine ecosystem. At the face value the removal of predatory species by capture fisheries could imply effects on food web in the ecosystem but the absence of any dramatic impact on the ability of marine ecosystem to sustain catches suggests that ecological links are functioning, and probably there are predators which do not form the catch but are able to maintain prey population in a balance. This is not to suggest that fishing produces no impact on marine ecosystem in Qatar but because of the regulatory measures put in place the dynamic equilibrium is maintained within the ecological thresholds. This could be the reason that the basic character of capture fisheries in Qatar cannot be characterized as fishing down the food web or in other words as a shift from high-trophic level fish to low trophic level species; the exploitation pressure remains on the same species.

MTI has some limitations which include: dependence on catch composition data as index of relative abundance, and on the quality of catch data with no means of verification. The determination of MTI from fisheries data could be descriptive, without accurate reference points. MIT can only show a slow response to structural changes in the ecosystem because of the complexity of the trophic web and the number of species involved.

The fact that no single indicator alone can provide information that comprehensively reflects the health of the marine ecosystem, the relevance of MTI cannot be unfairly judged. Evolving indicators and evaluating their effectiveness in the context of unique features of the marine ecosystem of the Arabian Gulf is a topic for a long-term research program involving scientific sampling of natural populations to represent species composition.

2.3.1.5 Population of Seashore Birds:

Qatar supports a diverse community of seashore (or sea) birds. The intertidal and sub-tidal zones are ecologically important for migratory birds, especially during winter. The information documented by RLIC (1999) indicates the presence of 24 species of seashore birds in Qatar (Table 2.5). This is a good number that suggests that the marine ecosystem provides niches and resources for their living activities. Sea birds (Figure 2.10) are predatory and depend on marine food webs. They also use seashore habitats for nesting and shelter. Intertidal and sub-tidal zones are the main attractions for migratory birds during winter. Using birds as an indicator of marine ecosystem health will require specially designed studies on yearly record of the number of birds, number of those that are migratory, trends in the breeding population and man-made changes in the coastal marine environment. The fact that shooting of seashore birds is not in practice in Qatar, they would be a good numeric indicator of the health of coastal marine environment.

Figure 2.10. Shore birds find suitable habitats along the coastline of Qatar.

2.3.2 Fisheries Indicators:

The objectives of determining fisheries indicators are management and conservation of fish stocks and their use in evaluating sustainability of fisheries, and stability of the larger marine ecosystem exploited for seafood supplies. Sustainable development of fisheries as a policy objective is receiving due attention in Qatar. In this connection, scientific data is being collected to measure progress towards sustainability and to apply knowledge-based approach to management that offers stable or improved socio-economic conditions for all those involved in the fisheries sector. The fact that fish do not live in the sea in isolation but are a part of a complex web of life in a dynamic environment, a great deal of ecosystem information has to be examined for devising strategies for preserving the resource links necessary for survival of populations of species exploited for commercial fisheries. Because of the significance of fisheries, the indicators for this sector are biological (ecosystem-based) as well as socio-economic to meet the sustainable development criteria. This categorization of indicators as elaborated below is basically according to the Driver-Pressure-State-Impact-Response framework (Figure 2.11). In ecosystem-based indicators, the 'pressure' is the size of the catch whereas the stock status defines the 'State', 'response' is in the form of quotas and other restrictions. Social indicators are fishing effort and number of fishermen. Quantity of fish catch, catch composition, trend in fish landings and catch-per-unit-effort are suitable biological indicators that describe the fisheries condition in Qatar. Interpretation in this report covers information synthesized from catch statistics. It is an undeniable fact that fishing represents one of the strongest impacts on marine environment (Costello et al., 2010). Several ecological indicators can be used to assess its impacts on the marine ecosystem and to explain the rationale for scientific advice (Coll et al., 2016). Analysis of fishing through trends is among the important criteria that can guide the selection of indicators (Rice and Rochet, 2005) that can reveal the effect of this activity on marine ecosystem.

Driver	• Increase in fish demand • Investment in commercial exploitation
Pressure	• Increase in fishing effort • Environmental changes
State	• Stock status • Commercial viability of fishing operations • Number of fishermen • Ecosystem condition
Impact	• Reduced fish recruitment • Ecosystem degradation • Decline in abundance of some species
Response	• Fisheries regulations (limitation on gears, closures, other restrictions) • Marine protected areas

Figure 2.11: DPSIR framework for fisheries in Qatar.

Data on fisheries can be used as indicators of change in the state of marine ecosystem. Due to interrelated nature of marine ecosystem services, it is prudent to recognize the dependence of fisheries on marine ecosystem, especially biodiversity. Fish netted out of the sea grows using resources of the marine environment, especially the trophic links in the complex web of life (marine biodiversity). This is a typical case that demonstrates the strong linkage of biodiversity with the fisheries production and unambiguously shows that targeted overfishing disturbs the trophic structure, which, in turn, leads to decline in fish catch. It has been established beyond any iota of doubt that fishing changes the trophic relationships by altering the relative abundance of predators, prey and competitors as well as the genetic make-up of wild populations (ICES, 2006). This is supported by the views of Hauge et al. (2009) who examined the depletion of global fish stocks and concluded that overfishing, habitat destruction, loss of biodiversity, pollution, climate change and invasive species contribute to depletion or even collapse of commercial fisheries. In Qatar, the marine ecosystem also faces many pressures from anthropogenic activities. However, there are regulatory mechanisms to reduce their impact. Furthermore, alternative means of livelihoods for a decent living exist in Qatar and local population is not entirely dependent on fish catch.

Indicators for sustainability of fisheries are intended to reveal and monitor the conditions related to the fishery sector to allow evaluation of the effectiveness of management efforts towards the existing fishery system. Inherent in this approach is assessment of ecosystem condition, status of resources, and economic and social considerations in an integrated manner. The complexity of such bio-socio-economic models has demanding data requirements, which pause a significant challenge and is a constraining factor in Qatar as in most countries. A national program that supports research jointly by department handling fisheries management and R&D institutions can address it. Catch rates and trends, CPUE, stock biomass, recruitment, costs, revenues and other parameters can be related to sustainability. However, interpretation of their fluctuations in terms of sustainability depends on the criteria set for allowable landings. Integrating all the considerations that form the three pillars of sustainability for fisheries systems would require comprehensive data as explained above to establish the DPSIR framework. In Qatar, this is being done broadly, but to prevent overloading of the data collection system, the DPSIR system can be built using only a selected number of parameters. Probably, multiple DPSIR systems or at least in a more simplified process envisaging:

Indicators of pressures (direct and indirect driving forces affecting the resource systems), indicators of state (conditions of the system being affected) and indicators of response (reflecting management measures (regulations) to reduce, eliminate or compensate (rehabilitation) for the stress factors can be developed. In Qatar, the analysis of the issue of overfishing identifies overcapacity as the pressure (driving force), low catch rate as the state (condition) and reducing the fishing effort as the response. Likewise, for the issue of littoral habitat degradation, the pressure identified is coastal trawling but state (condition) is not clearly defined although it could be the percentage of seagrass cover and juvenile mortality, while response in the form of protected areas and closed seasons has been effective. This report includes biological indicators relevant to Qatar that can reflect on marine ecosystem health. Spawning stock biomass and fishing trends—landings and catch composition—are among the indicators used by EEA (2002).

2.3.2.1 Spawning Stock Biomass:

Spawning stock biomass (SSB) is defined as the 'combined weight of all individuals in a fish stock that are capable of reproducing'. Direct determination of SSB of commercial species is a comprehensive exercise but it generates useful information of practical importance in management. However, when various aspects of fisheries are thoroughly examined, some usable proxies for SSB which can serve as indicators of state of fish population, or in a broader perspective, of the state of marine environment emerge out. Significance of such proxies has been discussed by Probst and Oesterwing (2014). Catch per unit effort (CPUE) is one of such parameters that can be pursued for this information. Supplementing the CPUE metrics with empirical data on the pattern of yields of different species in the catch over a sustained period of time can reflect on the SSB and recruitment.

There is a parallel in the dynamics of CPUE and yields over the last six years in most of the 56 species observed. This can be taken to suggest the ability of the populations of exploited species to withstand the fishing pressure, effective breeding stocks in the population for recruitment and an environment that allows the populations to proliferate. With the published information available to date, it is evident that CPUE has a high level of correlation with the stock abundance.

In Qatar, CPUE metrics (Appendix 2.1 and Figure 2.12) indicated increase in the pattern of normalized CPUE which could be linked to management efforts. However, due to complexity of issues involved and the amount of data available, there can be no simple and straightforward explanations vis-à-vis dynamics of CPUE metrics.

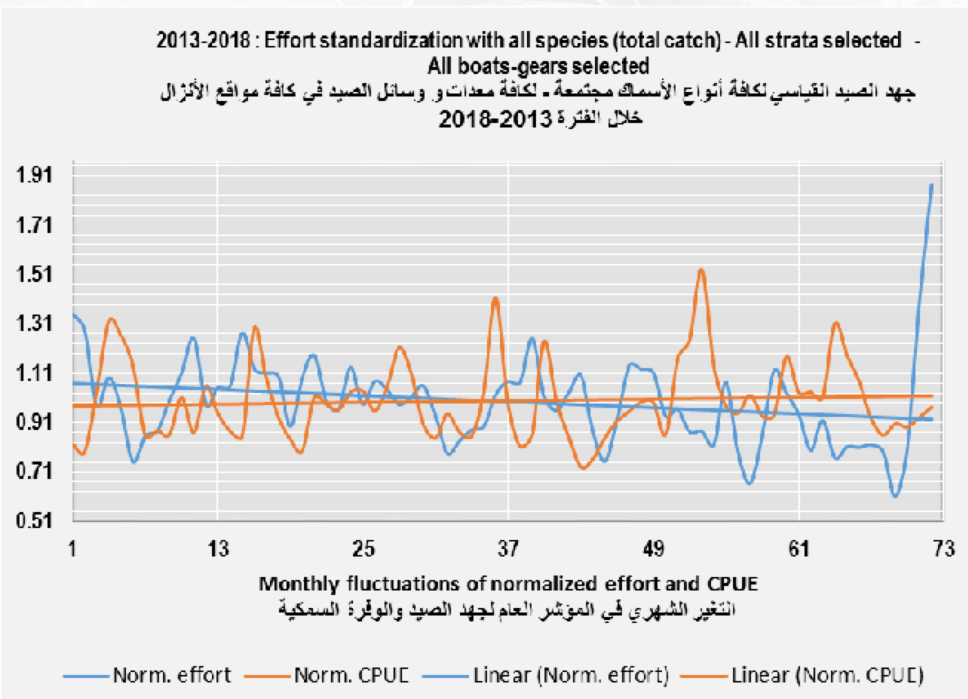


Figure 2.12: CPUE (Catch, Kg/Standard fishing day) for the period 2013-2018.- Source: Department of Fisheries (2019).

2.3.2.2 Fishing Trends - Landings and Catch Composition:

Data has been regularly collected by the Department of Fisheries on composition of catch and quantity of landings of different species in the commercial fishery. However, this report is based on yearly data since 2014. 56 species formed the commercial catch (Appendix 2.2). There are some unidentified species under the miscellaneous category but the species composition under this group varies between landings.

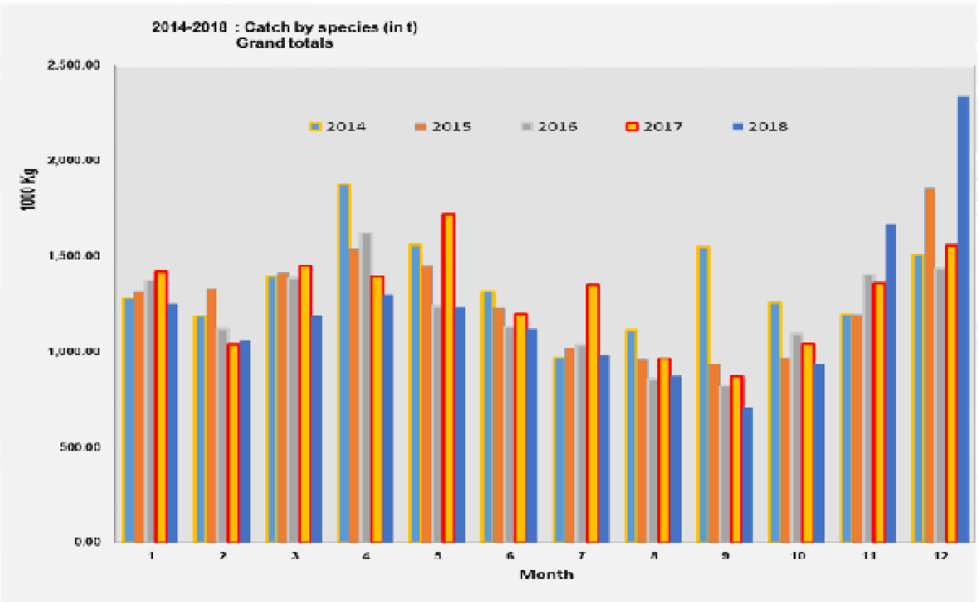


Figure 2.13. Monthly total Catch during 2014 – 2018. (Source: Department of Fisheries, 2018).

Percentage composition of species in the catch is variable (Appendix 2.2 and Appendix 2.3). Looking at the 2014-2018 statitics, the spangled emperor formed the highest percentage of the catch (15.6%), followed by narrowbarred Spanish mackerel (11.5%). Five species (spangled emperor, Spanish mackerel, pink ear empror, whit-spotted spine foot and orange spotted grouper), contribute to 46.1% of the catch.

Obviously, there are yearly variations but the pattern does not suggest any impending population crash. The reproductive capacity of the spawning stock in the population subjected to fishery exploitation is evidently able to generate new recruits that tend to compensate for fishing mortality. Understanding the scale of recruitment will require scientific observations, especially for species of concern. It is pertinent to emphasize that the fluctuations in abundance can be caused by environmental variability as well as selective pressure of exploitation of the natural populations by the fishing activity. Distinguishing the environmental effects from fishing effects would require comparing the temporal variability of unexploited and exploited fish stocks in the same marine zone over an extended period of time. It is an established fact that fishing increases variability in the

abundance of exploited species caused by truncation of the age structure which reduces the capacity of population to face the environmental pressures (Hsieh et al., 2006). This provides insights into the state of wild fish populations in Qatar. Relative stock biomass (B/BMSY) indicator is used by Fisheries Department to measure the abundance of 39 fish stocks as a component of fishery stock.

Where;

- Biomass (B): The total weight or volume of a stock of fish.
- BMSY : The biomass that would provide the highest long-term aver-

age catch (or maximum sustainable yield, MSY) of a fish stock.

• B/BMSY : For a particular fish stock, the ratio of observed biomass to the biomass that would provide maximum sustainable yield. When B/BMSY = 1, then biomass equals BMSY. If B/BMSY falls below 1, biomass is too low to provide maximum sustainable yield.

During the baseline period of 2013 through 2018, the ratio of observed biomass (for altogether fish stocks) to the biomass would provide maximum sustainable yield (Fig. 2.14).

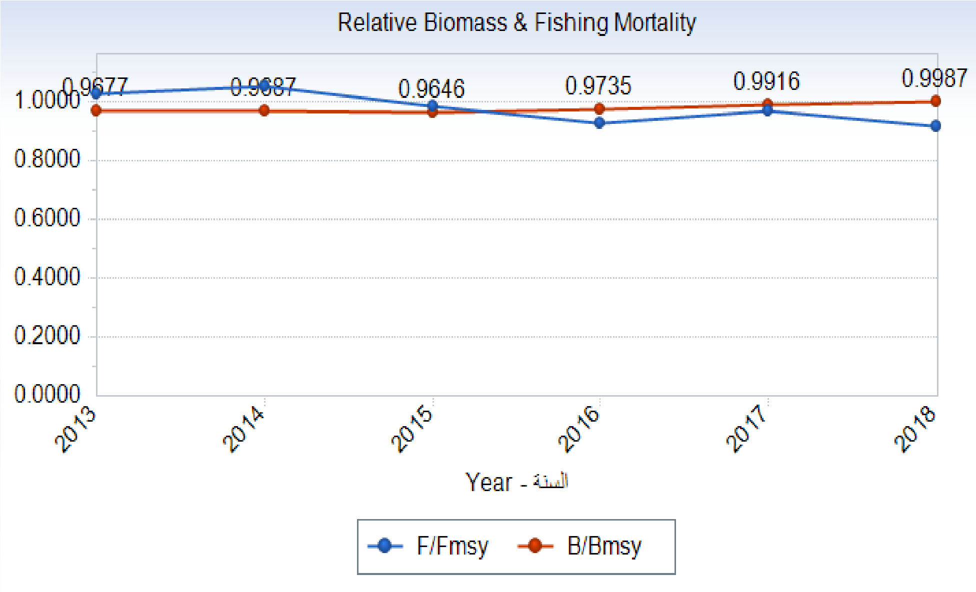


Figure 2.14 Relative Stock Biomass (B/BMSY) and Fish mortality (F/FMSY) for all stocks.

Species specific relative stock biomass analysis showed the following three categories: • Twenty six (26) fish Species with (B/BMSY) ≥ 1:

Gerres longirostris (silver-biddy), cephalopholis hemistiktos (yellowfin hind), rhabdosargus haffara (haffara seabream), epinephelus polylepis (smallscaled grouper), tylosurus crocodilus (hound needlefish), atule mate (yellowtail scad), epinephelus bleekeri (duskytail grouper), lethrinus lentjan (pink ear emperor), carangoides bajad (orangespotted trevally), euthynnus affinis (kawakawa), netuma thalassina (giant catfish), lutjanus fulviflamma (dory snapper), platax orbicularis (orbicular batfish), acanthopagrus latus (yellowfin seabream), siganus canaliculatus (white-spotted spinefoot), scolopsis taeniata (black-streaked monocle bream), scomberomorus commerson (talang queenfish), crenimugil seheli (Bluespot mullet), lethrinus microdon (smalltooth emperor), epinephelus multinotatus (white-blotched grouper), parupeneus margaritatus (pearly goatfish), portunus pelagicus (blue swimming crab), scomberoides commersonnianus (talang queenfish), nemipterus bipunctatus (delagoa threadfin bream), sepia pharaonis (cuttle fish) and lutjanus malabaricus (malabar blood snapper).

• Seven (7) fish species with low biomass for which (B/BMSY) $<1 \geq 0.5$:

Lethrinus nebulosus (spangled emperor), pinjalo pinjalo (pinjalo), acanthopagrus bifasciatus (twobar seabream), plectorhinchus sordidus (sordid rubberlip), scarus ghobban (blue-barred parrotfish), lutjanus argentimaculatus (mangrove red snapper) and carangoides malabaricus (alabar trevally).

• Six overfished species with (B/BMSY) < 0.5:

carangoides gymnostethus (bludger), rachycentron canadum (cobia), sphyraena flavicauda (yellowtail barracuda), argyrops spinifer (king soldier bream), epinephelus coioides (orange-spotted grouper) and gnathanodon speciosus (golden trevally). Qatar's marine capture fisheries policies aim at sustaining the viable biomass and CPUE. While regulating fishing gears and mesh size, and increasing the minimum size at capture have helped in sparing the virgin class of many species from commercial landings, other measures deserving periodic review are: increasing and connecting marine protected areas and for reducing fishing pressure in spawning grounds. Enforcing ban on benthic trawling for shrimp fishery for the sake of protecting the benthic habitats that support fisheries, and protection of breeding populations may have contributed to the sustainability but adaptive management involving new approaches as and when needed will go a long way in rational development of fisheries resources of Qatar in a long-term. Considering that a sustained fishing operation that leads to truncation of age structure reduces population recruitment and leads to increase in population variability, the national fisheries policy essentially follows a precautionary approach. A more comprehensive ecosystem approach to management will help the marine fisheries face environmental pressures, including the effects of climate change, and continue to supply seafood to meet the demand.

Under the DPSIR framework pertaining to socio-economic sustainability, the principal ‘driver’ is demand for fish and the gap between supply and demand. Although fish production has increased, Qatar is far from achieving self-sufficiency in fish supply (Figure 2.15). According to the latest figures, the highest production amounting to 14,665.65 metric tons was recorded in 2018 but it meets only 33.057% of self-sufficiency in fresh fish demand.

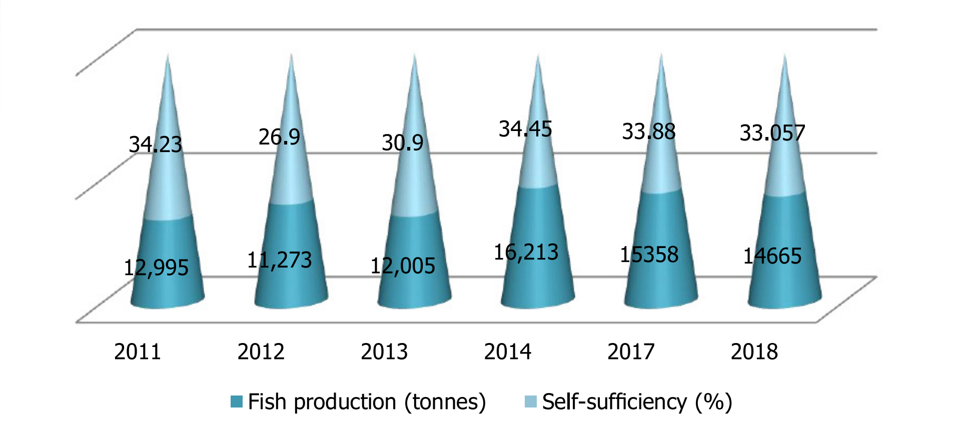


Figure 2.15. Fish production and level of self-sufficiency.

Qatar exports as well as imports fish. The data (Table 2.10) indicates that no fish was exported due to the blockade while the quantity of fish imported exceeded the local production in the ratio 2.03:1 (2018). It is clear that the local production achieves a self-sufficiency ratio of 81.27% of the species inhabiting the Arabian Gulf environment. Interestingly, sardine is imported in the largest quantity, accounting for more than 50% of the total import. The large quantity of import Sardine and Salmon may be to cater to the demand of the expatriate community which finds the fish affordable and has a tradition of consuming it. Import of large quantities of shrimp is understandable due to demand as well as lack of local shrimp supply. To protect the stock and ecosystem the shrimp fishery was closed through Decree no. 17 of 1993. This regulation still remains in force and has been credited for improving the environment for fish populations. The boat-gear categories include launches using traps, kingfish nets and miscellaneous gear whereas the speedboats deploy miscellaneous gear (Stamatopoulos and Abdallah, 2015). The existing management measures comprise:

• Discontinuing new fishing licenses for large boats (launches).

Reducing the fishing effort by limiting the landings (3 landings/vessel/month) during April-May.

• Setting minimum legal length for major commercial species.

• Prohibiting bottom trawling.

• Prohibiting trammel net.

• Prohibiting nylon mono filament gill nets.

• Prohibiting Green Sawfish fishing.

• Imposing definite specifications for kingfish fishing nets

Table 2.10. Local Fish production, Imports, exports and Percentage Self-Sufficiency during the years 2018.						
Item	Species	Percentage of Self-Sufficiency	Quantities (in Tons) during the Year 2018			
			Total Fish Consumption	Exports	Imports	Local Production
(Fish Species From Gulf Environment)	Spangled emperor	52.51%	4,002.52	0	1900.72	2,101.80
	Spanish mackerel	92.28%	2,062.64	0	159.24	1,903.40
	Orange-spotted grouper	78.52%	857.82	0	184.22	673.6
	Whit-spott spinefoot	89.74%	1,095.49	0	112.39	983.1
	Blue swimming crab	95.90%	515.77	0	21.17	494.6
	Others	89.46%	9,509.93	0	1002.23	8,507.70
	Total	81.27%	18,044.17	0.00	3379.97	14664.2
(Fish Species From Outside Gulf Environment)	Tilapia	0	976.74	0	976.74	0
	Bluespot mullet	0	107.89	0	107.89	0
	Sardine	0	2531.71	0	2531.71	0
	Salmon	0	2991.26	0	2991.26	0
	Tuna	0	377.54	0	377.54	0
	Sea bass	0	712.18	0	712.18	0
	Sea bream	0	776.42	0	776.42	0
	Others	0	11495.96	0	11495.96	0
	Total	0	19969.69	0	19969.69	0
(Shrimp, Lobster & Oysters)	Shrimp	0	6059.81	0	6059.81	0
	Lobster	0.14%	284.14	0	283.74	0.4
	Shellfish	0	7.79	0	7.79	0
	Total	0.01%	6351.74	0	6351.34	0.4
Grand Total		33.05%	44365.59	0	29700.99	14664.6

- Prohibiting crab fishing during the spawning season.
- Prohibiting kingfish fishing nets from August-October 2015.
- Prescribing specifications for set long-line and net gear.
- Banning the harpoon and spear gun during the spawning season.
- Provision for local skipper onboard the speedboats.

The fisheries policy and practice are reviewed from time to time to strengthen the knowledge base for sustainable management. The current approaches will increase the role of catch-effort data in research and stock assessment purposes.

The fact that the quantities of fish imported by Qatar exceed the exports, the goal of self-sufficiency in seafood remains elusive. In 2018, Qatar imported 29,700.99 metric tons of fish to meet the local demand. This makes Qatar a net importer of seafood. The trend suggests that progress is being made but it will be known in future years whether Qatar can ensure self-reliance in fish production. With conservation intervention, the natural fish stocks were spared from excessive fishing pressure to meet the demand, and aquaculture recently developed to supplement seafood supply from capture fisheries, which is expected to attain self-reliance.

Aquaculture:

It is important to explain the situation vis-a-vis aquaculture and where to position it as an indicator. Any consideration of aquaculture as an environmental indicator would be because this sector has both positive and negative impacts on marine environment. Many aquaculture practices adversely affect the marine ecosystem. The nature of impact varies according to the type and scale of practice and coastal hydrodynamic features. Aquaculture effluents often contain harmful chemicals and when discharged into sea produce negative consequences for marine ecosystem. Overharvesting for prey fish to feed aquaculture stocks has a major effect on marine environment. On a positive note, aquaculture lessens pressure on natural populations by increasing supply of seafood to meet the demand. It also offers alternative means of livelihood to anglers, so instead of indulging in overexploitation of marine fish populations, they can be engaged with fish farming. As far as Qatar is concerned, the government policy as laid down under Qatar National Vision 2030 is to develop this sector in sustainable ways. Qatar has entered the aquaculture sector by establishing the Aquatic Research Center on an area of 101000 square meters, which acts as the gateway for Qatar in the aquaculture sector. It provides a research center specialized in marine sciences, that carries out experiments and research that utilize the latest rearing fish and shrimp technologies. Moreover, the center helps the private sector in the aquaculture field, and establishes production protocols for fish hatching and growing species, it also sets up a long term fish stock enhancement program, while providing coastal communities with alternatives to wild fisheries, which protects the wild fish stock. finally, the center aims to train the local staff in the aquaculture technology field.

The strategy of Qatar from 2018–2022 considers the aquaculture sector by including the following projects:

- Establishment of three sites for cage culture with an annual production of 2000 tons each, one of the sites is currently in the production phase.

- Establishment of one site for shrimp farm with an annual production of 1000 tons.

2.3.3 Water Quality Indicator

In marine environmental monitoring, the issue is protection of coastal marine environment as a habitat for marine life, and the objective is to achieve good ecological conditions for coastal and marine waters for healthy survival of marine life and protection of marine ecosystem services. Indicators selected are:

a) Water quality index

b) Beach litter

Scope of the ongoing marine monitoring program covers sampling at 11 locations along the coast, and developed to include 14 locations in 2018, in both stages (costal and beaches), as shown in Figure 2.16.

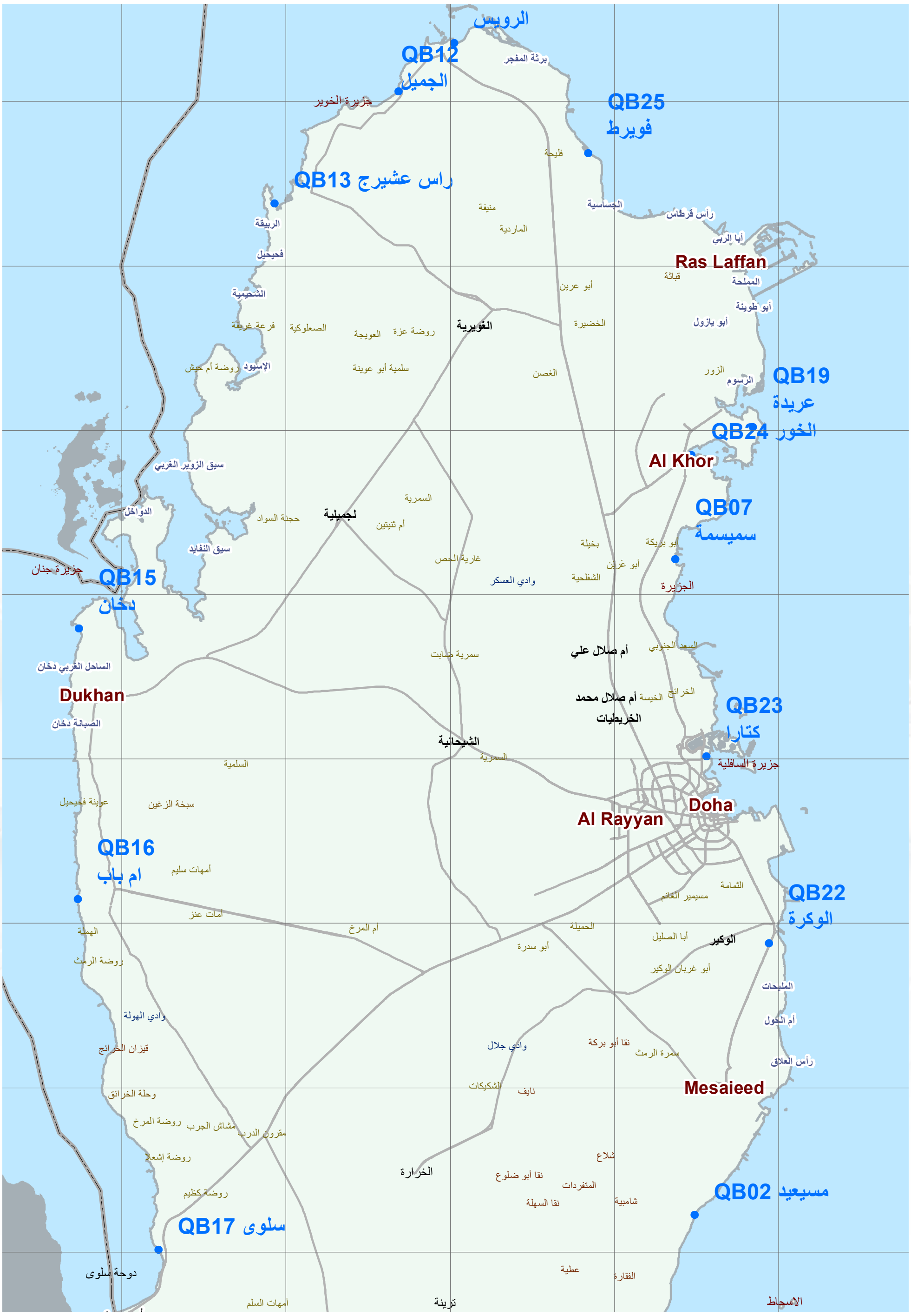


Figure 2.16. Marine sampling locations.

For chemical and biological examination of seawater, techniques outlined in Standard Methods of Water and Wastewater (APHA) and/or Manual for Chemical and Biological Analysis of Seawater are followed (Figure 2.17).

Figure 2.17. Field observations and sample collection for analysis.

Observations on the marine environment included physical, chemical and biological parameters, which reflected the prevailing marine environmental condition. Values of the parameters examined in 2016, 2017, and 2018 were in normal range (Table 2.11). Heavy metal concentrations were low. However, a rigorous monitoring should remain because of their potency and the fact that the reference standards in Qatar do not include all the metals.

Table 2.11. Qatar National Water Quality Standards and observed values (from 2016-2018).

Parameters	Qatari Limit, Units	Observed values during 2016 -2018
pH	6.5-8.3	Normal range
Salinity	33-45 ppt	Exceeding this range is normal for certain hypersaline locations
Oxygen (DO)	More than 4 mg/l	Normal range
Total Suspended Matter (TSS)	30 mg/l	Normal range
Phosphorus (PO_4-P)	30μ/l	Normal range
Nitrate (NO_3)	100 μ/l	Normal range
Silicate (SiO_3)	900 μ/l (=0.9 mg/l)	Normal range
Nitrite (NO_2)	35 μ/l	Normal range
Ammonia (NH_4-N)	15 μ/l	Normal range
Total Petroleum Hydrocarbon (TPH)	5 mg/l	Not detected
Cadmium (Cd)	0.7 μ/l	Normal range
Nickel (Ni)	20 μ/l	Normal range
Mercury (Hg)	Less than 0.4	Normal range
Iron (Fe)	90 μ/l	Normal range
Copper (Cu)	15 μ/l	Normal range
Lead (Pb)	12 μ/l	Normal range
Vanadium (V)	10 μ/l	Normal range
Chlorophyll a	1 μ/l	most of the locations were within the Qatari limit

2.3.3.1 Water Quality Index:

Evaluation of Water Quality Index (WQI) as reported here based on the parameters measured on 2016, 2017, and 2018. This index was calculated according to the recommended procedure in the technical report of the Canadian Council of Ministers of the Environment (2001). The WQI model consists of three measures of variance from selected water quality objectives (Scope; Frequency; Amplitude). The “Scope” represents the extent of water quality guideline non-compliance over the time period of interest. The “Frequency” represents the percentage of individual tests that do not meet objectives. The “Amplitude” represents the amount by which failed tests do not meet their objectives. These three factors combine to produce a value between 0 and 100 that represents the overall water quality. WQI classified into one of the categories shown in Table 2.12. WQI has been widely used, including in the Arabian Gulf, with latest application being in Kuwait Bay (Al-Mutairi et al., 2014).

Table 2.12. Categories of water quality index (WQI)		
WQI score	WQI Value	Description
Excellent	95-100	Water quality is protected with a virtual absence of impairment; conditions are very close to pristine levels; these index values can only be obtained if all measurements meet recommended guidelines virtually all of the time.
Very Good	89-94	Water quality is protected with a slight presence of impairment; conditions are close to pristine levels.
Good	80-88	Water quality is protected with only a minor degree of impairment; conditions rarely depart from desirable levels.
Fair	65-79	Water quality is usually protected but occasionally impaired; conditions sometimes depart from desirable levels.
Marginal	45-64	Water quality is frequently impaired; conditions often depart from desirable levels.
Poor	0-44	Water quality is usually impaired; conditions usually depart from desirable levels.

The water quality is compared against the reference standards used by Ministry of Municipality and Environment. The fecal coliform bacteria (E-Coli) is currently measured but has no Qatari standard and therefore the US-EPA standard has been used.

Qatar WQI values for the various locations during 2016, 2017, and 2018 are presented in Figure 2.18. Most of WQI suggested the quality to be very good and excellent, two locations (namely, Doha Bay, and Ras Abu Funtas) showed good ranks. Obviously, WQI can be used to express differences from location to location along the coast of Qatar as well as between the seasons. It can detect localized changes brought to bear on marine environment by land-based anthropogenic activities.

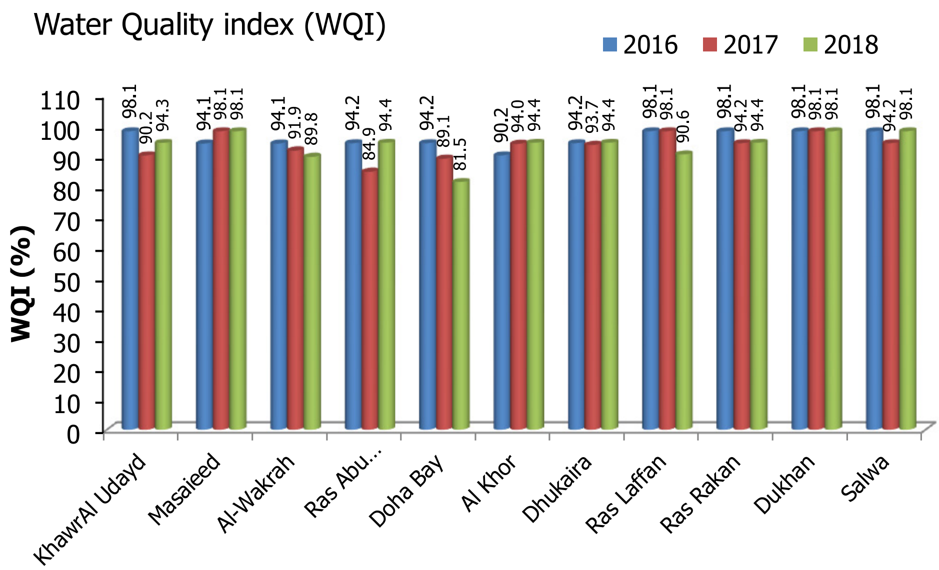


Figure 2.18 Qatar Water Quality Index at various locations in 2016, 2017, and 2018.

2.3.3.2 Beach litter:

It is a human-produced waste that deliberately or accidentally finds its way to the beaches. Marine debris originating mainly from anthropogenic activities in the sea is also deposited on the beaches by currents and becomes a part of the beach litter.

In Qatar, beaches are used for a variety of purposes that result in littering. Boating and picnicking (especially during winter) are the main recreational activities generating debris. The rapidly growing urbanization as evident from infrastructure development, improved access due to construction of roads and increase in human population density along the shoreline contribute to litter on the beaches. Maritime disposal linked to boating, fishing and other economic activities is yet another source of debris. In Qatar, there are no permanent surface water bodies in the form of rivers and streams, so the debris do not originate from such sources.

The existing monitoring program covering 13 locations (Figure 2.19) revealed that the litter comprises a wide variety of items which can be divided into 10 categories, namely plastic, foam, abandoned cloth, metal, glass, coal, wood, food stuffs, fishing nets and ropes.

Of all the types of debris, the plastic component causes more concern due to the environmental threat it poses. Most plastic products persist for long in the environment because of slow degradation. The thick plastic items are known to persist for decades. During the monitoring program, not all these types of items were found on any one beach at one time. It, nevertheless, shows multiple uses of the beaches in Qatar. Occurrence of wood, coal and leftover food suggests recreational activity involving barbequing. Pieces of metal, glass, cloth, foam and plastic could be due to activity on the beach itself or disposal from nearby residential areas. Fishing nets and ropes probably drifted from the sea or else anglers abandoned these products on the beach. If not cleared from the beaches regularly, the litter can enter the sea and prove harmful to marine life by causing injury through entanglement (mainly, turtles, marine mammals and sea birds), death through drowning, internal damage through inges tion and starvation when food pipe gets chocked, and in other ways. Some marine species looking for food end up consuming plastic waste, especially bags.

Beach litter

- Plastic
- Metal
- Cloth
- Foam
- Glass
- Coal
- Fishing nets
- Ropes
- Wood
- Food remains

Figure 2.19. Composition of beach litter.

Turtles seeking jellyfish can consume plastic bags instead. Sea birds eat polystyrene and plastic pieces, mistaken for fish eggs and crustaceans. Marine mammals often consume plastic waste. Litter also disrupts the nesting grounds of turtles and shoreline birds.

Given the high level of spatial and temporal heterogeneity, it will require a structured study to understand the origin of different types of litter along the coast at different times of the year. This monitoring program envisages surveys of the existing situation. Analysis of trends would

require monitoring to start after initial cleanup to eliminate the existing debris. Monitoring the beach litter will then provide accurate data on the changes in the quantity and quality of litter over time or to examine the effect of management efforts. It is difficult to establish any particular pattern of beach use or to understand the effect of public awareness programs due to lack of synchronization in dates of observations being carried out by the Environmental Monitoring and Laboratory Department and beach clean-up which is undertaken by the respective municipalities.

2.4 Pressures and Response:

2.4.1 Pressures:

Pressures on the marine environment of Qatar are anthropogenic as well as natural, and these are a continuing threat to ecological processes and marine biodiversity. Some of the main risk factors are described below.

2.4.1.1 Overfishing

It happens when harvesting of fish resources exceeds the carrying capacity of a fishery and this is one of the main non-sustainable uses of the ocean resources. Overexploitation is among the major pressures on marine biodiversity. Analysis of statistical data on catch and fishing efforts carried out by Fisheries Department, indicated that 6 species out of 39 represent overexploited biomass.

2.4.1.2 Coastal Developments

When involving reclamation and other activities for construction of buildings, ports, harbors, marinas, lagoons, artificial islands, roads, canals, oil and gas installations, and other infrastructure facilities these activities affect intertidal areas, seagrass beds, mangroves and coral reefs, and communities associated with these habitats. Because reclamation in Qatar has largely depended on sediment obtained by dredging, this has wiped out some productive seabed habitats that served as breeding, feeding or spawning grounds for many species of fish and shellfish. Coastal developments such as those involving dredging increase turbidity and re-suspend the sediments that settle over a period of time. These factors affect marine biodiversity. Where breakwaters are created, some species might take advantage of less turbulent environment by colonizing the area, and this changes the species composition. Loss of habitats undermines the roles they play in the ecosystem and in the security of coastal zone. For example, mangroves in addition to providing an important habitat for marine life also helps in stabilizing shoreline, trapping sediments in their extensive root system and filtering wastes. Their removal leads to waste entering the sea and smothering many invertebrate animals and deteriorating the water quality. Deprived of mangrove, the affected

coastline becomes vulnerable to currents, waves and storm surges that cause erosion which increases sediment load in the water.

Seagrasses also filter the sediment and protect the environment for corals. If mangrove and seagrass beds are degraded or lost, unfiltered water containing nutrients and sediments will flow towards the coral reefs and affect their health. Coral reefs thrive in low nutrient water. Eutrophication promotes excessive growth of harmful algae and threatens the coral reef communities. Certain major reclamation projects lead to fragmentation of habitat that threatens ecological connectivity, biodiversity and composition of animal communities. This sequence of disruptions adversely affects fisheries.

Reclamation is a matter of necessity in Qatar to create facilities for housing, ports, roads and businesses since the pristine land has to be conserved for protecting aquifers and ecologically sensitive areas, especially 'Rawdha', and some other hotspots for desert wildlife.

Since the entire human population in Qatar lives within less than 100 km of the sea, and urbanization and infrastructure development are rapid, the marine environment is obviously under pressure. In Qatar, it is not a matter of choice to settle near the coast but the fact is that the country at its widest point is less than 100 km. This is a formidable physical and spatial constraint. The coastal developments outlined above have resulted in increased concentration of population and multiplied the anthropogenic interaction with the sea.

2.4.1.3 Coastal Hydrodynamic Modifications

Natural seawater movement performs many important roles, including transport of nutrients, sediment distribution and flushing among others. Change in the bathymetry of the area interferes with the current pattern and all these processes that might result in sediment deposition and erosion elsewhere, and eutrophication in places that were naturally protected from this process.

2.4.1.4 Hydrocarbon Pollution

Oil and gas industry, which is the backbone of the country's economy, comprises a wide range of operations from drilling, extraction and processing, leading to final products. All these steps have environmental footprints. The usable form of the fossil fuel is stored and transported during which the chances of leakage and pollution are omnipresent. Habitats are degraded by oil pollution and may take a long time to recover. Organisms affected by oil pollution may suffer heavy mortality. Despite the best possible precautions the accidental oil spill can happen. While Qatar uses modern technology and deploys an elaborate plan of action to deal with the problem of oil spill, the technology and mechanisms are not fool-proof, and as a result directly or indirectly the marine environment is exposed to the impacts. Presence of tar balls on the sea shore is an indication of oil contamination of the marine environment. With the internationally recognized systems of managing the oil pollution the scale of environmental problems has been reduced.

2.4.1.5 Pollution (Other Than from Hydrocarbons)

Undesirable substances from industrial or other activities can enter the sea from land-based activities. These could be heavy metals, nutrients, effluents from cooling plants or other sources. They can impair the quality of marine environment, degrade the habitats, directly affect the marine life and some of the toxic substances can contaminate the seafood, making it unfit for human consumption. Contamination of the affected organisms' spreads through biological magnification by way of food chain. In Qatar, the agriculture is done on a small scale and land runoff is limited to occasional rains that happen only during winter, so there is little impact related to these sources. Eutrophication triggers the growth of harmful algae that deplete the oxygen.

2.4.1.6 Desalination

This process involves pumping of huge volumes of seawater and release of concentrated brine and other wastes to the sea. Because of arid conditions, absence of permanent surface water and very limited ground water, desalination of seawater meets the bulk of water demand in Qatar. Desalination on a massive scale leads to discharge of concentrated brine to the sea. Pumping out large volumes of seawater and releasing the concentrated brine to the sea must have impact on the marine ecosystem. While methods of discharge follow impact mitigation stipulations, there is a need to conduct thorough scientific investigations on the exact nature of effect on marine life.

2.4.1.7 Littering

Discarded objects left on the beaches or blown by wind can enter the sea and degrade the environment. Some aquatic animals can even consume plastic mistaken as food which causes health problem or even death.

2.4.1.8 Tourism

This increases the use of seafront for leisure activities. Infrastructure facilities are also created along the sea front. Besides, artificial islands too have been developed. These have varied levels of impact on the marine environment.

2.4.1.9 Navigation

It has direct as well as indirect effect on marine environment. It is associated with emissions of greenhouse gases, and sound and oil pollution, collision with endangered wildlife and discharge of ballast water.

2.4.1.10 Climate Change

This global environmental change is adversely affecting the marine environment and Qatar is no exception to it. Generally, the effects are reported to be in the form of: rise in sea level, acidification and warming of sea water, expansion of oxygen deficit areas, change in hydrodynamic events leading to altered mixing, stronger currents and severe weather conditions. These processes will cause coral bleaching, geographical shift in vulnerable marine organisms, acidosis in marine animals, coastal erosion, inundation of coastal land and saltwater intrusion.

Qatar faces many challenges from these effects of climate change because of limited landmass, a major part of which is surrounded by the sea. In fact, due to geographical conditions characterized by extremes of temperature and salinity, the changing climate will produce more detrimental consequences for the marine environment in Qatar. The coastal infrastructure (including buildings, business houses, industrial establishments and desalination plants among others) will bear the brunt of extreme weather events, land will be lost to erosional forces, and saltwater intrusion will further increase the salinity of aquifers and soil. A number of farmlands have already been abandoned because the soil became too saline for agriculture, thus adding to the scarcity of fertile land. Biodiversity of marine life will be under serious stress and this will produce adverse consequences for sustainability of fisheries. The other problems will be caused by blooming of harmful algae and jelly fish and increase in the concentration of pathogens in coastal waters.

2.4.2 Management Response:

2.4.2.1 Response Mechanisms:

Qatar has institutionalized methods for managing pressures on the marine environment. For harvesting seafood, there are permitted methods for regulating fishing. These include permission for the type of gears, protection of marine critical habitats and allowable catch quota. Fishing is permitted by gill nets, hooks and lines, trolling and traps. Use of trawl nets that are dragged by fishing vessels along the bottom and some other types of gears that damage the ecosystem and threaten the capture fishery are not allowed. Performance of the adopted measures is examined for determining the best method that can contribute to sustainability. Marine protected areas and conservation zones have been created to provide a healing touch to the marine ecosystem and respite to the stressed forms of marine life.

Coastal development projects are subject to guidelines of environmental impact assessment. Protection of marine critical habitats in the ecological sensitivity maps is given serious attention.

Project proposals are required to include practically feasible impact mitigation plans for implementation. Environmental Impact Assessment Department handles such matters. This department also evaluates projects such as desalination of seawater which releases concentrated brine to the sea. Industrial Inspection and Pollution Control Department has enforcement authority to check the quality composition of discharges entering the sea. Oil spill is regularly monitored for prompt action if the situation so requires.

There is a concern that the cumulative impact of the factors described above might exceed the threshold limits of marine ecosystem. However, due to knowledge gaps in our understanding of threshold levels or tipping points and determining quantitative critical values which, if crossed, could generate abrupt changes in the state of marine environment, a precautionary approach to management is considered a wise option. It requires that the stressors are identified and managed. While natural climatic extremes are linked to the geographical location and these will prevail, and climate change impacts are of a global nature, but human-induced pressures are being minimized to prevent abrupt shift in the state of marine ecosystem. Mitigating these impacts is important for normal functioning of ecological processes in the sea and sustainable benefits from the marine ecosystem services.

Building resilience in the marine ecosystem is the current policy direction in Qatar for offsetting the effects of climate change. Towards this end, initiatives have been taken for regulating commercial fisheries, controlling discharge of waste into the sea, conservation of marine critical habitats and marine biodiversity, and the establishment of marine protected areas and conservation spots such as those for facilitating nesting of turtles and protection of their eggs.

Qatar has pledged to join the global efforts for combating the effects of climate change and fulfilling its obligations as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC). Measures have been taken in response to the need to adapt to climate change while making progress towards the goals of sustainable development. Mechanisms for reducing carbon emissions, intensifying research on renewable sources of energy, diversifying economy, environmental impact assessment guidelines, sustaining seafood supplies through rational fisheries policies, protection of aquifers and reduction in discharge of land-based sources of marine pollution are among the ongoing efforts. While carbon sequestration by the coastal vegetation is an on-going natural activity, which is sought to be protected by conservation of mangrove and seagrass beds but policy initiative for blue carbon projects is a topic for future interest.

2.4.2.2 Response Descriptors:

Through various measures taken and their periodic review, Qatar seeks to maintain a good status of its marine environment so that it continues to provide ecosystem services to the current and future generations. Because of the complex nature of marine ecosystem and factors affecting it, many descriptors have to be used to characterize its attributes and values for different functions. Such an approach has been suggested by EC (2008). In the context of Qatar, the descriptors of a healthy marine environment are explained below.

2.4.2.2.1 Descriptor-1:

Marine Biodiversity is Understood and Conserved: Marine biodiversity denotes the variety of life in coastal and ocean environments in Qatar. It has 3 elements (genetic, species and habitat) that contribute to the natural sustainability of the marine ecosystem. A more diverse marine ecosystem is in a better position to withstand environmental stress and to stay productive through complex mechanisms. These attributes of the ecosystem decline with the loss of species. Marine biodiversity is under stress from a variety of factors, including fishing, pollution, habitat modification and degradation and global climate change among others. Constraints and Management Actions: There is a paucity of data on species inventory that constrains specific actions on a comprehensive scale for knowledge-based decisions with long-term implications. In Qatar, management actions for marine biodiversity conservation have followed the ratification of international conventions such as Convention on Biological Diversity, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), UN Fish Stocks Agreement dealing with Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish. Recommendations of the United Nations Environment Program (UNEP) for protection of red-listed marine animals that provide guidance for environmental impact assessment of coastal and marine development projects have helped in marine conservation. Fisheries regulations enforced by the Fisheries Department have contributed to conservation of marine biodiversity.

Prospects:

Marine biodiversity in Qatar will continue to face pressures because land is arid and its area is limited, thus pressure is intense. Some new strategies are needed to address this situation. Enforcement measures are being strengthened for protection of marine environment and this should augur well for conservation of species diversity and marine critical habitats. For research on marine biodiversity, there will have to be earmarked funds and expertise, but it is uncertain when this will happen.

2.4.2.2.2 Descriptor-2:

Exotic Species are not Introduced: The policy of the government is not to grant permission for introducing non-native species into the marine waters of Qatar to protect the integrity of marine ecosystem. In this context, the Ministry of Municipality and Environment strictly follows the concern enshrined in the Convention on Biological Diversity, which highlights the threats that non-native species pose to marine biodiversity. Marine environment of Qatar remains vulnerable to non-native species due to ballast water of cargo ships, fouling species attached to ship hull originating from elsewhere which establish population in the wild, and those introduced in other countries but entering the marine waters of Qatar.

Constraints and Management Actions:

There are practical difficulties in enforcing the international convention on the control and management of ships' ballast water. Also, controlling the invasive species possibly introduced in neighboring countries from entry into marine environment of Qatar seems impossible for now. Inadequate data on marine biodiversity will continue to complicate problems in identifying alien species. If an exotic species has naturalized in the marine ecosystem of Qatar it will be difficult to selectively eradicate it. Targeted management actions will require consolidation of available data on biodiversity and generation of more information in this area.

Prospects:

The national policy for nature conservation will contribute to protecting marine biodiversity. Commercial aquaculture, which is among the main reasons for introduction of non-native species and their inadvertent escape into natural environment elsewhere, has not started in Qatar. Furthermore, lack of any niche market for non-native species obviates the need for ranching of alien species.

2.4.2.2.3 Descriptor 3:

Population of Species Supporting Commercial Fisheries are Sustainably Managed: Fisheries policy aims at ecologically sustainable development that seeks to protect the ecosystem and the reproductive capacity of the population for recruitment and population fitness. Proportion of larger sized specimens could be an indicator of healthy spawning biomass and viable population.

Constraints and Management Actions:

One of the main constraints is inadequate scientific data on individual species in commercial catches. While the data is available on some species, the scope will have to be expanded. Knowledge gaps in marine biodiversity at all its three levels make it difficult to establish cause-and-effect relations for targeted actions. Another impediment is dependence on capture fisheries for seafood supply due to lack of investment in aquaculture as an alternative means of seafood production. Recommended actions include: adopting a precautionary approach in exploiting the fish populations, analysis of catch composition, especially size-frequency distribution, to determine proportions of size groups, number of species in the catch, catch per unit effort, sex ratio (if possible for selected species) and health condition indicators of population samples and regulating the types of fishing gears and fishing efforts, enforcing allowable catches as and when necessary and transforming current fisheries policies consistent with the guidelines of Ecosystem Approach to Fisheries Management (EAFM). While regulatory frameworks are reviewed when required, the EAFM as an instrument of national fisheries policy is yet to evolve although some elements of it are already in the basic structure of the fisheries policy.

Prospects:

National policy is supportive of fisheries from a seafood security perspective and this will continue to receive investment. Alternative means of livelihood exist in Qatar and this will prevent further overfishing when the catches decline. The fishing community is largely law abiding and this holds better prospects for enforcement. Coupled with this, effective governance of commercial fishing, especially registration of fishing boats, restrictions on fishing gears and catch are favorable conditions for a healthy fish population management.

2.4.2.2.4 Descriptor 4. Food Webs Required to Support Wild Populations are Intact:

Food webs are networks of feeding interactions (or trophic relationships) in an ecosystem. Marine food webs are complex interconnected chains. At the base of the food chain are the autotrophs that convert energy from sunlight into biomass. This energy moves along the food chain. Biomass decreases with each trophic level. Thus, there are always more autotrophs than herbivores and more herbivores than carnivores. A productive marine ecosystem can support large populations of species at the highest trophic level (for example, predatory tuna and sharks). A balanced proportion of various links is needed for a healthy ecosystem. The structure of food web defines the flow of energy, a vital feature of a vibrant ecosystem. Monitoring of all levels of food webs is necessary for assessment of condition of marine ecosystem. Data on the following aspects related to food web can be used to provide a basis for assessment of the state of marine environment:

- Dynamics of organisms constituting different levels of food webs in terms of species diversity and abundance.
- Ability of representative marine species populations to withstand environmental variations.
- Production of species targeted in fishing operations.
- Condition of species associated with the community structure of marine critical habitats.
- Proportion of top predators.

Constraints and Management Actions:

There is a lack of sufficient baseline data on nutritional webs and natural history of wild populations, and any trend of changes over the years. Fishing has an impact on marine ecological links and because it is selective there is bound to be an influence on marine communities. Prey, as well as predatory species, are harvested, and normal links are difficult to discern accurately.

Degradation of habitats such as coral reefs, mangrove and seagrasses that are used by many species as spawning, nursery and feeding grounds has happened as a result of many anthropogenic activities. While environmental impact assessment regulations have contributed to reducing the impacts, there is no published scientific evidence to assess their effectiveness.

Prospects:

There are some reasons for optimism vis-a-vis marine trophic food webs for wild populations in Qatar due to the following reasons:

a) Trophic webs, or for that matter, web of life, will be better off as interest catches up in ecosystem approach to fisheries management.

b) Progress in enforcement of the various clauses under the Convention on Biological Diversity, as a national policy, will build-up resilience in trophic webs.

c) There are no indications that commercial aquaculture will be established any time soon in the near future, and this will have sparing effect on prey fish which in most other countries are heavily fished to feed high value carnivorous fish in aquaculture.

d) Growing interest in marine ecosystem will lead to generation of more knowledge, and that will provide a basis for reviewing management policies, including bringing more marine areas under protection.

2.4.2.2.5 Descriptor 5: Marine Water Quality Does not Deteriorate Beyond Threshold Limits:

Health of marine environment is a topic of serious concern. Coincidently, as our dependence on the sea is increasing, the level of threat to the marine ecosystem from direct anthropogenic impacts and the effects of climate change are on the rise. Ecosystem services that the sea provides have to be protected for human welfare. Coastal marine areas have many ecologically sensitive habitats which bear the brunt of land-based activities. Our ability to manage the marine ecosystem greatly depends on reliable knowledge, practical capability and governance. Also, the quality of marine environment is influenced by regional and global factors, and while national programs of action are extremely important, they alone are not adequate to mitigate the condition of the marine environment. This calls for a great deal of cooperation, investment and concerted action by all the countries, especially those in the region.

Constraints and Management Actions:

Due to multiple factors involved in this intergovernmental, interdisciplinary and intersectoral program, and lack of adequate and reliable data, the ideal management of marine environmental quality is difficult at this stage. This sort of impediment to governance is not limited to Qatar but is a widespread scenario around the world. It is recommended to start collection of baseline data using selected tools and methods so that changes in the state of the environment could be measured by the help of sensitive indicators. Marine area of Qatar is more than three times its land area and, therefore, the task of managing the environment requires far more resources and coordination efforts. While assessment of water quality that is being done is important but in a holistic management, other significant components of environmental quality need to be considered. Currently, we have reference standards for 19 parameters, namely pH, salinity, dissolved oxygen, total suspended matter, phosphorus, ammonia, nitrite, nitrate, silicate, total organic carbon, cadmium, nickel, mercury, iron, copper, lead, vanadium, phenol and chlorophyll-a. There is a need to increase the list by developing standards for more parameters, including those that are covered under the on-going marine monitoring program and those that are not, this will improve the targeted management actions. Moreover, the monitoring program currently envisages sampling and collection of data from selected locations along the coast of Qatar twice a year. Use of smart sensors for real-time water quality monitoring will be more representative of water quality but that would require a great deal of investment in developing monitoring stations, staffing and procuring equipment needed for the purpose, and bearing the operational expenses.

Prospects:

Inception of a separate Environment Monitoring Department under the Ministry of Municipality and Environment has resulted in a greater focus on monitoring the state of marine environment. Plans for strengthening and expanding the scope of the program are under active consideration. While some signs of improvement are visible, any significant expansion will take time, depending on decision support and availability of financial and human resources. Shortage of manpower and high costs associated with the marine monitoring and analysis are constraining the frequency and scope of marine expeditions and restricting the number of samples for analysis. A reorientation of the program to generate vital information on ecological integrity of the system will be more informative.

2.4.2.2.6 Descriptor 6: Eutrophication is Controlled:

Excessive amounts of nutrients in coastal waters impair the quality of coastal-marine ecosystem. Nutrients enter the sea from many sources, including agriculture, municipal and industrial waste, desalination plants, energy extraction operations, coastal developments and atmosphere. When regulatory measures are not strictly applied, the nutrients can cause many problems such as harmful algal blooms, oxygen depletion, fish mortality and loss of biodiversity, and these can undermine the marine ecosystem services.

Constraints and Management Actions:

In Qatar, the entire population lives within less than 100 km from the coastline as explained earlier. This close proximity is bound to affect the ecosystem. For projects involving coastal developments and commercial installations in the sea, mitigation measures are suggested by experts reviewing the environmental impact assessment. Adherence to guidelines is also monitored regularly. However, mitigation measures are not fully effective and impact, albeit in varying degrees, is brought to bear on the marine environment.

Prospects:

The land in Qatar is largely arid, and agriculture is confined to only limited areas. There is, therefore, no widespread problem of nutrient release from agriculture operations. It is quite contained. Aquaculture which could be a major source of eutrophication is in trial stages. There is no riverine source of nutrient discharge to the sea. Number of marinas is increasing, and this could significantly impede the flushing process. A ceiling on marines and incorporation of environment-friendly measures in design and operation will protect the environment of the coastal sea.

2.4.2.2.7 Descriptor 7: Coastal Litter is Regularly Removed from Beaches:

Many types of solid wastes generated by society end up on the beaches. Litter is an environmental, economic, health and aesthetic problem. When scattered along the beaches it diminishes the amenity value. Besides, regular clean-up of beaches costs the government a considerable budget. When the litter enters the sea, it causes habitat degradation by smothering of the seabed, and impairing the environment for seagrass beds and coral reefs. Items such as plastic are accidently ingested by marine turtles and mammals, leading to health problems and even death. Fish can be accidentally caught in abandoned fishing gears, especially hooks and lines, and traps (ghost fishing) and are lost. Discarded fishing line, rope and plastic trash can disable boats and ships by wrapping around boat propellers or being sucked into outboard boat engines.

Constraints and Management Actions:

In Qatar, the beach litter mainly comprises plastic, foam, metal, clothing, glass, wood, charcoal, food stuff, fishing nets and ropes.

Beach clean-up operations, being undertaken by the municipalities, are not synchronized with the on-going beach monitoring conducted by the Ministry of Municipality and Environment. This makes it difficult to examine the change, if any, in litter occurrence as a result of several campaigns launched by the government for public awareness and enforcement. Seabed cleaning will also be a very helpful intervention.

Autopsies on endangered marine animals are not generally performed to examine any evidence of ingestion of plastic waste to ascertain whether or not it is the cause of mortality.

Prospects:

Beach clean-up is regularly carried out but there are suggestions to schedule this activity to synchronize with the beach monitoring program. Due to an effective waste collection system at source, medical wastes and wastes originating from construction projects are not normally encountered on the beaches or coastal waters. Products such as food remains, and water bottles seen in small quantities are due to recreational activities at the beach. While abandoned fishing gears could be due to angling conducted from coastal land, these items can also drift from the sea during fishing operations. Public awareness programs that are frequently launched by the government will probably improve environmental concerns and care.

2.4.2.2.8 Descriptor 8: Mechanisms are Developed and Improved to Combat Effects of Oil Spills:

Release of liquid petroleum hydrocarbon into the sea constitutes the oil spill. It is a form of pollution that has multiple effects on marine environment and users of this resource. Spilled oil is harmful to marine life because of the toxic nature of its chemical constituents. Oil pollution harms the organisms through external exposure as well as internal exposure through ingestion. It smothers small fish and invertebrates. Oil coats the feathers of sea birds coming into contact due to which they cannot fly and fail to maintain body temperature. Likewise, mammals with fur have problems regulating their body temperature in addition to suffering from skin and eye irritation from oil. They also find it difficult to float in water with oil treated bodies. Marine animals such as dolphins and fish among others often lose their vision from repeated exposure to oil. Sedentary animals like snails and clams also suffer mortality if the oil covers the intertidal or seashore areas. Many animals are simply chocked to death. Oil is disastrous for coral reefs. Marine animals that survive short-term exposure to oil suffer from health problems and may not recover, and eventually die. Young ones of some animals that are nourished by parents also die of starvation because when disoriented by oil the parents cannot reach their offspring or fail to recognize them as their own and are unable to show parental care. Not just marine animals, but seagrasses and mangrove also suffer to varying degrees. Oil is hazardous to humans who happen to breathe its fumes or come into physical contact. Oil persists in the environment for long, and despite massive clean-up efforts the marine ecosystem continues to suffer for extended periods. Oil spill has economic implications in terms of the oil lost, cost of clean-up operations and healthcare of workers requiring treatment of exposure symptoms. It affects fisheries and tourism activity since oil spill areas are unfit for swimming or boating. Seafood contaminated with oil chemicals is unsafe for consumption. It is imperative to have proactive measures to prevent oil spills and to contain its damage should that happen.

Constraints and Management Actions:

Since oil production is a major economic activity in Qatar and this natural resource is the largest trading commodity in the Arabian Gulf, oil tankers are always navigating the Gulf waters and chances of oil spill are omnipresent.

There is no guarantee that oil spill will not happen during these operations even under good management conditions. Structural or mechanical failure in machines and accidents continue to pose risks. The extreme weather conditions can create a response gap that adds to the damaging effects of spills.

The scientific constraints are lack of information on long-term ecological effects of spill event in the type of environment found in Qatar and inadequate data on the efficiency of biological clean-up agents. Bioremediation proceeds slowly and how far it is effective in dealing with major oil spills under the local environmental conditions is unknown.

Prospects:

Qatar Petroleum is the main agency for dealing with oil spills in the country. It is a state-owned company that handles oil and gas activities, including exploration, production, refining, transport, and storage. Qatar port has also developed response plans for oil spills. There is a round-the-clock monitoring program that triggers contingency response when oil spills happen. The human resources management department has trained staff to handle the situation. All the protective tools, gears and other resources needed for the operation are maintained in a ready-to-use form. While the impact of oil spills on the environment is considerably reduced by such efforts, but no matter how much efforts are invested there is still a certain degree of impact that is brought to bear on the marine ecosystem. These measures will reduce the effects of oil spills to a great extent. Some green solutions, that will probably be under serious consideration for implementation, include the use of biostimulation and biofermentation products to facilitate the bioremediation efforts. The use of underwater deterrence system is currently an idea that will probably move to the stage of discussion for trials for its efficacy in keeping marine animals away from the oil- spill areas for their protection.

2.4.2.2.9 Descriptor 9: Heavy Metals and Other Contaminants in Seafood Do not Exceed Permissible Levels:

There is a growing interest in fish consumption due to health benefits. Many species of marine animals constituting the seafood accumulate toxic contaminants and pose health risks. Contaminants accumulating in organisms can be transferred along the food chain and their concentration increases through biomagnification. Main seafood contaminants of concern are heavy metals and industrial chemicals. It is often difficult to relate health problems when chemiclas are ingested in small quantities but some of these chemicals persist in the body and are difficult to eliminate. Contaminants can enter the marine environment through sea-based activities such as hydrocarbon extraction and transportation that cause oil spills, and land-based activities such as farming, urbanization and industrial operations. Atmospheric deposition also contributes, to a lesser extent, to the contaminant load in seawater. A comprehensive monitoring program can detect these problems.

Constraints and Management Actions:

Seafood traded in the local markets originates from the fishery conducted in the country in addition to the imported consignment. Random inspection of the products traded in the local markets,backed by? a thorough chemical analysis using sophisticated equipment operated by trained personnel are constraints that need to be addressed. Concerned authorities will probably look into this matter.

Prospects:

Due to the lack of a drainage system, so surface runoff is not a causative factor. Industrial Inspection and Pollution Control Department of the Ministry of Municipality and Environment rigorously checks the industrial output to ensure that the industries comply with the requirements. Serious attention is being given tofood safety in Qatar, efforts are being made to ensure that the seafood production meets the standards consistent with the Codex Alimentarius (FAO/WHO) requirements for food safety.

2.4.2.2.10 Descriptor 10: Coastal Hydrodynamics is not Significantly Altered:

Hydrodynamic conditions in the sea influence the marine life. These conditions include physical parameters of seawater (temperature, depth, density, currents, waves, turbidity and turbulence).

Certain physical developments in the coastal marine areas that lead to permanent alteration of hydrographical conditions adversely affect the marine ecosystem. Physical factors are important in developing habitat conditions for marine life. Distribution and dispersal of many species, especially plankton and juveniles of several species of marine animals are strongly influenced by physical parameters. Hydrodynamic factors also determine the processes of mixing and oxygen distribution. Areas with poor flushing, oxygen deficiency, and accumulation of waste and nutrients can create conditions fatal for marine life.

Constraints and Management Actions:

In many cases, coastal developments are considered essential for reasons of national security, economy and services to the society. Infrastructure related to oil and gas extraction and desalination is located in the sea. Ports, harbors and fish landing jetties are at the seafront, and so are the maritime security facilities. For a country like Qatar, with limited land area, some reclamation will continue to take place in near-shore areas but with more attention to marine environment.

Prospects:

Policy directives in favor of incorporating environmental perspectives in physical developments in coastal-marine areas augurs well for preserving or developing coastal hydrodynamic patterns that do not undermine the essential processes linked to water movement. West Bay Lagoon is a good example of what can be achieved to mitigate the impacts. Such an approach can be applied for coastal developments elsewhere.

2.4.2.2.11 Descriptor 11: Measures are Taken for Dealing with the Effects of Climate Change:

Undoubtedly, climate change affects the marine environment. Qatar is no exception to potential risks from changing climate that include sea-level rise, acidification and warming of seawater, algal blooms, invasive species, zoogeographical shifts in marine life, increase in pathogen load and jelly fish abundance. There are glaring knowledge gaps in our understanding and also uncertainty about the actual nature of future scenarios linked to changing climate in arid countries in the Arabian Gulf. Data collection on pertinent topics and establishing trends are helpful in devising adaptation strategies.

Constraints and Management Actions:

In Qatar, marine ecosystem has not received the attention it deserves. There is a lack of adequate baseline empirical data on marine ecosystem, inadequate investment in research for establishing trends or correlation of marine ecosystem features with the past environmental fluctuations. There is also limited knowledge of marine ecosystem complexity in terms of structuring of various dynamic processes and interaction with marine life, and insufficient data on marine biodiversity and response of indigenous species to environmental change. Tools that could help in specific predictions on a scale needed for management action have not been developed. Developing action plans would require giving more importance to generating scientific data on such aspects. Harsh natural conditions that prevail in Qatar severely limit the carbon sequestration and offset solutions. Blue carbon stocks are limited. Only one species of mangroves grows in some areas. Coverage of seagrasses is small relative to the size of the marine area of the country. The only green carbon stocks found are scattered bushes typical of arid regions and the planted trees. Corals bleach very often due to warming of seawater leading to the formation of ocean hotspots and possibly other oceanic conditions. Occasionally, mass mortalities of marine organisms also happen due to these conditions. These are among the natural constraints that will have to be taken into consideration for designing strategic management systems.

Prospects:

Precautionary measures will have to be taken to build resilience in vulnerable marine ecosystems and developing adaptations to deal with the vagaries of nature related to changing climate. Interest in climate change has started in Qatar since it joined the United Nations Framework Convention on Climate Change (UNFCCC). Climate Change The department of the Ministry of Municipality and Environment is the focal point for matters related to this topic. This department is in the process of building human resources while consolidating facts and figures needed to implement the UNFCCC requirements. Scientific analysis of the scenario suggests that Qatar will be among the severely affected countries by the changing climate for the following reasons:

A) It is an arid country with rainfall that averages only about 80 mm annually and climate change might reduce it further.

B) There is no permanent surface water body and no freshwater catchment that could facilitate recharge of scarce groundwater resources. The nature of soil is one that does not help in seepage of rainwater into aquifers.

C) Qatar has very limited land suitable for agriculture. Climate change will further reduce the suitability of soil for agriculture. The previous, along with intrusion of saltwater will increase soil salinity and further reduce its fertility.

D) Due to high temperature and evaporation, and absence of freshwater drainage from land, the salinity of seawater is high and, in some places, reaches a value of 60–70‰. Most marine organisms here might be living in the upper range of their tolerance and increase in warming of seawater will be detrimental to their survival.

E) Rising seawater temperature will reduce the resilience of marine organisms to acidification that is taking place simultaneously, and some species might succumb to the combined action of multiple factors acting adversely on the marine ecosystem.

F) Climate change is increasing the formation of hot spots in the sea that are oxygen-deficient, and this condition is fatal for some marine species. g. The Marine ecosystem of Qatar is not so rich in biodiversity compared to some other areas such as the Coral Triangle region in the Pacific Ocean, and any loss of marine biodiversity linked to the effects of climate change will have more devastating effects on the ecosystems' functioning. This will potentially undermine some marine ecosystem services.

Establishing scientific evidence on these aspects will take time but will provide a strong basis for decisions based on valid information Qatar needs to invest in this area on a priority basis.

2.5 Governance and Future Outlook:
2.5.1 Institutionalized Procedures:

Marine environment monitoring and governance plans in Qatar have evolved over time. The system of governance comprises a governing body headed by the Minister and a hierarchy of think-tanks who focus on the 'big picture' while planning and developing the appropriate strategies and policies. The management personnel appointed by the governing body organize the assigned duties and carry out the required operations with the help of monitoring staff. Monitoring is done by systematic sampling of sea water, and marine sediment and biota in order to observe and study the nature of environment to generate knowledge for potential use in management. Some parameters are observed in situ while others are analyzed in laboratories.

In view of the growing realization of the significance of the environment in Qatar, it is considered essential to support all the three pillars of sustainable development, namely, economic development, social development and environmental management.

Relevant agencies in Qatar are involved in monitoring different aspects of the marine environment and taking steps as deemed necessary to understand, prevent or mitigate the impacts.

The Ministry of Municipality and Environment is the focal point for matters related to marine environment of the country. The ministry delivers its mandate through the various departments (Figure 2.20).

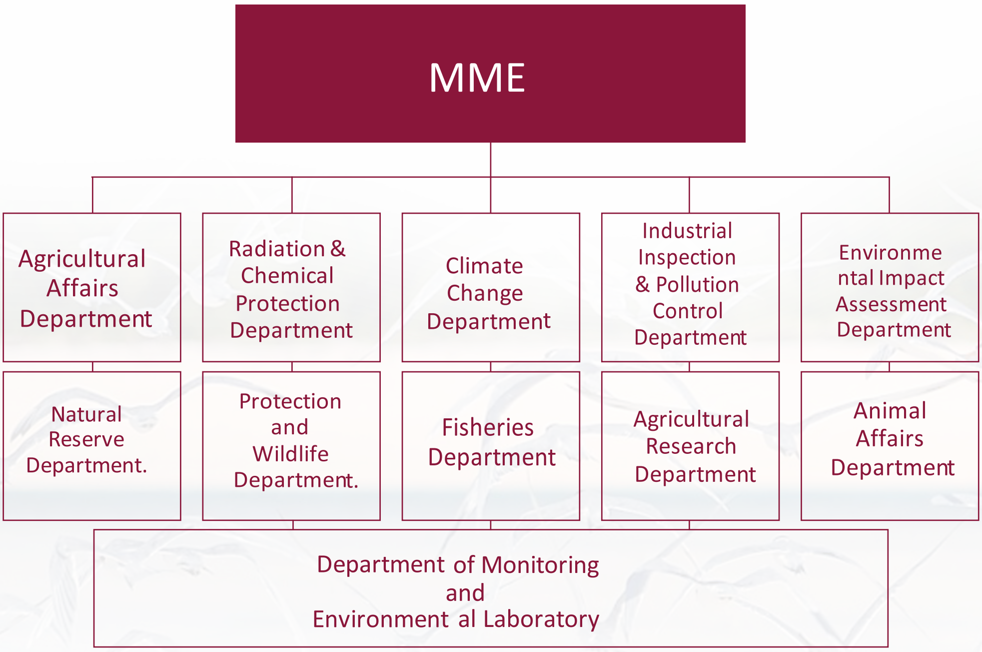


Figure 2.20. Departments of the Ministry of Municipality and Environment.

This organizational structure helps in the development and implementation of environmental laws and is responsible for signing and ratifying international conventions and agreements as explained below.

National Regulations:

1. Law number 4, 1983: Exploitation and protection of living aquatic resources.
2. Ministerial decision number 2, 1985: Prohibiting capture of turtles and collection of turtle eggs from nesting grounds.
3. Law number 1, 1993: Preventing razing of agricultural and beach sand.
4. Law number 11, 2000: Inception of Supreme Environment Council on Natural Reserves.
5. Law number 30, 2002: Promulgating environmental protection low.
6. Law number 19, 2004: Protection of wildlife and natural habitats.
7. Law number 30, 2005: Environmental protection (expanded).
8. Council of Ministers› Resolution No. 37 of 2009 on the Creation of the Permanent Committee on the Convention on the Law of the Sea.
9. Law Number 9, 2015: promulgating the safety regulation for ships with small cargoes not covered by international maritime treaties in the GCC states.
10. Law Number 8, 2017: regulating maritime business in the State of Qatar.
11. The Decision of the Council of Ministers No. 13 of 2018 Amending Certain Provisions of Decision No. 37 of 2009 Establishing the Standing Committee of the Law of the Sea Convention.
12. Law Number 12, 2019: the maritime zones of the State of Qatar.

International Agreements:

- a. United Nations Convention on the Law of the Sea (UNCLOS III) introduced in 1994 and ratified by Qatar in December 2002.

- b. Prevention of Marine Pollution by Dumping of wastes and Other Matters (1992).

- c. Convention on Biological Diversity signed in 1992, became a party to the Convention on 21 August 1996.

- d. United Nations Framework Convention on Climate Change (1996).

- e. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes (1996).

- f. Convention on International Trade in Endangered Species of Wild Fauna and Flora (2001).

- g. Stockholm Convention on Persistent Organic Pollutants (2004).

- h. Kyoto Protocol (2005).

- i. International Maritime Organization Convention on Marine Pollution (2006).

- j. Decree No. 15 of 2018 approving the accession of the State of Qatar to the International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004.

Besides, the Ministry of Municipality and Environment is the referral point for issues related to conservation and sustainable development of marine resources as elaborated in Figure 2.21.

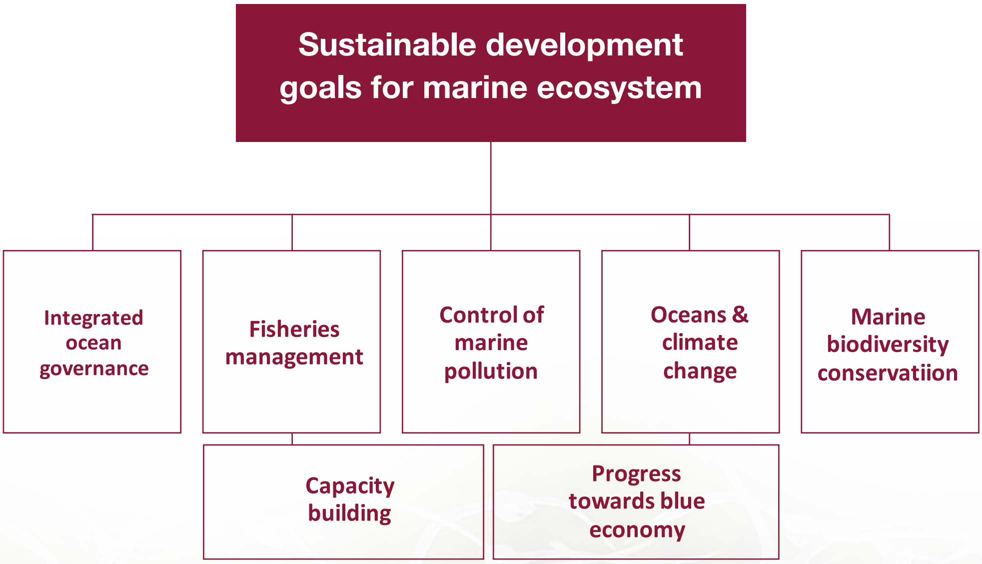


Figure 2.21 Issues related to sustainable development of marine ecosystem in Qatar.

2.5.1.1 Integrated Ocean Governance:

To ensure that the decisions are knowledge-based, a regular monitoring of the coastal and marine environment is carried out by Environment Monitoring Department. There are more than 10 locations along the coast of Qatar for sampling of seawater, plankton and benthos. In addition to standard water quality parameters, profiles of many chemicals are also screened for investigating the possible environmental problems.

At a regional level, Qatar participates in the Regional Seas Program of the United Nations Environment Program, through

Regional Convention for Cooperation on the Protection of the Marine Environment (ROPME). Qatar is one of the 8 countries bordering the Arabian Gulf contributing to the implementation of the relevant protocols associated with this convention. Projects deal with issues related to coastal zone management, fisheries, land-based impacts, sea-based pollution, marine biodiversity, oceanography, GIS, remote sensing, marine emergencies, environmental awareness and capacity building.

ROPME also provides a platform for addressing the matters concerning shared resources, conservation of biodiversity and protection of vulnerable ecosystems. The Department of Environmental Protection, Natural Resources and Wildlife in the Ministry of Municipality and Environment focuses on the general protection of environment. It shares the responsibility of marine conservation with other departments dealing with related issues while paying attention to the conservation of living marine resources.

2.5.1.2 Ocean and Climate Change:

More attention has been given to Climate change in Qatar. Climate Change Department handles this matter. It is responsible for implementing the recommendations as envisaged under the UN Framework Convention on Climate Change focusing on monitoring, mitigation, adaptation, capacity building and public education. Qatar is particularly more vulnerable to vagaries of changing climate by virtue of its geographical conditions and is, therefore, in the process of evolving action plans designed to meet some specific challenges. It is a work under progress.

2.5.1.3 Conservation of Marine Biodiversity:

In Qatar, there are many activities, including reclamation, fishing, navigation, and extraction of oil and gas, and desalination that are being conducted on a large-scale. These operations put pressure on marine biodiversity. To mitigate their possible impacts there are regulatory mechanisms handled by Environmental Impact Assessment Department. This has allowed necessary developments in ways that do not exert major impacts on the marine ecosystem. For example, the coastal reclamation projects and brine discharge from desalination plants are subjected to environmental impact assessment. An important area of consideration in such cases is marine biodiversity.

Capture fisheries that supply the seafood regulate the use of certain fishing operations that could threaten biodiversity in the sea as well as sustainability of the fishery itself. There are also specially structured marine biodiversity conservation programs, notably for endangered species but a lot more work needs to be done in this field.

2.5.1.4 Fisheries Management for Food Security and Socio-economic Welfare:

Matters related to fisheries are managed by Fisheries Department. Fisheries data are examined to generate information on catch composition, possible pattern in landings and other features that help in reviewing the problems, if any, and devising adaptive management measures.

With the efforts being made, Qatar is progressing towards the Ecosystem Approach to Fisheries Management (EAFM). The first step in this process, as we see it, is recognition of fishery governance as a systemic concept that envisages due consideration of the policy support, administrative authority for enforcement and economic objectives.

EAFM will shape up over a period for pursuing sustainability by balancing ecological conservation and utilization of marine biological resources for human well-being through good governance. The change in focus on targeted species in isolation from their environment and other influences to the functional viability of ecosystem will be a harbinger of hope for rational management of marine fisheries in Qatar. The perspectives of 3 key components of EAFM guiding this development are explained in Figure 2.22.

EAFM

Ecological Integrity : Helthy habitats, food webs sustainable fishing

Societal Benefits

Increased production seafood security, sustainable economic benefits.

Good Governance:

Right policies capable institutions, sffective administrative authority

Figure 2.22. Main components of fisheries management for EAFM.

EAFM will be key to scientifically calibrating the fishing capacity and determining practices that do not lead to overfishing, and curbing fishing by methods that are detrimental to sustainability. As a result of these efforts, the natural fish populations in the sea are expected to grow and their capacity to absorb fishing pressure will increase. The strategy is to support replenishment of the depleted stocks by easing out pressure on wild populations and providing healing touch to the marine ecosystem.

In the context of Qatar, EAFM has a good chance of wider acceptability because it complements and incorporates the existing approaches to fisheries and coastal marine resources management such as integrated coastal zone management, marine protected areas, and generally in the broader context of the ecosystem-based management of natural resources of Qatar.

2.5.1.5 Control of Marine Pollution:

Marine environment of Qatar has been subjected to a wide variety of anthropogenic activities, both land-based and sea-based. Sedimentation as a result of coastal developments, discharge of waste, industrial pollutants and unintentional release of oil are among the major sources of pollution. However, Environmental Impact Assessment Department gives serious attention to assessment of impacts of coastal development projects on the environment. Projects are allowed if there are effective impact mitigation plans. Qatar follows the core components of the Global Program of Action for the Protection of the Marine Environment from Land-Based Activities. Industrial Inspection and Pollution Control Department is charged with the responsibility of inspection of industrial areas with the aim of enforcing measures for controlling pollution. While the developments will continue to meet the demands of the growing human population, urbanization and industrialization, the stringent regulations will minimize their impact on the environment.

In addition to this framework for action at national level, Qatar takes part in pollution control and management at a regional level under the aegis of the Regional Seas Program of UNEP for the Arabian Gulf. Keeping in view the industrial-scale extraction of oil and natural gas as a major economic activity that also involves the risk of accidental oil spills, there are national and regional programs of action to deal with such incidents.

Even for activities as critical as drinking water security requiring pumping of massive volumes of sea water for desalination, the process is subject to environmental impact assessment requirements to ensure that the concentrated brine originating from desalination plants is disposed in a way as to minimize the adverse impact on marine ecosystem. However, there is an interest to verify it through structured research projects.

The administrative zones in the form of municipalities in Qatar (Madinat Ash Shamal, Al Khawar, Umm Salal, Al Daayen, Al Rayyan, Doha and Al Wakrah are responsible for collection and disposal of waste from human settlements. Without this role, most of it would find its way to the sea.

Beach monitoring is conducted at specific times of the year for examining the litter composition. Municipalities routinely conduct the beach clean-up operations in areas of their jurisdiction to prevent entry of this mostly land-based waste to the sea. Synchronization of beach clean-up and monitoring schedules is recommended for a policy decision. Public awareness programs are also held to instill concern for the environment.

2.5.1.6 Capacity Building:

Quest for knowledge-based development in Qatar has prompted the need for building human resources through institutions of higher education. In areas where there is a shortage of local expertise, the country has a liberal policy of inviting experts from around the world to work shoulder-to-shoulder with the local counterparts. This has helped in knowledge transfer as well as inculcating international perspectives to our on-going programs.

2.5.1.7 Progress Towards Blue Economy:

Interest in blue economy is relatively new. In dealing with this topic, it is important to elaborate the context of discussion which is marine-based economic development that leads to improved well-being of all sections of the society while reducing environmental impacts as well as ecological scarcities.

Fishing and navigation have a long history in Qatar but these activities have become increasingly sophisticated and intensified with the passage of time. From what used to be small-scale operations in the form of angling and shellfish collection, the fisheries now deploy modern gears. What used to be movement in small boats from simple jetties has changed to well-equipped means for transport of people and cargo. There are ports and harbors to support such activities. Marine tourism has also advanced, with people having their boathouses in marinas and spending leisure time at the sea, and visiting the islands and staying in resorts built on artificial islands. The services sector has expanded significantly to support this change in lifestyles.

The rich hydrocarbon deposits in the marine exclusive economic zone of Qatar form the backbone of the economy and are a key factor in improved well-being of the population. It has helped overcome, to a great extent, the harsh geographical conditions typical of this region, eradicated poverty, generated employment, offered decent livelihood to all sections of the population, and empowered the country to play an active role in international agreements and governance mechanisms concerning environment and maritime affairs.

In the light of irrefutable scientific evidences suggesting the ecological scarcity at the global level, Qatar has evolved adaptable management policies towards conservation of environment and natural resources. It is based on the premise that the environment is under pressure and natural resources are shrinking, and should no longer be accepted as a means to develop economies through a constant pattern of consumption. The policy direction in Qatar is crafted considering scientific facts as well as the difficult geographical conditions of the country. It is now a national policy to achieve decoupling of socio-economic development from environmental degradation by integrating conservation and sustainable use plans. Future years will see how far the country progresses in this direction.

Qatar's economy is mainly driven by the energy sector that depends on natural hydrocarbon deposits. This has to continue for socio-economic progress. Land is scarce and arid, there are no permanent surface water resources and groundwater recharge is extremely limited. Given these conditions, the country heavily depends on import of goods, including food products. Desalination of sea water mostly meets human demand of drinking water. The only major export from Qatar is that of oil and gas. Tapping of oil and gas reserves on a commercial scale has a carbon footprint with an impact on the marine ecosystem. However, measures are being taken to reduce it as far as possible.

The next sector of ocean-based economy is fisheries. The regulatory frameworks developed are aimed at achieving sustainable development using a precautionary approach. Due to lack of surface water bodies, any commercial-scale freshwater aquaculture is not feasible. Marine aquaculture, however, is a practically feasible option but it requires policy support for investment and motivation of entrepreneurs to take up maricultural as a profitable business. Needless to say that marine aquaculture has the potential to supplement seafood supplies from capture fisheries and could be a means of reducing pressure on natural fisheries resources. Furthermore, the method that deserves consideration is sea-based multitrophic aquaculture that provides one of the best methods available for introducing green approaches to seafood production.

Marine ecotourism is not a major activity at the moment. It is in the form of recreation for the purpose of game fishing and enjoying the seascape in boat houses around the coastal waters of Doha. The fact that it engages a labor force to maintain and operate boats, and manage the port together with its infrastructure facilities such as cafeterias, this can be considered as an emerging economic sector.

Greening the energy sector of blue economy is challenging but progress is being made in this area through accurate impact assessment, effective mitigation, embracing green technology wherever possible, and investing in research oriented towards harnessing clean energy.

Qatar has a very limited natural capacity for carbon offset projects; it has a desert climate, without a forest cover (or green carbon stocks) and only modest blue carbon stocks. Under this situation, it is hard to initiate major carbon offset projects. Reducing impacts and adopting efficient mitigation measures with a precautionary approach are the most viable options. An impediment could be knowledge gaps in certain important areas related to marine ecosystem, especially valuation of marine resources, incorporating values into economic decision-making, quantification of blue-carbon stocks, resilience of marine renewable resources, spatial planning in integrated coastal zone management, marine bioprospecting, seafood security, Surface Ocean-Lower Atmosphere (SOLAS) data, marine biodiversity, coastal hydrodynamics, mariculture and climate change adaptations. This calls for prioritizing research by agencies responsible for developing national blueprint for R&D and financially supporting the blue economy programs.

The scope and growth of blue economy in Qatar will depend on how the country invests and develops the drivers of this sector and makes valuation of the ecosystem services. The top driver of blue economy for now is energy, followed by seafood production and navigation. Other sectors are either on a small-scale or yet to develop. Marine aquaculture and marine biopharmaceutical sectors have yet to take off. Marine tourism is catching up. In Qatar, where the economy heavily depends on energy resources, this area will continue to lead the economic growth. However, with the plans and policies that are being put in place, other economic sectors will emerge over a period of time. Oil and gas exploitation are industrial operations that have impacts on the environment. There is an interest in minimizing this impact using modern technologies, but still there is a long way to go in achieving environmental compatibility. Renewable (clean) energy production could be the more appropriate topic when it comes to discussing ‘green-blue’ economy (blue energy) but this sector has not made a significant headway. Nevertheless, harnessing of the clean energy has emerged as a topic of research and development.

2.5.2 Governance Indicators:

Governance of marine environment of Qatar as handled by the Ministry of Municipality and Environment is consistent with the policy that advocates sustainable development for managing human interaction with the sea. It is done through rules, regulations, policies, practices, institutionalized arrangements and enforcement.

Governance goals of Qatar focus on strengthening sustainable management of marine environmental resources according to global, regional, national and local priorities. Scientifically sound evidence and effective decision-making guide our approach to governance. The existence of a marine environmental program is a governance indicator. However, to maximize the effectiveness of the indicator of effort (means to achieve the goals), and translate it into positive outcomes and achieved goals, however, it is very much important to strengthen management of the marine environment (Table 2.13).

Table 2.13. Program objectives and Indicator of effort.		
Objective	Initiative (s)	Indicator of effort
To enhance marine environmental conservation to international levels.	Signing and ratification of international conventions, treaties & agreements. Appointment of focal point. Development of national policy document. Institutionalizing reporting procedures.	Yes
To improve generation of knowledge needed to strengthen conservation.	Developing and implementing knowledge-based programs designed to generate data on marine environment and examining outcomes from efforts.	Yes
To strengthen enforcement mechanisms.	Legislations introduced to support marine conservation.	Yes
To increase in coverage of marine protected areas.	Gazetting of marine parks and institutionalization of enforcement mechanisms.	Yes
To strengthen capacity building.	Degree programs. Research projects. Training courses.	Yes

To improve public awareness.	Number of students graduating. Increase in output of degree holders. Increasing employment of local experts to lead marine science programs.	Yes
	To mobilize well-equipped trained human resources in surveillance, monitoring and enforcement.	Yes
	Increase in the number of stakeholders involved in surveillance, monitoring and enforcement.	Yes
	Community outreach programs. Media of mass communication. Roadshows.	Yes
	Community understanding and cooperating with the conservation plan.	Yes
To design and implement action plans for protection of marine environment from accidental hazards.	Structured action plan backed by trained staff developed to operational readiness. Oil spill contingency plan implemented.	Yes

These are non-numeric, qualitative indicators. Hopefully, in the near future through improved national data collection and coordination some figures on the above programs that requires numeric information and deliverables will be available to provide milestones and benchmarks of progress.

2.5.2.1 A Showcase of Eco-friendly Coastal Marine Governance:

West Bay Lagoon: Development of West Bay Lagoon in Doha (Figure 2.23) is a showcase of good environmental governance that reflects how environmental policies can guide social and economic developments.

Figure 2.23. West Bay Lagoon.

Historically, this area was a salt marsh where coastal development was carried out due to population pressure. This turned the salt marsh into a hyper-saline shallow pool of water. Subjecting this body of water to eco-development was challenging and required a smart design for a lagoon and connected channels to ensure efficient flow of water and preventing stagnation. The design worked well in this project, resulting in the key water quality parameters (temperature, salinity and dissolved oxygen) in the lagoon to be similar to those in the open sea. The islands in the area were modified to increase their size and alignment to create pathways for efficient water flow. West Bay Lagoon is surrounded by 1.0 million m2 of lagoon water (Van Lavieren et al., 2011), a fairly large volume to absorb the impact of flushing and exchange. Evidences of environmental enhancement presented in their report include successful propagation of transplanted seagrass which doubled covered in just one year, increase in the diversity and abundance of benthic infauna and macrofauna even though the area supports a large number of housing units, government administrative blocks and businesses.

2.5.3 Future Outlook

Qatar is keen to preserve its coastal and marine ecosystems so as to continue to benefit from their services that are rooted in history and culture and are important for socio-economic development. Significance of the sea is also growing as the society is taking increasing interest in marine ecotourism, climate change adaptations and strengthening scientific knowledge for decision-making. Undoubtedly, sea will continue to inspire future planning in Qatar given the harsh geographical conditions on the arid land and the fact that it is three times the size of the country's land mass. We cannot hope to combat the effects of climate change and develop adaptations by ignoring the marine environment. There is a realization that ecosystem-based management of all our coastal and marine environments is key to sustainable development and a secure future.

Qatar has pledged full support to the Sustainable Development Goals of the United Nations, the primary targets of which are sustainable management of natural resources and combating the effects of climate change. In this context, investment in generating scientific information and international coordination are vital for sound decision-making for long-term outcomes.

Stakes are too high for Qatar because of the extreme natural conditions that limit our options for action and the fact that the entire population lives within less than 100 km of the coast that defines the land constraint. Energy reserves are the backbone of the country's economy, but marine biological resources contribute a great deal to seafood security. These are among the reasons that provide us a strong basis for dedicated actions directed at conservation and sustainable development of marine environment.

Qatar's marine ecosystem is unique in many ways that also reflect its remarkable resilience. We need to understand it and capitalize on it. We cannot do so without filling the glaring gaps in our scientific knowledge, prioritizing issues and developing innovative ideas that are practically relevant. We also need to set the milestones for implementing our commitments under the international conventions such the Convention on Biological Diversity and United Nations Framework Convention on Climate Change among others while at the same time boosting local capability for addressing new and emerging challenges.

Good governance of marine environment that includes greater investment in knowledge, human capacity building, sound planning, adaptive management and effective stakeholder participation will provide reasons for optimism for sustainable development of marine ecosystem of Qatar. An effective governance system will define our success in ocean stewardship role.

2.6 Summary

Marine environment of Qatar supports economy, contributes to seafood security and water security, moderates weather conditions and provides other ecosystem services of vital importance to the country. The increasing trend of direct human interaction with the sea and climate change have varying levels of impact on the ecosystem processes that play such a high-profile role in the societal welfare.

There are institutionalized regulatory mechanisms for controlling anthropogenic activities. However, there is a need to develop an in-depth scientific understanding of the state of the marine environment, identify indicators that can be used to assess the condition, examine the pressures on the marine ecosystem and determine the effectiveness of the governance mechanisms. In generating this first ever report on the state of the marine environment, data was consolidated to establish baseline information on core topics such as the oceanographic features, some of which are unique to Qatar. Human activities that exert pressure on the environment are overfishing, coastal developments, alteration in coastal hydrodynamic pattern, pollution, desalination, littering and navigation. Climate change is a formidable factor in degradation of marine habitats. Its adverse effects in Qatar will be particularly strong due to a number of factors that have been described in this report. Because of the complexity of the marine ecosystem and many factors affecting it, the mitigation response should be multipronged. 11 descriptors have been selected to characterize the targets for action to meet the sustainability conditions. Constraints, management actions and prospects pertaining to each of these descriptors have been outlined. Indicators of marine environment are elaborated under 3 broad categories, namely, biodiversity indicators, fisheries indicators and water quality indicators. The marine biodiversity inventory is based on a total of 890 marine species (Plankton, Plant-like Protista, Porifera, Cnidaria, Annelida, Sipuncula, Arthropoda, Mollusca, Echinodermata and Chordates) and the coastal vegetation comprising mangrove and seagrass species in addition to 24 seashore birds. In describing the status of threatened species, those considered charismatic megafauna (whale shark, sea turtles, dolphins, dugong and whales) have been included. Their conservation status under IUCN Red List ranges from critically endangered, endangered and vulnerable. Some species among the marine mammals are categorized as of least concern but their global trend is either unknown or stable. Efforts made by Qatar for conservation of marine biodiversity include declaration of 721 km2 of the country's marine area of 35,000 km2 as marine protected area in addition to regulatory frameworks for designated regions of high ecological sensitivity (for example, turtle nesting sites, and spawning grounds of some fish species). Marine Trophic Index (MTI) was also determined to judge the ecosystem condition. Value of this parameter varied from 2.0 – 4.7, reflecting the composition of fish landed by commercial fisheries. There are limitations in using MTI data alone to characterize the health of marine ecosystem. It is recommended to consider this parameter together with others in environmental assessment. Use of population of seashore birds as indicator of marine environmental integrity was explored. While as many as 24 species of seashore birds have been encountered but it is difficult to make conclusions in view of the deficiency of data vis-à-vis dynamics of their population and use of coastal marine habitat resources. Realizing the fact that fisheries have a major impact on biodiversity and marine ecosystem, it was considered pertinent to examine fisheries indicators. Fisheries data collection in Qatar has specific objectives. Catch per unit effort (CPUE) data was used as an indicator for determining the effectiveness of the management measures being applied. Relative stock biomass indicator was used to measure the abundance of fish stocks as a component of fishery stock status. A specifically structured study has been conducted on 39 species in the commercial catch. Quantities of their landings were subjected to analysis of annual variability. The information generated some positive elements in the fisheries management, response of fishery to conservation intervention and concern of overexploitation of certain species. Water Quality Index (WQI) as the environmental indicator was examined. There is a need to expand the scope of parametric measurements for WQI value to be treated as reflective of the quality of marine environment. Beach litter was yet another environmental indicator, but interpretation of the current data is constrained by lack of synchronization between the monitoring and litter removal schedules.

Governance is an issue of fundamental importance in understanding the state of marine environment. Policy, actions and maritime affairs have been considered as cornerstones of ocean governance in Qatar. There is a framework of rules and regulations that seek to organize the ways of using the marine environment. Our policies are basically consistent with the international conventions that the country has signed in addition to codes of conduct it formulated in response to the ground realities by virtue of the unique conditions. There are 10 departments in the Ministry of Municipality and Environment assigned different roles. Due to this structured arrangement, the Ministry is a referral point for issues related to integrated ocean governance, climate change, biodiversity, fisheries, pollution control, blue economy and capacity building. There are non-numeric governance indicators in this report together with description of a showcase of ecofriendly development.

With the information available, it has been possible to structure the ecosystem-based indicators into the Driver-Pressure-State-Impact-Response framework in certain cases.

Future outlook of the marine environment will be determined by how we govern it today. Ecosystem-based approach to marine management is the best way forward in reconciling political, economic, social, and environmental interests. That will also integrate national, regional and international concerns. Strengthening of research base and policy support in favor of marine conservation will demonstrate how effectively we deliver our ocean stewardship responsibility

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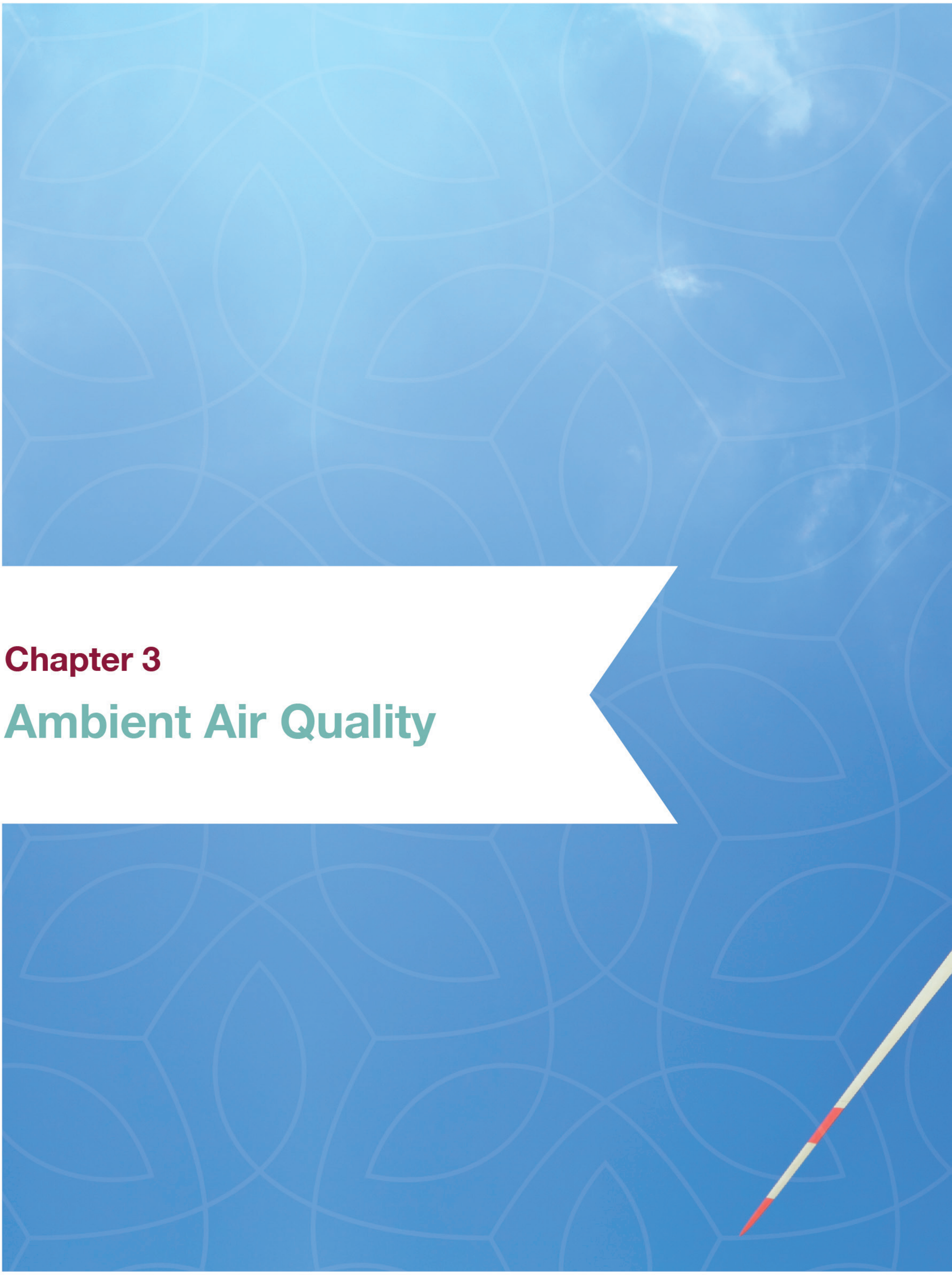
Chapter 3

Ambient Air Quality



Chapter 3

Ambient Air Quality

Chapter 3:
Air Quality

Data on ambient air quality monitored at different locations in Qatar were used to determine the Air Quality Index (AQI) consistent with the US-EPA procedure. Parameters measured included the gases (SO_2, NO_2, O_3, CO) and PM10. Data suggested that the country experiences high particulate matter concentrations due to different wind regimes and meteorological conditions in the region, namely, sub-tropical jet system and shamal wind system, strong local wind systems and tropical easterly jet system. These wind systems tend to degrade the air quality and account for a daily PM10 AQ sub-index value of 'Less than Normal' category. There are compelling reasons to believe that the cross-country pollutant transport during Shamal degrades the air quality. Emissions from vehicles, especially during heavy traffic jams, increase the NO_2 AQ sub-index in Doha city area. However, the values are within the range for national reference standard. The on-going measures for public transport and rigorous checks on combustion of fuel in vehicles are reducing the harmful emissions.

3.1 Introduction

Generally speaking, both anthropogenic activities and natural processes release significant amount of substances and chemical compounds into the atmosphere. These substances, which are foreign to clean atmospheric composition, can eventually result in air pollution. Once released into the atmosphere, these chemical compounds are subjected to various atmospheric processes, which control their transport, and can alter their chemical and physical compositions. Thus, the environmental impacts of these substances emitted to the atmosphere is greatly caused by these processes. The impacts of the air pollution, therefore, can vary from poor ambient air quality in the close vicinity of the emission sources, to the disruption of natural chemical cycles and physical processes that occur even on a global scale.

The Qatar National Vision 2030 is a development plan launched in the year 2008 by the General Secretariat for Development Planning in the State of Qatar. The aim of this plan was to “transform Qatar into an advanced society capable of achieving sustainable development” by 2030, also by achieving a decrease in environmental pollution.

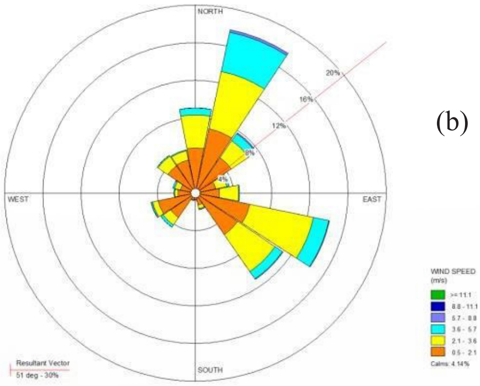
The main objective of this part of the State of the Environment (SoE) Report is to describe the ambient air quality status and conditions from the recently measured pollutant concentrations at various monitoring stations inside Qatar with respect to Qatar Air Quality Index (AQI) values. Ambient air quality data, collected at three ambient air quality monitoring stations operated by MME located in the Greater Doha Area, has been studied and presented in this Report.

3.2 Climate of Qatar

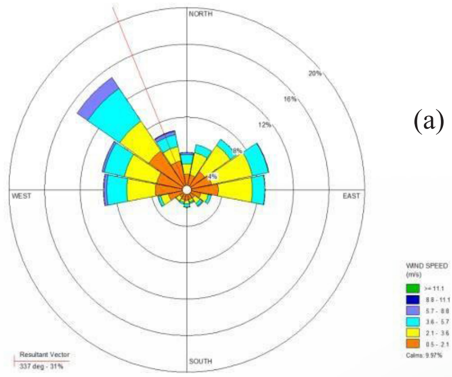
Qatar has a dry, subtropical desert climate, having low annual rainfall amount (i.e., less than 100 mm) extremely hot, and humid during the summers season (i.e., June till September). Spring and autumn are the best times in Qatar, when temperatures are warm but not hot, and the evenings are pleasantly cool. The daily mean temperature for June, July and August is around 42ºC, and hourly mean temperature can reach as high as 50ºC. In winter season (December to February), temperatures are cooler but still warm, with the average value around 23ºC. Almost all rainfall occurs during the winter season, mostly in the form of brief bursts of heavy rain. Since Qatar is a small country, there is a little regional variation in the weather conditions and pattern, even though coastal areas may be slightly cooler than inland areas.

Figure 3.1 presents the wind rose diagrams for Ministry of Municipality and Environment (MME) stations of Qatar University and Aspire Zone in Qatar. The annual prevailing wind at these stations are found from the NW direction with the annual wind speed of 2.38 m/s, and NNE direction with the annual wind speed of 2.0 m/s, respectively, according to the measurements taken in 2015 at MME stations. Surface observations also reveal that northerly winds are the most dominant winds in Qatar, particularly during the winter season. In addition, the prevailing wind direction is reported from the NW direction at the Doha Hamad International Airport in 2015.

Figure 3.2a to Figure 3.2e show the hourly minimum, hourly maximum, and daily mean air temperatures measured at MME Al-Corniche, Qatar University and Aspire Zone monitoring stations, respectively. These figures show that the highest hourly mean recorded air temperature went up to 49.7ºC,at Aspire Zone station in the month of July 2017, and hourly minimum recorded temperature value was about 6.3ºC at the Qatar University monitoring station in the month of February 2017.

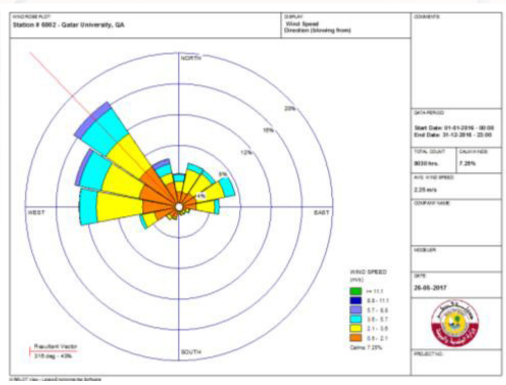


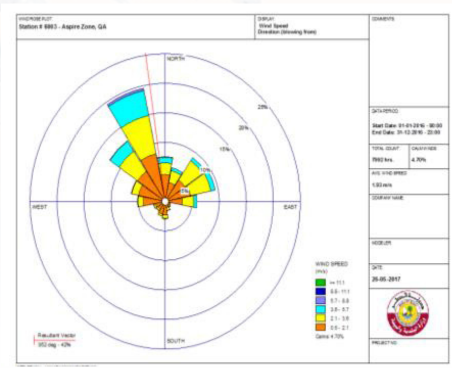
(b)



(a)

Figure 3.1a. The wind rose diagrams for a) Qatar University, b) Aspire Zone, and c) Doha Hamad International Airport meteorological monitoring stations in 2015.





(a) (b)

Figure 3.1b. The windrose diagrams for a) Qatar University, and b) Aspire Zone meteorological monitoring stations in year 2016, respectively.

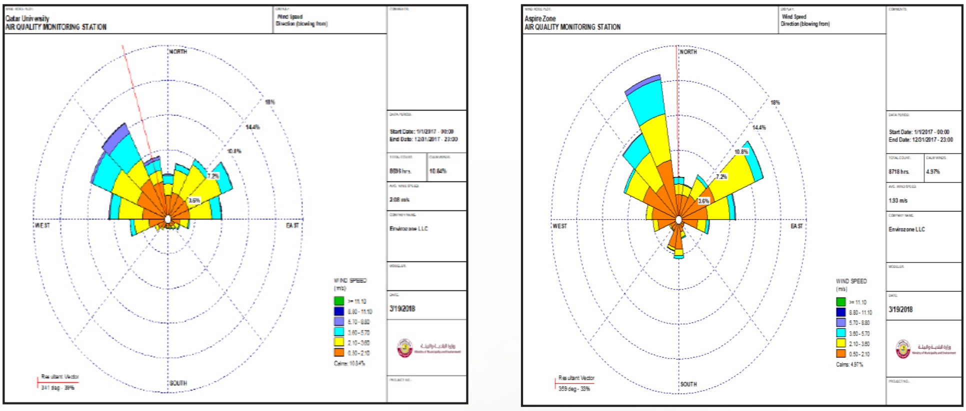
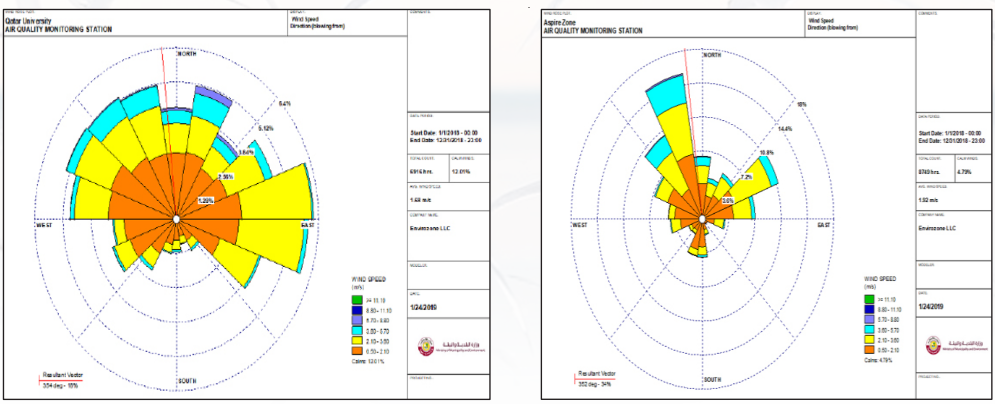


Figure 3.1c. The windrose diagrams for a) Qatar University, and b) Aspire Zone meteorological monitoring stations in year 2017, respectively.



(a) (b)

Figure 3.1d. The windrose diagrams for a) Qatar University, and b) Aspire Zone meteorological monitoring stations in year 2018, respectively.

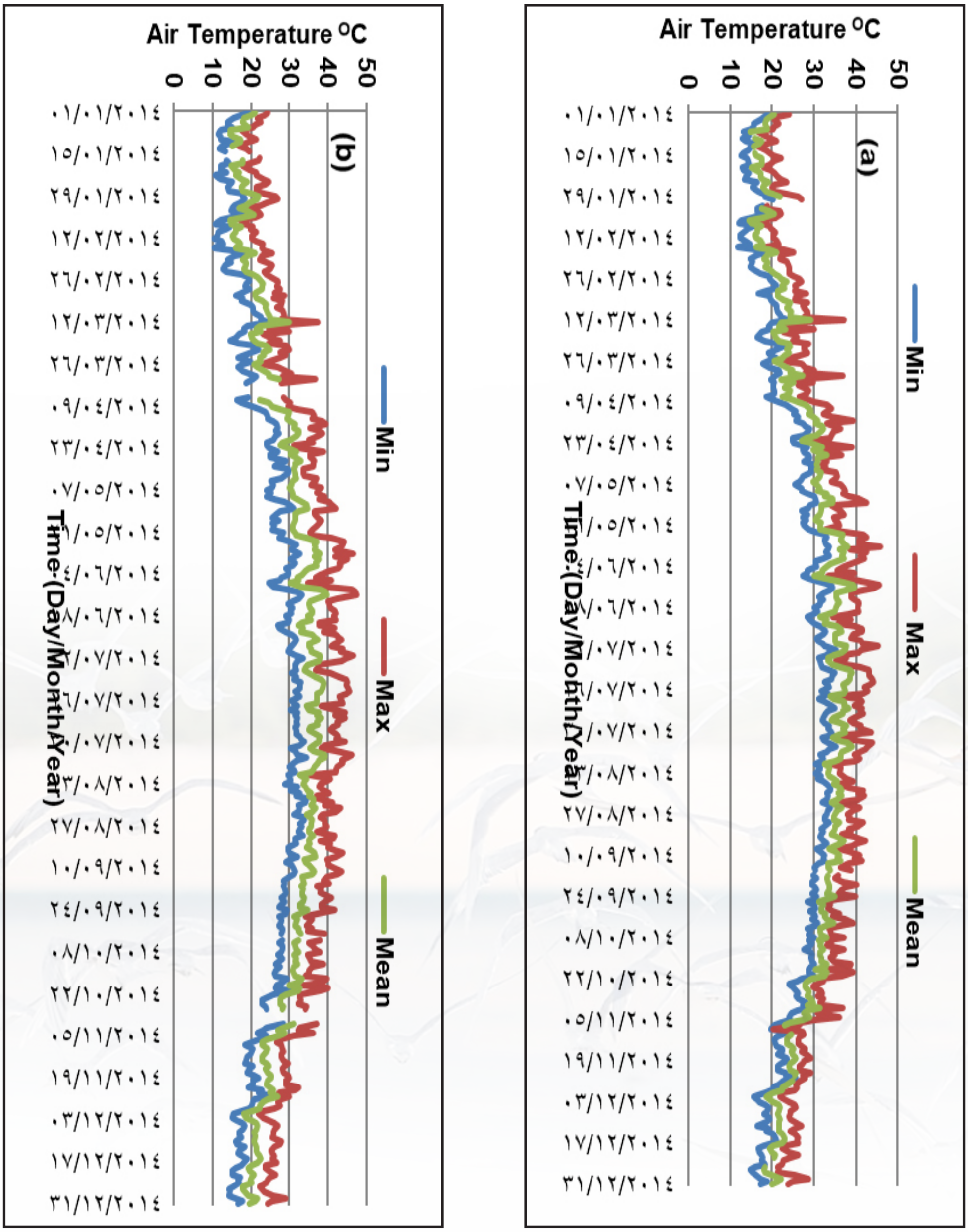


Figure 3.2a. Daily minimum, daily maximum and daily mean values of ambient air temperatures (°C) at (a) Al Corniche, and (b) Qatar University monitoring stations, respectively, Please note that this parameter was installed in Aspire Zone monitoring stations on 2016 so that no data was available for this station during the year 2014.

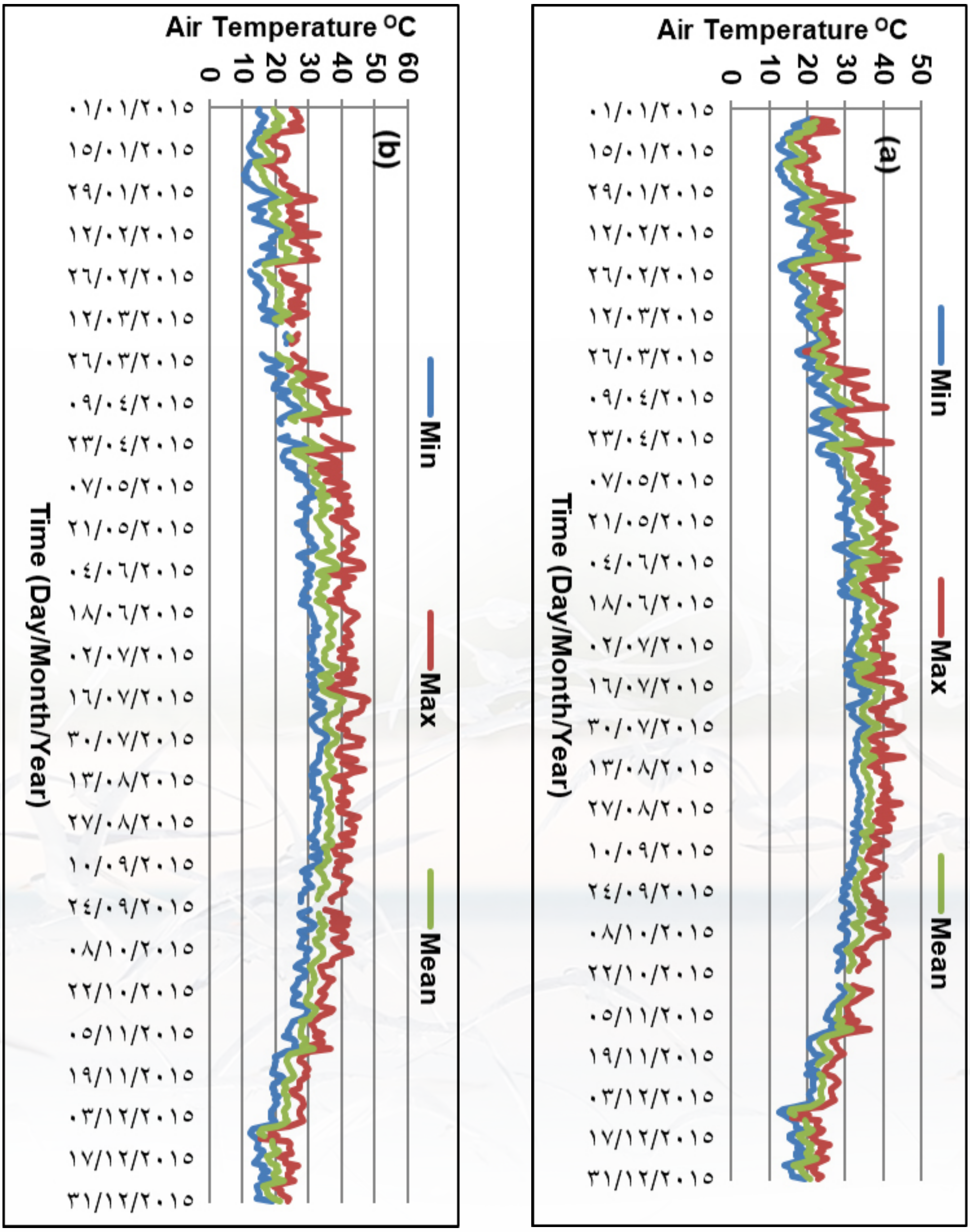


Figure 3.2b. Daily minimum, daily maximum and daily mean values of ambient air temperatures (°C) at (a) Al Corniche, and (b) Qatar University monitoring stations, respectively, Please note that this parameter was installed in Aspire Zone monitoring stations on 2016 so that no data was available for this station during the year 2015.

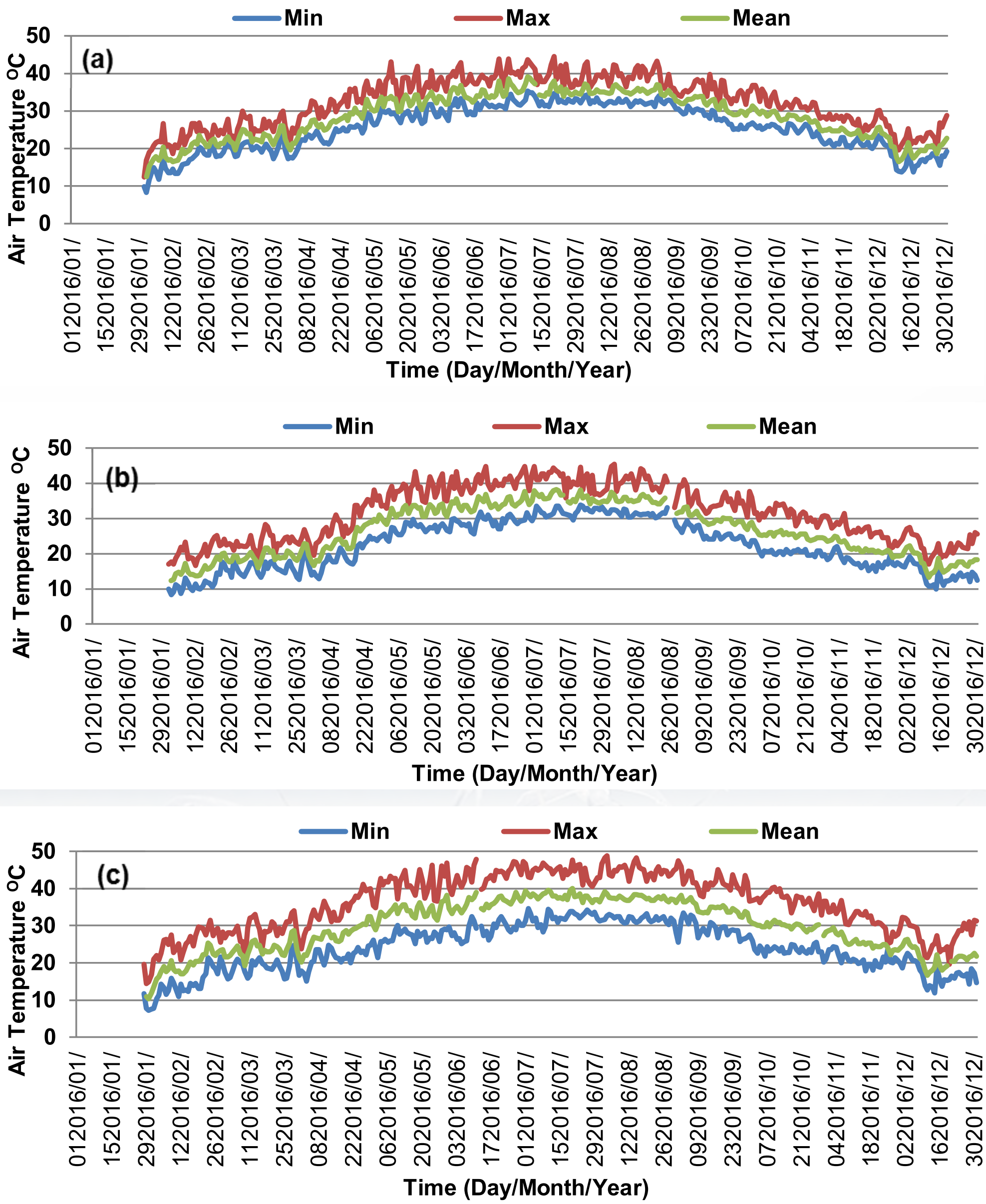


Figure 3.2c. Daily minimum, daily maximum, and daily mean values of ambient air temperatures (°C) at (a) Al Corniche, (b) Qatar University, and (c) Aspire Zone monitoring stations during the year 2016.

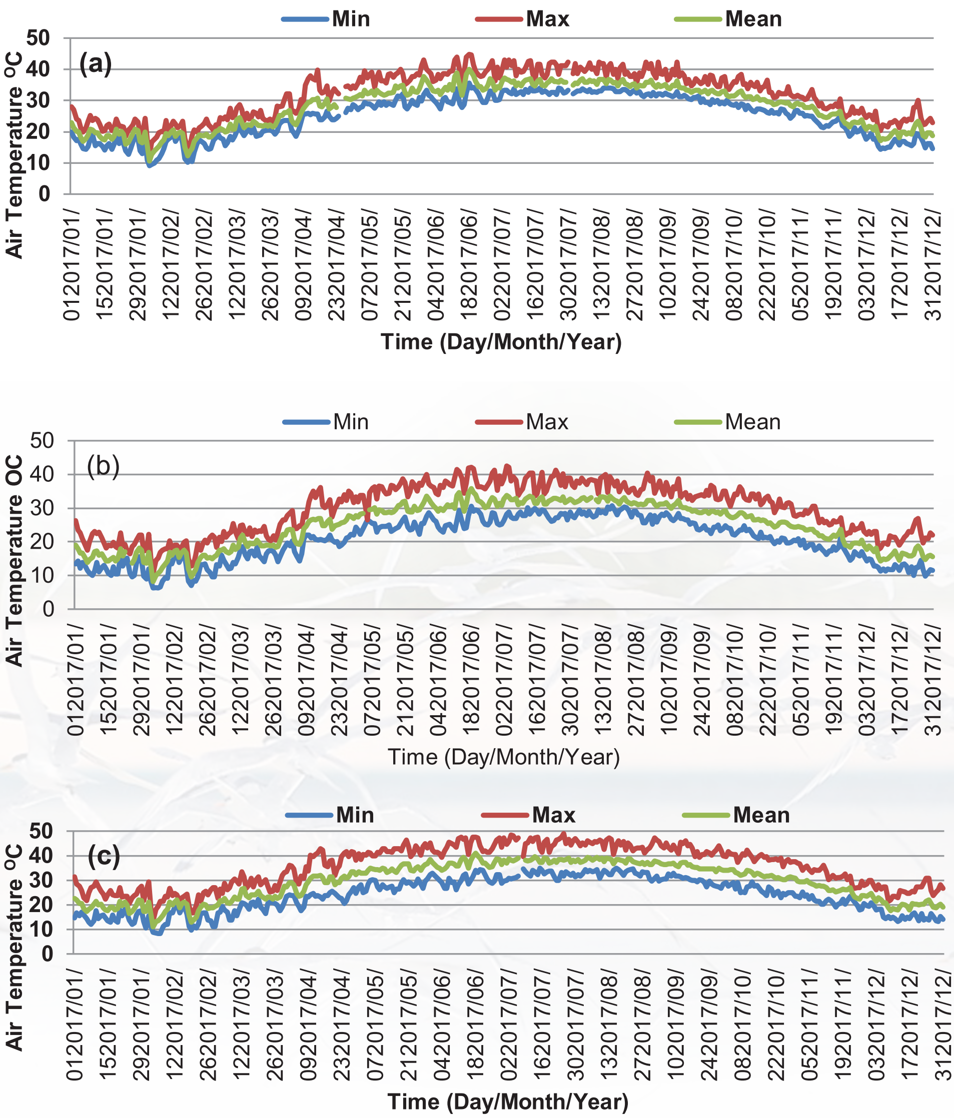


Figure 3.2d. Daily minimum, daily maximum, and daily mean values of ambient air temperatures (°C) at (a) Al Corniche, (b) Qatar University, and (c) Aspire Zone monitoring stations, respectively during the year 2017.

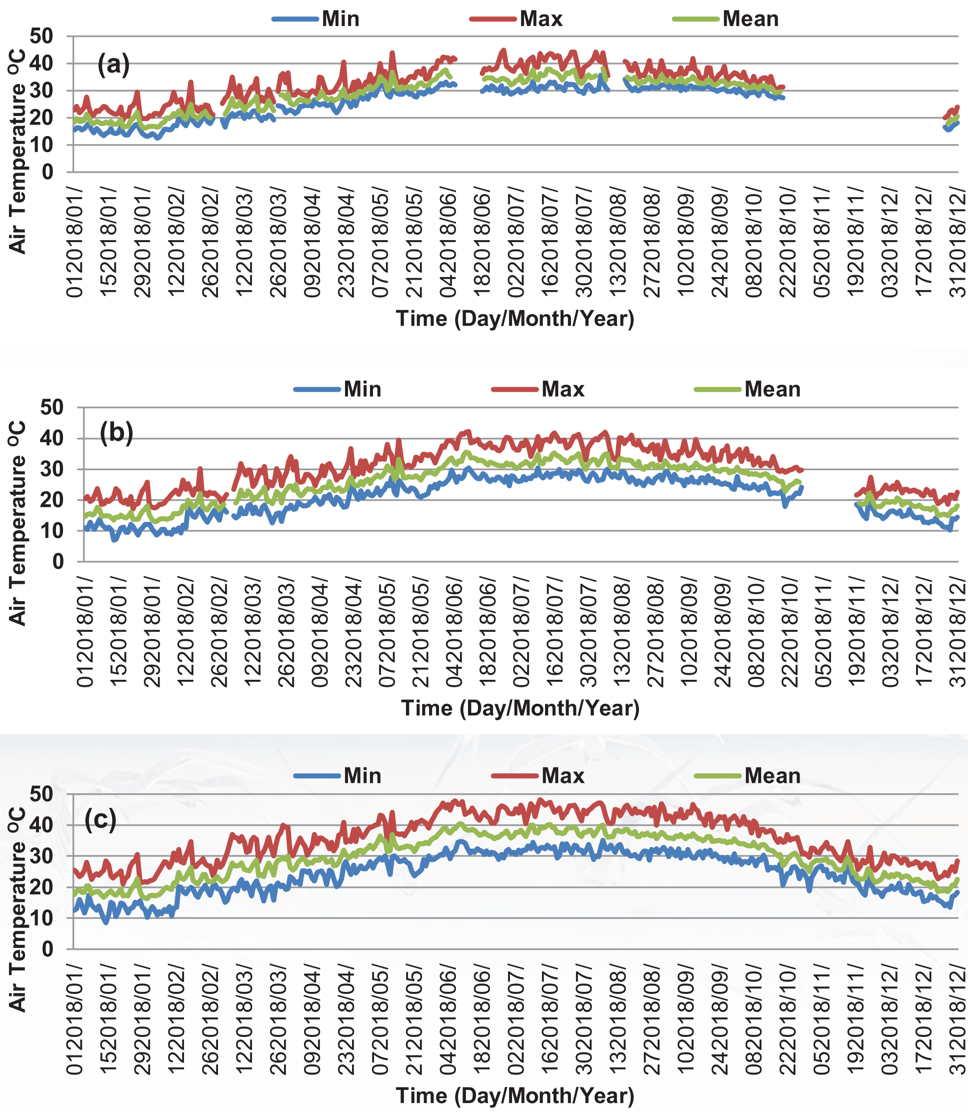


Figure 3.2e. Daily minimum, daily maximum, and daily mean values of ambient air temperatures (°C) at (a) Al Corniche, (b) Qatar University, and (c) Aspire Zone monitoring stations during 2018.

3.3. National Ambient Air Quality Regulations

Qatar has developed and adopted its own air quality regulations, standards and guidelines to control harmful substances that are emitted, discharged, or deposited, as well as controlling noise levels. Ambient air quality standards define the maximum amount of pollutant concentrations, which can be present in outdoor air, without posing harm to the public health. the standards are set at levels which are determined by the threshold of observable health effects on humans. The State of Qatar has established its own National Ambient Air Quality Standards (QNAAQS) for five principal pollutants, which are also called «criteria» air pollutants (Decree Law Number 30 issued in 2002 and executed by Law Number 4 for 2005). Periodically, the standards are reviewed and revised, if needed. The current air quality standards are summarized and listed in Table 3.1. Generally, units of measurements for these standards are expressed in parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (g/m3) by weight.

Table 3.1. Qatar national ambient air quality standards (QNAAQS) with the key interpretations.

POLLUTANT	AVERAGING PERIOD	LIMIT (QNAAQS)	AAQ Criteria
Sulfur Dioxide (SO_2)	24- hour	365 $\mu g/m^3$	A
	1-year	80 $\mu g/m^3$	B
Nitrogen Dioxide (NO_2)	1-hour	400 $\mu g/m^3$	D
	24-hour	150 $\mu g/m^3$	A
	1-year	100 $\mu g/m^3$	B
Groundlevel Ozone (O_3)	1-hour	235 $\mu g/m^3$	C
	8-hour	120 $\mu g/m^3$	G
Carbon Monoxide (CO)	1 hour	40,000 $\mu g/m^3$	D
	8-hour	10,000 $\mu g/m^3$	E
`Particulate Matter (PM_{10})	24-hour	150 $\mu g/m^3$	A
	1-year	50 $\mu g/m^3$	B
Lead	3 months average	1.5 $\mu g/m^3$	F

Key Interpretation of Ambient Air Quality Standards:

A. 99.7% for all daily averages within one calendar year.

B. Arithmetic mean of all daily measurements taken during a calendar year period.

C. 99.7% for all days within one calendar year containing measurements of a maximum of one hour at or below the standard.

D. 99.9% for all measurements per hour taken during one calendar year.

E. 99.8% of all maximum measurements averaged 8 hours per day for one calendar year.

F. The mean of all measurements per hour for 3 months.

G. 98% of all daily maximum measurements (8 hours average) within one calendar year.

3.4. Ambient Air Quality Monitoring Network in Qatar

In the State of Qatar, the ambient air quality monitoring has been carried out by Ministry of Municipality and Environment (MME), Qatar Petroleum (QP), Qatar Environment & Energy Research Institute (QEERI), Ministry of Public Health, and Hamad International Airport. Air quality stations distributed all over the state of Qatar, with total of around 25 monitoring stations in the country. MME operates 3 fixed ambient air quality monitoring stations; namely Al-Corniche (AC), Qatar University (QU), and Aspire Zone (AZ) in the Greater Doha Area (Figure 3.3). Thus, the air quality data from the 3 ambient air quality stations belonging to MME, have been studied and presented in this report.

Figure 3.3. Locations of MME ambient air quality-monitoring stations in the Greater Doha Area (Environmental Moitoring and Laboratory Department 2019)

3.5. Air Pollutants Considered and Data Processing

The criteria air pollutants include particulate matters (PM10), sulfur dioxide (SO2), oxides of nitrogen (NO/NO2/NO2), ground level ozone (O3), carbon monoxide (CO), and hydrocarbons (i.e., non-methane, methane, and total hydrocarbons). These air quality parameters have been collected on a continuous real-time basis using the dedicated standard gas analyzers and air particulate samplers. In addition, some of the meteorological parameters of wind speed (WS), wind direction (WD), air temperature (T), relative humidity (RH), and atmospheric pressure (AP) have been also monitored, processed, and included in this report.

Monitoring data from these station analyzers is acquired and stored locally at all monitoring stations. The data from monitoring stations is transferred to a central database server located at the Ministry of Municipality and Environment Office (MME) with the help of IP/VPN connection type on hourly basis.

The real-time collected data have been statistically analyzed according to the United States Environmental Protection Agency (US-EPA) procedures and guidelines. Subsequent hourly, daily, monthly and annual statistics have been made for reporting and further air quality assessments. Each week, there were automatic computer controlled zero and span checks on most of the air quality monitoring instrument, as part of the US-EPA procedures. In addition, each month, there is also a zero and multi-point calibration performed on most of the air quality instrument to assure the quality of data collected.

3.6. Air Pollutants in Qatar

Sources of air pollutants in Qatar includes (i) stationary sources (such as power plants, oil refineries, industrial facilities, and factories), and (ii) mobile sources (such as cars, buses, trucks, planes, and ships). Industrial facilities like chemical plants, steel mills, oil refineries, power plants, and hazardous waste incinerators emit major air pollutants and motor vehicles are also substantial sources of hazardous air pollutants. Carcinogens benzene, formaldehyde, acetaldehyde, 1,3-butadiene and diesel particulate matter Currently, there are 3 industrial cities in operation in Qatar: (i) Ras Laffan Industrial City (RLIC) in the northeast of the country, (ii) Mesaieed Industrial City (MIC) in the southeast of the country, and iii) Dukhan Industrial City in the western part of Qatar. Around 35 primary and secondary industrial plants are operating in these cities. As a result, significant amount of air pollutants is emitted from these stationary industrial plants into the atmosphere. The emissions of these air pollutants are monitored and reported by the pollution control departments of each of these industrial cities.

The air quality status of the monitoring region has been defined in this report in terms of Qatar Air Quality Index (AQI). Initially, AQI is developed and used by the United States Environmental Protection Agency (US-EPA) as a measure of overall air quality, and later adopted by the Ministry of Municipality and Environment (MME) of State of Qatar. The AQI is defined as a number determining how clean or polluted the air is at a particular time in a particular area and the environmental impacts associated with it. The higher the AQI value, the greater will the level of air pollution be and the more dangerous to the environment.

The AQI is based on pollutant standard index structure comprising of the five pollutants; namely SO2, NO2, O3, CO, and PM10 measured at all monitoring sites. For each air pollutant, a daily sub-index value is calculated from a segmented linear function that transforms ambient air pollutant concentrations onto a scale extending from 0-500. Six sub-index categories of AQI are considered in this report, namely: i) Clean, ii) Normal, iii) Less than Normal, iv) Limited Polluted, v) Polluted, and vi) Extremely Polluted.

3.6.1. Sulfur Dioxide (So2)

During the years 2014 till the end of 2018, the concentrations of sulfur dioxide, and their air quality sub-index values were low in the mentioned years, due to the fact that the main fuel used in Qatar is natural gas, which has low sulfur content. However, sulfur dioxide concentrations measured in the State of Qatar come from diesel engines, like trucks, buses and heavy machineries, which use diesel oil having about 1 % of sulfur content. In 2014, Al-Corniche station showed the highest AQI of SO2 sub-index values with frequent fluctuations towards the first and last quarter of 2014. On the other hand, Aspire Zone and Qatar University monitoring stations showed a stable uniform sub-index values during the years of 2016, 2017, 2018. However, in 2015 Al-Corniche station showed the highest fluctuations until the third quarter of the year. Relatively , in 2015 SO2 sub-index values tended to be higher with frequent fluctuations, which is attributed to the increase of civil activities that require more fuel burning processes (Figure 3.4). In short, the SO2 AQI sub-index values have been found to be in the “Clean Category” for Sulfur Dioxide gases as expected (i.e., AQI is in the range of 0 to 50) for this 5 year study period (i.e., 2014 to 2018).

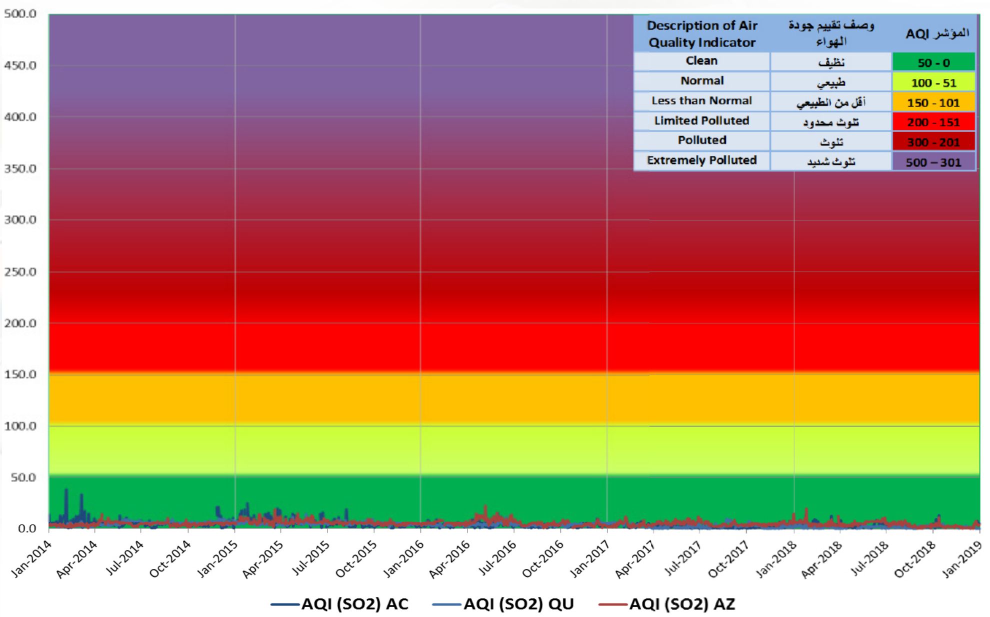


Figure 3.4. The sub-index values of AQI for sulfur dioxide for the years of 2014 to 2018 for the MME monitoring stations.

3.6.2. Nitrogen Dioxide (NO2)

The nitrogen dioxide air quality sub-index values in the Greater Doha Area have been found mainly in the Clean to Normal Categories during 2014 through 2018 (Figure 3.5). All three stations recorded similar trends in NO2 with slightly higher index values in Al Corniche station. In the same analogy, a similaris also observed in 2015, yet with higher indices compared to the years of particularly 2015 and 2016. However, Aspire Zone monitoring station showed superior stability due to nature of the area, which is more of a green land, and has less traffic as well as less of an open area. The observed trend of NO2 increased particularly in 2015 and 2016 compared to 2014, and other years. In years 2015 and 2016, Al-Corniche monitoring station recorded the highest readings among all stations which is due to the high volume of traffic in the area that in turn contributed to the overall effect of increasing NO2 concentrations as well as AQI. It has been known that high NO2 emissions from the road traffic is a key factor contributing to exceedances of the ambient limit value. At sites exceeding the ambient NO2 limit in Qatar, the focus should be on reducing total NOx emissions from the road traffic first. An automotive emission study inside Qatar is now recommended with this special report to investigate more and address all automotive emission related problems inside Qatar.

Nevertheless, the Qatari Government has already taken two major public transportation projects using i) the City Bus System, and ii) the Metro Project called RAIL in order to reduce the NO2 emissions form the road traffic. This public metro system has several lines covering the Greater Doha Area. When completely ready, the RAIL system is expected to significantly reduce the harmful emissions from the road vehicles

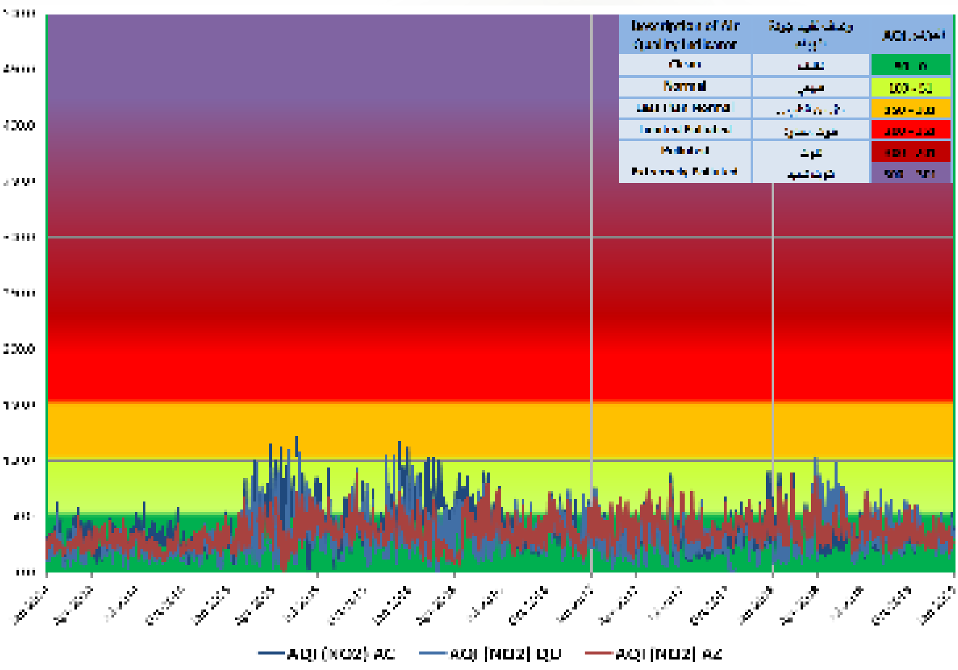


Figure 3.5. The sub-index values of AQI for nitrogen dioxide (NO2) at the MME monitoring stations for the years 2014 to 2018.

3.6.3. Ground level Ozone (O3), And Carbon Monoxide (CO)

Ground level ozone is a secondary pollutant that forms as a result of a photochemical reaction. For ground level ozone to form, three precursors; namely (i) oxides of nitrogen (NO2), (ii) volatile organic compounds (VOC), and (iii) sunlight must exist in the region of interest. Figure 3.6 shows the sub-index values of ground level O3 distribution observed at MME ambient air quality monitoring stations inside Qatar during the years from 2014 till the end of 2018, respectively. The overall sub-index of ground level O3 values were found for the Al-Corniche monitoring station in the Clean Category with some instances in the Normal and Less than Normal Categories in the years of 2015 till 2018, in case of Qatar University and Aspire Zone monitoring stations, the AQI values for the ground level ozone values were observed in the Clean Category only.

In 2014, the O3 AQI fluctuation throughout was rather low and tending to have almost uniform index series. However, during summer seasons (May-August) the sub-index values in Al Corniche and Aspire Zone monitoring stations tend to gradually increase in response to the increase in O3 concentrations, after then experience a gradual decay till December. On the contrary, in Qatar University monitoring station the lowest index value was observed during August rather than the 1st and 4th quarter of the year.

The status of O3 sub-index values in 2015 were observed to have a higher fluctuations in O3 concentration comparatively. In contrast to 2014, O3 was in the higher range of the Clean Category with occasional occurrences in the Normal to Less than Normal Categories of AQI. Over the five year period, O3 sub-index values were observed to have an increasing pattern, however, O3 is a cross-boundary pollutant. Due to its property to be transported long distances can contribute in increasing the level of ground level ozone locally.

In a special study entitled “Qatar Air Quality Modeling Project” conducted between Qatar Petroleum of Qatar, and French Total Oil Company in the 2009, one of the main findings of this study was that the photochemical system in Qatar is mostly VOCs driven (i.e., VOC sensitive). In VOC sensitive regimes, ground level ozone concentrations decrease with

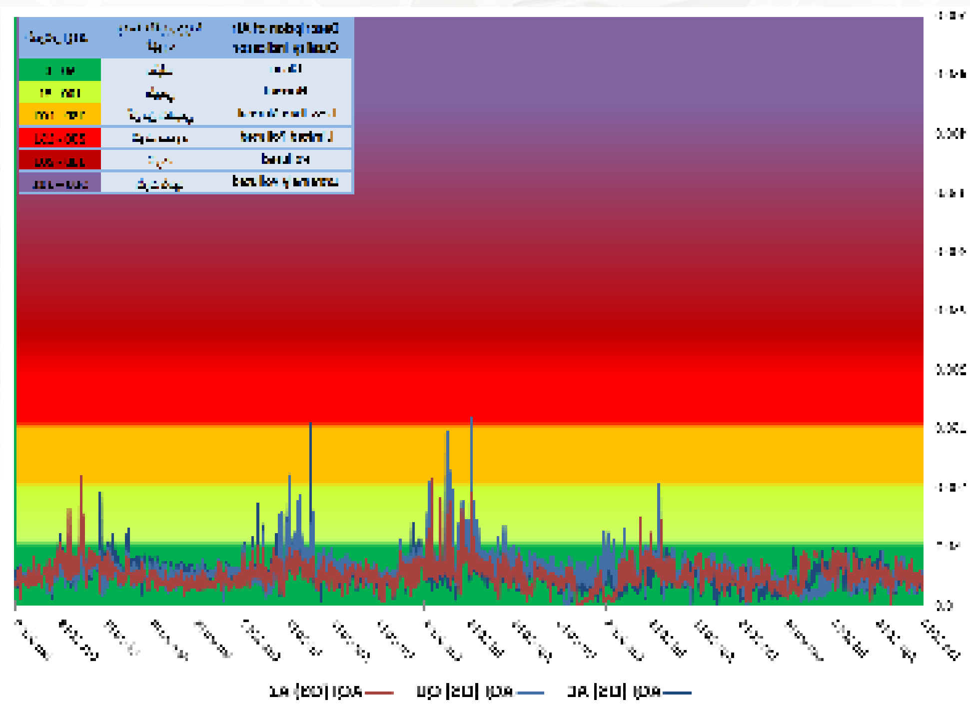


Figure 3.6. The sub-index values of AQI for ground level ozone at MME monitoring stations in the Greater Doha Area for the years of 2014 to 2018.

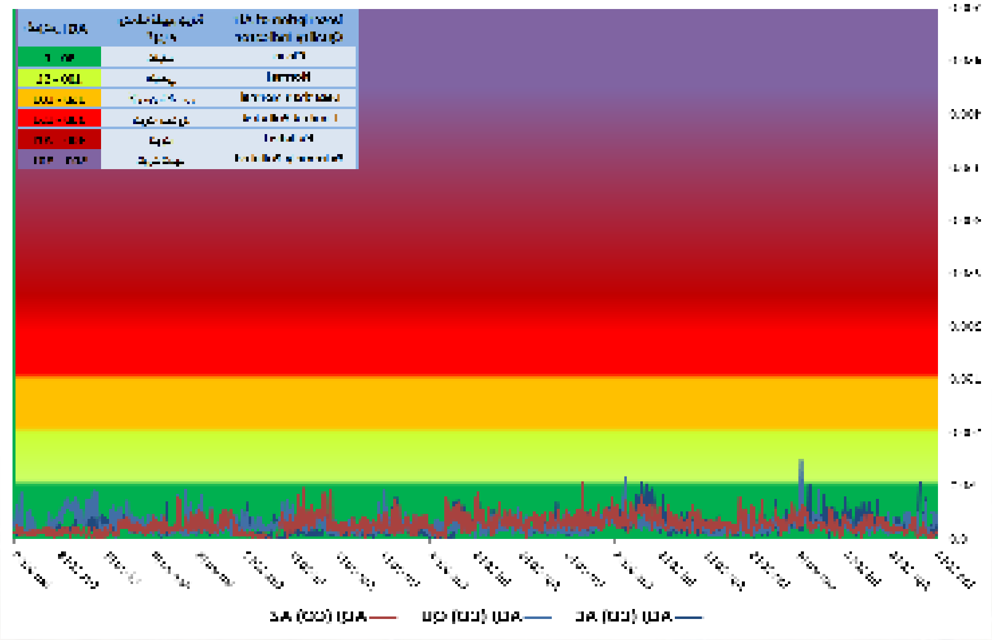


Figure 3.7. AQI of carbon monoxide at MME monitoring sites in the Greater Doha Area in the years 2014 to 2018.

3.6.4. Air Particulate Matter (PM10)

Air particulate matters (PM) are microscopic solid or liquid matter suspended in the atmosphere, that are classified by size such as PM10 (particulate matter less than 10 micrometer in size), PM2.5 and PM1. This parameter of special importance due to its inhalable and penetration capability. Moreover, the chemical composition is rather diverse depending on its source, whether it is natural or anthropogenic. However, in this, report only PM10 is studied and presented.

The status of PM10 in the Greater Doha Area has been mainly in the Normal Category of AQI with multiple occasions where it appeared in the Less Than Normal Category (Figure 3.8). In all 5 years, it was observed that the highest AQ sub-index values were found during summer seasons (2nd and 3rd quarters of each year), where the temperatures starts to rise. Yet 2015 showed an increase in PM10 AQI than that of 2014, which is a result of ongoing increase in civil activities in Doha. Furthermore, higher AQI fluctuations found in both Al-Corniche and Qatar University monitoring stations. In the case of Al-Corniche monitoring station, which is located near the shore area where liquid and mineral dust can contribute to the aforementioned fluctuations. In the Qatar University monitoring station, the construction activities near the area reflect on the relatively higher AQI readings. On the other hand, Aspire Zone is the lowest relatively, due to the effect of existence of larger green areas which reflects clearly on PM10 concentrations as shown in Figure 3.8, as this resembles as one of solution to further improve the status of PM10, as it limits the suspension and re-suspension of air particulate matter. The following discussions give physical explanations of air particulate matter observed in the State of Qatar. Observations indicated that high concentrations of air particulate matter in Qatar are considered as a natural occurrence due to the presence of suspended dust, frequent sand and wind storm events. The sand and dust storm events in Qatar are associated with mainly three different periodic wind systems: (i) local, (ii) regional (i.e. Shamal Wind System, particularly during the month of June), and (iii) the Subtropical Jet System from the Saharan Desert, effective during the months from October till the end of April. Thus, the major natural source of air particulates in Qatar is due to the long-range transport of dust and air particulates from the north African Saharan Desert (Kubilay and Saydam, 1995; Kubilay et al., 2000; UNEP, 2016).

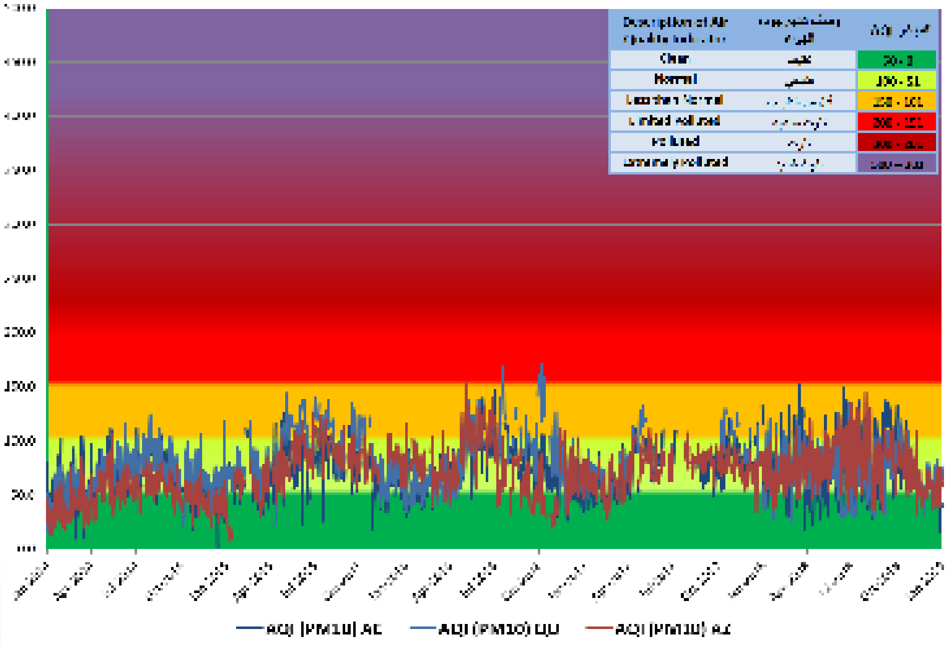


Figure 3.8. AQI of PM10 at MME monitoring sites in the Greater Doha Area in the years 2014 to 2018.

The World Health Organization (WHO) reports low death rates even though relatively high concentration of air particulate matter occurs in the Middle-East region. In addition, a study mentioned in WHO Report by Karagulian et.al. (2015) found that the natural contribution of soil dust and sea salt to PM10 and PM2.5 is about 44 % and 52%, respectively in the Middle-East region. This confirms that the composition of PM in the Middle-East region is partially from the natural sources, however, this does not imply that the rest is from the anthropogenic sources.

The severe sand and dust storms events are periodically observed phenomena in Qatar, which is attributed to coupling of two main weather systems; (i) existence of a low air pressure system over the North Africa, and (ii) the strong westerly subtropical jet stream above it (Figure 3.9). Indeed, the subtropical jet flow prevails from end of October till the end of April in the Arabian Peninsula region. Its negative impacts are periodically observed in the Arabian Peninsula, Qatar included.

Kubilay and Saydam (1995) studied the trace elements in atmospheric particulates found over the Eastern Mediterranean with their concentrations, sources, and temporal variability. They demonstrated the dominance of North African Saharan desert particles over the basin and stated that desert particles invade the region from March-May and October-November. Their three-dimensional air-mass trajectory analysis confirmed the invasion of the basin by intense concentrations of dust originating from the Saharan desert. In addition, Kubilay et. al. (2000) illustrated the transport and deposition of mineral dust onto the eastern Mediterranean region. They found that North African and Middle East desert derived dust particles are transported to the middle east region.

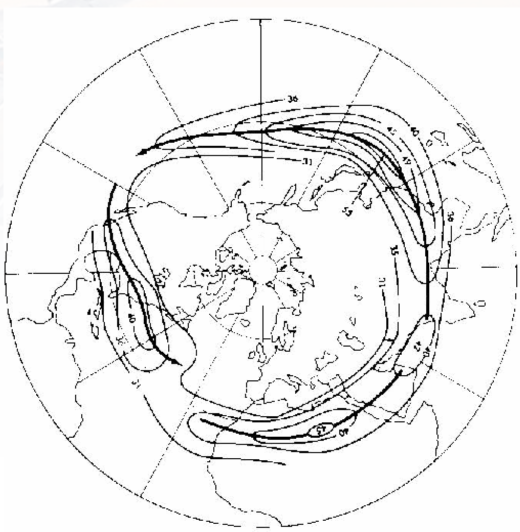


Figure 3.9. The typical position of sub-tropical jet stream in the month of January (Stern et al., 1994). Note that the wind speeds are in meter per second in this figure.

Alharbi et al. (2013) investigated the mechanisms that are responsible for the generation and maintenance of conditions favourable for severe and unstable atmospheric conditions, and the coupling mechanism which are responsible factors triggering severe sand storms in the Arabian Peninsula with respect to the sub-tropical and polar jet systems. The strong wind system brings considerable amounts of dust and sand mainly from the North African Saharan desert to GCC countries, including Saudi Arabia and Qatar (Figure 3.10a). This synoptic-scale weather system persists for several weeks before the subtropical jet moves to further north. By the end of March or even middle of April, the subtropical jet leaves the Arabian Peninsula and its effects are no longer observed till the following year (Figure 3.10b). During this time (particularly beginning of November and till April), the northern part of Saudi Arabia and Qatar receive its highest rainfall in the year time. The reason for this is that the dust particles in clouds serve as cloud condensation nucleus, which facilitate the condensation on these dust particles.

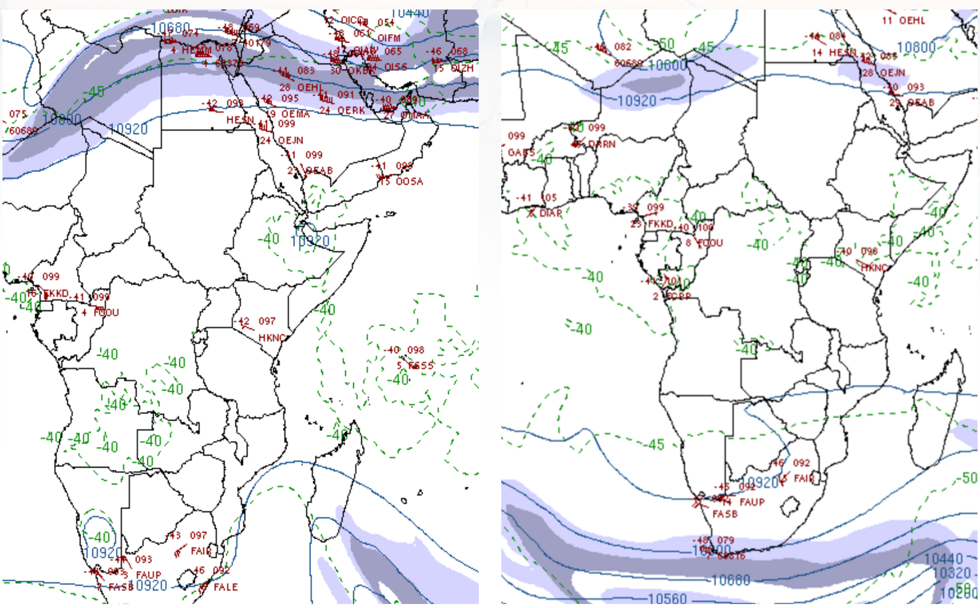


Figure 3.10. Upper level meteorological map, indicating the location of sub-tropical jet stream at 250 mb level on (a) 00 UTC 02 April 2015, and (b) 00 UTC 05 May 2015. Note that the depth of the jet stream was over 5,000 m on 02 April 2015, the height of the bottom of this layer was about 9,113 m from the Earth surface, and the maximum observed wind speed was about 206 km/hour at this level. In addition, the subtropical jet left the Arabian Peninsula at the end of April 2015. (Source: Department of Atmospheric Science, University of Wyoming, USA).

In addition, the construction, renovation and other developmental activities in Greater Doha Area, Qatar, are expected to contribute significant amount of air particulate concentrations. Observations also revealed that the atmospheric relative humidity (RH) plays crucial role in air particulate matter (PM) concentrations. RH affects the current PM measurement method (i.e., Beta-Attenuation Technique). Gilliam et al. (2016) have stated that air moisture in particular matter have an effect on radiation reading. Hence, sometimes PM recorded proportional higher concentration with RH. Thus, during the air sampling, sampling line has to be treated in order to avoid and any condensation removed for accurate readings.

3.7. DPSIR Framework for Ambient Air Quality Management

One of the main goals of air quality management is to protect human health, ecosystems and economy; a comprehensive monitoring would meet the criteria of sustainable development. This will require modifying the air quality assessment program, according to the internationally used and accepted frameworks approach as envisaged under the DPSIR (Driver-Pressure-State-Impact-Response) model. While elements of this model are inherent in MME air quality mon itoring program,more work is needed for transforming this basically qualitative model into a quantitative (or mathematical) one by input of empirical data.

Drivers in this model comprise the population density, energy demand, industrial activity and raw material inputs. the direct causes of air pollution (air emissions) for example,are road traffic, emissions from heating and cooling systems, industrial discharges and occurrence of PM10. Concentrations of air pollutants in certain areas can define the State. Impacts are the effects on health, ecosystems and economy resulting from air quality deterioration. Data on hospital admittances, death or disease linked to atmospheric pollution, and biodiversity loss will provide information needed to characterize the impacts. Responses should be in the form of actions taken by the Ministry of Municipality and Environment to improve the ambient air quality on a sustainable basis by way of regulations and compliance with good practices. DPSIR model, when complete, will contain a holistic approach to monitoring and sustainable management of air quality.

3.8 Summary

The ambient air quality and meteorological data have been collected and studied at MME monitoring stations. In this study, ambient air quality parameters included SO2, NO2, CO, O3, and PM10, along with meteorological parameters, such as wind direction, wind speed, relative humidity, air temperature and atmospheric pressure. All monitored data have been analysed, validated as per US-EPA procedures, and AQI sub-index values for the five parameters have been calculated and presented in this report, as per US-EPA approach.

The following main summary and conclusions can be briefly made from this study:

- Ambient air quality measurements and meteorological observations show that the State of Qatar experiences high particulate matter concentrations due to different wind regimes and prevailing meteorological conditions in the region, namely: (i) sub-tropical jet stream system for the months beginning end of October till the end of April, (ii) Shamal wind system in the month of June, and (iii) frequent local wind systems. These wind systems cause to degrade the air quality significantly. In addition, there is also another jet system (i.e., Tropical Easterly Jet) which affects the region from the middle of July till the end of October annually, that brings the excessive moisture from the Arabian Sea area to Arabian Peninsula.

- Observations showed that the nitrogen dioxide concentrationin Doha City Area is due to traffic emissions, however, concentrations are still less than the annual national standard. With the help of both current public transportation and with the city buses system, that is already in operation, and the RAIL project, harmful vehicular and road emissions will be reduced

- Occasional exceedances of ground level ozone concentrations during summer season are observed at MME stations in Greater Doha Area, and several exceedances are also observed outside Doha stations as well. The number of exceedances of eight-hourly averaging ground level ozone concentrations are more at outside Doha stations, which maybe attributable to the cross-country pollutant transport of ground level ozone.

• Even though, the annual mean concentrations of carbon monoxide in 2015 have significantly increased by about 40% in Doha City Area, however, no exceedances of 1-hour and 8-hour averaged carbon monoxide concentrations have been observed nor recorded. In addition, observations show that steadily increasing high carbon monoxide concentrations in Doha City Area is due to vehicle emissions.

• The ambient air quality monitoring results also show that the hourly mean concentrations of SO2 as well as AQI values were quite low and below the QNAAQS throughout the year due to use of natural gas as the main fuel inside Qatar.

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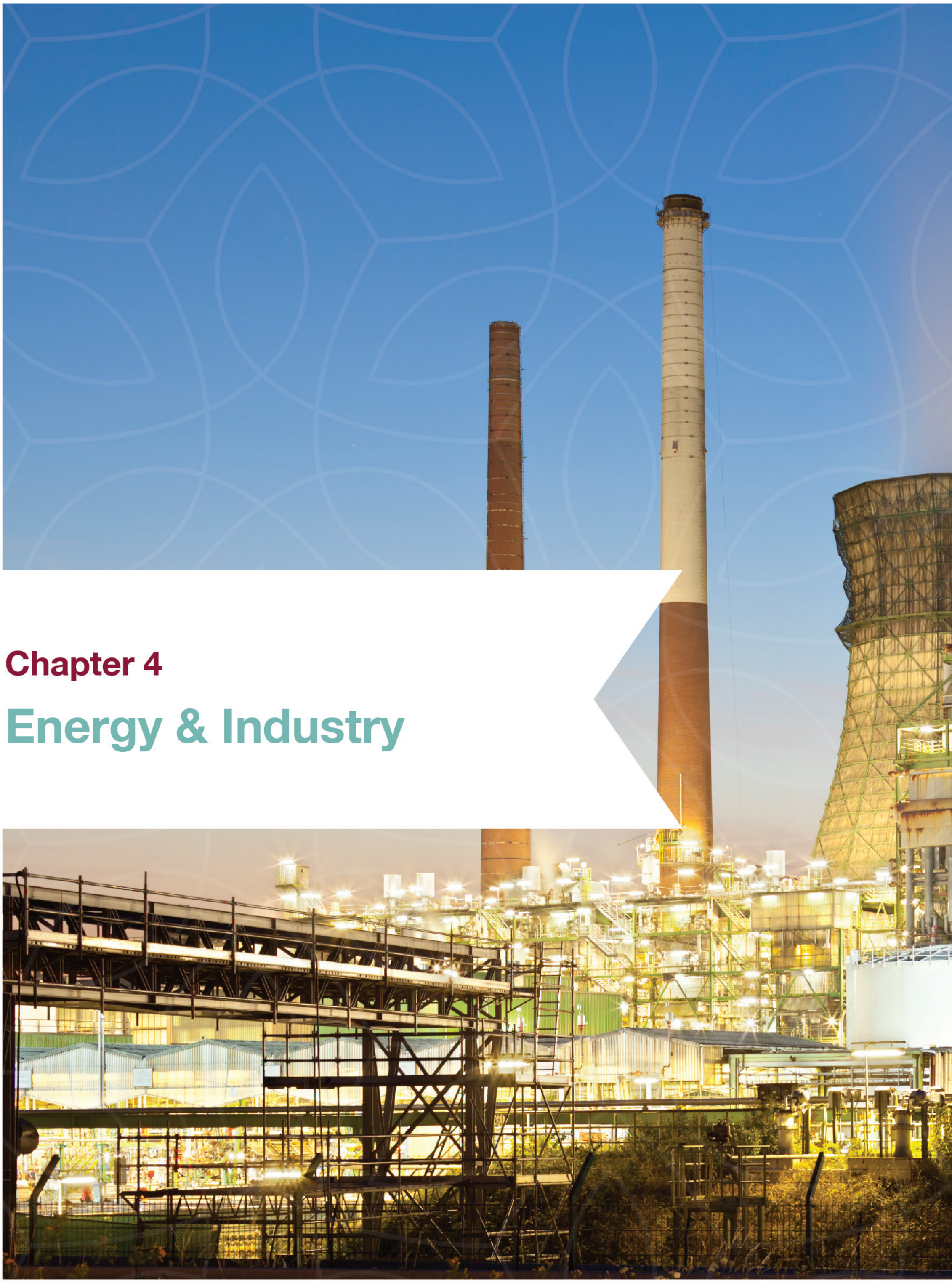
Chapter 4
Energy and Industry



Chapter 4

Energy & Industry

Chapter 4:
Energy and Industry

Qatar's economy heavily depends on energy resources and the linked industries. The country produces and exports crude oil, natural gas, natural gas liquids, liquefied gas, gas-to-liquids, refined products, high-value-petrochemicals and fertilizers. Qatar is the world's largest exporter of liquefied natural gas. Investment in production of high-value commercial substances and diversification, and incorporation of environmental compatibility have paid rich dividends. Initiatives are being taken in Qatar for effecting changes in the energy systems. These are directed at reduction in greenhouse emissions lessening of carbon footprint consistent with the sustainable development goals. Visionary government policies have contributed to a great extent in insulating the country from price volatility in the global market. This has helped continued development despite downturn in hydrocarbon value in the market. Because of some major natural limitations, the country has to mobilize more resources towards environmental mitigation through reduction of carbon dioxide emissions by way of energy efficiency, use of green technologies in energy production and devising long-term plans for a decisive shift in the direction of clean energy.

4.1 Introduction

Qatar has undergone rapid industrialization to build a strong economy, modernize the infrastructure and develop the services sector. Petroleum products and liquefied natural gas are the pillars of Qatar's economy, accounting for a major share of the government revenue, gross domestic product (GDP) and export earnings.

Discovery of fossil fuel reserves proceeded a long period of exploration. The industrial-scale production started in early 1970s and this has changed the socio-economic landscape of the country, providing it with one of the highest per capita incomes in the world.

Ministry of Industry and Energy handles matters related to exploitation of energy resources and industrialization. The Ministry supports the industrial sector to diversify sources of national income, develop value-added products, strengthen the manufacturing base, increase the contribution of private sector to industrial development, and help in the integration of oil and gas industry with other industrial sectors to further enhance the national income and the GDP.

Qatar's crude oil reserves are estimated at 25.2 million barrels, representing 1.7 % of the world's reserves (MFA, 2015). The natural gas reserves amounting to 872 trillion cubic feet constitute 12.3 % of the reserves in the world, making the country next to Russia and Iran only in this natural resource (MFA, 2015).

Energy and industry have been categorized as a major sector of the national economy under the National Classification of Economic Activities of Qatar (SQEIS, 2013). This is consistent with the revised international standard industrial classification of all economic activities accepted by the United Nations Statistics Division.

Development of Energy Resources and Industry in Qatar follows a strategic direction as enshrined in the economic development pillar of Qatar National Vision 2030 (QNV 2030). The thrust is on development based on diversified economy for the sustainable welfare of the society. While hydrocarbon resources constitute the backbone of the country's economy, the diversification of industrial base and market penetration of internationally traded commercial products are key elements of the national policy.

4.2 Energy and Industry Sector

4.2.1 Energy and Industry Organizations

Energy and industry sector comprise upstream, midstream and downstream companies (Figure 4.1).

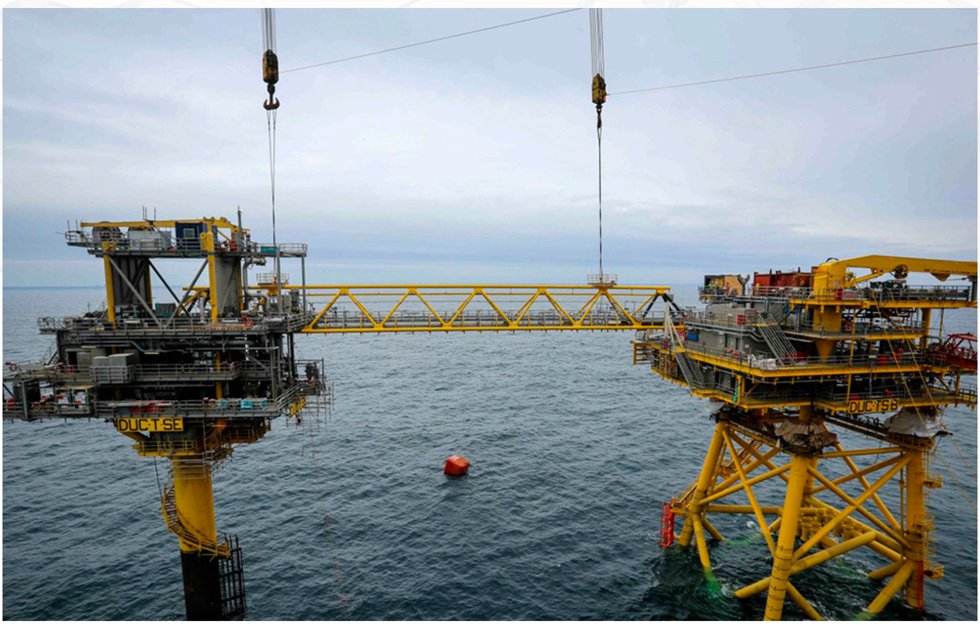


Figure 4.1. Hydrocarbon industry in Qatar. Source: Salam Petroleum (Left and middle). Hydrocarbon storage in offshore island in Qatar (Right).

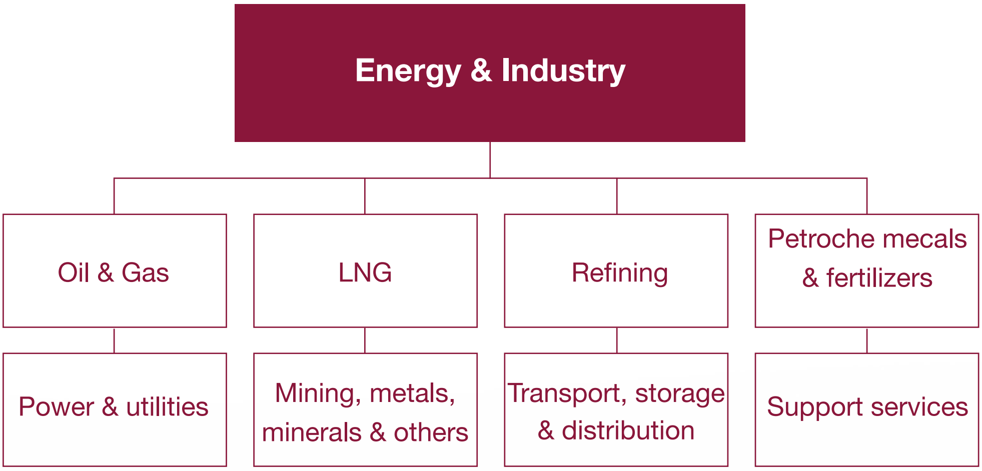


Figure 4.2. Energy and industrial sub-sectors.

The companies involved are clustered into 8 sub-sectors as shown in Figures 4.2 and 4.3 based on their primary products or services (SQEIS, 2013).

Oil & Gas	**Qatar Petroleum,** Qatar Petroleum Drilling Company, Gulf Drilling International, North Oil Company (NOC), TOTAL, Wintershall Holding GmbH
LNG	**Qatar Gas,** Dolphin Energy
Refining	**ORYX GTL,** Qatar Shell GTL, QP & Qatargas
Petroche mecals & fertilizers	**Qatar Chemicals Company,** Qatar Fertilizer Company, Qatar Fuel Additives Company, Ras Laffan Olefins Company, SEEF, Qatar Petrochemical Company, Qatar Vinyl Company, Qatofin Company
Power & utilities	**Qatar General Electricity and Water Corporation (KAHRAMAA),** Mesaieed Power Company, Ras Laffan Power Company, Ras Girtas Power Company, Qatar Electricity and Water Company (QEWC), Qatar Power Company
Mining, metals, minerals & others	**Qatar Aluminium,** Qatar National Cement Company, Qatar Steel
Transport, storage & distribution	**Qatar Fuel Company,** Gatar Gas Transport Company, Qatar Shipping Company, Qatar Jet Fuel Company
Support services	**ConcocoPhillips Qatar,** ExxonMobil Qatar, Saipem Qatar

Figure 4.3. Companies in the energy and industry sub-sectors.

4.2.2 Energy and Industry Activities

The economic contribution of these diversified companies is immense. Although petroleum and natural gas exceed all other sectors but currently the energy-linked companies have stabilized or they shall face the problem of oversupply and fall in prices. Data for 2016 released by the Planning and Statistics Authority (PSA, 2017) are presented in Figures 4.4 - 4.7.

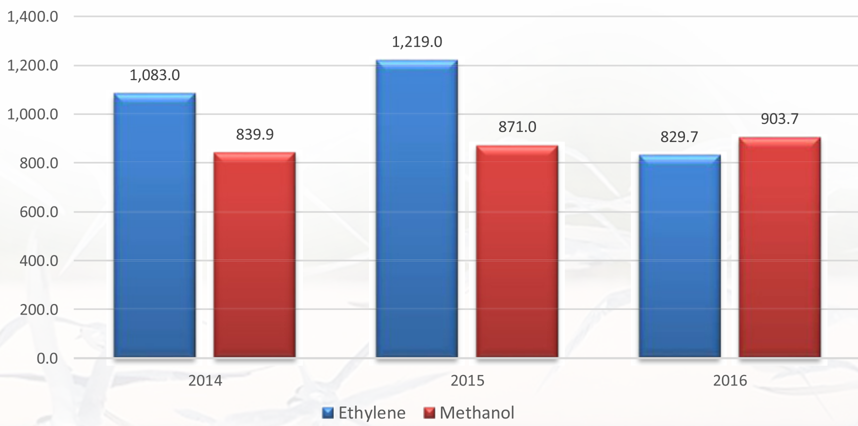


Figure 4.4. Production of petrochemicals (MT 000).

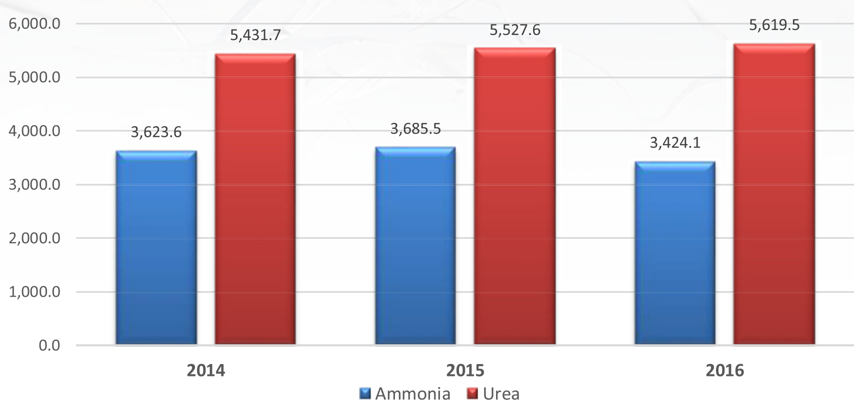


Figure 4.5. Production of fertilizers (MT, 000).

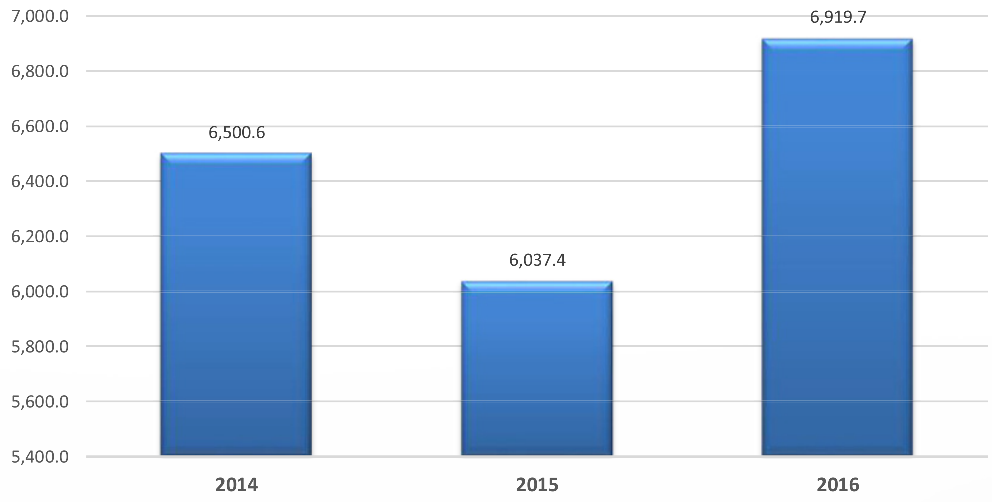


Figure 4.6. Production of basic iron and steel (ton, 000).

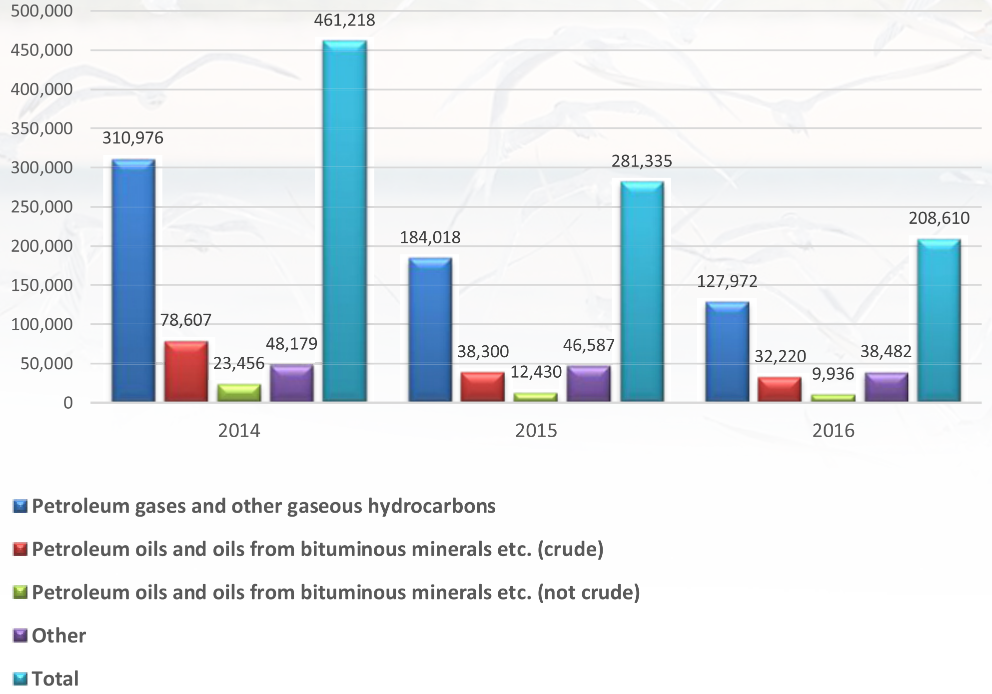


Figure 4.7. Components of foreign trade in terms of export (million Qatari Riyal).

Qatar established "Qatar Petroleum" (QP) in 1974 as the body responsible for managing the oil and gas sector. Activities of QP, together with its subsidiaries and joint venture partners, are exploration, drilling, production, transportation, storage, marketing and sale of crude oil and natural gas, and gas converted to liquids and liquefied gas, refined gas, petrochemicals and fertilizers.

QatarGas and Ras Gas, that were founded in 1984 and 2001, respectively were tasked with extraction, storage, processing and export of liquefied natural gas (LNG). Their production capacity in 2015 was reported to be more than 77 million tons per annum (MFA, 2015). Both companies merged at the end of 2017 and became QatarGas.

In March 2011, before the current downturn in energy prices, Qatar completed the expansion of LNG infrastructure with the inauguration of QatarGas IV. Since then the approach has been for consolidation and improvement. The product range in the energy-related sectors comprises crude oil, natural gas, natural gas liquids, liquefied natural gas (LNG), gas-to-liquids (GTL), refined products, petrochemical derivatives and fertilizers. Qatar has invited investment from international oil companies, namely ExxonMobil, Shell and TOTAL, who possess expertise and could be helpful in integrated projects. The country now ranks among the top producers of GTL. GTL technology uses a refining process to turn natural gas into liquid fuels, such as low-sulfur diesel and naphtha in addition to other products. Because of these high-value products originating from GTL projects, this technology has been receiving more attention in Qatar over the last several years.

Qatar's strategic vision envisages more focus on developing integrated projects linked to LNG exports and downstream industries requiring natural gas feedstock. This policy has paid off as evident from the track record of its dividends over the past 15 years. It has attracted some major international players for bringing substantial investment and technology. The country is the world's fourth largest dry natural gas producer and leading LNG exporter since 2006. Qatar exports account for 32% of global supplies, and this product remains the backbone of the country's economy despite downturn in energy prices (EIA, 2015). Energy consumption in Qatar is overwhelmingly met by natural gas and only about 20% from oil (EIA, 2015). The growth in the natural gas production in Qatar has contributed to increasing the country's total liquids production (as lease condensates), natural gas plant liquids, and other petroleum liquids since these are an important byproduct of natural gas production.

Regarding the oil sector, QP owns and operates some major onshore and offshore oil fields. International oil companies are also allowed to operate in the offshore oil fields according to production-sharing agreements.

4.2.2.1 Products

a- Natural gas

Qatar's priority on exploiting gas resources has contributed to insulating the economy from drastic variations in oil prices. Qatar's natural gas reserves are concentrated in the massive offshore North Field which covers an area almost equivalent to the country's landmass. It is located northeast coast of Qatar and ranks as the world's largest non-associated natural gas field. This field has supplied gas from

6,000 km2 area opened for development in collaboration with international partners. The natural gas supply has placed Qatar in the top ranks of the gas producers. Natural gas from other fields also helps in power generation and supplying raw materials for fertilizers, petrochemicals, and steel plants. The country will be able to sustain its economy, driven by gas even when oil prices dip or when oil reserves dry up. According to QP this field holds more than 900 trillion ft3 (QP, 2016) of recoverable gas. Concerned at the possibility of depletion of reserves or loss of pressure in the field by excessive production over a short period of time, Qatar placed moratorium in 2005 and decided to review it when the situation so demands. The ban applied to additional production and did not cover the scale of

b- GTL

Production of GTL has given Qatar a major competitive advantage. Its production involves processing of natural gas into heavier hydrocarbons by the process of refining to yield fuels including low-sulfur diesel and naphtha. Two operational facilities, Oryx and Pearl GTL, are responsible for the country's leading role in GTL production. While Oryx GTL plant is a joint venture between QP and Sasol, the Pearl GTL project involves QP and Shell.

c- Helium - a value - added GTL

Ras Laffan Helium plants, produce liquid helium, are located in Ras Laffan Industrial City. Qatar is now the second largest helium gas supplier in the world after the US

d- Oil

Because of Qatar's priority for natural gas exploitation, the country produces relatively small quantity of crude oil. Instead, the production of non-crude liquids has increased due to growth in output of natural gas condensates that yield heavier hydrocarbons in addition to natural gas.

The three main fields that contribute to the bulk of oil production are: Dukhan, Al Shaheen and Al Sharqi. Additional oil reserves are located at Bul Hanine, Maydan Mahzam, Al Khalij, Al Karkara and Al Rayyan. Qatar has two refineries for crude oil refining and condensate refining. Condensate production is a major driver of growth in the energy sector. Government's policy directions are clearly for boosting the production of value-added petrochemicals. Such decisions require consideration of profitability, capital investment and environmental impact among their factors. It might help if government facilitates a structured unit comprising the major industrial sectors and national R & D agencies to provide decision-makers with information needed for reviewing and possibly reforming the petrochemical sector according to prevailing conditions.

The economic contribution of hydrocarbon industry is immense. It does not only help in meeting the energy needs of the country and importing nations, but also in generating revenues for investment needed for start-up projects to spur the growth and diversification of the sources of income. Through appropriate policies this can contribute to lessening of the pressure on fossil fuels and boosting efforts for greening of the economy. This is a typical case where industrial exploitation of a natural reserve has given way to diversification of industrial base to lessen mining of that very natural resource for environmental reasons while sustaining the economic growth. Aiming at consolidating, coordinating and enhancing exports, the industrial activities have been clustered around certain demarcated areas, called industrial cities. These are in the form of designated zones for intense production, manufacturing and business activities, and general company operations. Petrochemicals, fertilizers and steel are among the main products manufactured there.

4.2.2.2 Production Areas

a- Ras Laffan Industrial City This city provides modern infrastructure for industrial and company operations. There is a hospital and many clinics to offer healthcare services to an increasing number of people who work or live there. The fire and safety department handles matters related to hazards that might arise and provides security to people and facilities. The city has LNG and desalination plants, port and other logistical supports. QP runs industrial operations involving energy resources. Qatar LNG Company Limited (Qatar Gas) is among the major companies that carry out their business activities.

b- Mesaieed Industrial City Mesaieed Industrial City has a diverse industrial base comprising crude oil refinery, petrochemical, iron and steel, and light and supporting industries. There is a modern portthat caters to the export and import of various commercial products. Qatar Petroleum gas complex and Qatar petroleum refinery are based in Mesaieed Industrial City.

c- Dukhan City Dukhan is the first zone of the country where oil exploration and production has started. For this reason, QP has a strong footprint in the area. The city is rapidly developing according to an urban strategic plan.

d- Halul Island Located some 80 km northeast of Doha, this island serves as the crude oil export terminal for marine crude oil produced from offshore oilfields of Qatar. Considering the ecological significance of Halul Island, Qatar Petroleum pays special attention to activities that seek a balance in its operations with nature (Qatar Petroleum, 2017). The conservation and mitigation programs that are implemented have positive outcomes.

e- Small and Medium Enterprise (SME) SME industrial zone is located southwest Doha city border, where it includes all infrastructure services such as roads, lighting, gas, sewage, water and integrated services building. The area accommodates hundreds of projects distributed over nine key sectors to achieve integration and coordination in its establishment and is considered an addition to the national economy (MOCI, 2019), the nine sectors include the following:

- Food and Beverage

- Leather and textiles

- Wood and furniture

- Paper and printing

- Manufacturing industry
- Plastic
- Iron and metal forming
- Tobacco and its derivatives
- Petrochemicals and oil products

4.3. Supporting Sectors

4.3.1 Information and communications technology Economic development and environmental protection that are the pillars of sustainable development need Information and Communications Technology (ICT) for supporting the core sectors of economy and achieving the sustainable development goals. Qatar has moved aggressively in this direction. This was made possible by reducing the state-run monopoly and liberalizing the telecom services following a successful market-driven model. An outcome of these efforts is the significant progress in transformation of administrative proceduresthat meet the needs of e-government. Joint efforts of the public and private sectors towards this end have resulted in the development of advanced infrastructure, strong presence of the ICT sector throughout the country, improved communications, strengthening of national security, besides modernizing the international trade and management of economic growth.

4.3.2 Transport

Government's efforts towards sustainable transport covering roads, aviation and maritime sectors are borne out of the realization of the multiple roles of this sector in supporting the sustainable development goals. The upcoming integrated rail network is a major investment project in this sector.

Due to the rapid growth of population and economic developments, the need to modernize infrastructure for the public, and in preparation for Fedération Intérnationale de Football Association (FIFA) World Cup 2022, the transport sector has modernized and grown in capacity. Among the most massive expansions of the transport network, is the development of Hamad International Airport to replace

the old airport. Spreading over an area of 2,200 hectares, the airport can handle more than 50 million passengers, 320,000 aircraft movements and 2.0 million tons of cargo annually. The airport design and decoration reflect environmental concerns and water conservation themes.

The country has also upgraded the road transportation network and is providing many options of public transport. In addition to several taxi companies, the bus service covers dozens of routes. Tourists

can make use of special coaches operated by any private company throughout the year. The smart way to get around is to book a taxi online using mobile phone applications. Maritime transport is doing fairly well. Seaborne trade plays a key role in export and import. The port and harbor infrastructure is capable of effectively handling active shipping operations. There is a brisk movement of container vessels, oil tankers and natural gas carriers managed by the ports. Jetties facilitate the operation of fishing and leisure boats.

4.3.3 Construction

Qatar's construction industry is very vibrant (Figure 4.8). It is considered to be the engine of the non-oil (non-mining) economic growth. In 2018, the construction contributed QR 98.4 Bln to Qatar's nominal GDP (14%) (PSA, 2019).

There has been a significant rise in this sector in the last five years as a result of growing infrastructure needs and the economy's growth and diversification. Major projects include the developing of a rail system, the construction of Lusail City, Qatar's main seaport "Hamad Port", the New Economic Zones, the construction of the proposed stadiums of the 2022 FIFA World Cup, and all related infrastructure that is required (hotels, malls, highways, etc.).

RAIL الرّيـــل

Figure 4.8. Brisk construction activity in Qatar.

4.4 Sustainability Framework and Indicators

Ministry of Energy and Industry follows a frameworks approach to drive sustainability of this sector, the main elements of which are aligned with Qatar National Vision 2030, increasing visibility of contribution to national development, performance demonstration, innovation, smart business models and support to the linked companies. There are 6 framework components as shown in Figure 4.9.

The sustainable development reporting format is adaptive to incorporate additional perspectives. The format developed by the Ministry of Energy and Industry in 2013 has organized a series of indicators under 6 categories, namely economic contribution, climate change and energy, environment, health and safety, workforce and society. Details of the indicators are presented in Figures 4.10 – 4.15.

Figure 4.9. Energy and industry sustainability framework components. (Source: SQEIS, 2013).

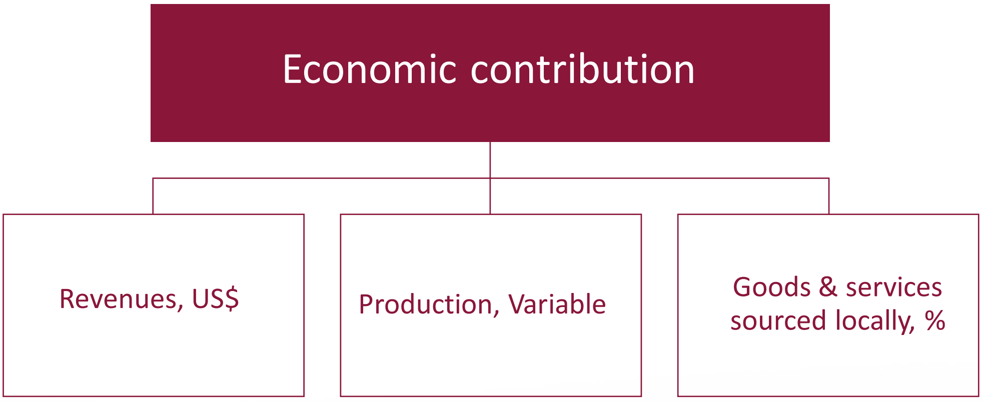


Figure 4.10. Economic contribution indicators.

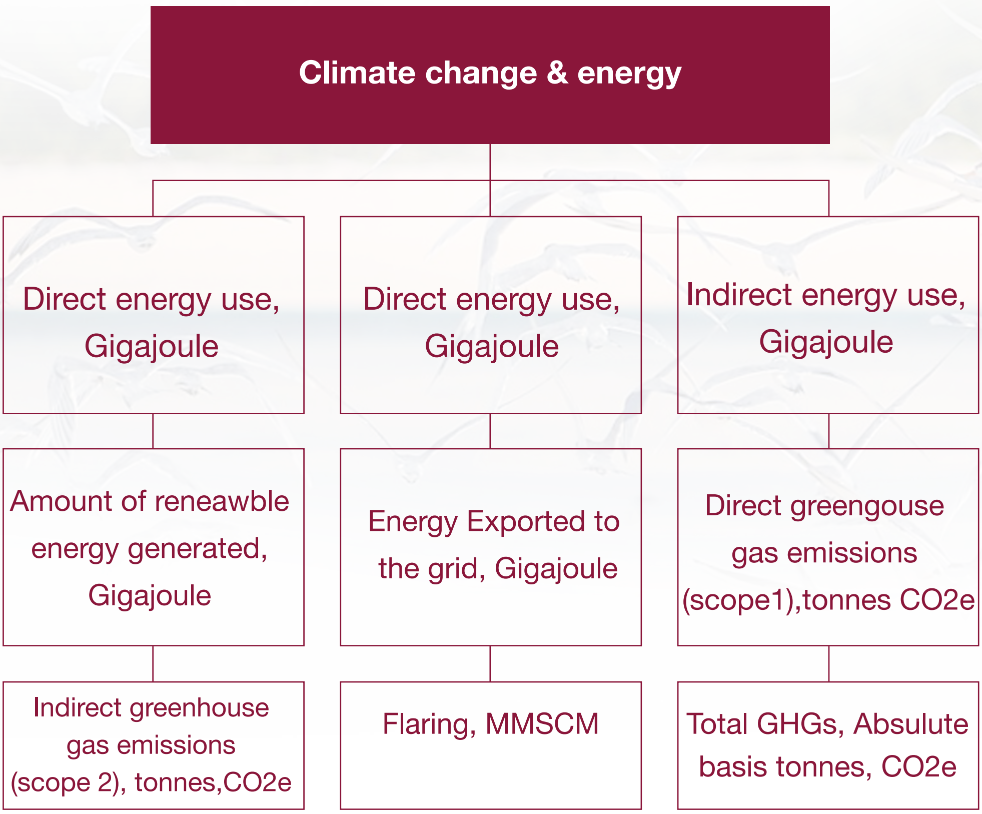


Figure 4.11. Climate change and energy indicators.

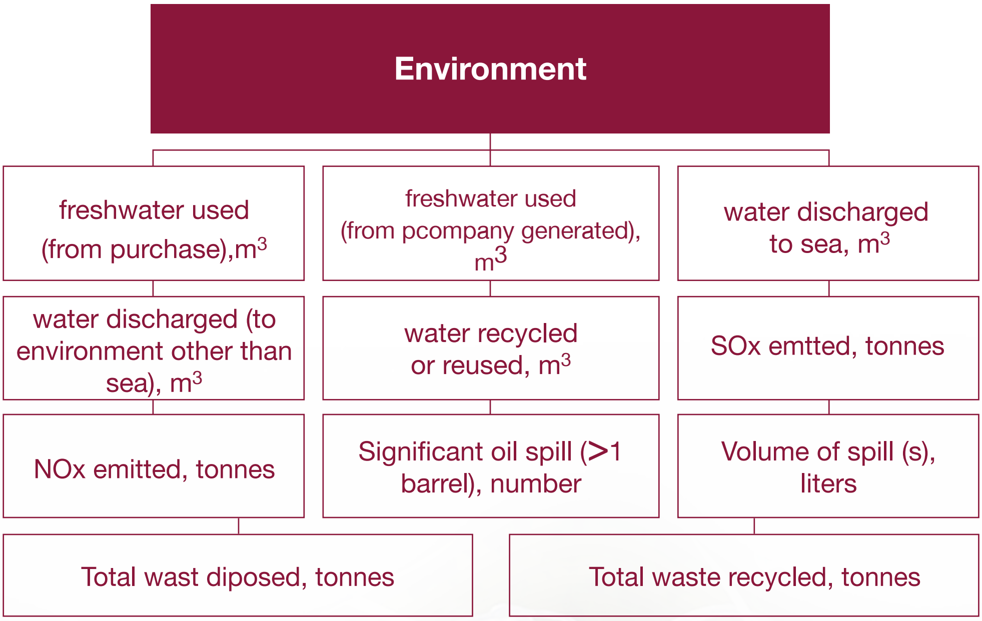


Figure 4.12. Environment indicators

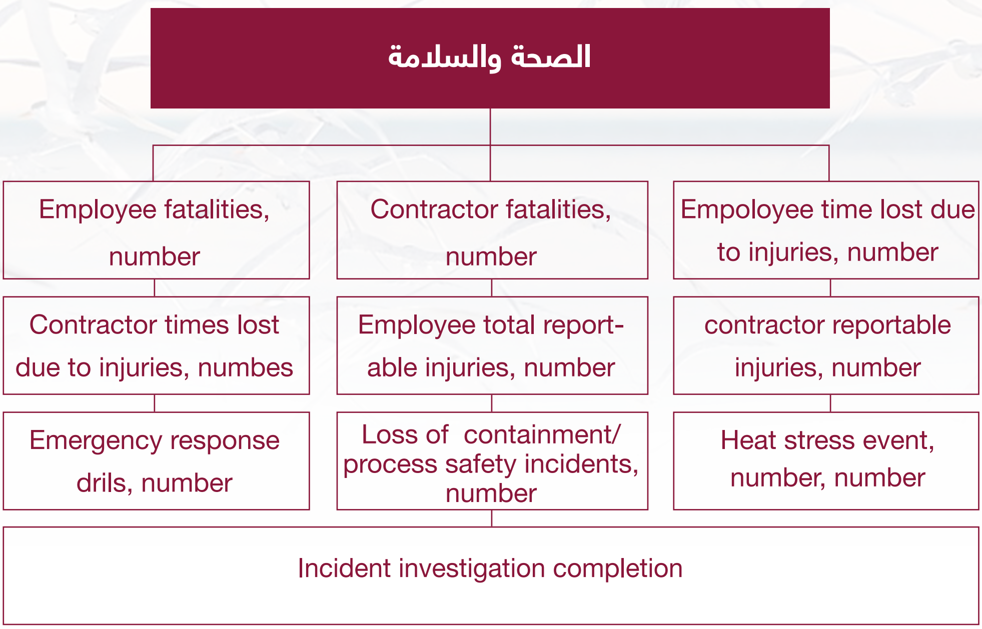


Figure 4.13. Health indicators.

Workforce

- workforce size, number
  - Employee satsfaction %
- Qatarization, %
- Female employement %
  - Total hours of training provided to employees, hours

Figure 4.14. Workforce indicators.

Society

- Total social investment bud-get US$
- Corruption of human rights incidents number

Figure 4.15. Social indicators.

4.5 Challenges and Strategic Response

The national economy has fluctuated over time due to variations in the gas production quota and price in the international markets. Recent years have witnessed a great deal of market volatility in the energy sector. For a country whose revenues depend heavily on the hydrocarbon trading, fluctuations in the energy market have significant implicationson national income and development projects. The year 2014 was challenging for the global energy market. Since June 2014 the oil prices fell by more than 70%. The decline continued through 2015 and reached as low as US$ 28 per barrel in early 2016. Thereafter, the price gained some ground, reaching US$ 49-50 per barrel by mid-2016.

Currently, Qatar is the world's leading exporter of LNG. However, a matter of concern is the significant increase in the supply of natural gas and aggressive marketing by US and players in the Asia-Pacific region that led to oversupply and motivated the buyers to renegotiate pricing. Japan, a major consumer of gas, has increased its reliance on energy from nuclear power plants. Qatar might have to explore markets elsewhere for favorable supply and price negotiations even as the country looks into value-added products that are likely to remain in demand in future years.

Gas prices are more important to Qatar compared to oil prices since the country's gas export is much higher than that of crude oil. In fact, in 2015 the value of LNG export alone exceeded all other hydrocarbon products. It is projected that oil fields are rapidly depleting but new discovery of vast reserves of natural gas gives reasons for optimism about economic stakes of the country in this natural wealth. In a planning that is timely and proactive the government has taken major initiatives to diversifying economy by increasing the investment in value-added industrial projects. Though chiefly known for its success in the oil and gas sector, Qatar is also home to a number of non-hydrocarbon industries that are playing an increasingly important role in its economy. The country stepped up refinery efficiency, steel production and output of inorganic fertilizer. These industries utilize mostly gas for fuel.

Due to a diversified range of commercially traded products, mainly natural gas, and downstream petrochemicals such as GTL and value-added condensates, Qatar is somewhat insulated from major shocks caused by price fluctuations. Besides, the country's liberal policies for attracting private sector investment, including international players, are contributory factors in production efficiency, product quality and investment. The country has restructured the public institutions, adjusted the budget, reviewed the phases of infrastructure development and selected the products needing priority in preparation for unlikely rebound in energy prices in the near-term.

4.6 Economic Importance

Earnings from the hydrocarbons and industrialization have helped Qatar attain one of the highest GDP per capita in the world. During 2013 till– 2017, the economy of the State of Qatar has recorded a compound annual growth rate (CAGR) of 2.8% (PSA, 2018). This period has been characterized by the maturation of Qatar's oil and gas mega projects and the moving towards a more diversified economy, fundamentally in sectors like transportation and storage, construction, financial and insurance, real estate, human health and social work activities. The maturing of the projects related to Mining and quarrying activities and the moratorium on oil and gas development explain the behaviour of the Mining and quarrying activities in real terms during the period 2013-2017, which showed a negative CAGR of 0.7% (PSA, 2018). During the period 2013 - 2017, the gross domestic product (GDP) at current prices has contracted 16.0% registering a negative compound annual rate of 4.3% (PSA, 2018). This decrease in GDP at current prices is mainly explained by lower international prices for oil and gas prices comparing 2017 to2013. However, comparing 2017 to2016, the nominal GDP increased by 10.0%, partially explained by the recovery in the oil and gas prices. Among all the economic sectors the construction industry recorded the strongest growth as the projects involving public investment and infrastructure related to FIFA World Cup 2022 continued their phased development. Financial and insurance activities sector has contributed 8.1% to Qatar's nominal GDP 8.1% in 2017 (PSA, 2018). This sector has moved at a compound annual rate of 6.0% during 2013-2017.

4.7. Environmental Protection and Enforcement

Qatar has given increasing attention to ensure protection of the environment through the various regulatory enactments and monitoring of the compliance. Efforts made in this direction are explained below.

4.7.1 Policy direction

State of Qatar has enacted many laws and regulations to protect the environment., the country has also signed several international conventions aimed at conservation of the environment. Ministry of Municipality and Environment is responsible for assessing the impact of industries on the environment and enforcing environmental protection Law and adherence for mitigation measures. Industrial cities should provide quarterly reports in addition to the periodical industrial inspection visits by MME inspectors. If any of the industrial companies was found to be non-complying , they should provide a compliance action plan to the MME. The companies are required to adopt best practices in compliance with the ISO procedures. Ministry of Municipality and Environment is responsible for checking the impact of industries on the environment and adherence to mitigation measures. These efforts are complimented by nature conservation measures such as designation of ecologically sensitive zones as nature reserves, minimizing the use of natural resources, water recycling and treatment of wastewater for greening. There is a comprehensive oil spill control and management plan duly reviewed by experts.

Interest is also catching up in developing the environmental management systems to reduce the carbon footprint. Main components of environmental management in response to operations related to harnessing of energy and industries are summarized in Figure 4.16.

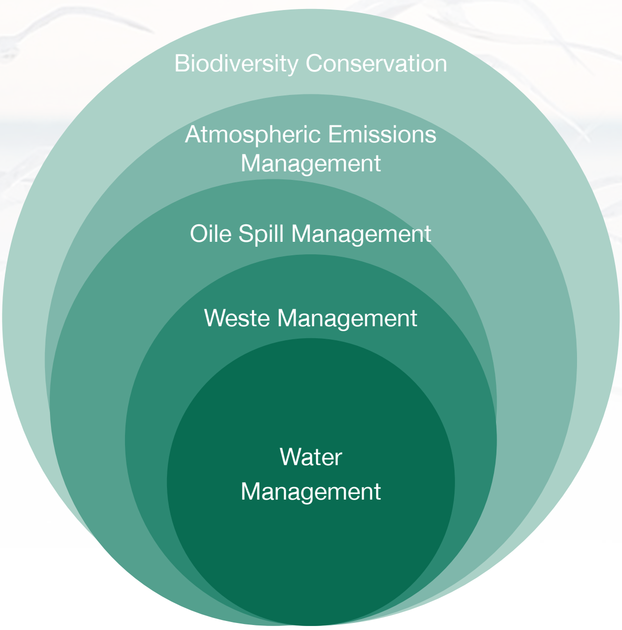


Figure 4.16. Main components of environmental conservation.

The companies are increasingly investing in conservation of nature by generating knowledge and taking measures that provide a healing touch to the marine environment, with regard to biodiversity. It is worth mentioning in this reagrds, the projects on whales, sharks, marine mammals, sea turtles,

artificial reefs and blue carbon stocks. The corporate social responsibility momentum is intensifying to include rehabilitation of other environmental components.

4.7.2 Emissions control and renewable energy

Qatar is taking steps to live up to the reality of changing energy systems as the world seeks ways and means of moving away from dependence on fossil fuels that produce more than one-third of global greenhouse gas emissions. The country has launched R & D initiatives to look for low-carbon renewable energy alternatives. Issues of interest are costs, benefits and risks associated with the various energy options. Considering Qatar's desert, conditions characterized by abundance of sunshine and geographical location, the renewable means like wind and solar are receiving more attention. Interest in exploring opportunities for shifting towards more sustainable path in the energy sector has never been greater. Government endeavors to reduce greenhouse gas pollution, while meeting the energy needs and developing a competitive economy. There is still a long way to go in fostering collaboration amongst the many energy stakeholders in Qatar, including producers, retailers, users, businesses and regulating agencies.

Energy economy in Qatar faces tremendous challenges that are in many ways not radically different from other oil-producing countries inthe Gulf. After signing the Paris Agreement on Climate Change, the government has reaffirmed its commitment to accept the energy sector as a key strategy for joining global efforts towards meeting the climate challenge. There should be no illusions about any dramatic transition to renewable energy. Changes in the energy sector happen slowly due to intricate linkage of energy use with routines, business, lifestyles and national economy. A long-term planning is critical and this should entail investments in technology, and a proper analysis of costs and benefits.

Challenges in transformation to a clean, low carbon energy system are commercial production and the power grid, andothers. The existing power grid is strong and stable but based on energy from fossil fuels. It is linked to power plants and electricity distribution. To make the power grid more flexible and dynamic, that would allow energy to come from multiple sources, will be a formidable undertaking. Progress in this direction will require investment, technology transfer and technical skills in regulating and managing the integrated energy system. These new paradigms will have to be considered comprehensively for decision-support in near future. The focus for now is on energy efficiency. It is entirely possible to drastically reduce the amount of energy used in offices or homes by slightly changing the routines but without compromising with the comfort level. In a country with surplus energy from fossil fuels, changing mindset and routines, will require major public awareness and regulatory initiatives. Qatar has science and theme parks which could provide facilities for launching such projects to motivate individuals to contribute to energy efficiency and inculcating a feeling that this initiative is better for themand for the future generations. Currently, the Qatar Science and Technology Park (QSTP) coversan area of 45,000 m2 it focuses on energy, environment, health science, and information and communications technology. It is well integrated with the institutions of higher education as part of the Education City, set up by the Qatar Foundation. About 3 dozen companies are now operating in this park. This impressive facility is aimed at providing a physical place for supporting academia-industry-government cooperation for the sake of advancing worthwhile knowledge and innovation, and generating new technology. The Park offers logistical facilities for joint efforts towards R & D collaboration and incubators. In light of the far-sighted vision and appropriate policies, the Park is likely to emerge as an active platform for knowledge transfer and technological innovation, and yield spin-off benefits to the economy. QSTP has already signed a memorandum of understanding with international agencies for developing clean energy technologies.

In an attempt to reduce the environmental impact of energy and industry sectors, measures have been taken to reduce flaring which is a source of greenhouse gas emissions. Considerable progress has been achieved in meeting the 2016 target of curtailing the flaring by 50% of the levels in 2008. It remains a work in progress through emissions capture technologies and sophisticated stack monitoring systems.

Through its membership of the International Renewable Energy Agency and other partnerships, and joint venture agreements with green technology providers, Qatar strives to achieve clean energy and climate change mitigation goals. Although still at R & D stage, a sustained investment in such programs has resulted in structured projects on solar energy and wind-solar hybrid energy.

Arid conditions, abundance of sun light,moderate to strong winds, and rains confined to a few days only in winter, provide advantages to pursue the sustainable energy option. The only problem could be dust storms but that can be managed by clearing away dust from solar panels or some other technological interventions. QSTP is geared up for housing the prototypes and incubating the products with potential application on a large-scale.

In addition to aggressively pursuing the renewable energy options, Qatar has launched many programs to reduce carbon footprint. These include strict checks on emissions from vehicles, supply of unleaded petrol, heavy penalties for keeping the lights on outside the buildings during daytime and campaigns in favor of using LED (light-emitting diode) electrical appliances to replace incandescent lamps. Longer life span and higher energy efficiency of LED are popular with the consumers.

Qatar aims to be recognized as the ‘Eco-country’ in the Gulf through a steady progress in environmental sustainability, where all the possible energy efficiency options will be practiced. Conservation zones will be expanded to include areas that are in pristine form, and thus off-limits for any development projects so that the natural attributes of the place are preserved. and where programs for rehabilitating the degraded resources, especially the marine critical habitats, receive priority.A place where the entire ecosystem is given the healing touch that it needs to build resilience. Reducing dependence on fossil fuels and emissions, deployment of renewable technologies and pushing for green solutions are important steps in this direction.

Qatar has an impressive record of achieving the UN Sustainable Development Goal no. 9 that refers to building resilient infrastructure, promoting sustainable industrialization and fostering innovation. The country has invested heavily in infrastructure related to transport, energy, and information and communications technology that are accepted as crucial to achieving sustainable development. Infrastructure helps in driving growth in productivity, improving incomes, and assisting the community in healthcare and education. Industrialization in Qatar follows some core principles of sustainability by timely improvement that seeks to make its energy and resources efficient, resilient and adaptable to changing scenarios, especially consumer demand. Industries also fund research oriented towards environmental conservation as a part of corporate social responsibility, although their contribution is still meager compared to the impact of carbon footprint that the industrial operations produce. In recent years, Qatar's investment in sustainable transport is notable and an ambitious effort is made for greening of this sector which is a major source of greenhouse emissions. Public transport system, represented in the form of the bus network, helps inmass movement of people. An extensive railway system that is developing will make transport fuel-efficient besides providing comfortable, safer and cheaper service to the society.

4.7.3 Reducing and offsetting carbon footprint

Qatar has made significant efforts in reducing the carbon footprint. Lowering the energy consumption in homes and offices is one of the measures taken. Promoting the use of energy-efficient lightening using LED bulbs, regulating the air-conditioning temperature in centrally cooled buildings and curtaining radiations in summer by sunscreens are among the steps taken. Qatar General Electricity

and Water Corporation (Kahramaa) has launched a massive drive called "Tarsheed law", which bans wastage of electricity and water at industrial, commercial and residential facilities across the country. Tarsheed law imposes fines that reach 10,000 & 20,000 QR for lighting the open spaces outside the house during daytime and wasting water while washing vehicles, using hose or pressure pipes in the open respectively outside of a building . The law is carried out by inspectors with judicial powers, who are responsible for monitoring the commercial, industrial and residential facilities across the country.

Reducing carbon footprint from food by consuming locally produced food is also practiced (Figure 4.17). Growing land-based food crops is constrained by desert conditions because it is a relatively small-scale activity. However, sustainable methods for exploiting local seafood resources are used to increase supplies and reduce the dependence on imported food.

Figure 4.17. Date festival in Doha to popularize locally produced fruit.

Reducing carbon footprint from driving is still a major challenge, but options are being made possible, thourgh using low-carbon vehicles, reducing traffic jams, boosting public transport and car-pooling. To encourage people to avoid driving over short distances, walkways have been developed. These are mostly lined with trees for shading, and flowering plants for enhancing aesthetics and making the areas more appealing. There are very visible programs for offsetting carbon footprint by urban greening (Figure 4.18).

Figure 4.18. Urban greenery for aesthetic reasons and environmental enhancement in Qatar.

Table 4.1. Measures taken to reduce the carbon footprint.		
Reducing carbon footprint	Nature or programs	Status
Public transportation	Extensive network of public bus service.	Very effective (especially, expatriates and low-income groups).
	West Bay Shuttle.	Partially effective.
	Qatar Rail projects: Doha Metro, Lusail Light Rail Transit.	Phase 1 of the Doha Metro project is almost done. Two of three lines are opened to public and the third line will be operated on 2020.
	School bus services.	Operational, very effective.
	Low carbon vehicles.	Kahramaa represented by the National Program for Conservation and Energy Efficiency (Tarsheed), has installed eight electric car charging stations free-of-cost to encourage the motorists to adopt electric cars. The initiative is eyeing to help switch up to five per cent of total cars into electric ones in Qatar by 2022. KAHRAMAA, Mowasalat "Karwa" and China Harbor Engineering Co. have also started the pilot testing of electric buses in Qatar. Also, Mowasalat has strengthened its public transport fleet with 63 buses operated on compressed natural gas (CNG) to reduce carbon emissions.
	Emissions control through mandatory checking of vehicles.	Operational, very effective.
	Upkeep of vehicles for energy efficiency, tire inflation, engine tuning.	Effective.
	Speeding.	Effective, speed generally follows limits set by the transport department.
	Housing near workplaces.	Partially effective.

Table 4.1. Measures taken to reduce the carbon footprint.		
Reducing carbon footprint	Nature or programs	Status
Efficient electrical appliances	Use of LED to replace incandescent lamps. Eco-friendly (energy-efficient) refrigerators, washing machines and other gadgets.	Operational, effective.
Reducing home energy carbon footprint	Unplugging gadgets, switching off lights when not in use. Switching off lights outside the house during day times.	Effective. Fines imposed since 2016 for leaving lights on outside the houses during daytime deters energy wastage.
Energy efficient kitchen gadgets	Microwave.	Effective.
Effective.	Microwave.	Energy-efficient kitchen gadgets
Reducing carbon footprint from food	Consuming predominantly vegetarian diet.	Ineffective. No change in peoples' eating habits No effective public awareness for sustainable food solutions.
	Food sustainability and buying locally produced food to reduce energy consumption during transportation.	After blockade, His Highness Sheikh Tamim bin Hamad Al Thani called for greater food self-sufficiency for Qatar's long-term sustainability and independence.A number of organizations has launched innovative food security programs such as promoting the value of food sustainability in schools, starting greenhouse planting in selected schools and selling the products in local markets, also launching "Torba Farmers Market" in Education City to provide access to organic, locally-grown food, and homemade products, and supports agricultural and other food producers around the country. (WCM-Q, 2018)

Table 4.1. Measures taken to reduce the carbon footprint.		
Reducing carbon footprint	Nature or programs	Status
Reducing water consumption	Drip irrigation.	Effective in public places. No data on home use.
	Bulk supply of bottled drinking water.	Effective. Many companies supply. Because of price people generally avoid wasting the water. Bulk transport also saves energy. Tap water is considered safe for drinking.
	Sensor-activated taps in public washrooms.	Effective wherever installed.
	It is prohibited to wash vehicles, the yard of the house or the house itself using hoses or pressure pipes in the open.	Effective. Fines imposed since 2016.
Sun screens	Widely used.	Effective. Energy efficient curtains reduce heat penetration that saves cooling demand on air conditioners during long summer season.
Reducing energy in cooling systems	Advanced technology introduced in cooling systems.	Partly effective.
Reduce, Reuse, Recycle	Campaigns launched.	Partly effective.
Relying on renewable energy sources	The first large solar power plant to produce electricity in Qatar using photovoltaic technology	Under construction
Offsetting carbon footprint	Tree plantation and including urban greening.	Effective despite natural constraint typical of desert climate.
	Carbon sequestration projects.	No blue carbon stock program but rehabilitation is ongoing.

4.8. Future Outlook

Fiscal management in Qatar has followed a policy of protection from monetary uncertainties. A part of this strategy is to build fiscal reserves from earnings and hold foreign assets. The latter is achieved

through investments that can be relied upon for financing the budget and absorbing economic shocks from volatility in the energy prices. Together with a conservative budget calibration, this measure stands the test of time when volatility in energy prices occurs, something that the country has been experiencing over the last two years. If global energy prices improve to yield favorable returns and the economy picks up, the 2016 deficit of 7.7% of GDP might remain stable in 2017 (PSA, 2016). Price rebound in the range of US $40-50 per barrel will help reasonable marketing structure to prevail. In the next two years, the hydrocarbon sector is likely to consolidate while the non-hydrocarbon sector will solidify its growth dynamics to boost income. Construction and services sectors are expected to remain vibrant and so will the population, contributing to overall growth. The construction-linked demand for cement and metals is likely to sustain momentum in other manufacturing activities through 2018. When the on-going construction projects are completed and no additional infrastructure projects are planned, this activity will slow down. If there is no oversupply problem, the investments in physical development will generate income through business, tourism and other programs that the government might be contemplating. Integrated megaprojects for essential supplies such as power and water that might mature and become operational soon will contribute to growth in the utilities and services. Hopefully, the interest in greening of the energy sector that is catching up will grow rapidly in future years and decades as the country formulates policies in favor of transition to a low-carbon energy future. In Qatar, natural gas will continue to play an important role albeit with regulations effective enough to minimize emissions. A comprehensive strategy for shifting towards green growth in the energy sector will require innovative approaches for energy efficiency in production as well as consumption, incentives for compliance, penalties for non-compliance, increasing the contribution of energy sector towards carbon offset programs and other means seeking synergies between environmental and development objectives with a long-term perspective.

4.9. Summary

Energy reserves and related industries are the main pillars of the economy of Qatar, providing a significant portion of the government revenues. The country produces and exports crude oil, natural gas, natural gas liquids, liquefied gas, gas-to-liquids, refined products, high-value-petrochemicals and fertilizers. Through a visionary approach and quest for sustainable income, the government has invested in industrialization for production of high-value commercial substances, diversification and nurturing a culture of environmental compatibility and sustainable development. Reduction in flaring from hydrocarbon extraction, improving technology for energy efficiency while reducing exploitation of natural resources have produced tangible outcomes. Government has taken initiatives for embracing the trend of change in energy systems. Reduction in greenhouse emissions and interest in harnessing renewable energy are visible in structured programs that are contributing to lessening of carbon footprint. Qatar has also made significant headway in sectors such as information and communications technology, transport and construction not only for improving industrial efficiency and ensuring social benefits but also for meeting the sustainable development goals. A prudent fiscal planning inherent in government policies has contributed a great deal to insulating the country from price volatility in the global market. This has allowed development to continue despite downturn in hydrocarbon value in the market and fostered an outlook of positivity and optimism on the future horizon.

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Chapter 5
Society, Culture and Education

Chapter 5

Society, Culture & Education

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Society, Culture & Education

Qatar has undergone an unprecedented development post-independence in socio-economic landscape and educational profile. This has contributed a great deal to knowledge empowerment and modernization of all sections of the society even as the country preserved its core cultural heritage and values. The country's national development plan 'Qatar National Vision 2030' launched in 2008 guided the development efforts towards attainment of advanced society status. As a result, Qatar achieved success in all the eight Millennium Development Goals set by the United Nations in 2000 and has the ability embrace the Sustainable Development Goals identified for implementation post-2015. A steady increase in human development index from 0.831 in 2011 to 0.848 in 2019 decline in illiteracy, high life expectancy at birth, drastic improvement of healthcare system and strengthening of services sector to help the society are among the visible signs of social development. Qatar enjoys highest per capita income and GDP in the world. Educational indicators suggest changes at all levels, including from pre-primary (kindergarten) learning, and primary, Preparatory, secondary education and tertiary (university) education. Assessed over a period of 3 years (2015/2016 – 2017/2018), the enrolments increased at pre-primary (53,469 to 55,633), primary (138,715 – 153,548), Preparatory (53,170 – 58,754) secondary (43,280 – 47,865) as well as university (28,668 – 33,922) levels.

A prominent feature of the country's social and educational development is the very visible progress achieved by women. They are now active players in national development.

5.1 Introduction

Qatar has been continuously and sparsely inhabited since prehistoric times and was ruled by many different empires in the past. The modern history of Qatar spans from the date it became an independent nation in 1971. The years that followed saw transformation of Qatar into a modern state defined by balanced social, economic, human and environmental developments at a pace not seen elsewhere in the world. Prudent management of revenues from abundant hydrocarbon resources brought rapid developments and socio-economic progress. Qatar is now a high-income economy with the highest per capita income in the world and ranks among the top countries in human development. While making progress economically, Qatar has successively preserved its cultural values even as the society embraced change with time. Heavy investment in infrastructure, public welfare, education, and services sectors provide good quality of life to all its citizens and residents. Qatar is also in a position to play an active role at world stage in promoting peace and stability, and hosting events that are a showcase of the country's ability to mobilize resources for positive outcomes. The country's efforts to enhance global interaction and inculcating an understanding of the importance of unity in diversity of cultures are widely acclaimed. This chapter provides a factual, lucid and succinct account of the society, culture and education in Qatar. It reflects on the relevance of growth-oriented, environmentally compatible and socially inclusive policymaking in achieving progress.

5.2.1 Progress, Prosperity and Security in Society

Population in Qatar has grown to 2,799,202 in 2019 (PSA, 2019). A significant demographic change has occurred over the last 13 years mainly due to arrival of foreign nationals to take up employment opportunities in the country. However, due to peace, shared prosperity, education, employment opportunities and internal security mechanisms, Qatar is one of the safest and family-friendly countries to live. Individuals including ladies, young adults and elderly don't seem to worry when moving around the city even in late hours. Qatar has seen tremendous modernization in education, infrastructure, services and social life while retaining the core elements of a tolerant Arabian culture. The trend of progress is consistent with the roadmap laid down under Qatar National Vision 2030. It was launched in 2008 for transforming Qatar into an advanced society capable of achieving sustainable development through 4 main goals that include economic, social, human and environmental development. Inherent in this vision are all the eight Millennium Development Goals (MDGs) identified by the United Nations in the year 2000 to achieve a set of important social priorities worldwide over a period of 15 years. With a proactive approach to delivering social justice to all sections of the society, Qatar rapidly progressed towards fulfilling the national priorities while accepting the Sustainable Development Goals (SDGs) that evolved at Rio+20 Earth Summit held in 2012 for implementation post-2015. The strategies put in place have succeeded in generating economic prosperity and ensuring decent living and knowledge empowerment of the society while preserving the heritage and natural resources of the country.

Any description of the social environment of Qatar is incomplete without highlighting the emancipation of women and their changed status in the society. The role of women in education, healthcare, art, literature, banking and other vital sectors of employment and economy cannot be underestimated. Their modesty in dressing and social conduct does not come in the way of their professional development to become scientists, doctors, engineers, journalists, lawyers, business executives, bankers and administrators. The independence that comes with moderation, modernization, and economic and knowledge empowerment is reflected in their routine activities such as driving, lecturing, treating patients and interacting with the general public for delivery of their job requirements.

Family values are at the core of Arab culture that prevails in Qatar. No matter how much change in the literacy and socio-economic landscape has occurred in the country, the family institution has remained stable and highly respected. In Qatar, the strong family bond is believed to contribute to harmony in society and can be credited for guiding the youth behavior and moral values largely.

Foreigners working in Qatar are well accepted at workplaces and socio-cultural events. They need to follow etiquettes, refrain from any rude behavior and be considerate to local cultures and traditions.

5.2.2 Human Development Indicator

Qatar excels and continues to improve the global metrics for the key dimensions of human development. Human Development Index (HDI) which is used by the United Nations Development Program (UNDP) to determine the quality of human life, is reflective of this positive trend over successive years (Figure 5.1). This is possible to implement due to rational policy decisions that aim at strengthening the socio-economic empowerment of the masses through knowledge, healthcare, economic prosperity, and the services that help the community. These advantages accruing to the society are coupled with a sense of respect towards the environment and natural resources that primarily support economic prosperity and realization of the priority for sustainable development.

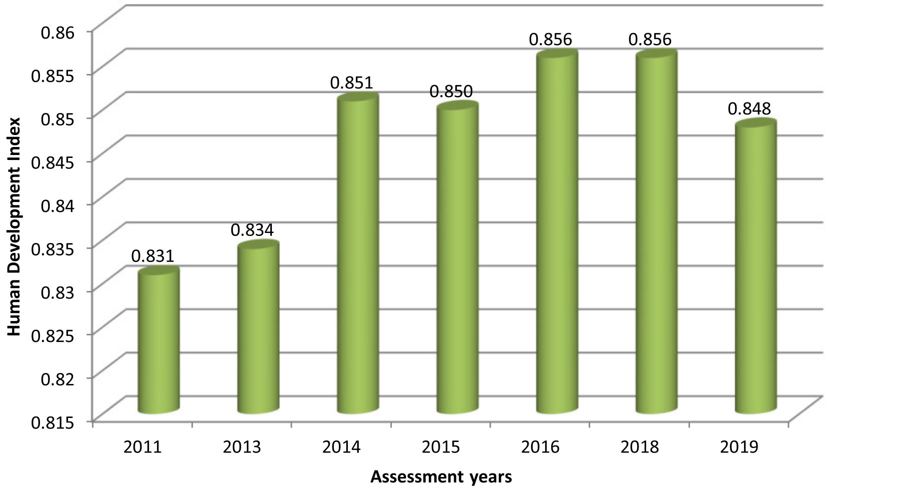


Figure 5.1. Human Development Index for Qatar. Each assessment year presents analysis of data for the preceding calendar year. (Source: UNDP, 2019)

5.2.3 Healthcare

Healthcare is a prominent social service sector in Qatar. The National Healthcare Service Strategy (2011-2016) guides the developments in this sector through 7 goals (Figure 5.2).

Goals of national healthcare service

- Comprehensive wordclass healthcare
- Integrated system of healthcare
- preventive healthcare
- skilled national workforce
- Ntional health policy
- Affordable services
- high quality research

Figure 5.2. Main goals of National Healthcare Service Strategy (2011-2016). (Source: MFA, 2015).

The indicators of progress in this sector are described in Table 5.1. It is evident that the healthcare system in Qatar has come a long way in terms of convenience to public and quality of treatment. The holistic approach to healthcare is directed at improving the overall quality of life.

Table 5.1. Healthcare system. Source: Sustainable Development Indicators (PSA, 2011-2018a).

Particulars	2011	2012	2013	2014	2015	2016	2017	2018
Number of hospitals	11	13	13	13	-	14	-	20
Number of beds in hospitals	2,203	2,502	2,402	2,385	-	2627.0	-	3,535
Population per bed	787	733	834	930	-	966.0	-	781
Number of physicians	5,125	5,789	4,267	5,500	-	7152.0	-	7,260
Population per physician	338	395	363	403	-	366.0	-	380
Number of nurses	9,722	10,649	12,388	12,768	-	16968.0	-	20,767
Population per nursing staff	178	172	162	173	-	154.0	-	133
Coverage Percentage of Basic Vaccination At The First Year Of Age								
Tuberculosis (BCG)	97.0	97.0	96.0	90.0	97.0	97.3	98.5	98.6
The third dose of Polio	93.0	92.0	96.9	99.0	99.0	98.1	97.0	98.0
The third dose of Triple Vaccine DPT (Diphtheria, Pertussis, Tetanus)	92.0	93.0	96.0	89.0	99.0	98.2	97.1	98.0
The third dose of Hepatitis B Vaccine	92.0	95.0	93.3	89.0	99.0	98.2	96.9	98.0
The third dose of Measles, Mumps & Rubella	100.0	97.0	97.3	100.0	91.0	91.2	99.9	99.9
The third dose of Haemophillus Influenzae	94.0	95.0	96.0	89.0	99.0	98.0	97.1	98.0
The first dose of Varicella	100.0	98.0	96.9	-	100.0	100.0	100.0	99.6
Conjugated Pneumococcal	98.0	93.0	100.0	100.0	96.1	96.6	97.7	98.4

The percentage of vaccination is probably higher than the record presented in Table 5.1 since babies born to Qataris overseas should be receiving this healthcare support wherever they happen to be. In addition to hospitals, there are many private clinics offering general and specialized treatments, and pathology laboratories using modern gadgets for analysis of samples for diagnostic purposes. Hospitals are encouraged to provide voluntary services to public through open camps and kiosks in supermalls, and to organize simple health screening in government departments.

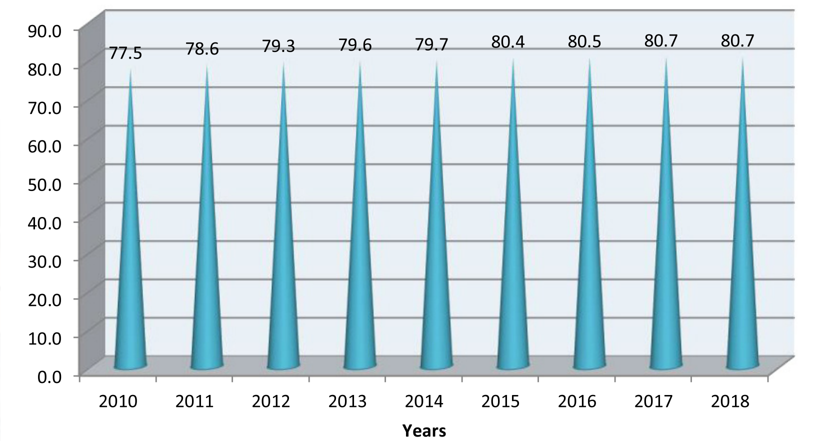


Figure 5.3. Life expectancy at birth. Source: Sustainable development indicators (PSA, 2019).

Increase in health care expenditure has resulted in a decline in infant mortality (Figure 5.3) and to some extent increase in life expectancy. In Qatar, the income gains have in many cases contributed to some healthy lifestyles, which are among the factors that could matter in the life expectancy. However, how much prosperity has ? into life expectancy is unclear at this stage.

5.3 Culture
5.3.1 Cultural Ethos

Qatar has a rich history where many empireshad ruled the country in the past. Many relics and architectural sites found here narrate the journey of civilizations and their cultural transformations through time. Qatar National Dayheld on the 18 December is dedicated to remembrance of the country's unification and independence that was translated into a success story of progress. Activities on this occasion are a reflection of what has been achieved and nurtures a sense of identity. The elaborate celebrations generally lined up for this national day (Figure 5.4) are enjoyed by the whole society and tourists, and

Figure 5.4: Sights and sounds of vibrant Qatar on the occasion of national day.

are an excellent occasion to witness the sights and sounds of Qatar. Qatar follows the Islamic and Arabian culture, but the country is tolerant to other religions, cultures and nationalities. This has allowed people from different parts of the world to live peacefully and work together to develop the country to what it is today. Visitors of Qatar can experience how the society embraced modernity while preserving the Arabian values that define peaceful coexistence, inclusiveness and shared prosperity. Many places of worship have been designed to reflect modernization and include facilities for imparting understanding and discussion of the true essence and peaceful nature of the religion of Islam (Figure 5.5).

Figure 5.5. Places for spiritual practice in Qatar.

Qatar has undergone significant developments, and lifestyles of its people have changed but the society continues to value its culture and traditions. This unique blending of culture and modernity is helping the country emerge as an important destination for sight-seeing, cultural awareness and tourism (Figure 5.6). An outstanding example is Katara Cultural Village. It is a place that blends cultural ethos with nature in a tranquil environment away from the hustle and bustle of city life. With its vast open space, facilities to feel close to nature and sandy beaches, theatres, concert halls, exhibition galleries, restaurants, playground and boutiques, Katara is a favorite place for multicultural activities and pastime for people of all age groups. It frequently hosts local, regional and international festivals, performances, exhibitions and other events.

The Pearl is a recent infrastructure project. Considered a 'jewel in the crown', this iconic real estate development is home to a number of enchanting precincts with luxurious apartments, villas, townhouses,

marinas, serene beaches along the breathtaking view of the Arabian Gulf, international fashion brands, high-end shopping outlets, eateries to cater to different tastes, business houses and entertainment facilities.

5.3.2 Cultural Indicators

There can be a variety of cultural indicators but those selected in this chapter are the ones that are measurable and relate to society's habits of reading, using public libraries and entertainments (Table 5.2). Data for a 2-year period (2017-2018) presented in this table indicates that there is an increase in the number of Arabic and English books as well as periodicals acquired, it dates back to the opening of the Qatar national library in 2017. The number of newspapers is in a slight increase, reflecting the people's growing interest in getting the news through TV, internet and other sources. Number of cinemas is 51 as of now but the number of cinemagoers has fluctuated and so is the screening of films in Arabic and foreign languages.

Figure 5.6. Favored spots for outdoor activities (left) and indoor entertainment (right).

Table 5.2. Culture indicators.							
Particulars	2012	2013	2014	2015	2016	2017	2018
Public libraries	7	7	7	7	7	78	8
Arabic books	562,537	566,917	570989	570,988	576,359	710,394	736,037
English books	58,775	59,342	60,868	55,377	61,338	762,442	779,316
Periodicals	1,415	1,420	2,818	1,450	1,450	3,045	3465
Number of borrowers	28,030	24,186	33,363	37,887	33,794	207,651	74848
Number of borrowed books	53,924	43,090	44,871	66,959	58,065	228,322	835,841
Average books/ borrower	2	2	1	2	2	5	11
Daily newspapers	7	7	7	7	8	8	9
Monthly magazines	6	10	11	6	4	4	4
Weekly magazines	1	0	0	0	0	0	0
Cinemas	38	31	38	37	51	51	51
Visitors to cinema (cinema/day)	4,392	6,146	4,981	8,263	3,026	2,372	1,861
Screening of Arabic film	119	51	46	70	75	118	113
Foreign films	1,225	817	794	1,135	1,301	1,765	2,025

Qatar gives special attention to promoting cultural awareness and organizing events that are very popular with the natives, expatriates and tourists. Many festivals, open space concerts, roadshows and various sorts of performances are held regularly, especially during autumn and winter, that attract people of all ages and walks of life. Interestingly, tourists often outnumber the locals in some cultural activities and festivities for an exotic experience. In addition to local, regional and international cultural events, exhibitions also take place in Qatar. The most popular are the film festivals and exhibitions of the work of creative art and culture, and handicraft (Figure 5.7). Internationally renowned artists are often invited to display their talents.

Figure 5.7. Traditional handicraft of Qatar draws many tourists.

Interest in developing Qatar's own theatrical performances gained support in the 1970s, resulting in the formation of troupes, which were later blended into a more integrated body called The Qatar Theatrical Troupe. This troupe regularly holds performances that attract many people. Qatar Philharmonic Orchestra comprising over 100 musicians has come a long way and has gained much popularity in recent years. Doha Film Institute provides a platform to nurture creative talents and help those keen to pursue their passion so that the film industry can grow. the initiative of Holding an annual film festival in a picturesque KATARA is being boostedthrough interaction communication with international professional artists and amateurs. The excellent infrastructure and hospitality industry along with peace and security that prevail in Qatar, have contributed to the growing number of visitors keen gto live the experience of the rich Arab history and culture. The leisure facilities around the heritage sites and shopping malls cater to visitors looking beyond their journey into the past and allows them to enjoy various types of cuisines or to indulge in shopping. Qatar offers diverse dining options combined with local, regional and international flavors. Many high-end restaurants offering special culinary favorites have opened up. Popular international coffeehouses also provide excellent dining experiences. Fast food remains popular with youth and expatriates. The upscale shopping malls combine marketing of luxury brands, theaters, family entertainment, restaurants, banking services and facilities for relaxation under a serene atmosphere (Figure 5.8).

Figure 5.8: A family-friendly supermall in Qatar. Visitors go there for shopping, eating out and leisure

5.3.3 Heritage, Museums and Architectural Marvels

Qatar has made great efforts for preserving its history and heritage. It has certain very old structures depicting the past besides museums housing collections of artifacts and other objects of artistic, cultural, historical, or even scientific significance. These are made available for public viewing. Besides, the love for unique designs embracing modernity was reflected in state-of-the-art high-rise buildings. The architectural designs and locations have turned some of them into iconic landmarks of the country (Figure 5.9).

Figure 5.9. Some iconic landmarks of Qatar. Top- left (Museum of Islamic Arts), right (Islamic Cultural Centre). Below- left: Uniquely designed towers in the Corniche-west Bay area, right (National Museum of Qatar).

Al Zubarah once a thriving pearl for fishing and trading, Al Zubarah (Figure 5.10). is Qatar's largest heritage site, with city walls, ancient residential palaces, houses, industrial areas and mosques. It is a showcase of one of the best-preserved 18th and 19th century merchant towns ,named by the UNESCO as aWorld Heritage site in 2013.

Figure 5.10: Zubara Fort- a well-preserved historic site in Qatar.

Khor Al Udaid is a unique place to explore nature. Located some 60 km from Doha in the south-eastern part of the country, this place is called as 'Inland Sea' where sea extends deep into the desert. It is a UNESCO-recognized nature reserve with its own ecosystem. When viewed from the surrounding rolling sand dunes during sunrise and sunset, this spot gives a spectacular view not seen anywhere else in the world.

Museum of Islamic Art is housed in an iconic building on an artificial peninsula located along Corniche. It is unique in design and is strategically located overlooking the mesmerizingly beautiful Doha Bay and lush green park around the Corniche sea front. Occupying a total area of 45,000 m2, it houses an impressive collection of Islamic art in the form of metal works, ceramics, jewelry, woodworks, textiles, and glass from three continents with historic perspectives. This 5-story museum has many facilities, including library, prayer rooms, café, upscale restaurant, gift shop, auditorium, cloakroom and ATM. A Reception and Information desk which provide guide to the visitors. A 290,000 m2 park located behind the main building provides a vantage point for viewing and photography. The museum is open to all residents and visitors.

Arab Museum of Modern Art situated in the Education City this museum hosts exhibits and programs providing an Arab perspective on contemporary art.

Al Wajba Fort has been preserved to depict the residential areas built by influential and resourceful people, and the spectacular event of the 18th century when Qatari forces won the battle against the Ottomans.

Sheikh Faisal bin Qassim Al-Thani Museum contains more than 15,000 exhibits of art, artifacts and traditional items that provide a glimpse of life in Qatar before the industrialization that followed the discovery of hydrocarbon deposits.

Other avenues offering windows to Qatar's past are some historic sites, especially Barzan Towers that were once used to determine dates of the lunar calendar and protecting the local water resources. Also contributing to Doha's lively cultural scene are Al Riwaq Gallery, Qatar Museums Gallery, Arab Postage Stamp Museum, Souq Waqif Art Center and Al Markhiya Gallery.

5.3.4 Socio-cultural Melting Pots

The spot most popular with the locals as well as tourists alike is the Souq Waqif (Figure 5.11). Dating back to more than 100 years, in the proximity of a dry riverbed known as 'Wadi Musheireb,' this market was renovated in 2006 to preserve its traditional architectural styles and expand the area to blend it with the changed lifestyles. What used to be a gathering place for native tribes and traders, is now humming up with activity and catering to diverse interests. In addition to a 980-seat indoor ,Al Rayyan Theatre, an impressive Souq Waqif Art Centre, posh hotels, this sprawling area has dozens of restaurants, souvenir and handicraft shops, textile stores, and marketing outlets for traditional goods, dry fruits and spices, among other merchandize. Open space concerts, musical and theatrical performances and local festivals are regularly held here. Souq Waqif has now emerged as the melting pot of many cultures thriving in one place. It is an ideal place for those willing to enjoy local and international cuisine, or to relax in a café. The "Souq" attracts a lot of people especially during autumn and winter seasons, and when there are occasional events such as the date festival. This is the best time to witness the sights and sounds of Qatar.

Figure 5.11. Souq Waqif – A ‘melting pot’ of cultures.

Figure 5.12. Green spaces in the form of parks draw many local people and foreigners looking for healthy recreation and relaxation.

Public parks in Qatar are among the best in the region. They are clean, with proper sanitation, safe and have a serene environment where families can relax without worrying about security. These places also act as a'green lung'. Despite arid conditions, the parks are lush green and oasis in a desert landscape and are favorite spots for natives and visitors alike (Figure 5.12).

The most popular is Corniche Park. It is a sprawling area starting from Dafna section of West Bay and extending over several kilometers along the seafront. One can take a stroll on grassland or enjoy a boat ride in Doha Bay and nearby areas. The park sees a large turnout of joggers and those looking for relaxation in autumn and winter. The leisure boats with bright lights (Figure 5.13) anchored in the harbor area offer leisure to visitors interested in taking a breathtaking view of the scenic bay. Increasing interest in boating is promoting nature tourism due to presence of nearby islands.

5.3.5 Sports

Qatari people are very enthusiastic about sports. Their interest in traditional sports has not waned with time. Thus, camel racing (Figure 5.14), horse racing (Figure 5.15) and Dhow festivasl that are rooted in the country's past, are still popular. Foreigners keen to learn Arabian sports find the camel racing quite delightful and enjoyable. Falconry is still practiced by a limited number of people. Contemporary sports such as basketball, golf, cricket, swimming, football (soccer), table tennis, basketball, and volleyball are widely played by the youth. Football is particularly very popular.

Figure 5.14: Camel racing a traditional sport in Qatar.

Qatar's strategy for development of sports is guided by the vision of creating a healthy and active population, and providing the youth different means of channeling their energy into constructive lifestyles (QOC, 2011). In fact, the strategies dedicated for the sector of sports form an essential part of the National Development Strategy under the Qatar National Vision 2030. Inherent in this approach is investment in popularizing outdoor sports and linking outdoor activities with environmental awareness and sustainable living. The priorities of these sports development program are indicated in Figure 5.16.

Impressive infrastructure and successful staging of the 15th Asian Games in 2006 and other major sporting events have helped Qatar

Qatar National Vision 2030

- Athelete pathways development
- Sport management
- Sports & leisure facilities
- Sports education & participation
- Promotion & publicity
- Hosting international sports events

Figure 5.16: Priorities for sports development in Qatar.

emerge as a global sports hub. The institutionalized development of Qatar is reflected by the existence of specialized federations for archery, athletics, basketball, boxing, cycling, equestrian, fencing, football, gymnastics, handball, judo, rowing, sailing, swimming, table tennis, taekwondo, tennis, volleyball and weightlifting. There are many sports clubs dotting the country to develop interest in sports. Qatari teams have been competing in international matches, including Asian Games and Olympics.

It is not without reasons that the country is a favorite place for many regional and international sports events and will be hosting the Federation International de Football Association (FIFA) World Cup in 2022. Winter is the best time in Qatar for games and outings. It is also a high time for indulgence in outdoor leisure for residents, expatriates and tourists alike, especially along the mesmerizingly beautiful seafront (Figure 5.17).

5.4 Education
5.4.1 Changing Educational Profile

In Qatar, education receives utmost importance as a means of enlightenment and empowerment of society. Article 49 of the constitution of Qatar recognizes education as the right of every citizen and the State provides commitment to work on conditions and mechanisms to achieve full literacy. The turnaround in this sector happened in 1995 as part of a long-term development plan for the country. This was the time that saw the laying down of the foundation of Qatar Foundation for Education, Science and Community Development, and implementation of several programs of action culminating in the formulation of National Development Strategy (2011-2016) and (2018-2022) in which education was given prominence. It is a blueprint for using knowledge in making informed decisions, transforming the society and economy and meeting challenges of modern life. In pursuance of this national goal, investment in education has steadily increased and knowledge has reached all sections of the society with no gender bias. The period between 2000 – 2014 has seen a significant increase in spending on education from 1.6 Billion QR to about 26 Billion QR in 2014 and in 2019 about 19.2 Billion QR (MFA, 2019).

The initiatives taken by the government targeted all levels of education- early childhood, primary, secondary and tertiary. In addition to government schools, private schools and those run by international education providers are also allowed. Their quality of education is regularly monitored for compliance with the standard yardsticks. From the very beginning, students are exposed to winds of modernization and introduced to new tools of interactive learning. The higher education sector has grown by leaps and bounds following the thrust given to it in the last decade. It has all the ingredients of emerging as a provider of tertiary education in the region. Qatar Foundation can be credited with spearheading the education, science, research and community development with the aim of nurturing knowledge economy and unleashing human talent for problem-solving outcomes. Its most prestigious project is the Education City that is home to local branches of Carnegie Mellon School of Medical Science, Georgetown University School of Foreign Service, Texas A & M School of Engineering, HIS Paris University, University College of London and other excellent institutions. Qatar University is the country's oldest and largest institution of higher education. Hamad Bin Khalifa University is yet another institution of tertiary education that has recently been founded. Local and foreign students seeking higher education in many areas of science, engineering, medical science, art and social sciences, including education, business, economics and Islamic studies, and other topics of current interest, can join any of the specialized programs at undergraduate or postgraduate levels.

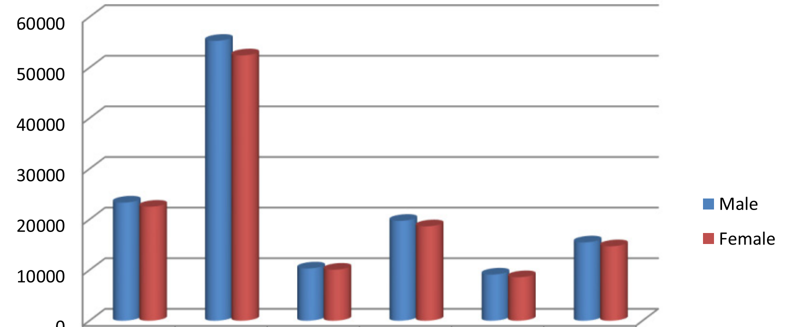
Qatar Foundation has several institutes and research centers, namely Qatar Biomedical Research Institute, Qatar Cardiovascular Research Center, Qatar Environment and Energy Research Institute, and Qatar Computing Research Institute. Qatar University also manages Social and Economic Survey Research Institute, Wired and Wireless Communication Center, Environment Research Center, Gas Research Center, Advanced Material Center, Sustainable Development Center, Road Safety Studies Center,in addition to Science and Technology

Oasis. The Ministry of Interior has a Strategic Studies Center and Hamad Medical Corporation has a Medical Research Center. A government-supported Arab Center for Research and Policy Studies deals with social, political and economic issues related to the Arab world.

Qatar Foundation has several centers for social development and community enlightenment. These centers are: Social Development Center, Qatar Debate, Qatar Music Academy, Qatar Philharmonic Orchestra, Bloomsbury Qatar Publishing, Doha International Family Institute, Reach Out to Asia, Qatar Vocational Development Center, Al-Shaqab Equestrian, Aljazeera Children Channel, Qatar Diabetes Society, Research Center for Islamic Legislation and Ethics, Musheireb Properties Company, Qatar National Library, Quranic Botanic Garden and Qatar Green Building Council.

5.4.2 Education Indicator

Key education indicators are literacy rate, facilities for all levels of education (kindergarten, schools for primary and secondary education, colleges and universities), and student enrolment (PSA, 2018). As a result of these efforts, the illiteracy rate has declined, and this is greater in the female population (Figures 5.18 - 5.20). In the higher age group (15-24 years), the job opportunities for thosedone with undergraduate level could account for their decision to quit formal education. Qatar’s investment for education is consistent with Sustainable Development Goal 4: which states ‘Ensure inclusive and quality education for all and promote lifelong learning’.



	Primary-Qatari	Primary-Non-Qatari	Preparatory-Qatari	Preparatory-Non-Qatari	Secondary - Qatari	Secondary - Non-qatari
Male	23335	55290	10315	19724	9112	15467
Female	22511	52412	10075	18640	8586	14700

Figure 5.18. Number of students at various levels of education, 2017/2018 (PSA, 2018).

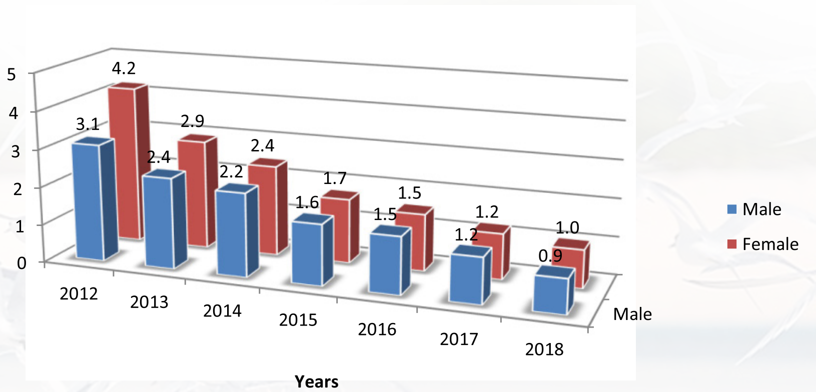


Figure 5.19. Illiteracy rate (15 years and above). (Source: PSA, 2019) Figure 5.20. Youth illiteracy rate (15-24 years). (Source: PSA, 2013 - 2019).

Government has invested heavily in infrastructure for schools, colleges and universities to cover all levels of education. This has led to an increase in the enrolment in the education sector.

Pre-primary education

Qatari parents take keen interest in exposing their kids in the early childhood to education so they can develop interest in learning and interacting with others of their age group. Currently, there are 445 kindergartens in Qatar in 2016/2017, an increase from their number of 405 in 2015/2016 and 383 in 2014/2015. Kindergartens have adequate number of teachers; the teacher/student ratio in 2017/ 2018 is 12 (PSA, 2018). This has contributed to increasing the student enrolment in the pre-primary education (Figure 5.20).

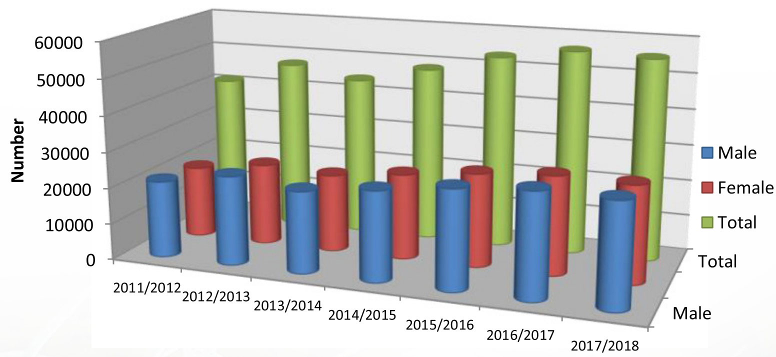


Figure 5.21. Student enrolment in pre-primary education. (Source: PSA, 2018).

Primary education

The primary education has seen increasing enrolment from 101,424 to 232173 from 2011/2012 to 2017/2018 (Figure 5.21).

Figure 5.21. Student enrolment in primary education. (Source: PSA, 2019)

The teacher/student ratio is similar to that for pre-primary education, i.e., 0:1.

Preparatory education

Similar to the trend in primary education, the preparatory education also saw increased registration for higher level of education (Figure 5.22).

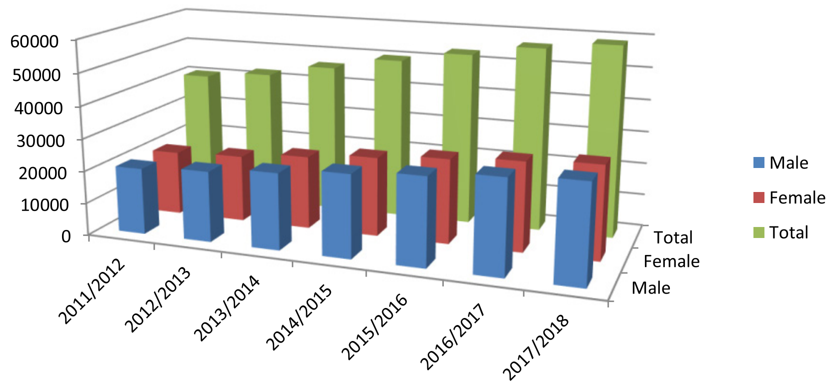


Figure 5.22. Student enrolment in preparatory education. Source: (PSA, (2017/2018).

Secondary education

The trend of increase in secondary education (Figure 5.23) is not much different from that of earlier level education. Recruitment of more teachers has resulted in student/teacher ratio of 10 and this increased since 2012 til 2018.

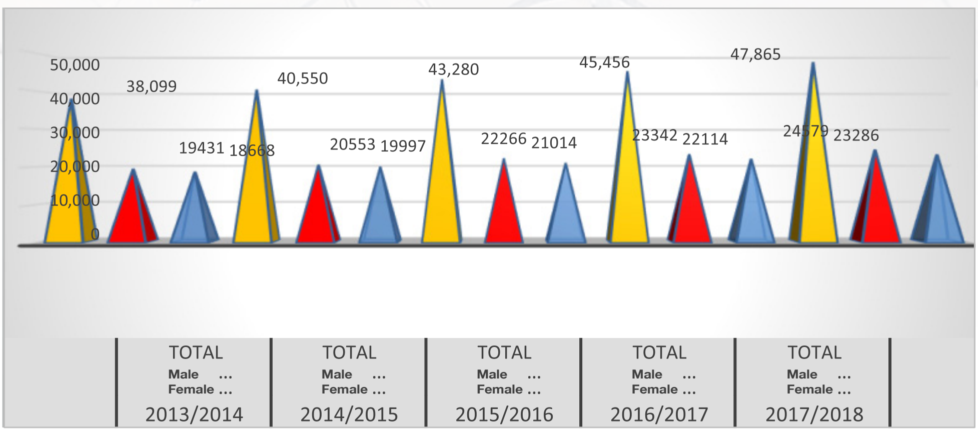


Figure 5.23. Student enrolment in secondary education. Source: PSA (2011/2018).

University education

The number of students joining universities for degrees in higher education or professional courses is increasing (Figures 5.24 and 5.25). The enrolment has increased from 28106 in 2014/2015, to 28668 in 2015/2016 to 34000 in 2017/2018.

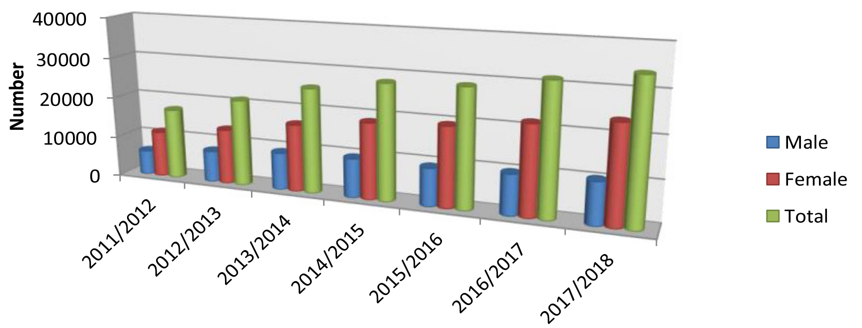
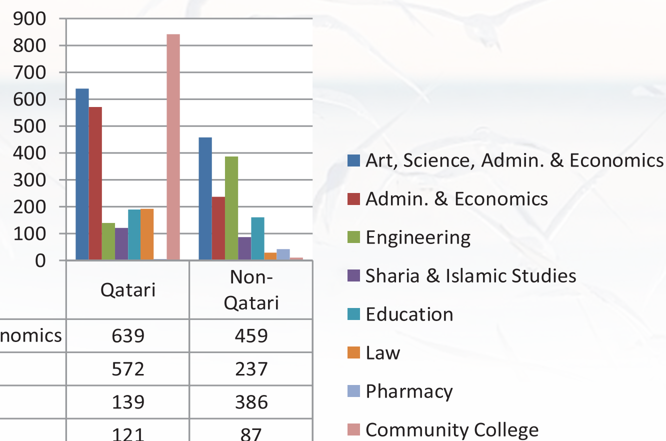


Figure 5.24. Student enrolment in universities. (Source: PSA, 2019)



	Qatari	Non-Qatari
Art, Science, Admin. & Economics	639	459
Admin. & Economics	572	237
Engineering	139	386
Sharia & Islamic Studies	121	87
Education	189	160
Law	191	30
Pharmacy	6	42
Community College	841	11

Figure 5.25. Graduate students in public colleges and universities, 2017/2018.

An interesting feature is a significant rise in female population in the tertiary education. Females now far exceed the male students in universities. This could be due to their interest in obtaining education and increase in population. For graduate classes, the teacher/student ratio is 13.

In addition to enrolment in local university campuses, many students have been funded for studies overseas (Figure 5.26). Their number increased drastically in 2017/2018.

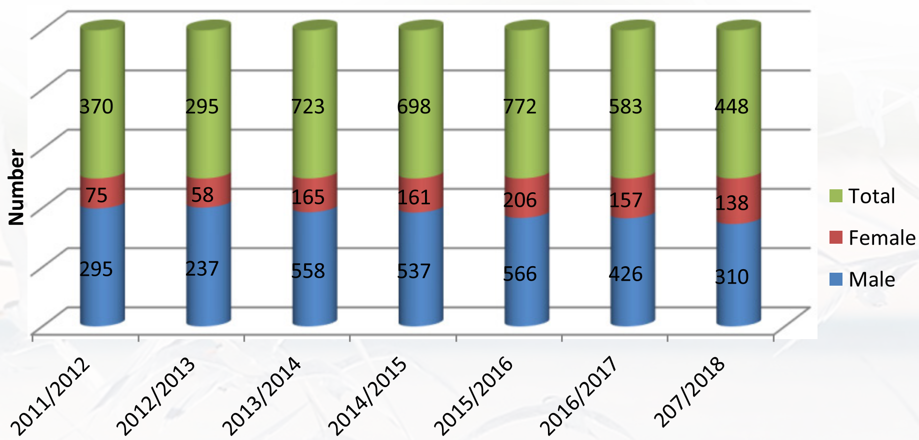


Figure 5.26. Students in scholarship abroad. Source: Annual Statistics Bulletin (PSA, 2019).

Environmental education receives considerable thrust in the teaching curricula. Besides regular teaching courses, students are also introduced to issues concerning the environment during outdoor projects and special events such as World Environment Day celebrations and wildlife conservation among others available for public outreach.

Development of knowledge parks and nature conservation areas to inculcate sustainable living themes are pointer to the growing significance of environmental management in everyday life. Some festivals are occasions for public outreach aimed at environmental conservation in popular spots such as Souq Waqif and Katara. For example, date festival promotes consumption of local produce that is more environment-friendly inasmuch as it saves fuel energy spent in transportation of dates from abroad. Although it makes a small contribution to reducing carbon footprint, but it carries a bigger message for environmental sustainability. Eating local produce also demonstrates a sense of local community welfare that benefits the indigenous farmers. Many agencies organize campaigns for water conservation, energy efficiency and organic food with an encouraging public participation. Qatar is a unique example that aims at showing the world that prudent policies and planning can help so much in dealing with the difficult natural conditions.

5.5 Future Outlook

Qatar's phenomenal success in socio-economic development and knowledge empowerment bears witness to careful selection of national priorities and strong fundamentals of governance. The country's quest to preserve its core cultural values and embrace modernization is a showcase for progress, stability and prosperity. Qatar's national income relies on fuel prices, but diversification is receiving attention so the state would be ableto face theuncertainties that has gripped the energy markets in recent years. The wise national plans and policies, and prudent spending will help Qatar stand in good stead in sustaining its trajectory of inclusive socio-economic, human and educational developments in future years. Key elements that hold out optimism for the future include sustainable management of environment and natural resources, high quality education and services sectors, empowerment of women and balanced socio-economic development.

5.6 Summary

Modern history of Qatar, post-independence, is defined by unprecedented socio-economic developments, transformation of educational landscape and modernization. These efforts have contributed a great deal to empowerment and prosperity of all sections of the society, in the same time the country preserved its core cultural heritage and values. The four main pillars of Qatar National Vision 2030 launched in 2008 guided the country's development efforts towards attainment of advanced society status. This is reflected by the success of Qatar in all the eight Millennium Development Goals set by the United Nations in 2000 and its ability to carry forward the gains in fulfilling the national priorities and to embrace the Sustainable Development Goals identified for implementation post-2015. A steady increase in human development index from 0.841 in 2012 to 0.850 in 2015, decline in illiteracy, high life expectancy at birth, drastic improvement of healthcare system and strengthening of services sector to help the society, are among the visible signs of social development. Qatar enjoys the highest per capita income in the world. GDP (by expenditure at prevailing prices)changed from million QR 552,305 in 2016 to million QR 607,620 in 2017 to million QR 696,557 in 2018. Educational indicators show changes at all levels, startingfrom pre-primary (kindergarten) learning, going through primary, ending at secondary and tertiary (university) education. Assessed over a period of 3 years (2015/2016 – 2017/2018), the enrolments increased at pre-primary (53,469 to 55,633), primary (138,715 – 153,548), Preparatory (53,170 – 58,754) secondary (43,280 – 47,865) as well as university (28,668 – 33,922) levels. A prominent feature of the country's progress is empowerment of women because of which they have been able to unleash their tremendous inherent potential, which is now very visible.

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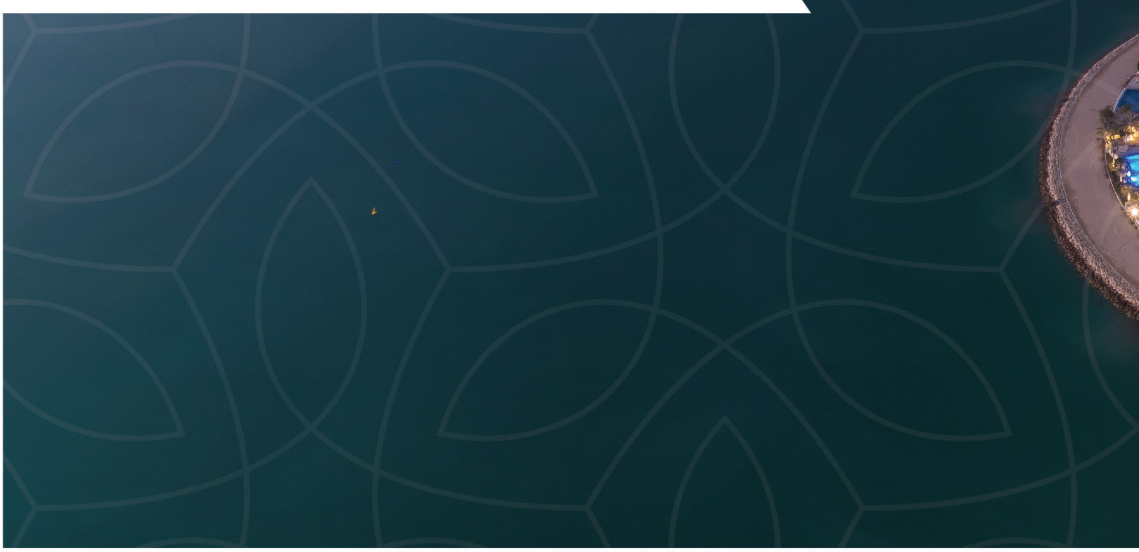
Chapter 6
Economy

Chapter 6

Economy



Chapter 6:

Economy

The mining and quarrying activities are top contributors to the GDP. According to statistics updated in 2018, Qatar's natural gas reserves are 24.7 trillion cubic meters, oil reserves stand at 25.2 billion barrels and LNG exports amount to 76.4 million tons. Other main non-mining and quarrying activities in Qatar include manufacturing, building and construction, business services, wholesale and retail, agriculture, electricity, water, transport and communications, and others.

Gross value-added pertaining to the mining and quarrying sector for the year 2017 has been estimated at QR 196.0 Bn, showing an increase of 19.5% over the GVA of the previous year. This increase is attributed to rising international prices for oil and gas in 2017 compared to 2016. Due to the impact of lower international prices for oil and gas products, the Mining and quarrying sector has witnessed a decrease in its contribution to GDP compared to the peak in 2013 (55.7%), representing 32.3% of nominal GDP in 2017. In real terms, mining remained virtually unchanged at a Compound Annual Growth Rate (CAGR) of 0.03% mainly due to moratorium on further gas development from the North Field.

Within the Non-mining and quarrying group, Construction (15.0% of nominal GDP), Manufacturing (8.7%), Finance and insurance activities (8.1%), Wholesale and retail trade (7.8%), and Public administration services (7.3%) made the largest contribution to nominal GDP in 2017. The share of these activities in nominal GDP increased from 41% in 2011 to 63.9% in 2018.

6.1 Introduction

Economic development and environmental sustainability are two sides of a coin, achieving both must be one of the prime interests of any economic or environmental activity. The economic development of any country or society focuses on achieving a competitive and diversified economy capable of meeting the needs of, and securing a high standard of living for, all its people, in present and future times. On a broader note, environmental development, , ensures harmony among economic growth, social development, and environmental protection. The concept of sustainable development roots back to the early existence of humankind, but the ideology has been given more importance than ever in the current terms considering the ever increasing environmental jeopardizes.

6.2 The Interaction Between Economies and the Environment

Productive economic activities make up an economy›s GDP and display the competency of the nation to the world. Qatar is one of the world's richest economies, the commercial activities that the country witness is numerous. Qatar is a natural hub to hydrocarbon resources and complementary minerals. Because of which, the mining and quarrying activities top the GDP contribution from year to year. According to statistics updated in 2018, Qatar's natural gas reserves are 24.7 Trillion Cubic Meters (TCM), oil reserves stand at 25.2 billion barrels and LNG exports are 76.4 million tons. Other main non-mining and quarrying activities in Qatar include; manufacturing, building and construction, business services, wholesale and retail, agriculture and others. Bearing in mind the significance of value-adding activities, the impact of such activities on our socio-economic, health and environmental dynamics of the economy should also be considered.

National strategies like QNV 2030 warns that overly aggressive economic development could result in many negative risks,ones that might harm the environment. Though economic development and adequacy are vital, the 21st-century economic attributes are analyzed and chosen based on their ability to sustain and transmit positive externalities. In Qatar, national-level strategies are formulated, implemented and enforced to oversee the achievement of sustainability including environmental and resource sustainability while performing economic activities. Articulating strategic plans like Qatar National Vision (QNV) 2030 and supporting it with short term strategy like Qatar National Development Strategy 2011-2016 to ensure the implementation ofprogress, undoubtedly displays how Qatar paves the way of sustainable development and environmental protection. The fourth pillar of QNV 2030, which states that «the management of the environment in a manner where there is harmony between economic growth, social development, and environmental protection» is what it termed as environmental sustainability. The Qatar National Development Strategy 2011-2016 states objectives and action plans to tackle environmental degradation issues in the country. They list a series of Key environmental stress points, which include:

• A rising water table in Doha, which leads to economic stress and escalating the city’s environmental challenges, translated into raising construction costs and increasing the requirements for surface-groundwater drainage infrastructure and threatening the marine environment.

• Fresh groundwater sources depleting and their salinity increasing. T’his environmental issue lead the government in 2007 to issue the ministerial decree No. 20 on “Rationalizing the use of groundwater and preventing its deterioration” that banned the digging of new production wells and banned the use of existing wells in the specific areas under a "Water Protectorate (Salinity <2000 ppm)" from irrigating fodder crops. This was done to prevent the over-extraction. In 2008, the Qatari government set its goals to protect and sustain its natural environment namely the depletion of natural water sources and had included this in its national vision for the year 2030 under the environmental development section.

Consequences of this environmental issue lead to economic stress, translated into threatening the food security of the country. This pushed authorities in charge, including the economic sector, to support the agricultural sector and to look for; agricultural investment opportunities inside the country, encouraging and supporting local farmers, investing in wastewater treatment with the purpose of reuse, and looking for agricultural investments in foreign countries to secure the country's agricultural demand.

• Declining air quality, which in general results from chronically high levels of pollutants mainly chemicals plus dust. Globally, air pollution contributes to high rates of asthma and respiratory illnesses. Therefore, it can cause economic stress on the health sector, and require the sector to provide extra drug doses and more health care expenses. Qatar is paying serious attention to the air pollution issue,as the national environmental law (2002) set rules and limits of air quality parameters to be followed by activities that release emissions to the air e.g. mining & query, manufacturing, and construction.

• Climate change.Being a major energy producer, Qatar's carbon dioxide emissions contribute to greenhouse gases, this environmental stress opened the door for Qatar to start investing in clean energy through Qatar Solar Technologies company (QST), a company launched in 2010. It's a joint venture formed between Qatar Solar (a wholly-owned subsidiary of Qatar Foundation), Solar World AG and Qatar Development Bank. QST has the lofty goal of

diversifying the economy, providing the Middle East with the additional 100 Giga-watts of energy needed by 2020.

• Threats to biodiversity, which have left 171 vulnerable species (170 invertebrates & 1 mammal), 9 endangered species (5 birds, 3 plants & 1 mammal) and 2 extinct species (birds). The Qatari authorities responsible of wildlife, natural reserves, and public parks are investing in major projects for environmental protection related to their sector, these projects reserve the Qatari environment and are considered tourist sites, as discussed in Chapter (1).

Based on the priority of protection, the strategy for improved environmental management involves working towards seven outcomes that have direct interaction with the economy, these are:

• Cleaner water and sustainable use.

• Cleaner air and effective climate change responses.

• Reduced waste, more recycling, and more efficient use.

• Nature and natural heritage conserved, protected and sustainably managed.

- More sustainable urbanization and a healthier living environment.

- An increasingly environmental aware population.

- Improved governance and regional and international cooperation.

Each of the seven primary areas has its action plans on how to protect the environment from the economic harmful impacts.

Moreover, Qatar had the privilege to hold several international meetings that focus on biodiversity and environment sustainability. For instance, In Doha, Qatar, on 8 December 2012, the “Doha Amendment to the Kyoto Protocol” was adopted.

Qatar has come a long way in its environmental protection and sustainability Plans, actions and legal framework. Almost all government authorities and listed companies in the country, that has major contribution to the country’s economy, has improved their contribution to the safety of the environment by adopting self-monitoring mechanisms, applying latest technologies in their sectors (that helps reduce emissions and environmental pollution), research & development, increased awareness campaigns, trainings, and CSR (Corporate Social Responsibility) activities and events. These are done along with the close follow-up and monitoring carried out by the concerned regulators

6.3 Governance and Expenditure for Protecting the Environment

The first stepfor any government, , is the collection of a series of data related to the country's state of the environment (air, water & land). The Department of Monitoring and Environmental Laboratory was structured in the Ministry of Environment in 2014, by the Amiri Decree No. (30) which was issued to form the organizational structure of the Ministry of Environment. The Department is responsible for monitoring the rates and percentages of pollutants in the air, water and soil environment, to ensure that they do not exceed the limits and permitted standards. The Department is also responsible for the preparation and implementation of air, noise, aquatic environment and soil monitoring plans and programs. Moreover, the Department is responsible for identifying sources of air, aquatic and soil pollutants and to determine the priorities to be followed by the competent authorities to control these sources to reduce their emissions and to determine the maximum allowable quantity of pollutants emission.

The Department of Monitoring and Environmental Laboratory prepared two reports of "The Marine Environment in Qatar". The reports described in details the Qatari marine environment. The Department also prepared the "Soil Monitoring Report" that described the soil quality of different locations/areas around Qatar.

Moreover, The Department of Monitoring and Environmental Laboratory established a network of ambient air quality monitoring stations around Qatar (the stations belong to the Ministry). The station's network is connected to the Ministry of Municipality and Environment, and the ambient air quality data are sent automatically and instantly to the Ministry.The stations are regularly inspected and maintained by the Department. The Department uses collected data to prepare regular air quality reports for the state of Qatar.

The Department of Environmental Protection at the Ministry of Municipality and Environment is the authority responsible for monitoring and protecting the land and marine life of the State through the development of plans for protection and implementation, in coordination with the competent authorities. The Department is also responsible for the control of environmental-land violations (e.g. contracted companies violating the environment by using un-adequate facilities, or leaving environmental damages on site after the end of their contract of utilization) . They are transmitted to the competent authorities and remove the causes of these violations by the administrative way in coordination with the competent authorities.

The Inspection and Industrial Pollution Control Department of the Ministry of Municipality and Environment is the authority responsible for the inspection of establishments, businesses and practices,

factories, installations, works and practices involving and dealing with hazardous materials, and to monitor violations related to them. The Department also Issues operating permits for establishments after ensuring that they meet the environmental conditions and requirements Table 6.1 below presents the number (annually) of requests from various entities to obtain an environmental permit (new and renewal) for operation, and the number of issued environmental permits for operation.

Table 6.1 Requests and issued environmental permits for operation (including renewal).		
Year	Received applications	Issued Environmental Permits
2010	621	566
2011	632	571
2012	648	598
2013	663	603
2014	672	617
2015	685	620
2016	700	656
2017	571	485
2018	486	416
2019	339	264

Source: The Inspection and Industrial Pollution Control Department - Ministry of Municipality and Environment.

Other Chapters of this report present more details on conserving the Qatari environment, the Land Chapter discusses the investment in the wildlife conservation through the protected areas & the Oryx breeding, the conservation of the wildlife plants (e.g. Al-Ghaf plant). The Land Chapter also presents the conservation of the sub-urban areas through the urban-forests project. The Sea Chapter discusses the investment in conserving the Qatari marine environment, for example through monitoring whale sharks and biodiversity in the Arabian Gulf at Al-Shaheen oil field. The Energy Chapter & the Waste and Hazardous Materials Management Chapter discuss the investment in keeping the environment clean through establishing modern energy and waste management facilities.

6.4 Economic Activities

There are 17 main economic activities in Qatar - listed in Table 6.2 below, the table also presents the Gross Domestic Product (GDP) by economic activities at current prices for the years 2011 – 2018 (in million QR), while Table 6.3 presents the percentage Of GDP share of each economic activity out of the country's total GDP. The share of mining and quarrying activities (mainly oil and gas) in nominal GDP (at current prices) is 58.8%, 58%, 55.7%, 52.5%, 38.6%, 29.7%, 32.3%, 36.1% in the years 2011 to 2018 respectively, this shows the big contribution of the oil and gas sector to the nation's economic growth. The share of non-mining and quarrying activities adds up to 41.2%, 42%, 44.3%, 47.5%, 61.4%, 70.3%, 67.7%, 63.9% to the GDP (at current prices) in the years 2011 to 2018 respectively. The manufacturing industry is the highest contributor in the non-mining sector followed by wholesale and retail, building and construction, water and electricity, and the agricultural sector has the least share of the country's GDP (Planning and Statistics Authority).

Table 6.2 Estimates of annual Gross Domestic Product (GDP) by economic activities at current prices (in Million QR) for the years 2013 – 2018

	A. Economic Activity	2013	2014	2015	2016	2017	2018
1	Agriculture, forestry and fishing	695	880	950	1016	1129	1222
2	Mining and Quarrying	403.031	394.190	221.041	163.984	195.981	252.397
3	Manufacturing	73820	76133	52489	46814	52785	64189
4	Electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management and remediation activities	2994	3290	3950	5979	616	5809
5	Construction	39305	50031	60693	77079	91089	104900
6	Wholesale and retail trade; repair of motor vehicles and motorcycles	42570	47746	51465	46981	47575	48864
7	Transportation and storage	14817	15967	21657	24927	25778	28219
8	Accommodation and food service activities	5261	6284	6231	5620	5378	5370
9	Information and communication	8136	9124	10109	9810	9615	9707
10	Financial and insurance activities	38741	44047	45320	47019	48977	51969
11	Real Estate	28594	34244	38762	42776	43130	41675
12	Professional, scientific and technical activities;Administrative and support service activities	16251	17309	19531	21080	21656	22095
13	Public administration and defence; compulsory social security	37243	40817	44294	43857	44373	47515
14	Education	9426	10327	10862	12089	13183	14098
15	Human health and social work activities	8669	9813	11397	14.009	13.901	14.826
16	Arts, entertainment and recreation; Other service activities	6916	7694	8119	8466	8.589	9,068
17	Activities of households as em-ployers; undifferentiated goods and services producing activities of households for own use	2720	3225	3473	3817	4006	4172
18	Financial Intermediation Services Indirectly Measured (FISIM)	18973	22773	23404	24153	26405	27948
19	Import duties	3156	2311	1795	1137	720	765
	Gross domestic product (GDP) at market prices	723,369	750,658	588,733	55,2305	607,620	698,914

Source: Planning and Statistics Authority .

Table 6.3 Percentage of GDP for the estimates of annual GDP by economic activities at current prices for the years 2013 – 2018.

	A. Economic Activity	2013	2014	2015	2016	2017	2018
1	Agriculture, forestry and fishing	0.1	0.1	0.2	0.2	0.2	0.2
2	Mining and Quarrying	55.7	52.5	37.5	29.7	32.3	36.9
3	Manufacturing	10.2	10.1	8.9	8.5	8.7	9.2
4	Electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management and remediation activities	0.4	0.4	0.7	1.1	1.0	0.8
5	Construction	5.4	6.7	10.3	14.0	15.0	14.1
6	Wholesale and retail trade; repair of motor vehicles and motorcycles	5.0	6.4	8.7	8.5	7.8	7.0
7	Transportation and storage	2.0	2.1	3.7	4.5	4.2	4.1
8	Accommodation and food service activities	0.7	0.8	1.1	1.0	0.9	0.8
9	Information and communication	1.1	1.2	1.7	1.8	1.6	1.4
10	Financial and insurance activities	5.4	5.9	7.7	8.5	8.1	7.5
11	Real Estate	4.0	4.6	6.6	7.7	7.1	6.2
12	Professional, scientific and technical activities;Administrative and support service activities	2.2	2.3	3.3	3.8	3.6	3.2
13	Public administration and defence; compulsory social security	5.1	5.4	7.5	7.9	7.3	6.8
14	Education	1.3	1.4	1.8	2.2	2.2	2.0
15	Human health and social work activities	1.2	1.3	1.9	2.5	2.3	2.1
16	Arts, entertainment and recreation; Other service activities	1.0	1.0	1.4	1.5	1.4	1.3
17	Activities of households as employers; undifferentiated goods and services producing activities of households for own use	0.4	0.4	0.6	0.7	0.7	0.6
18	Financial Intermediation Services Indirectly Measured (FISIM)	-2.6	-3.0	-4.0	-4.4	-4.4	-4.0
19	Gross domestic product (GDP) at market prices	0.4	0.3	0.3	0.2	0.1	0.1
	Gross domestic product (GDP) at market prices	100.0	100.0	100.0	100.0	100.0	100.0

Source: Planning and Statistics Authority .

Below we will discuss activities of the Economic Sector (17 main Economic Activities) in two groups, the Mining and Quarrying Sector & the Non-Mining and Quarrying Sector (16 Economic Activities).

More details about 6 main non-mining activities will be presented, these are Agriculture, Manufacturing Industry, Electricity and Water, Building and Construction, and Transport and Communications.

6.4.1 Mining & Quarrying Activities

The mining and quarrying sector is the backbone of many economies around the globe. This sector has important economic, environmental, labor and social effects in countries or regions where mining and quarrying activities are carried. For many developing countries mining accounts for a significant proportion of GDP, as well as for the bulk of foreign exchange earnings and foreign investment. (Jennings)

The contribution of the mining and quarrying sector to the Qatar GDP has been humungous ever since the exploration of oil and gas in the Qatari borders.

Mining and quarrying activities in Qatar include extraction of crude petroleum and of natural gas, other mining and quarrying (quarrying of stone, sand, and clay), and mining support service activities (support activities for petroleum and natural gas extraction). In the year 2018, the total number of workers in the Mining and Quarrying sector is 98,992 workers in the different establishments operating in all mining and quarrying activities (116 facilities):

- Crude oil and natural gas extraction (7 facilities),

- Mining support services - quarrying of stone, sand, and clay (21 facilities),

- Other activities of mining and quarrying

- Support activities for petroleum and natural gas extraction (88 facilities).

6.4.2 Non-mining and Quarrying Activities

6.4.2.1 Agriculture

Agriculture is one of the strategic sectors for the role it playsin securing food for the increasing population of the state. Attaining self-sufficiency in food production and supply is crucial for any given nation, considering the sector's contribution to economic growth and human nutrition needs. Unfortunately, the Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) face a combination of hindrances that constrains the local economic agriculture production to meet the food demand of the current and continuing population growth. For instance; water scarcity, declining arable land, poor soils, hyper-arid environment, climate change has a significant negative impact on the development of the agriculture sector in the GCC area (Shahid and Ahmed, 2014).

In the past couple of years, the Qatari Government has undertaken a wide variety of steps to expand the sector by formulating and implementing technical assistance and subsidies to improve the supplies of different agricultural products.. For instance, the area suitable for cultivation in the state is only 5.66% of the country's total area. And about 14% to 18% of this area was brought under cultivation from 2010 through 2015. Now it became 18.1% - 20.3% through 2015 to 2018. Furthermore, food security programs like the Qatar National Food Security Program (QNFSP) which was launched in 2008, concerned with the fulfillment of the principles of the Qatar National Vision 2030 – with regards to the people, community, the economy, and environmental development, has brought vital improvements to the agriculture sector. Likewise, joining hands with international organizations like the Food and Agriculture Organization (FAO) of the United Nations, Qatar has planned policies to Enhance agricultural and fisheries productivity and production of poultry, dairy, and to develop animal production facilities, animal feed milling units, and greenhouses. (FAO publications, 2016).

Table 6.4 below presents the percentages of self-sufficiency of agricultural production in Qatar in the years 2011 to 2018, the presented percentages of self-sufficiency of agricultural production in Qatar shows the big gap between quantities of local agricultural production and required quantities for full sufficiency.

Table 6.4 Percentages of self-sufficiency of agricultural production in Qatar, 2011 - 2018.

Agricultural Production	2011	2012	2013	2014	2015	2016	2017	2018
Cereals	5.78	7.90	10.60	9.12	6.80	6.70	7.00	5.60
Fruits and Dates	13.40	14.10	23.50	15.03	1.30	11.20	13.10	10.68
Vegetables	13.38	12.80	11.20	15.20	14.70	12.30	16.40	14.10
Meat	6.25	6.30	8.50	9.97	8.50	11.90	11.90	15.41
Milk & Milk Products	26.71	24.30	39.10	36.56	33.20	26.80	26.80	67.70
Eggs	19.68	17.20	15.40	13.34	11.60	13.10	13.60	18.90
Fish	34.24	26.90	30.90	34.45	30.50	28.10	31.70	29.80

Source: Planning and Statistics Authority .

This gap in local agricultural production puts more pressure on the governments to find solutions to increase local agricultural production, mainly agriculture harvests, livestock, and fisheries. To encourage local farmers and agricultural producers to increase their products, the Agricultural Affairs Department of the Ministry of Municipality and Environment in cooperation with the Consumer Economy Protection Department of the Ministry of Economy and Trade launched "The Qatar Vegetable Improvement Program". The program aims to market Qatari vegetables in distinctive consumer complexes to ensure increased demand for these products, creating an increasing demand for Qatari products, which encourages producers to invest more in agricultural production and increase their products.

It also aims to increase local production of vegetables on one hand and conserving the country's groundwater sources, on the other hand, the Agricultural Affairs Department in 2016 has distributed 73 greenhouses to several Qatari farms as a grant from the State to spread the modern water-saving technology in the Qatari farms. Moreover, several selected Qatari farms have been rehabilitated to start honeybee production, in 2015 (80) farms were prepared to receive beehives as a grant Phase III of the project, (in Phase I & II of the project, (50) farms were supported and supplied with beehives). Farmers in these farms were trained on beekeeping and on the preparation of dedicated places within these farms to receive hives. The strategic Qatari plan of using all TSE (mainly for fodder production) can cover a big gap in the country's fodder demand. Forecast for TSE that will be produced in the year 2030 is 819,410 m3/day, this can allow 10,170 ha of fodder to be irrigated, if all TSE will be produced by the year 2030 is used for fodder production, however, there will be strong competition between different TSE users. Using TSE will not only support filling the gap in agriculture production but also will help to shift from using groundwater which is already depleted and hence protecting the Qatari groundwater sources and environment (Osman et al., 2016). While increasing the country's production of animal products (meat, milk & milk products, and eggs) and encouraging sheep breeding in local farms, Qatari authorities support livestock farmers through soft loans for the purchase/import of high-quality animals. In 2016, the veterinary clinics (in Al-Jumailiya and Rawdat Al-Faras) were rehabilitated, 9 new clinics and a veterinary hospital were allocated, plus the increasing focus on the artificial insemination to produce an improved breed of cattle.

6.4.2.2 Livestock

In the years, 2015 - 2016 (8) animal production projects in registered farms were awarded new license and renewal of the licenseinclud-ing projects for the production of broiler chickens, eggs, sheep, goats, and milk. After the completion of these projects, it is expected that there will be a production boom, products will reach more than double the current domestic production. To increase the country's self-sufficiency of fishery products, the Ministry of Municipality and Environment, represented by the Department of Fisheries, has given particular attention to fish farming projects as it is considered the most appropriate way to increase the self-sufficiency of fish to pre-serve the fish stocks without increasing its depletion. By the end of December 2016, (92%) of the buildings of Ras Al Kheishat, Water Research Center was completed. The Water Research Center is a research and development project aiming to achieve a high percentage of self-sufficiency through the development of the fish farming industry.

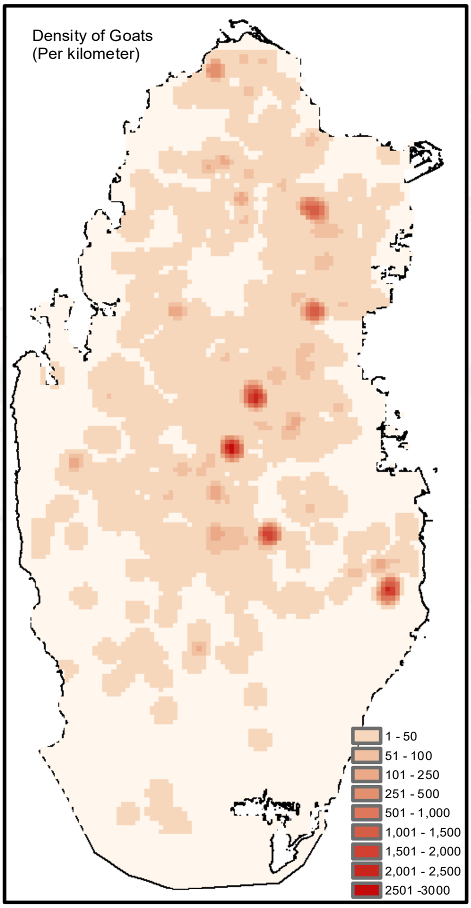
According to 2019 data (MME), number of animals in Qatar, in descending order,are sheep, goats, cattle, camels, horses and others. Sheep is the major animal in Qatar, with more than 63% of total animals. For livestock, its number in descending order is other poultry, broilers, layers and beehives. Table 6.5 shows the number of both animals and livestock and number of farms for each group in Qatar according to Qatar 2015- 2019.

Table 6.5 Number of Livestock 2015 – 2019

	2015		2016		2017		2018		2019	
Live-stock	(Head)	The Ratio %	(Head)	The Ratio %	(Head)	The Ratio %	(Head)	The Ratio %	(Head)	The Ratio %
camels	84825	7.9	91182	7.3	105404	7.3	126378	8.1	131679	7.6
cows	17673	1.7	20138	1.6	24958	1.7	38198	2.4	43700	2.5
goats	320845	30.0	359885	28.6	382504	26.5	409911	26.1	447700	25.9
Sheep	646408	60.4	784985	62.5	932471	64.5	994882	63.4	1102801	63.9
Total	1069751	100.0	1256190	100.0	1445337	100.0	1569369	100.0	172588	100.0
The annual percentage increase of the animal wealth registered in the country										
				17.4		15.1		8.6		10.0

Source: Livestock Department - Ministry of Municipality and Environment

To encourage the private sector to invest in fish farms and shrimp projects, coastal and marine sites have been allocated by responsible authorities, to allow Qatar to achieve a high level of self-sufficiency in fish and shrimp. The establishment of fish and shrimp farms by the private sector would be in coordination with the concerned authorities (Ministry of Municipality and Environment and the Ministry of Economy and Trade) to prevent the exploitation of allocated sites.



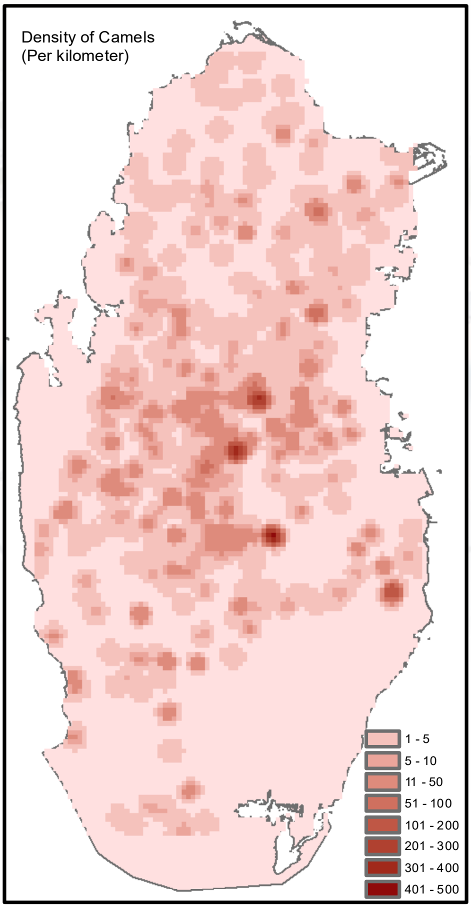


Figure 6.2: Spatial distribution of livestock.

Figure 6.3 Livestock Department – Ministry of Municipality and Environment, veterinary clinic activities.
(Source: Livestock Department - Ministry of Municipality and Environment)

6.4.2.3 Manufacturing Industry

The Manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The major manufacturing in the Qatari industrial sector are the manufacturing of food products, beverages, textiles apparel, leather, and related products, wood & wood products, paper, and paper products, coke and refined petroleum products, chemicals and chemical products, basic pharmaceutical products and pharmaceutical preparations, rubber and plastics products, basic metals, non-metallic mineral products, and fabricated metal products - except machinery and equipment, electrical equipment, motor vehicles, trailers and semi-trailers, furniture plus other manufacturing industries.

In 2017, the number of establishments operating in all of the manufacturing activities in the state were 3,440 facilities, their majority are establishments dedicated to the manufacture of wearing apparel (1,544 facilities), followed by the manufacture of fabricated metal products (594 facilities), and the manufacture of food products (293 facilities). While the least number are establishments used for basic pharmaceutical products and pharmaceutical industry equipment (2 facilities). The total number of employees in this sector in the year 2017 was 123,147 workers.

6.4.2.4 Electricity & Gas, Water & Wastewater

Qatar Electricity and Water Company, and Qatar General Electricity and Water Corporation are the governmental authorities responsible for the generation and distribution of electricity and the production and distribution of water. Activities in this sector include electricity supply, production, and distribution of water, gas, steam and air conditioning.

The increasing number of populationaccompanied by an increased demand for water and electricity has led the concerned authority and the government to create awareness to reduce their usage. Therefore, with the purpose of rationalization of water and electricity consumption, and with the vision of empowering all people in Qatar to make their homes, workplaces and lifestyles reflect a sustainable, efficient and environmentally friendly nation, Qatar Electricity and Water Company (Kahramaa) launched “Tarsheed” the National Campaign for the Conservation and Efficient Use of Water and Electricity in Qatar, under the patronage of His Highness Sheikh Tamim Bin Hamad Al- Thani, the Emir of the State of Qatar (Kahramaa official website, April 2017).

In the year 2017, the total number of facilitiesinvolvedin the activities of electricity, gas, water desalination and supply, steam and air conditioning supply was 7 facilities, and the total number of workers was 4,859. The Public Works Authority “Ashghal” is the governmental authority responsible for governing the design, construction, delivery and maintenance of all major projects including storm and rainwater, wastewater and sewerage drainage and treatment across Qatar. In 2017, the total number of facilities working in Sewerage activities was 10 facilities, and the total number of workers was 691. In 2013 Ashghal invested in the preparation of Qatar Integrated Drainage Master Plan (QIDMP) with the vision that “The Master Plan will be the basis for planning world-class infrastructure to allow sustainable development through balanced management of the water cycle, giving recognition to the high value and scarcity of water in Qatar”. This vision of creating “sustainable urban environments” is the same as the creation of a Water Sensitive City a philosophy of flexibility in supply and use to meet all users’ needs underpins the collection and movement of water. The Master Plan achieves many of the objectives of the Qatar National Vision (QNV 2030) and Qatar National Development Strategy (QNDS) and utilizing a rigorous process, provides strategy which optimizes water reuse, is flexible and is environmentally sustainable (MWH, 2013). To find a long-term wastewater treatment solution to serve the needs of the southern part of Doha (Al Wakra and Messaieed) Ashghalis currently involved in a key program that provides vital drainage infrastructure for the area, it’s the complex project of the “Inner Doha Re-sewerage Implementation Strategy – IDRIS” (2012 – 2019) to upgrade and expand the sewerage infrastructure the south catchment to meet its long-term demands for the next 50 years, and to accommodate the projected population growth of an additional one million people (the official Ashghal’s webpage, http://www.ashghal.gov.qa/en/Projects/pages/default.aspx). Moreover, Ashghal is currently investing in major drainage projects that will have a huge positive impact in the environment, resident’s wellbeing and welfare, and in Qatar’s economy, these are;

- Doha North Sewage Treatment Plant:

Under construction (Feb. 2008 – 3rd Quarter 2017) with a total cost of (3,633,060,000 Q.R.), the sewage plant is planned to serve a projected population of over 900,000 and subsequently extend to serve a population of over 1.2 million people. The treated water will be recycled for irrigation of greater Doha (Ashghal’s, 2017).

- Temporary Package Treatment Plants (PTPs):

Temporary Package Treatment Plants at Various Locations in the state, under construction (2011 – 2020) with a total cost of (294,888,888 Q.R.), this project has a strategic environmentally related intention, and it is the elimination of the disposal of tanker sewage into Karaana lagoon. The project will Provide two package treatment plants that are exclusively designed for tankers reception and for treating the delivered sewage (10,000m3 /day each) to produce TSE suitable for irrigation and agricultural purposes. The plants are located at Al Karaana and Umm Birka (almost 162 km apart) The TSE shall be used to irrigate the green area planned to be planted by HASSAD within the same parcel (Ashghal’s, 2017). 6.4.2.4 Domestic Waste and Hazardous Waste Domestic waste and hazardous waste in the state include ;waste collection, treatment, and disposal activities,in addition to materials recovery and remediation activities and other waste management services.

Based on the Environmental Sustainability Strategy for Qatar National Vision 2030, the targeted recycling project was approved through public-private sector cooperation in the Environment Sector Strategy for the years 2011-2018, which aims to reduce waste, and increase recycling & reuse more efficiently.

Outputs from the project were identified as; preparation of a national solid waste management plan in Qatar aimed at reducing waste production and separating wastes from the source, develop the recycling industry in the private sector and fast-profit recycling. Therefore, Qatar took a practical move and invested nearly 4 billion Q.R. in the construction of the modern Domestic Solid Waste Management Centre (DSWMC, 300 ha, located near Mesaieed) plus 4 transfer stations (4 ha each) located across Qatar, handed to the responsible authority in 2011. DSWMC is designed to treat up to 2,300 tons of mixed domestic solid waste per day, serving the waste treatment needs for the whole of Qatar. The DSWMC comprises state-of-the-art waste sorting and recycling facilities, an engineered landfill, a composting plant, and 1,500 tons per day Waste-to-Energy (WTE) incineration plant. Qatar is currently constructing a new solid waste transfer station in Al-Khor (Waste Treatment Department, Ministry of Municipality and Environment).In 2017, the total number of facilities working in the waste management activities in Qatar was 21 facilities (6 of collection of non-hazardous waste, 2 for the treatment and disposal of hazardous waste, 4 f for the treatment and disposal of non-hazardous waste, and 9 for the materials recovery), moreover, Qatar has 6 facilities for the remediation activities and other waste management services. In 2017, the total number of workers in the waste collection, treatment and disposal activities and materials recovery was 1,457 workers, while the total number of workers in the remediation activities and other waste management services was 378 workers. As for the hazardous waste there are seven facilities (processing centers, (processing centers, factories, and companies) working on hazardous waste management, which will be described in more details in the “Waste Management” Chapter.

Figure 6.5 Package Treatment Plant

6.4.2.5 Building and Construction

Building infrastructure is a crucial criterion for socio-economic development. Construction companies in Doha are incorporating modern technologies including building insulation and going for sustainable and environmentally friendly green buildings. Construction companies in Qatar apply the latest innovative concrete solutions and use sturdy construction chemicals. The industry in Qatar is witnessing a major boost in various activities like infrastructure projects, buildings, hospitals, airports, rail, shopping complexes, roads, and tunnels.

This sector includes 3 main activities, these are a construction of buildings, specialized construction activities, and civil engineering (infrastructure, including roads, bridges, banks, water treatment, and power generation stations, etc ...).

In 2018, the total number of facilities operating in the building and construction sector is 3,479, and the total number of workers was 839,918 workers.

Figure 6.6 The Domestic Solid Waste Management Centre.

Examples of major undergoing building and construction projects in Qatar are Qatar's hospitality facilities (accommodation and foodservices), and Qatar's World-Cup 2022 stadiums. It was estimated that Qatar will receive 4.3 to 5 million visitors in 2022 and estimated to welcome between seven and nine million tourists annually by 2030. This emerges the government to invest 40 to 45 billion dollars under its National Tourism Sector Strategy 2030. The strategy forms a part of Qatar's efforts to increase tourism's contribution towards the GDP over the next decade (The Commercial Bank of Qatar ,2012.). The plan includes working to position the country as a world-class center with cultural roots, by creating an exclusive product that will appeal to all market sectors, from national tourists and families to sports fans and business travelers alike. Doha will see 14 new hospitality properties entering the market in 2017, including Pullman Doha West Bay (468 rooms), JW Marriott West Bay (297 rooms), Hilton Garden Inn Doha Al Sadd (225 rooms) and Millennium Plaza Doha (232 rooms).

Figure 6.7 Major under-going construction project in Qatar – World-cup 2022 stadiums. (Source: Supreme Committee for Delivery & Legacy)

Lusail

Lusail Stadium | Capacity: 80,000 seats | Opening: 2021 | Status: in planning

Al Khor

Al Bayt Stadium | Capacity: 60,000 seats | Opening: 2019 | Status: under construction

Al Wakrah

Al Janoub Stadium | Capacity: 40,000 seats | Opening: 2019 | Status: opened on 16 May 2019 construction

Al Rayyan

Al Rayyan Stadium | Capacity: 40,000 seats | Opening: 2021 | Status: under construction

Doha

Khalifa International Stadium | Capacity: 40,000 seats | Opening: 2017 | Status: opened May 2017

Doha

Qatar Foundation Stadium | Capacity: 40,000 seats | Opening: 2021 | Status: under construction

Doha

Al Thumama Stadium | Capacity: 40,000 seats | Opening: 2022 | Status: under construction

Doha

Ras Abu Aboud Stadium| Capacity: 40,000 seats | Opening: 2022 | Status: under construction.

6.4.2.6 Transport and Communication

In recognition of the significant role of transport and information & communication technology (ICT) in building a robust knowledge-based economy in light of Qatar National Vision 2030, the Ministry of Transport and Communications was established as per "Emiri "Order No. 1 of 2016 to be responsible for communication and transport businesses and to oversee and develop the information and communications technology sector to serve the national development requirements, to ensure that people have access to well-functioning, safe and reasonably priced transport, and communications networks. Transport and ICT are also Fostering a competitive environment that is conducive to investments; implementing and overseeing e-government programs. In 2017, this sector included 592 establishments, and the total number of workers was 72,339. - Doha Metro, Lusail Tram, and the Long-Distance Rail Projects: The latest and most talked-about transport networks projects are the three projects of - Doha Metro, Lusail Tram, and the Long-Distance Rail (which will link Qatar with the GCC Rail Network), the 3 projects are expected to be completed by 2030, and are expected to be the “backbone of the transport network in Qatar. The Doha Metro was planned to serve both the capital and the suburbs through four lines (Red, Gold, Green, and blue), enabling easy reach to all major locations. Once complete, the Doha Metro will reduce congestion and pollution while offering sustainable, attractive and fast public transportation choices for the first time. Most of the Doha Metro lines were designed to be underground, so tunneling plays a major role in construction as presented in Figure 6.8 below (Institute of Civil Engineering (ICE) circulations – MENA Group, Doha - Qatar, 2017).

Phase one of the metro system is now under construction (the construction of three out of the four lines (Red, Gold, and Green) and their stations. These lines are expected to be open to the public by 2020.

The second phase expected to be completed by 2026 and will involve the expansion of the phase one-lines, and the construction of the Blue Line plus other stations.

Figure 6.8 The Doha Metro lines.

Figure 6.9 Doha Metro Gold Line underground – Al Sadd Station and Mined Subway. (Source : ICE circulations – MENA Group, Doha - Qatar, 2017).

- The Expressway Program:

The Expressway Program - by Ashghal (2010 - 2017) - is a nationwide road infrastructure scheme that will improve the way people and places are connected across the city of Doha and all of Qatar, the strategy of the Expressway Program is to develop roads networks that benefit all communities and provide sustainable traffic management solutions that resembles those available in advanced countries. Qatar's entire network of expressways, highways and local roads has been reviewed as part of this program, this will provide national road networks capable of sustaining the future development and expansion of a world-class infrastructure within Qatar. They will also provide vital transportation links across Qatar, connecting key cities, towns, and villages with high-quality national freeways and urban arterial routes. Ashghal (which is responsible for the design, construction, delivery, and maintenance of all expressways and major roads that cater to current and future traffic demands in Qatar) aims to enable greater mobility and shorten travel times and improve public safety on the roads. Construction work began in 2012 on six expressway projects bringing the total number of projects under construction to ten. The Expressway Program contract value of all projects currently under construction is estimated 16 Billion Qatari Riyal.

Figure 6.10 The Expressway Program. (Source: Ashghal's)

6.5 Economic Indicators

6.5.1 Main Economic Indicators of Mining and Quarrying Sector

The gross value added (GVA) of the Mining and quarrying sector for 2017 has been estimated at QR 196.0 Bln, showing an increase of 19.5% over the GVA of the previous year. This increase is attributed to rising international prices for oil and gas in 2017 compared to 2016. Due to the impact of lower international prices for oil and gas products, the Mining and quarrying sector has witnessed a decrease in its contribution to GDP compared to the peak in 2013 (55.7%), representing 32.3% of nominal GDP in 2017. In real terms, Mining remained virtually unchanged (at a Compound Annual Growth Rate (CAGR) equal to 0.03%) mainly due to the moratorium on further gas development from the North Field. (Planning and Statistics Authority).

6.5.2 Main Economic Indicators of Non-mining and Quarrying Sector

The Gross value added (GVA) of the Non-mining and quarrying sector for the year 2017 has been estimated at QR 411.6 Bln, showing an increase of 6.0% over the GVA of 2016. For the period 2013 to 2017, the nominal GVA for the Non-mining and quarrying sector has increased at an annual rate of 6.5%. The share of this sector on nominal GDP increased from 44.3% in 2013 to 67.7% in 2017. (Planning and Statistics Authority).

Within the Non-mining and quarrying group, Construction (15.0% of nominal GDP), Manufacturing (8.7%), Finance and insurance activities (8.1%), Wholesale and retail trade (7.8%), and Public administration services (7.3%) made the largest contribution to nominal GDP in 2017 (Planning and Statistics Authority).

6.6 Investment in Mega Environmental Friendly Projects

6.6.1 Lusail project

The re-designing of the Lusail project has combedcombing more environmental protection criteria into the master plan.

Lusail is a 20 km2 area north of Doha, Qatar, which will be developed into a city with 200,000 inhabitants and catering for commercial, recreational, entertainment and tourism activities. Considering the socio-economic impact of Qatar's future city – the Lucail city, the masterminds behind the plan has redesigned the architecture to be more sustainable and eco-friendlier. The original master plan of the project which had crucial environmental impacts was identified and alerted to minimize the impact on the biodiversity of the locality. The consulting team at COWI along with environmentalists and the designers on the project team approached ten alternative layouts for the shoreline of the Master Plan. The key criteria for the choice of the final alternative were minimization of the negative impact on seagrass, good water quality in coves and channels and good quality beaches.

Figure 6.11 Development of Lusail Master Plan (A: Original illustrative master plan for Lusail development; B: Shoreline of the final master plan for the Lusail development). (Source: COWI, 2016).

The original Lusail Master Plan was considered an illustrative concept only, thus giving the possibility to change it to be in harmony with the marine environment. The initial environmental assessment showed that the plan would have a major negative environmental impact, with the result that has changed completely. The final Master Plan minimized the impact on the environmentally valuable seagrass beds on the tidal flats and included a complete redesign of the channels and lagoons to ensure good water quality (COWI report, 2016).

6.6.2 Jetty Boil-Off Gas Recovery (JBOG) Project

The very prestigious 1 billion US Dollars Jetty Boil-off Gas Recovery (JBOG) Project was inaugurated in Qatar in April 2015. Qatar officially unveiled what it said to be the world's biggest environmental project, a 1 billion $ plant in Ras Laffan was inaugurated by HE the Prime Minister and Interior Minister Sheikh Abdullah bin Nasser bin Khalifa al-Thani in early 2015. The JBOG facility will recover the gas flared during Liquefied Natural Gas ((LNG) which is gas cooled to 160 degrees Celsius until it turns into a liquid and can be transported by boats. loading at the six LNG berths in Ras Laffan Port. Instead of the wasted gas being burnt off, JBOG would collect the fuel and transport it to an area where it is compressed to be ready for use again either as LNG or fuel gas. At the time of the project's implementation, the officials expect that the project would capture enough gas to power 175,000 cars per year or 300,000 homes and save the equivalent of 1.6 million tons of CO2 each year. The project was given more credit due to its massive positive contribution to environmental protection than that of its economic value. "The JBOG project demonstrates the commitment of Qatar to balance industrial development with care for the environment and reinforces our pioneering and leadership role in the energy industry", stated Saad Sherida al-Kaabi, president and CEO of Qatar Petroleum (The Pioneer, 2014).

6.7 Summary

The mining and quarrying activities top the GDP contribution of Qatar State from year to year. According to statistics updated in 2018, Qatar's natural gas reserves are 24.7 Trillion Cubic Meters (TCM), oil reserves stand at 25.2 billion barrels and LNG exports are 76.4 million tons. Other main non-mining and quarrying activities in Qatar include; manufacturing, building and construction, business services, wholesale and retail, agriculture, electricity and water, transport and communications, and others.

The Gross value added (GVA) of the Mining and quarrying sector for the year 2017 has been estimated at QR 196.0 Bln, showing an increase of 19.5% over the GVA of the previous year. This increase is attributed to rising international prices for oil and gas in 2017 compared to 2016. Due to the impact of lower international prices for oil and gas products, the Mining and quarrying sector has witnessed a decrease in its contribution to GDP compared to the peak in 2013 (55.7%), representing 32.3% of nominal GDP in 2017. In real terms, Mining remained virtually unchanged (at a Compound Annual Growth Rate (CAGR) equal to 0.03%) mainly due to the moratorium on further gas development from the North Field. (Planning and Statistics Authority).

On the other hand, The Gross value added (GVA) of the Non-mining and quarrying sector for 2017 has been estimated at QR 411.6 Bln, showing an increase of 6.0% over the GVA of 2016. For the period 2013 to 2017, the nominal GVA for the Non-mining and quarrying sector has increased at an annual rate of 6.5%. The share of this sector on nominal GDP increased from 44.3% in 2013 to 67.7% in 2017. (Planning and Statistics Authority).

Within the Non-mining and quarrying group, Construction (15.0% of nominal GDP), Manufacturing (8.7%), Finance and insurance activities (8.1%), Wholesale and retail trade (7.8%), and Public administration services (7.3%) made the largest contribution to nominal GDP in 2017.

The Jetty Boil-off Gas Recovery (JBOG) Project (1 billion $ of investment), and the re-designing of the Lusail project are examples of mega-investment national projects done for the protection and conservation of the Qatari environment and natural resources. Other investments for the protection and conservation of the Qatari environment and natural resources, and it includes the investment in the wildlife conservation, the conservation of the wildlife plants, the conservation of the sub-urban areas, the investment in conserving the Qatari marine environment, and the investment in keeping the environment clean from generated waste by establishing modern energy and waste management facilities.

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Chapter 7

Waste Management

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Considerable quantities of wastes are produced in Qatar like many other industrialized countries, requiring proper management. Waste is classified into two general types namely, municipal waste and hazardous waste. Municipal waste consists of domestic waste, green waste, food executions, slaughterhouse waste, sludge, solid waste, construction waste, tires and others. There are dedicated services under the control of municipalities responsible for domestic waste collection, deportation and processing. These agencies also work with other stakeholders in management of waste-handling facilities. Municipal waste management facilities are in the form of four stations, a center for waste treatment, and two areas designated for landfill/burying.

The highest sort of waste is the construction waste, accounted for 95% of the total waste generated in the country in the year 2012, this figure dropped down to 50% in the year 2018. The average per capita share of domestic waste amounted to approximately 0.89 kg/day for the period 2012 to 2015 despite the upward trend in consumerism. This amount is in the lower range of waste generation in the Middle East and North Africa according to the world Bank report.

The state of Qatar takes serious measures to deal with hazardous waste, even industries have been instructed to minimize the hazardous waste originating from their operations. While waste recycling is an established practice in Qatar, but for now most of the recycled waste happens to be from raw solid waste and the waste from the construction sector.

Seriousness with which the country takes the management of all sorts of wastes is evident from the number of projects undertaken and those on-going. The objectives of these projects are to enhance the overall environmental quality, improve the aesthetics and protect the environment for the whole society.

7.1 Introduction

Solid waste is classified into two general types, municipal waste and hazardous waste. The Qatari national Law No. 30 on environmental protection of the year 2002 defined the municipal waste as the garbage or waste that is left behind by individuals or groups, residential buildings, or non-residential buildings, such as governmental buildings, buildings of institutions, bodies, companies, factories, commercial and industrial shops, camps, barns, slaughterhouses, markets, clubs, amusement parks, public places and others. The Qatari national Law No. 30 on environmental protection of 2002 also defined the hazardous waste as the remains or ashes of the various activities and processes which preserve properties of hazardous substances, and that have no original or alternative uses, such as clinical waste of therapeutic activities and waste resulting from the manufacturing of pharmaceuticals, drugs, solvents, organic inks or dyes and paints.

7.2 Municipal Waste

There are two governmental administrative authorities responsible for municipal waste management in the Ministry of Municipality and Environment, these are the General Cleanliness Department and the Waste Treatment Department, they are responsible of municipal waste collection, transfer, and processing, and working to oversee and manage the country's waste facilities. Moreover, there are some other non-governmental entities (contracted private companies) working on waste collection and disposal.

7.2.1 Municipal Waste Facilities

The Qatari government, with the objective of environmental and human health protection and improvement, invested in constricting a Domestic Solid Waste Management Centre (DSWMC) located near Mesaieed, in addition to four transfer stations, the capital of the investment reached to nearly 4 billion Qatari Riyals. The 300 ha modern DSWMC is designed to treat up to 2,300 tons of mixed domestic solid waste per day, and commenced operation in 2011. The center receives waste from the four transfer stations; these are West of Doha, South of Doha, Industrial Area, and Dukhan Stations. Additionally, there were two solid waste management facilities in the state, these are Mesaieed Landfill that continues to operate until now, and Um-Al Afai Landfill which is currently closed and not receiving any new waste since 2013, it is now only managing the treatment and disposal of old received tires.

There are also two waste dumpsites in the state to receive Construction & Demolition (C&D) waste, these are Rawdat-Rashid (which is the only dumpsite that receives old & used tires), and Um-Thenaitain which is newly opened In June 2016, and was designated to receive C&D waste only since Um-Al Afai landfill was closed.
Private companies at Rawdat-Rashid are recycling C&D waste, whilst it is used as a daily cover material at Mesaieed landfill. Table 7.1 and Figure 7.1 below present waste management facilities in the state.

Table 7.1: Waste Management facilities in the state.

No.	Waste transfer stations	Waste treatment centres	Landfills	Dumpsites
1.	Doha West Station.	Domestic Solid Waste Management Center (DSWMC)	Mesaieed landfill	Rawdat- Rashid
2.	Doha South Station.	-	Um-Al Afai*	Um-Thenaitain
3.	Industrial Area Station.	-	-	-
4.	Dukhan Station	-	-	-
5.	Al-Khor Station (under construction).	-	-	-

Closed in 2013, now only managing the treatment and disposal of old received tires.
(Source: Ministry of Municipality and Environment - Waste Treatment Department).

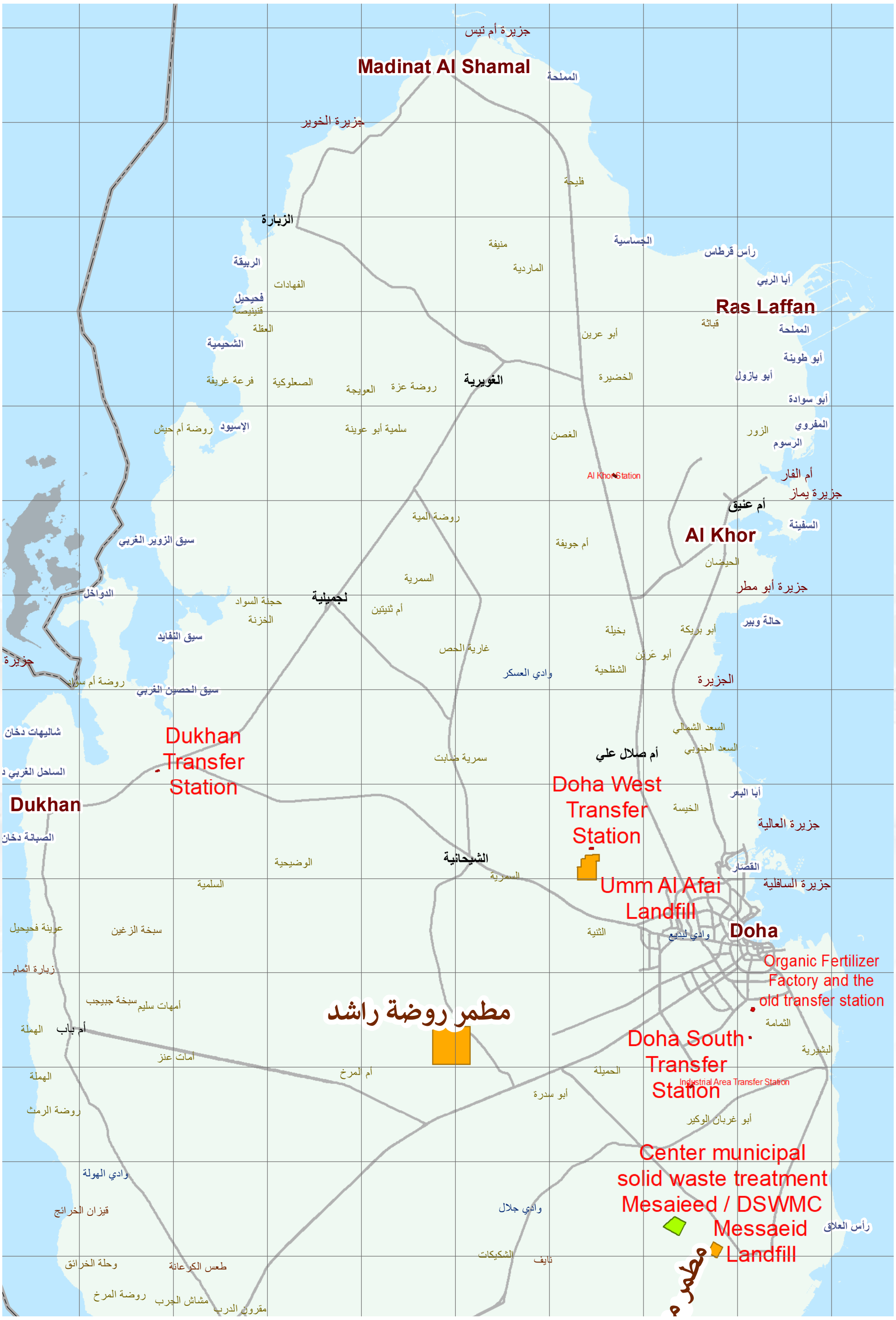

Figure 7.1: location of waste facilities in Qatar map

There is an on-going project with the objective of establishing a new Transfer Station near Al-Khor city, with a capacity of 1,500 ton/day and an automatic waste sorting capability. The new transfer station will be the first automatic waste sorting station in Qatar, the transfer station is meant to cater for the northern districts of Qatar. The different types of collected solid waste generated in the state (domestic waste, green waste, food executions, slaughterhouses' waste, sludge, solid waste, Construction & Demolition (C&D) waste, tires and others) are then sent to the waste management facilities (DSWMC, Dumpsites & Landfill). These facilities are managed by the Waste Treatment Department. Statistics show (as presented in Tables 7.2 a-c below) that the majority of the solid waste in Qatar is the construction waste, accounting for 95% to 50% of the total waste generated in the country in the years 2012 to 2018.

Table 7.2a: Solid waste received at DSWMC sorted by waste type, in Tone/Year (2012 - 2018).

Type of solid waste	2012	2013	2014	2015	2016	2017	2018
Domestic waste	502,219	591,456	619,189	631,226	618,155	664,597	639,714
Slaughter Waste	3,506	3,324	3,347	3,211	2,112	2,186	2,082
Green waste	5,630	7,127	7,007	6,257	8,509	7,098	6,929
Bulk waste	6,130	0	0	0	0	0	0
Others*	677	443	18	0	3.3	26	2,311
Total	518,162	602,350	629,561	622,695	628,779	673,907	651,036

Other waste received in DSWMC includes perishable goods & confidential documents

Table 7.2b: Solid waste received at other WTD facilities (landfill & dumpsite) sorted by waste type, in Tone/Year (2012 - 2018).							
Type of waste	2012	2013	2014	2015	2016	2017	2018
Domestic waste	0	0	0	482,640	537,313	536,050	664,959
Construction & Demolition Waste	9706,885	9354,487	7056,350	4276,414	4644,286	4092,111	3006,287
Bulk waste	0	0	0	2048,954	2333,567	2661,504	2198,780
Tires waste	25.994	26.544	31,605	36,297	37,823	37,186	39,406
Others*	104	5,183	4,380	202,046	53,383	42,115	37,379
Slaughter	0	0	0	5,321	6,492	8,915	9,386
Expired Food	0	0	0	10,103	6,433	13,854	10,241
Sludge	0	0	0	138,772	146,713	107,028	53,430
Wood	0	2,183	4,129	49,340	46,798	37,503	29,638
Plastic	0	0	187	958	783	393	179
Glass	0	0	0	1,672	36,340	36,460	7287
Scrap	104	3,000	0	221	1,134	188	112
Carton	0	0	64	980	1,034	384	162
Total	9732,983	9386,214	7092,335	7046,351	7852,099	7573,691	6057,246
Other waste received in Landfill & dumpsites includes glass, wood, slaughter, scrap, cartoon, plastic, sludge, expired food.							

Table 7.2c: Total solid waste received at WTD facilities (landfill & dumpsites & DSWMC) sorted by waste type, in Tone/Year (2012 - 2018).							
	2012	2013	2014	2015	2016	2017	2018
Domestic waste	502,219	591,456	619,189	1095,866	537,313	536,050	664,959
Construction & Demolition Waste	9706,885	9354,487	7056,350	4276,414	4644,286	4092,111	3006,287
Bulk waste	0	0	0	2048,954	2333,567	2661,504	2198,780
Tires waste	25.994	26.544	31,605	36,297	37,823	37,186	39,406
Animal waste	3,506	3,324	3,347	3,235	12,518	11,425	41,790
Green waste	5,630	7,127	7,007	6,257	1,109	14	240
Others	781	5,626	4,398	202,046	53,383	42,115	37,379
Total	10245,015	9988,564	7721,896	7669,069	7619,999	7380,405	5988,841
Other waste received in Landfill & dumpsites includes glass, wood, slaughter, scrap, cartoon, plastic, sludge, expired food.							

Table 7.2d: Percentages of the different types of solid waste received in WTD facilities (landfill & dumpsites & DSWMC) sorted by waste type, in Tone/Year (2012 - 2018).							
Total waste	2012	2013	2014	2015	2016	2017	2018
Domestic waste	4.9 %	5.9 %	8 %	14 %	7 %	7 %	11 %
Construction & Demolition Waste	95 %	94 %	91 %	56 %	61 %	55 %	50 %
Bulk waste	0.00 %	0 %	0 %	27 %	31 %	36 %	37 %
Tires waste	0.25 %	0.27 %	0.41 %	0.47 %	0.50 %	0.5 %	0.7 %
Animal waste	0.03 %	0.03 %	0.04 %	0.04 %	0. %	0.15 %	0.70 %
Green waste	0.05 %	0.07 %	0.09 %	0.08 %	0.01 %	0.0002 %	0.004 %
Others	0.01 %	0.06 %	0.06 %	3 %	0.7 %	0.57 %	0.6 %

7.2.2 Functions Performed by the State's Waste Facilities

There are 3 facilities that handle waste management in the state, these are:

- Waste transfer stations: Waste collected at the state level is sent to the transfer station, where waste is compressed and sent in special trailers of 25 tons capacity to DSWMC.

- Treatment centre (Domestic Solid Waste Management Centre (DSWMC)): Where collected waste is received and sorted, compost/organic fertilizer is produced from green waste and organic types of waste, slaughterhouses waste is incinerated with other non-recyclable waste to produce energy. Figure 7.2 below presents the waste management processes in the centre.

- Landfill and dumpsites: where all kinds of wastes are received including; solid waste, construction waste, tires and other. Non-recyclable waste is dumped, while recyclable waste (wood, cardboard, glass, plastic, steel scrap) are put up in local market for sale through bidding for companies operating in the area. The used tires and C&D waste are contracted through bidding for local companies to be handled and recycled.

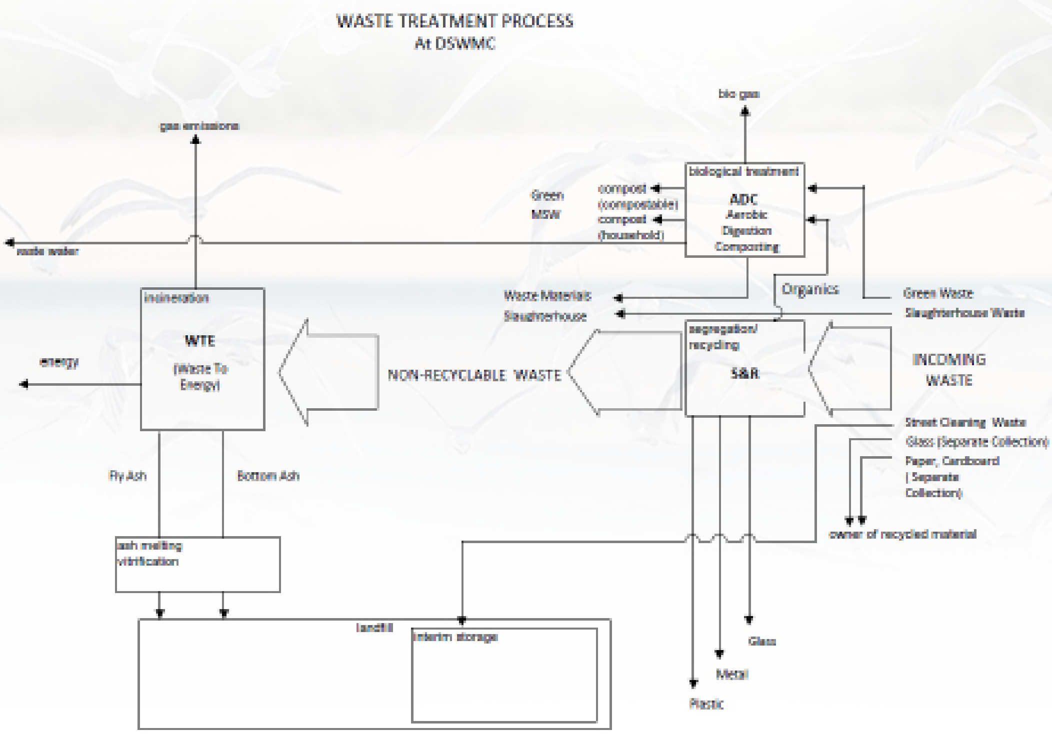

Figure 7.2: Waste management processes in DSWMC.
Source: Ministry of Municipality and Environment - Waste Treatment Department.

Figure 7.3 below present the waste cycle system in the state, the cycle is divided into 3 sections; source of waste, collection and transportation of waste and waste management.

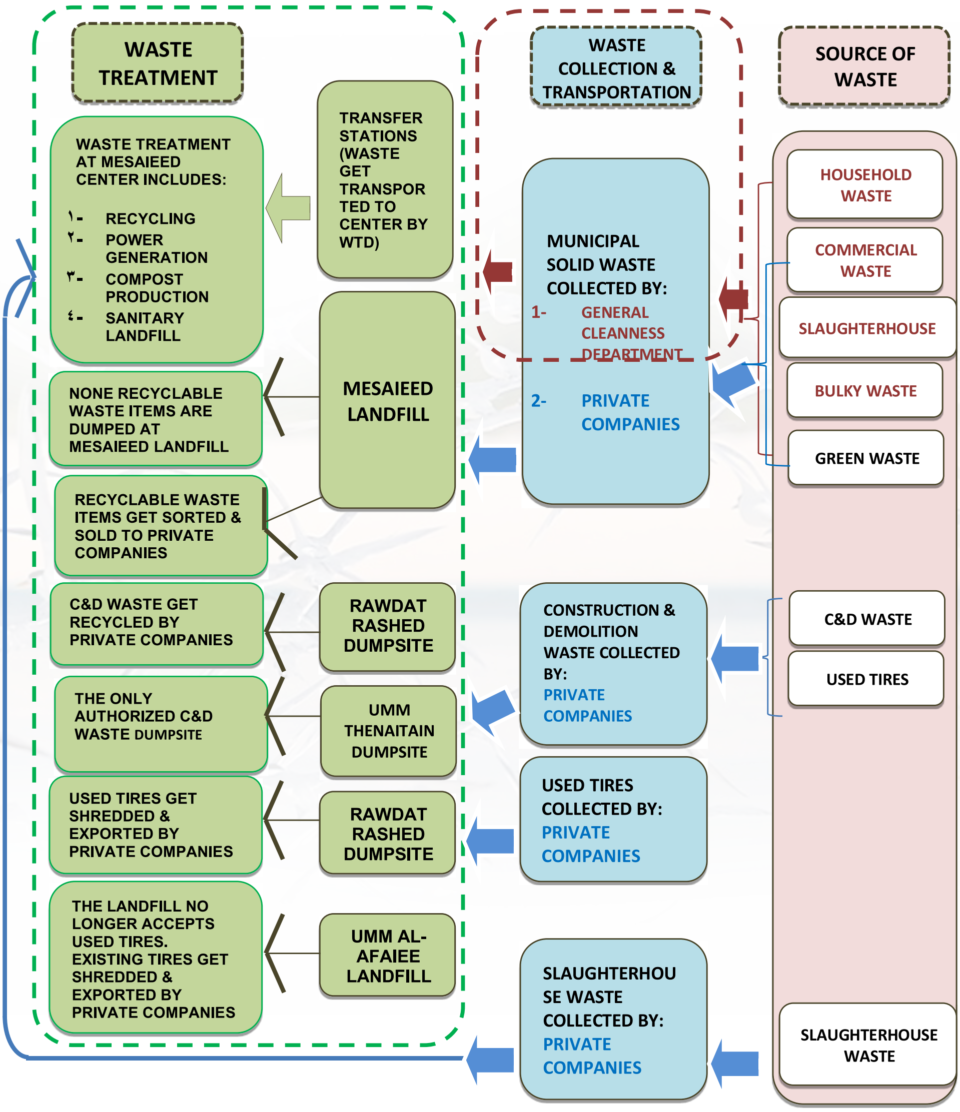

Figure 7.3: The waste cycle systemSource: Ministry of Municipality and Environment - Waste Treatment Department.

7.2.3 General Indicator for the Solid Waste Generation in the State

The per capita share of household waste in the state is in continuous increase since 2012 till 2018 as presented in Table 7.3 & Figure 7.4 below, where the per capita share was ranging from 0.75 to 1.46 kg/day.

According to the World Bank report of 2010, the global Municipal Solid Waste Generation (MME) levels was approximately 1.3 kg/capital/day and are expected to increase approximately to 1.42 kg/capital/day in the year 2025. The report stated that in the Middle East and North African countries the per capita waste generation was ranging between 0.16 to 5.7 kg/capital/day, this information indicates that waste generation in Qatar State falls in the lower end of the range of waste generation stated by the World Bank.

Table 7.3: The per capita share of household waste.

Domestic waste, population & per capita share	2012	2013	2014	2015	2016	2017	2018
Domestic waste (ton/year)	502,219	591,456	619,189	1,095,866	1,155,468	1,200,647	1,304,673
Daily household waste in kilograms.	1,372,182	1,620,428	1,696,410	3,002,374	3,165,000	3,289,000	3,574,000
Number of Population mid-year	1,832,903	2,003,700	2,216,180	2,437,790	2,520,620	2,614,625	2,662,844
نصيب الفرد من النفايات المنزلية بالكيلوغرام في اليوم	0.75	0.81	0.77	1.23	1.29	1.34	1.46

Figure 7.2: Waste management processes in DSWMC.
Source: Ministry of Municipality and Environment - Waste Treatment Department.

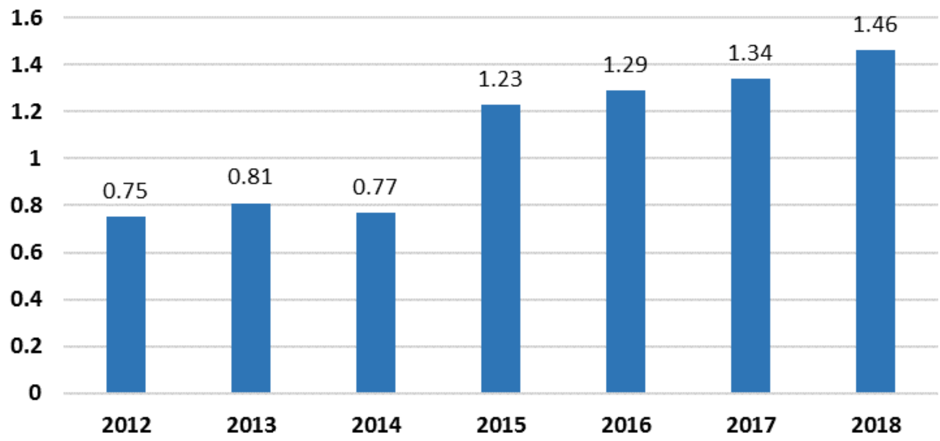

Figure 7.4: Per capita share of household waste (kg/day).

7.2.4 Recycled Waste

DSWMC is the first centre of its kind that a Singaporean company has delivered in the Middle East, which applies in practice the latest ideas on sustainable development, and waste as-a resource, through an integrated waste management concept and the combination of several technologies in one place, operations include ; pre-processing, mechanical and organic recycling and power-generating technologies. This offers synergy, which would be unattainable if each technology was employed individually.

DSWMC receives five types of waste; these are domestic waste, animal waste, green waste bulk waste and others (perishable goods, confidential documents). A key feature of DSWMC integrated waste management system is the pre-processing of waste received, where materials suited for processes (such as recycling and energy recovery through Waste to Energy (WTE) technology are separated and transferred to their respective processing lines. This allows each process to achieve the highest performance and obtain the maximum value out of each waste fraction (Ministry of Municipality and Environment - Waste Treatment Department).

DSWMC has an Incinerator Bottom Ash (IBA) Treatment Plant, where received waste -after screening and sorting- is incinerated in order to standardize the material and remove contaminants, this process results in generating electricity that is utilized within DSWMC (small quantity of the electricity is exported outside the DSWMC). This shows that through proper management domestic waste can be considered as a resource. The IBA treatment plant is equipped with magnetic separators that separate ferrous metals from the IBA which are sent for screening and sieving and recycling afterwards. DSWMC also has an Aerobic Composting Hall, where the organic fraction is further decomposed by aerobic microorganism, active composting generates heat and releases carbon dioxide and water vapor into the air, thereby reducing the volume and mass of the final product. Other waste (wood, glass, plastic, crap) that is reliable for recycling after screening is put up in bidding for companies operating in the area.

As for the other two types of waste (C&D waste and tires); there are currently 4 companies working in recycling C&D waste in Rawdat-Rashid, and 6 companies working in recycling tires, 4 of them in Rawdat- Rashid dumpsite and 2 in Um-Al Afai landfill. A number of proposals were prepared by companies willing to invest in recycling C&D waste, the proposals are currently under evaluation and assessment by the responsible authorities. Also there is a proposal for contracting one of the factories based in Qatar that is willing to invest largely in tires recycling by importing large production capacity machineries in order to carry out the task of getting rid of all used tires in Um-Al Afai landfill within two years (Ministry of Municipality and Environment - Waste Treatment Department).

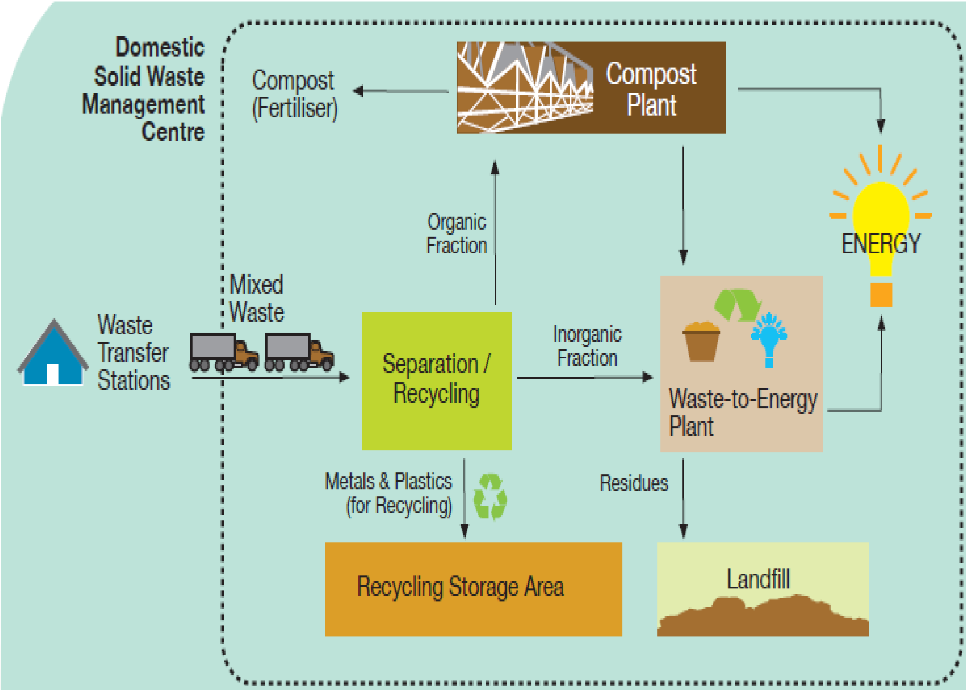

Figure 7.5 Steps of waste management in the Domestic Solid Waste Management Centre. (Source: Keppel Seghers Engineering, 2015)

7.3 Hazardous Waste

The Radiation and Chemicals Protection Department in the Ministry of Municipality and Environment is the governmental administration that is in charge of the management of hazardous waste, chemical materials. The management is through treatment, recycling and disposal facilities, and in cooperation and coordination with other parties.

The Qatari national Law No. 30 on environmental protection of the year 2002, defined the hazardous waste as the remains or ashes of the various activities and processes which preserve properties of hazardous substances, and that have no original or alternative uses, such as clinical waste of therapeutic activities and waste resulting from the manufacturing of pharmaceuticals, drugs, solvents, organic inks or dyes and paints.

Executive regulations of the Law No. 30 of the year 2002 divided hazardous waste (based on materials that contain any of hazardous characteristics listed in Annex 6/7 of the Convention) into categories, through the issue of the decree No. (4) of the year 2005, those categories are:

- Categories of waste to be monitored (Annex (4/7)).

- Categories of waste that requires special considerations (Annex (5/7)).

7.3.1 Hazardous Waste Management

7.3.1.1 Guidelines for the Disposal of Hazardous Waste

Based on the provisions of Articles No. (22-41) of the fourth chapter of Law No. 30, 2002, entitled waste and hazardous materials to the Legislative Decree No. 30 on protection of the environment of the year 2002 and the regulations and directives issued under this Act, the responsible administration has developed necessary procedures for the disposal of hazardous waste at the level of the State of Qatar (inside & out-side the the country disposal). Figure 7.6 below presents those procedures in steps.

Figure 7.6: Procedures to be adhered-to by the waste generator or by the person responsible (through a contract) of the waste disposal.

The competent authority submits a written request to get rid of waste showing (waste type and quantity).

The competent authority (hazardous waste licensing section)

Disposed inside the state:

The person who provide a request should fill a form for waste disposal, the filled form should meet the following points:

• Data about the generator of the hazardous waste.

• Data about the generated waste and specifications of the storage place.

• Data about the carrier and specifications of the vehicle and the transport.

In certain cases, it is required to take a sample of the waste to be disposed of for laboratory analysis.

The competent administrative authority is then match presented form, with accompanying documents.

Studying the application from environmental aspects:

• Ensure the generator has a establishment license.

• Ensure that the carrier authority has a vehicle license.

After auditing the application is then sent for inspection:

• Ensure the nature and quantity of the waste and the data submitted.

• Ensure the packaging safety and specifications were compatible in accordance with environmental specifications.

• Ensure the specifications of the vehicle and transport.

• After inspection is satisfied a report of inspection is then written and sent for administrative authorities that provide licenses.

• Ensure that the entity has a record of hazardous waste.

The administrative authorities that provide licenses is then issue a license for disposal routed to the proper disposal facility according to the waste type.

Disposed outside the state:

All data should be provided in Arabic or English or any language requested by the import or transit countries. If the foreign facilities accept receiving the waste, then it's a must to get the approval of the competent environmental authorities in the country of import, and the communication letter should include all the requirements for packaging, labeling and transportation and should define access point.

After the approval from the countries of import and transit a form should be filled for notification for shipping or transporting hazardous waste across borders as set out in Annex No. 2/10 of the regulation, as well traffic authorities should be notified.

The notification provider should submit the transportation insurance that the carrier assures. The transporting company undertakes the grant for packaging and putting approved labels in accordance with the provisions of international standards. The carrier undertakes the provision of copies of the disposal and insurance data to cover any emergency incidents. The carrier undertakes the provision of six copies of data that should be available in the shipment or transportation across the border document that set out in Annex 7/9 data.

The notification is then submitted to the competent administrative authorities in the Ministry of Municipality and Environment, then after obtaining the approval the waste will be shipped. Upon arrival to the State of import, all copies of the transportation document will be signed by the disposer who then return two signed copies of them to the carrier.

The carrier retains a copy and provide a second copy to the generator and the disposer keeps four copies. After completion of the disposal process, the generator provides a copy of the transportation document to the competent authorities in the state (State of export) to prove the completion of transport. The disposer in the importing countries after the signing and the adoption of the four copies is then send two copies to the competent authorities in the country of export (for the generator and the authorities competent for licensing).

7.3.1.2 Hazardous Waste Facilities

There are seven facilities in Qatar (processing centres, factories and companies) working on the hazardous waste management in the state, these are described in the Table 7.4 below, they are working on managing different types of hazardous waste. Some of the hazardous waste are treated, others are burned, while others are recycled (some of the recycled hazardous waste are used oils and acidic-lead batteries). The majority of waste that is not burned or recycledis used for landfills, while the remaining waste that is not burned is either neutralized or packed and installed. The industrial, oil and mining facilities have their own facilities that handle their hazardous waste.

7.3.2 Hazardous Waste Management Laws and International Conventions

National and international lows and conventions governing waste management in Qatar are:

- The national Law No. 30 on environmental protection of the year 2002.

- Rotterdam Convention on the Prior Informed Consent Procedure for chemicals, pesticides and hazardous materials, September 1998 and entered into force on 24 February 2004 .

- Stockholm Convention on Persistent (non-changeable) Organic Pollutants signed in 2001 and entered into force on May 2004 .

- Basel Convention on the Control of trans-boundary transportation of Hazardous Wastes and their disposal adopted Based on the decree number 15 for the year 1996 .

- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987

- Manama mercury convention, 19 January 2013 and adopted on 10 October 2013.

7.4 Recommendations

• Development and modernization a legal framework that organizes and monitors waste affairs of all kinds.

• Implementing a national cooperation program with waste-related international organizations to transfer waste-related expertise and technology.

7.5 Summary

The General Cleanliness Department and the Waste Treatment Department in the Ministry of Municipality and Environment are the authorities responsible of managing municipal waste in the state. Municipal waste management facilities in the state four stations to transport the waste, a center for domestic solid waste management

DSWMC, one landfill, and two dumpsites. Types of municipal waste generated in the state are domestic waste, green waste, food executions, animal's slaughterhouses' waste, sludge, solid waste, construction waste, tires and others. The highest sort of waste is the Construction & Demolition waste, accounted for 95% of the total waste generated in the country in the year 2012, this figure dropped down to 56% in the year 2015. Per capita share of domestic waste in the state has increased slightly from 0.75 kg/day in the year 2012 to 1.23 kg/day in the year 2015, where average per capita share for the period 2012 to 2015 estimated to be 0.89 kg/day .

DSWMC incinerates non-recyclable materials resulting the generation of electricity that is utilized within DSWMC (small quantity of the electricity is exported outside the DSWMC), this shows that under the wide guidance of a proper management, domestic waste can be recycled and considered as a resource. DSWMC also has the ability to decompose organic waste by aerobic microorganism producing fertile sludge. Other waste (wood, glass, plastic, crap) that is reliable for recycling after screening is put up in bidding for companies operating in the area. There are currently 4 companies working in recycling Construction & Demolition waste in Rawdat - Rashid, and 6 companies working in recycling tires, 4 of them in Rawdat- Rashid dumpsite and 2 in Um-Al Afai landfill. A number of proposals were prepared by companies willing to invest in recycling construction & demolition waste, are currently under evaluation and assessment by the responsible authorities. In addition, there is a proposal for contracting one of the factories based in Qatar that is willing to invest largely in tires recycling by importing large production capacity machineries in order to carry out the task of getting rid of all used tires in Um-Al Afai landfill within two years (Ministry of Municipality and Environment - Waste Treatment Department). The Radiation and Chemicals Protection Department in the Ministry of Municipality and Environment is the authority responsible for managing hazardous waste, chemical materials. The responsible administration has developed necessary procedures for the disposal of hazardous waste at the level of the State of Qatar (inside & out-side the country disposal). There are seven facilities in Qatar (processing centres, factories and companies) working on managing different types of hazardous waste . Some of the hazardous waste are treated, burned while others are recycled. The majority of the waste that is not burned or recycled are landfilled, while the remaining are neutralized or packed and installed.

7.6 Referances

- Governmental reports and data sheets (2014), Planning and Statistics Authority reports, Doha, Qatar.

- Governmental reports and data sheets (2016), Radiation and Chemicals Protection Department, Ministry of Municipality and Environment, Doha, Qatar.

- Governmental reports and data sheets (2016), Waste Treatment Department, Ministry of Municipality and Environment, Doha, Qatar.

- Keppel Seghers Engineering (2015)., Domestic Solid Waste Management Centre at a glance, Doha Qatar.

- World Bank urban development series (2013), waste generation, The World Bank publications.

Chapter 8
Sustainable Development

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Sustainable Development

The chapter on sustainable development presents policy-relevant perspectives on sustainable development in line with the contents and spirit of Qatar National Vision 2030. The chapter emphasizes that sustainable development is a ‘continuing journey’, and there is a need for developing and sustaining momentum towards exploring all the possible approaches that may be helpful in: a) examining the science-policy interface and, b) strengthening the integration of inter-linkages related to sustainable development goals, and c) identifying and addressing emerging issues. Contents of this chapter explain the importance of understanding the challenges and pathways to sustainable development as enshrined under the Qatar National Vision, namely its environmental, social, economic and human dimensions. The country’s blueprint for sustainable development will help in making progress in achieving all the 17 Sustainable Development Goals (2015-2030) suggested by the United Nations.

Considering the fact that climate change poses a significant threat to sustainable development, this issue has been discussed in detail with special reference to options that are available for adaptations under the unique conditions in Qatar. Discussions on this topic builds on our Ministry’s 2015 report on ‘Intended Nationally Determined Contributions’. Successive National Development Strategies covering the timeframes: 2011-2016 and 2018-2022 give due weightage to environmental sustainability in our activities. While the core concepts and frameworks for sustainability have been outlined in concerned chapters, it is important to mention that the sustainability transition in Qatar has permeated even the construction sector. This is evident from inception of Qatar Green Building Council (QGBC) and inclusion of green designs under Qatar Construction Specifications (QCS) 2014. Inherent in the green designs are elements for energy efficiency, reduction in use of natural resources, waste reduction and recycling, and other means of minimizing environmental degradation while promoting the quality of social environment and economizing mitigation measures. The main components of Qatar's environmental management approach that will augur well for sustainable development include boosting resilience of natural ecosystems, improving environmental quality, enhancing resource efficiency, investing in socio-economic development and knowledge empowerment of the society.

8.1 Introduction

The State of Qatar is developing rapidly. This continuous growth and the associated urban and industrial developments it entails, generates an increasing pressure on the nation›s natural resources, creating major environmental stresses. Therefore, managing Qatar's environment is immensely challenging. To ensure that the development of Qatar is truly sustainable, Qatar National Vision 2030 (QNV) has laid out several guidelines to secure major environmental policy improvements in key areas.

In permanent constitution of the State of Qatar, environment was given notable attention. It is stated that in Article 33: "The State shall preserve the environment and its natural balance in order to achieve comprehensive and sustainable development for all generations."

8.2 Key Elements of Sustainable Development Aligned with QNV 2030

Sustainable development is defined as in the Brundtland Report of 1987 as "the development that meets the requirements of the present generation without compromising or endangering the ability of the future generations to meet their needs" (Brundtland, 1987). Sustainable development depends on three interrelated pillars that are Environmental protection, Social integrity, as well as Economic growth, which all play an important factor in sustainability. However, as an act to create a balance between the present and future interests and needs through the three aspects of sustainability, the State of Qatar has developed QNV 2030 to embody that purpose.

QNV 2030 establishes a substantive framework for achieving sustainable development. It underlines, inter alia, the importance of environment management such that there is harmony between economic growth, social development and environmental protection, in a national setting characterized by many critical challenges. These include exceptionally rapid economic and population growth, coupled with fundamental social changes that are affecting all aspects of Qatar's environment.

The four pillars of QNV 2030 are shown in Figure 8.1. However, with the aim of achieving a state of prosperity and flourishing in economic and social integrity as well as environmental protection, an establishment of purposeful development and plans was necessary.

Qatar's National Vision Rests on Four Pillars

Human Development
Development of all its people 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.

Figure (8-1): The Four Pillars of Qatar National Vision 2030.
(Source: Emiri Resolution No. (44) of 2008 approving the comprehensive vision for development, Qatar National Vision 2030)

Economic Growth, Social Development and Environmental Management

Economic development and protection of the environment are two demands neither of which should be sacrificed for the sake of the other. Development patterns can, and often do, have negative effects on the natural environment. Environmental degradation can be reduced through investment in advanced technologies and the adoption of sustainable engineering practices which are designed to minimize the damage caused by projects which contribute to the growth of the economy. Coordinating population growth, expected and other sustainable development strategies is also necessary to minimize impact on the environment and resource consumption. Even with Qatar's best efforts, it is impossible to entirely avoid harming the environment, given a development pattern 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. The country must also commit to making its future path of development compatible with the requirements of protecting and conserving the environment. As the population rises, the demand for resources will increase accordingly, especially those related to energy, water and food. Therefore, it is necessary to manage these three resources and to consider 'nexus'? that presents itself between the resources (i.e. the inter-dependency between resources).

QNV 2030 Foresees a Balance Between Development

needs and protecting the environment. Environmental degradation can be reduced through investment in advanced technologies designed to minimize the damage caused by economic projects, by avoiding rapid and unplanned growth, and by changing behavioral patterns.

The Fourth Pillar – Environmental Development

The State of Qatar seeks to preserve and protect its unique environment and nature granted by God. Therefore, development will be carried out with responsibility and respect, balancing the needs of economic growth and social development whilst maintaining the integrity of the environment.

Considering the QNV 2030, the environmental pillar will be increasingly important as Qatar is forced to deal with local environmental issues, such as the impact of diminishing groundwater resources, and the effects of pollution and environmental degradation. Furthermore, global environmental challenges which will have an impact on Qatar also need to be considered in development planning. This includes the potential impact from climate change and global warming on water levels and quality in Qatar and thereby on coastal urban development and on water utilization as a whole. Furthermore, the rising temperatures will not only result in increased demand for cooling but also contribute to desertification within the State of Qatar. Therefore, in order to ensure national resilience, it is necessary to assess the severity of risks and prioritize national vulnerabilities. This will require the mobilization of capacities and coordinating efforts between all concerned entities.

The QNV 2030 seeks to maintain a balance between development needs and protecting the environment including air, land, water and biological diversity, through:

- Improved environmental awareness: an environmentally aware population that values the preservation of the natural heritage of Qatar as well as the corresponding regional and global environment;
- Sustainable urban development: a comprehensive urban development plan for Qatar that focuses on sustainable urban expansion for a growing population;
- Responsible industries: economic development that is compatible with the requirements of protecting and conserving the environment
- Robust legal system: a comprehensive and fair legal system that protects all elements of the environment, responding quickly to challenges as they arise
- Effective institutions: effective and responsive environmental institutions that build and strengthen public awareness about environmental protection, and which encourage the use of environmentally sound technologies, tools and methods;
- Regional cooperation: encourage regional cooperation to put in place preventive measures to mitigate negative environmental externalities such as pollution and climate change; and

- International leadership: a proactive and significant international role in assessing the impact of climate change and mitigating its negative impacts, particularly on countries in the Gulf

QNV 2030 provides the foundation for the formulation of a National Strategy. The Strategy will help the nation to realize the Vision by setting and prioritizing concrete development goals with time-bound targets. It will also articulate the necessary processes, stakeholder roles, and the expected performance standards which are needed to deliver on the Vision

8.3 National Strategies

The QNV 2030 established a framework of aspiration, calling for programs and projects that ensure sustainable prosperity for future generations. After launching QNV 2030 in October 2008, the government led an extensive process of stakeholder consultations, studies and analyses that culminated in the first National Development Strategy 2011– 2016 (NDS) and the second National Development Strategy 2018-2022. The Strategy identified specific actions and outcomes to overcome challenges and advance QNV 2030 goals.

The NDS provides an integrated, medium-term framework for policy formulation, as well as determined national and sectorial goals. It also identified the broad means for achieving these goals, including monitoring, evaluation and learning mechanisms to measure progress and improves outcomes. Qatar's National Development Strategy 2011–2016:

- Identifies the most critical development goals and challenges.

- Outlines strategic initiatives aligned to QNV 2030 goals.

- Provides strategic coherence for national development planning and budgeting, moving from ad-hoc development projects to forward looking, outcome-based planning.

The first National Development Strategy 2011–2016 was prepared to set a path towards achieving the goal of sustainable development. The NDS developed through a combination of top-down and bottom-up approaches (Figure 8.2). The determination of national priorities was guided by the QNV 2030's long-term development goals and desired end-state. It is also based on the baselines and intermediate targets identified in sectorial strategies.

The government led an extensive process of stakeholder consultations and analyses that resulted in the formulation of 14 sector strategies, one of which was Qatar's Environmental Sector Strategy (ESS) 2011-2016, which set out programs and projects that formed a part of the National Development Strategy (NDS) implemented between 2011-2016.

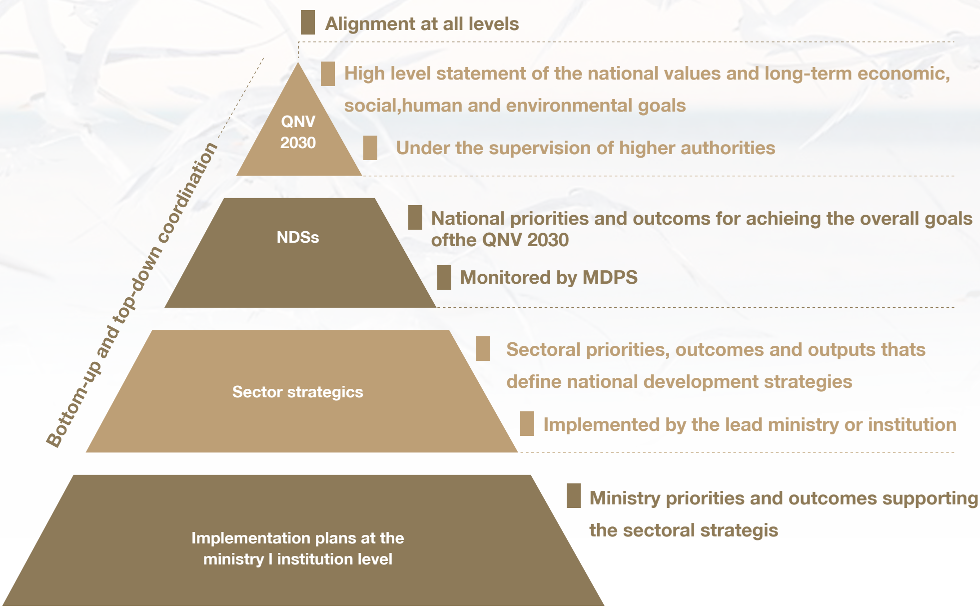

Figure 8.2 NDS developed through a combination of top-down and bottom-up approaches.

8.3.1 Environmental Sector Strategy 2011-2016 (ESS)

The Environmental Sector Strategy, 2011-2016 (ESS) defines the environmental priorities that have been integrated into the NDS. It presents the key environmental outcomes that the country intends to achieve by 2016 based on a rigorous analysis of the current state of the environment and a careful consideration of emerging challenges. It also recommends a set of high-priority projects that should be implemented throughout its duration.

The ESS identified seven key outcomes for the environmental sector for the period beginning 2011 till 2016, which are supported by a series of outputs, with baselines and targets to 2016. A Task Team led by the Ministry of Environment (currently Ministry of Municipality and Environment), identified the priority sector initiatives required to contribute towards those 7 inter-related development outcomes. Achievement of these outcomes will ensure a balance between development needs and protecting the environment. The 7 environmental outcomes are:

(1) cleaner water and sustainable usage;

(2) cleaner air and effective climate change responses;

(3) reduced waste, more recycling and efficient reuse;

(4) nature and natural heritage conserved, protected and sustainably managed;

(5) more sustainable urbanization and a healthier living environment;

(6) an increasingly environmentally aware population; and

(7) improved governance and regional and international cooperation.

Initially, 11 projects were identified in the ESS to achieve the seven outcomes. Two projects out of outcome three; reduced waste, more recycling and efficient reuse were combined, raising total number of projects to 10. A list of projects classified according to the seven outcomes, together with their expected outputs and related targets, is given in (Table 8.1). Thus, in effect the projects serve to operationalize the related goals and objectives of QNV 2030's environmental development pillar.

The 7 sector outcomes and 10 projects are presented within a framework encompassing 4 thematic areas for supporting Qatar's environmental management:

(1) preserving and protecting the environment, represented in air, land, water and biological diversity ;

(2) a comprehensive urban development plan for Qatar that adopts a sustainable policy with regards to urban expansion and population distribution;

(3) supporting international efforts and playing a significant regional role in climate change adaptation and mitigation, and

(4) encouraging regional cooperation to mitigate negative environmental impacts from development.

The ESS also reiterates and takes into account Qatar's international commitments through signing of 13 major Multilateral Environmental Agreements (MEA), including the Ramsar Convention on Wetlands (1971); World Heritage Convention (1972); Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973); Convention on the Conservation of Migratory Species of Wild Animals (1979); UN Convention on the Law of the Sea (1982); Vienna Convention (1985) and Montreal Protocol (1987); Basel Convention (1989); Convention on Biological Diversity (1992); UN Convention on Climate Change (1992); UN Convention to Combat Desertification (1994); Kyoto Protocol (1997); Rotterdam Convention (1998); and the Stockholm Convention on Persistent Organic Pollutants (2001).

QNV Goal: A Balance between Development Needs and Protecting the Environment

NDS Outcome 1: Cleaner water and sustainable use

P1.1 National water act

P1.2 Urban water table management plans

T_1: Support the development of an integrated water management system by consolidating all regulations into a National Water Act and filling gaps in the legal framework.

T_2: To mitigate the negative impacts of a rising water table on the urban population and Qatar's environment, and to consider reuse of the water for improved water security

I_1: Per capita household water consumption (cubic meter)

NDS Outcome 2: Cleaner air and effective climate change responses

P2.1 Improve air quality management

P2.2 Reduction of gas flaring and venting

T_3: Eliminate instances of excess ozone levels through improved air quality management.

I_2: Air quality – ambient concentration of air pollutants in urban areas: (i) carbon monoxide, (ii) nitrogen dioxide, (iii) sulfur dioxide, (iv) ozone and (v) particulate matter

I_3: Estimated number of deaths of children under 5, Qatari, from exposure to outdoor airborne particulate matter and ground-level ozone per 100,000 children under 5

T_4: Halve gas flaring to 0.0115 billion cubic meters per million tons of energy produced from the 2008 level of 0.0230 billion cubic meters per million tons of energy produced.

I_4: CO2 emissions in million metric tons

I_5: Gas Flaring in bcm/million metric tons of energy production

NDS Outcome 3: Reduced waste, more recycling and more efficient use

P3.1 Establishing a solid waste management plan

T_5: Establish a solid waste management plan, strongly emphasizing recycling.

I_6: Waste by type: Municipal domestic and non-domestic (million metric tons)

T_6: Recycle 38% of solid waste, up from the current 8%.

I_7: Volume of recycled municipal waste (%)

T_7: Contain domestic waste generation at 1.6 kilograms per capita per day.

I_8: Municipal domestic household waste generated, kgs/capita/day

NDS Outcome 4: Nature and natural heritage conserved, protected and sustainably managed

P4.1 Creating a national biodiversity database

T_8: Expand and actively manage 30% of total land and sea area as protected areas

I_9: Area of selected key ecosystems protected as a percentage of total area (land and marine) (%)

I_{10}: Abundance and change in threat status of selected key species

I_{11}: Quality of coastal waters in Qatar: (i) salinity (psu), (ii) temperature, (iii) dissolved oxygen, (iv) biochemical oxygen demand and (v) chemical oxygen demand.

T_9: Establish a comprehensive electronic biodiversity database

NDS Outcome 5: More sustainable urbanization and a healthier living environment

P5.1 Functional green spaces

T_{10}: Establish three shady greenspace corridors in Doha and monitor their effect on urban air quality and health.

NDS Outcome 6: An increasingly environmentally aware population

P6.1 Environmental awareness

T_{11}: Build an environmentally aware society.

T_{12}: Appoint a well know national champion for the environment to raise awareness and commitment through demonstration projects and conservation partnerships.

NDS Outcome 7: Improved governance and regional and international cooperation

P7.1 Environmental information database

P7.2 Strategic partnerships

T_{13}: Create a searchable electronic information source at the Ministry of Environment

T_{14}: Lead one regional environment effort, and launch two environmental projects involving private sector participation

I_{12}: Qatar's official development assistance (% of GDP)

The results chain methodology (Figure 8.3) shows NDS 2011-2016 being employed in each project with outcomes and outputs. It illustrates how activities undertaken by implementing agencies are expected to meet NDS outcomes and contribute to the goals of QNV 2030.

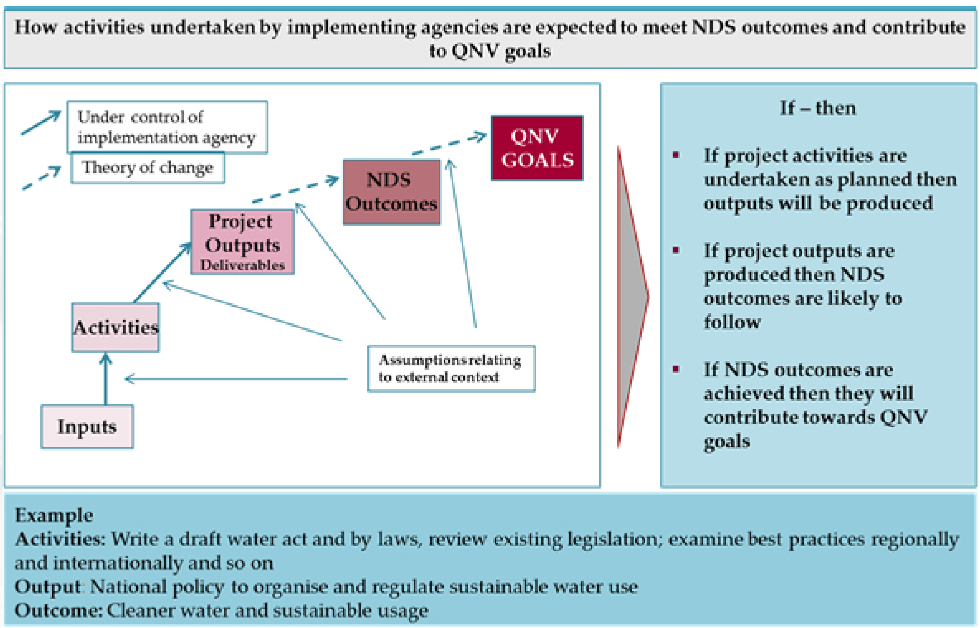

Figure 8.3 Results chain of NDS 2011-2016 (Source: NDS 2011-2016, 2010)

8.3.2 ESS 2011-2016 Outcomes

In the following, outcomes from the ESS are presented as were given in the main ESS report, prepared by General Secretariat for Development Planning (GSDP) in 2010. Mid Term review was carried out for ESS and for whole NDS in 2014.

8.3.2.1 Integrated Water Management: Working with the Water of Life

Among Qatar's environmental challenges, the most pressing is the need to effectively manage water. Qatar's annual rainfall is only 75 mm. Yet per capita water consumption is amongst the highest in the world, at an average of 310 liters per person per day – two times the average for western European countries. Almost all this quantity is produced from seawater using the process of desalination, at considerable cost to the economy and the environment.

Effective water management is currently limited by a fragmented governance framework that makes it difficult to manage uncertainty related to scarce water resources. Regulations are scattered across individual by-laws of the Environmental Act of 2002, contained within the operating permits of individual companies, embedded in the established, often long-term, contracts mainly between Kahramaa and Independent Power and Water Producers. The ESS proposed National Water Act would bring together and synthesize these scattered regulations. The Act will set manageable standards for quality and distribution, control contamination and wastage and assist the Government to increase water security.

This will help move Qatar towards an integrated water management system and ensure that it enjoys ample safe drinking water in the future.

Significant quantities of Qatar's desalinated water leaks into Doha's water table every year. A large volume of that water is subsequently pumped out to sea, with potentially detrimental impacts on marine life. This however still leaves a significant amount of this leaked water to accumulate in the water table.

This rising water table has direct effects on urban life. In Abu Hammour the water table is high enough to flood basements and septic tanks. The flooding of septic tanks spills the sewage out of the tanks into residential neighborhoods, posing serious health risks. In much of the city, building foundations filled with water from the water table, forming pools of water containing construction pollutants and low levels of untreated human sewage. These pools attract mosquitoes, rodents and other pests that potentially harbor disease. Managing these issues increases the costs of construction, as developers must pump water from their foundations before building can take place. The saturation of the ground also causes roads and other infrastructure to settle unevenly.

The ESS foresees that the net inflow to the water table will be reduced, after which the ground water should reach equilibrium. On the short term, it is proposed that this will be achieved by increasing the pumping of the water table into the sea. This pumping will be in accordance with new standards set to minimize this discharge's effect on marine life. On the long term, it is proposed that Qatar will use this water to help meet its growing water demands through innovative use strategies. These include:

- Treatment of groundwater for distribution through the treated sewage effluent network

- Irrigation of specific plant species which will naturally filter contaminants and transpire large quantities of water

- Distribution to the depleted groundwater aquifer beyond the city limits

- Distribution of managed wetland habitats as an important contribution to Qatar's biodiversity conservation and tourism programs.

8.3.2.2 Climate Change and Pollution: A Cleaner Carbon Economy

The oil and gas industry underpin Qatar's current financial prosperity, and its role deserves special attention. This is a highly technological driven global industry which lies at the heart of concerns about climate change, transportation, packaging and pollution. Effective management of air pollution in Qatar is essential for the protection of human health, specifically the prevention of heart and lung diseases. Effective air quality management requires best practice regulations of air pollution, as well as a diligent ambient air quality management framework. The ESS proposes:

- A rigorous study of the effects of air pollution on human health in Qatar
- Integrating Qatar's air quality monitoring stations
- Developing a predictive modeling tool to provide warning of poor air quality days
- Regional cooperation for air quality management led by Qatar.

Reducing the energy intensity of electricity consumption also plays a central part in the ESS's proposed public awareness campaigns, from both the supply-side and the demand-side. On the supply-side, plant capacity will be optimized across the system allowing for the seasonal shut down of one or more plants. On the demand-side, the introduction of a number of new incentives and awareness campaigns will encourage consumers to reduce their demand. When combined, these initiatives will reduce generation levels by 7% by 2016.

Reducing greenhouse gas (GHG) emissions in the energy industry will require cooperation between the industry and the government. An estimated 12 percent of Qatar's current GHG emissions are caused by flaring as a part of energy production. Despite the significant improvements that have been achieved in recent years this is still an unacceptable level. The ESS calls for further substantial reductions in flaring and venting. Success here will benefit the local and global environment, whilst also making more efficient use of the nation's most economically significant non-renewable resource.

8.3.2.3 An Effective Waste Management Strategy: Waste not, want Not

Globally, affluent societies tend to produce large quantities of waste. Qatar is no exception, and the current situation is made worse because almost everything consumed is imported. The ESS's waste reduction initiatives targets the over-all quantity of domestic waste generated to stabilize at the 2009 level of 1.6kg per capita per day through to 2016. Given the rate of industrial development, the extent of new construction, and increasing affluence, this is an ambitious yet achievable target.

At present, there is very little waste separation, reuse or recycling. In 2009 only 8 percent of Qatar's waste was re-used or recycled. By 2016 the ESS foresees that an impressive 38 per cent will be recycled, and a further 9 percent will be burned to generate electricity. Introducing a comprehensive Solid Waste Management Plan as proposed in the ESS will entail :

- Launching the Domestic Solid Waste Management Center (DSWMC) in Mesaieed by late 2011, which will reduce the share of domestic waste sent to the landfill from 91 percent to 3 percent,

- Introducing source separation for domestic and non-domestic waste,

- Building a Material Recovery Facility (MRF) to receive pre-separated recyclables, increasing the percentage of waste recycled to 38 percent,

- Beginning the construction of a Non-Domestic Solid Waste Management Center (NDSWMC), which when complete will reduce the share of non-domestic waste sent to the landfill to only 3 percent,

- Enhancing hazardous waste management, in part by building the capacity to treat combustible substances. The implementation of this plan will make Qatar a regional leader in waste management.

The ESS also focuses on building the capacity of local recyclers. Increased separation at source will be achieved in part by helping key industries to deal with their own waste products. For example, the catering and hospitality industries are well placed to tackle food waste, whilst construction and demolition companies need to take the lead in the active management of waste building materials, while retailers need to set much higher industry standards for waste packaging. There is also a need to establish new markets for recycled materials, such as compost, waste wood and car tires, and this will offer opportunities for new environmental businesses and social enterprises

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8.3.2.4 Qatar's Biodiversity: Natural heritage – a national asset

The central component of Qatar's natural heritage is its Biodiversity. Biodiversity is the natural life support system needed for the land and sea to remain healthy and capable of adding value to Qatar. Biodiversity is essential to national identity and culture, and nature conservation is viewed as a moral duty. The National Biodiversity Strategy and Action Plan states, "conservation of the natural environment is an imperative commanded by Allah." Robust ecosystems help sustain food security, offer tourism and recreation benefits and provide grounds for scientific and medical research.

Biodiversity in Qatar is facing threats posed by a range of human activities. Exceptionally high population growth is putting pressure on the country's natural ecosystem, crowding out biodiversity; coastal, infrastructure and industrial development, and the associated land use changes, are releasing pollutants into fragile ecosystems and damaging habitats. Overexploitation, such as overfishing, is threatening food security and affecting the food chain. International shipping and trade have resulted in the introduction of invasive species that are harmful to the survival of indigenous species. Climate change will increasingly drive biodiversity loss. At least 31 species are known to be threatened with extinction.

Responses to threats to Qatar's biodiversity are limited by a lack of understanding of what species exist in the country and their current population levels. Estimates of the number of species represented range widely, from ~400 (International Union for Conservation of Nature) to ~3000 (Qatar Statistical Authority). As a first step towards improved biodiversity protection, the ESS proposes the building of a Comprehensive Biodiversity Database. By 2016, Qatar will be the first country in the GCC to have catalogued and shared biodiversity information from this region to the world's biodiversity researchers Qatar should seize the opportunity for regional leadership and facilitate the improvement of its own understanding and protection of Biodiversity.

8.3.2.5 Urban Environmental Quality: Improved livability

One of the benefits of successful sustainable development is that it should make life less stressful and healthier. Given the dramatic rate of urban growth in Doha, and in the country's other urban settlements, much of the urban landscape lacks greenery and coherence with its surroundings. There is little incentive to make journeys on foot and in Qatar's relatively hostile climate ,the lack of natural protection makes the use of outdoor spaces unappealing by contrast, where there is substantial greenery the atmosphere is more pleasant, even in the height of summer. Big trees and climbing vines cool and purify the air by filtering pollution and a dominance of large shade trees can cool and calm the city, help to moderate the heat, island effect and benefit public health and wellbeing.

The ESS proposes that Qatar will establish a continuous network of shady and sheltered green corridors around and between Qatar's built developments. People will be more likely to make more short journeys on foot or by bike, especially in the climatically more moderate winter months. A network of living landscapes will help to make people more aware of the changing seasons and it will bring the sweet sounds of birds much closer to where people live and work.

There are also health benefits to be gained by making Qatar's urban environment greener, shadier and more enjoyable to use.

8.3.2.6 Environmental Awareness-Raising: Reaching more people, more of the time

Successful environmental management will need active engagement. Large commercial corporations and public policy makers have vital roles to play. And so, does every individual. Personal lifestyle choices are as critical as investment decisions and policy options. The governmentdeclared commitment to environmental sustainability needs to be communicated with clarity and conviction to each stakeholder.

The environmental message should be as positive as possible. The ESS's awareness strategy is an opportunity to highlight Qatar's established strengths as well as its considerable challenges. Practical suggestions are offered for awareness-raising programs in schools and colleges, as well as involving the mass media and the country's marketing professionals. It recommends targeting of sections of the economy, such as construction and catering, where practical projects in the public sightcan help to raise awareness

Qatar is in need of high-profile environmental leadership. The exceptional influence that Her Highness Sheikha Mozah is having in the parallel fields of health, education, science and technology, at home and abroad, is an indication of this. Qatar needs an environmental champion of high-level status, someone with the ability to speak with authorities and to emphasize the importance of environmental sustainability for the country and the nation. Wise lifestyle choices hold the key to long term sustainability, and opinion formers can play a vital role in stimulating and supporting the necessary culture change. Business leaders, politicians and academics need to show that they are taking the issues seriously, whilst popular figures from the world of sport and entertainment can serve as inspiring role models, especially to young people. Qatar's teachers and parents also have particularly important roles to play.

The QNV 2030 underlined the importance of environmental sustainability, and the ESS establishes a plan to bring sustainability to daily life. Popular awareness of environmental issues will support the achievement of broader goals.

8.3.2.7 Capacity Building in the Ministry of Environment (MoE): Spirit of Partnership

The exceptional scale and pace of change in the country is placing great demands on the administration and the existing environmental control systems. The MoE has demanding responsibilities and, despite investment in training and the progress that is being made, there is a need to strengthen the ministry's capacity. There is a shortage of professionals, particularly with scientific qualifications, and at present it is proving difficult to administer the basic environmental controls and to monitor the environmental impact on Qatar's burgeoning economy. The MoE needs to be fully capable of leading on the QNV 2030's commitment to a secure and sustainable long-term future for the nation.

The ESS calls for the deployment of additional technical specialists to provide guidance and to supervise and secure the prescribed standards of development, resource management and environmental protection. The MoE also needs skills in breadth as well as depth. Managerial leadership must have the ability to make creative connections between departments and to deliver "joined-up government." There is a need to encourage active interdepartmental dialogue and to develop creative relationships on environmental issues with all parts of Government. Sound and sustainable environmental programs and policies will have a direct bearing on the work of professionals in other ministries and, by the same token, the work of other ministries will impact the environment. The ESS calls for inter-ministerial exchanges, inter-sectorial secondment and joint environmental initiatives, as ways in which the MoE can strengthen its capacity to become a more outward reaching organization.

Equally important is the need for the MoE to work with non-government partners if it is to deliver cost effective and sustainable outcomes. The Ministry needs to set standards and to monitor results. But the process of environmental management, the use of resources and the responsibility for success on the ground will largely depend on the performance of others. The ESS proposes that the MoE fosters a culture of partnerships with stakeholders, including companies and partners in the corporate sector, as well as non-government agencies such as UNESCO and the World Health Organization, community led interest groups, such as the Qatar Bird Club and the Qatar Natural History Group, and the country's mass media.

There is also a need for the MoE to have easy access to bespoke academic research and objective environmental monitoring. Sponsorship of a Chair of Sustainable Development is one possible means of securing and strengthening this facility. The hosting of a national environmental think tank is another way of capturing the best ideas from all sectors, of commissioning research, and of overseeing the delivery of best practices. The ESS proposes to support a number of Qatar Scholars each year and to prepare them for environmental leadership.

The ESS also outlined key implementation considerations, which include:

- Indicative resource requirements for each sector outcome, including estimates of the human and financial resources required;

- Management arrangements for implementing the ESS, including an assessment of institutional readiness and capacities; and

- Monitoring and evaluation tools for measuring progress and evaluating outcomes of the ESS.

8.3.2.8 Beneficial Outcomes

Qatar's ESS will deliver several positive outcomes. First, it will improve the environmental performance of the country in many practical ways. It will lead to much more efficient management of the country's waste stream, increase the wise use of water and energy and lower Qatar's collective carbon footprint. Second, it will raise public awareness of the need to take environmental sustainability more seriously, and it will encourage all sectors of the community to take appropriate action. Third, it will strengthen the country's reputation as a nation which is seriously committed to creating a knowledge-based economy, to facilitating innovative environmental problem-solving and to investing in sustainable solutions that will benefit future generations. Finally, it will make Qatar a healthier, more comfortable and more inspiring place to live and work. Sustainable development undoubtedly brings benefit the Earth, and can improve the quality of life for people, presently and for future generations.

8.3.3. Progress Towards the ESS

The Second National Development Strategy 2018-2022 (NDS-2) carried out a review of the outcomes of the first ESS which is origanted from the text of the NDS-2. The progress made towards the main outcomes and targets of the NDS-1 was reviewed and evaluated, particularly with the significant demographic increase and high demand for energy, water, food and infrastructure components, especially the major infrastructure projects of the FIFA World Cup, which greatly influenced the progress towards environmental conservation. This is in addition to the impact of the restructuring of ministries and stakeholders of the environmental sector,

Notably the merger of the Ministry of Municipality and Urban Planning and the Ministry of Environment into the Ministry of Municipality and Environment (MME), by virtue of Emiri Decree No. 4 of 2016. The pillars of the previous ESS (2011-2016) differ from those of the current ESS 2018-2022 that does not include the water sector since the water functions have been moved to the Ministry of Energy and Industry and the common aspects and pillars will be further highlighted. The ESS of the NDS-1 was developed under the rubric of preserving the environment for the future generations and it contained 6 sector outcomes and 12 specific targets (excluding the water sector outcome and targets). Two targets were achieved, while the others are still in progress with some being updated. Some of the programs and projects under the targets of the plan were implemented. The main NDS-1 sector outcomes and achievements are being developed.

8.3.3.1. Sector outcome 1: Clean air and effective climate change responses

The outcome has two targets: (1) Eliminate instances of excess ozone levels through improved air quality management; and (2) halving gas flaring from 0.0230 to 0.007billion cubic meters per million tons of energy produced.

The first target was not achieved as the number of days in which ozone safe levels were exceeded. However, some activities of the project of this target were implemented. Had not these activities and projects been implemented, the situation would have been worse. These activities include an advanced air quality monitoring, reporting and verification program that helped provide some necessary data; updating regulations and standards on air quality and implementation mechanisms to reduce pollution and increase compliance with environmental regulations; implementing the Tarsheed Program, which has succeeded in reducing harmful carbon emissions by about 5 million tons since its launch in April 2012, due to the reduction in per capita consumption of electricity and water. Through the Ministry of Energy and Industry, represented by Kahramaa and Tarsheed, the Green Car initiative was launched to transform 4% of transport vehicles into electric vehicles by 2022 reaching 10% by 2030. A regional air quality convention was launched through the GCC Green Initiative, in addition to a number of projects to reduce flaring during industrialization and extraction of oil and gas, some of which were completed, while others are still in progress.

The second target was achieved with gas flaring reduced from 0.023 billion cubic meters per million tons of energy produced in 2008 to 0.007 billion cubic meters per million tons in 2012. Qatar has also pledged that the FIFA 2022 World Cup will be carbon neutral.

8.3.3.2. Sector Outcome 2: Reduced waste, more recycling and more efficient use

This outcome contains three targets: 1) Establishing a solid waste management plan, strongly emphasizing recycling; 2) Recycling 38% of solid waste, up from the current 8%; and 3) Containing domestic waste generation at 1.6 kilograms per capita per day.

The first two targets were not achieved because they were too ambitious, so they have been adjusted in the NDS-2. The third target was achieved as the State managed to contain domestic waste generation at 1.3 kg per capita per day, which is better than the specified target. Some projects and activities in support of this outcome were implemented, such as the opening of a Domestic Solid Waste Management Center in Mesaieed and 4 waste transport stations in October 2011, the launch of a tire recycling project in Umm Al Afai in 2012, with a recycling rate of more than 60%, the adoption of a number of construction specifications that include recycled materials, and the development and issuance of national instructions on the management of medical.

8.3.3.3. Sector outcome 3: Nature and natural heritage conserved, protected, and sustainably managed

The third outcome contains two main targets: 1) Establishing a comprehensive electronic biodiversity database; and 2) Expanding actively managed protected areas. This means the management of programs for the conservation, preservation and sustainable use of natural resources and biodiversity. The two targets have not yet been achieved owing to a lack of human and financial resources for implementation.

Although the above two targets were not met, some activities of the project of the first target were implemented, in addition to many programs and projects that helped preserve nature and biodiversity, mainly: 1) A study on the biodiversity of wild birds through the Qatar Birds Project at the Friends of the Environment Center: the study detected 322 species of birds with an increase of 33% compared to the number recorded in the 4th National Report on the implementation of the Convention on Biodiversity. 2) A project on the biodiversity of lizards by the MME and Qatar Foundation (QF) (2012-2013): It detected 21 species of lizards compared with 15 species previously registered. The study registeredthe presence of two new types of lizards found for the first time in Qatar. 3) An MME project to enumerate and characterize the genetic resources of domestic animals: Over the period of 2013-2016, camels were enumerated and characterized. Sheep, goats and other species are being enumerated and characterized. 4) A pioneering and successful program for the breeding and resettlement of endangered animals in captivity, especially the Arabian oryx, goitered gazelle, ostrich and Houbara (MME). 5) Qatari Wildlife Rehabilitation Project was launched by the MME so as to; preserve the vegetation cover, rehabilitate natural areas (Rawdat) and cultivate wild life areas with localized plants, given the high degradation and loss of habitats affecting wild life in general and Rawdat in particular. 6) An MME inputs and 473 plant inputs. 7) A project to establish a Field Genetic Bank at the MME Rawdet al-Faras Research Station with the aim of conserving important, rare and endangered local species: Some trees and bushes were conserved, including Sacsaoul (Haloxylon), Acacia ehrenbergiana, Acacia tortilis, Lycium barbarum, Atriplex, Ziziphus spina-christi, Prosopis, Acacia nilotica, etc.

8.3.3.4. Sector outcome 4: More sustainable urbanization and a healthier living environment

The target of this outcome; namely, “Establishing three shady green space corridors in Doha and monitoring their effect on health and air quality in urban areas” was not materialized. However, numerous relevant projects, activities and programs were implemented in this regard through the increase of parks and green spaces, such as the establishment of 40 integrated parks all over the country during the period of 2010-2016, raising the number of parks to 87 compared to only 48 in 2010. Also, some 37,000 Ziziphus (sidr) trees and local plants were cultivated in various municipalities during the period of 2012-2016 and work is ongoing in this regard.

QF plays a major role in sustainability in the region and strives to make Qatar environment friendly. In 2012, the Qatar National Convention Center was awarded the Golden Certification in Leadership in Energy and Environmental Design (LEED) by the US Green Building Council. In 2013, QF's Student Accommodation Complex was awarded a Platinum LEED in the new buildings category, and it now has the highest percentage of buildings holding platinum LEED registered independently in the world. QF's Strategic Plan 2013-2023 focuses on ensuring an advanced position and a secure and sustainable infrastructure.

8.3.3.5. Sector Outcome 5: Increase the environmental awareness of the population

This outcome has two targets: 1) Building an environmentally aware society; and 2) Appointing a well-known national environment defender to raise awareness and commitment through demonstration projects and dialogue partnerships.

Overall, the first target made some progress through the implementation of a number of projects and activities, but it is still there in the NDS-2, which is necessary because it is impossible to build such awareness within a few years. It is also necessary to develop and implement a methodological tool to measure environmental awareness, such as sample surveys, before and after the implementation of the NDS-2 in order to determine the role of the programs, actions and projects proposed to achieve the target.

Regardingthe second target, Nasser Al-Attiyah (Qatari rally driver) was appointed a Goodwill Ambassador for Environment Protection on the 2013 Qatar's Environment Day to raise environmental awareness.

Various State actors play a significant role in environmental awareness through implementing numerous activities, programs and events. For example, MME activities during 2016 were as follows: More than 210 issues of the daily Municipality and Environment Bulletin were published and over 300 issues of the daily Media Monitoring Bulletin were issued to officials. The MME examined the proposals of more than 30,000 customers and followed-up on their observations through its many communication channels. The MME's accounts on social media had noticeable interaction and an increasing number of followers (e.g. over 100.000 followers on Twitter during 2016), in addition to organizing numerous major conferences, workshops and events, such as the Darb Assa'ee event, World Environment Day event and other activities.

The Tarsheed (Rationalization) campaign – launched by the Qatar General Electricity and Water Corporation – is a good example of sustainable awareness efforts that aim at promoting a culture of responsible consumption.

8.3.3.6. Sector outcome 6: Improved environmental management and regional and international cooperation

This outcome has two targets: 1) Creating a searchable electronic information source at the MME; and 2) Leading a unified regional environment project.

The two targets were not achieved during the Strategy period. However, through regional and international partnerships in this area, public-private partnerships were established to conduct scientific studies in cooperation with the World Bank (WB). Further, the Qatar Environmental Action Program (2011) was launched to strengthen the institutional capacity to achieve environmental sustainability. A highlight of Qatar's role at the international level was hosting the United Nations Climate Change Conference (COP18) in 2012.

8.3.4. Outcomes and targets for the environmental sustainability sector in the NDS 2018-2022

The 2nd NDS has been issued for the years 2018-2022. The 2nd NDS comes just within the historical event of World Cup in Qatar 2022. This makes the 2nd NDS the most important national strategy in Qatar. 2nd NDS completes the 1st NDS to achieve the goals of QNV 2030. Lessons learned from 1st NDS are reflected in 2nd NDS 2018-2022. There are some projects and outcomes of the Environmental Sector which are not achieved completely in the 1st NDS which are considered in the 2nd NDS. In the following section, the challenges, outcomes and targets of the environmental sustainability sector are introduced based on the 2nd NDS.

a. Challenges facing environmental sustainability sector (2018-2022)

The environment faces many challenges and pressures for many reasons related to environmental and climatic features. There are also many challenges due to the high population growth rate which puts pressure on the environment and natural resources, in addition to large urbanization taking place as a result of population growth and increased economic activities, especially since the majority of these activities depend on oil, gas and petrochemical industries, causing significant negative impacts on the environment and biodiversity as a result of pollution and increased waste; and climate change and its negative effects.

For thse reasons, the NDS must clearly enhance national prosperity and address the constraints of environmental determinants and features, and the operational, structural and managerial challenges to the implementation of environmental sustainability plans and projects.

Climatic and environmental features and challenges

The Qatari environment is one of the difficult environments with a very hot tropical climate, high humidity, low rainfall rate (80 mm/year) and no freshwater bodies like rivers and lakes. The groundwater is the only source of fresh natural water, in addition to low soil fertility, high salinity and low grazing load.

The environment should therefore be dealt with great care and sustainable professionalism. The high rate of population growth and the tremendous urbanization of recent years are already placing enormous strain on ecosystems and the necessary and essential systems that support wildlife. However, species living in these ecosystems have followed unique and interesting adaptations to survive in that very difficult environment. Such species have acquired unique features that must be tapped.

Exceptional population growth rate and related challenges

The population has continued to grow significantly, rising from 1.8 million in 2012 to over 2.6 million in 2016. This increase is expected to continue until 2020 and the number then will gradually decrease due to the completion of many major construction projects. The number may reach just over 2 million people in 2030. That large population increase affects all other areas and pillars of the ESS as a result of meeting people's needs for facilities and urbanization to create new residential areas, thus accelerating the pace of urban sprawl and increasing cars and construction equipment. This in turn increases greenhouse gas emissions, solid waste produced, pollution and pressure on natural resources, especially water. The environmental impact is undoubtedly closely linked to the increase in population and then to the welfare and the technologies used.

b. Main outcome, intermediate outcomes and specific targets in the environmental sustainability sector (2018-2022)

The interventions included in the environmental sustainability sector in the NDS-2 will build on what was achieved in the NDS-1, while correcting errors and learning objectives. This will put the State on the right track for a sustainable environmental development without hindering the increasing economic and social growth. Emphasis will be placed on building local capacity, drawing on global experiences to obtain the best new ideas and innovations.

The ESS has a main outcome: "Sustaining the environment for future generations" and intermediate outcomes: 1) A less polluted environment that ensures the health of humans and ecosystems; 2) A less climate-sensitive environment that ensures sustainable development, health and environment safety; 3) An environment that preserves biodiversity to ensure sustainable development and human health and well-being; and 4) Promote sustainable environmental practices.

There are nine targets and nine projects to achieve the ESS, namely. These are reproduced from the NDS-2 (part 6, chapter 1, annex 1).

Intermediate outcome 1: A less polluting environment that ensures the health of humans and ecosystem

Specific Targets

1.1 Reducing the levels of air pollutants in accordance with Qatar's ambient air quality standards by 2022.

Programs / Projects: Developing and implementing a national integrated air quality management plan

1.2 Improving coastal and marine water quality to conform with Qatar's standards by 2022.

Programs / Projects: Developing and implementing a comprehensive coastal and marine water quality control plan

1.3 Fixing the domestic waste generation rate under 1.6 kg per capita/day during the period 2018-2022.

1.4 Recycling 15% of the solid waste generated by the end of 2022.
Programs / Projects : Developing and implement a solid waste management plan to operationalize recycling mechanisms, rehabilitate contaminated sites and deal with hazardous materials and waste.

Intermediate outcome 2: A less climate-sensitive environment that ensures sustainable development, health and environment safety

Specific Targets

2.1 Creating a green belt around Doha and its environs by 2022.

Programs/Projects: Developing and implementing a national plan for adaptation and mitigation of climate change impact and promoting local, regional and international strategic partnerships

Intermediate outcome 3: An environment that preserves biodiversity to ensure sustainable development and human health and well-being

Specific Targets

3.1 Raising awareness of the current and future status of biodiversity, creating and operating a biodiversity database by the end of 2022.

Programs/Projects: Creating and operating a National Biodiversity Database

3.2 A sustainable management of nature reserves and ecosystems by 2022.

Programs/Projects: Developing and implementing an integrated plan for the management of protected areas and various ecosystems

Intermediate outcome 4: Promoting sustainable environmental practices

Specific Targets

4.1 Provideing the required data on the Qatari environment to promote and improve environmental management by 2022.

Programs/Projects: Create an electronic and researchable information database at the MME

4.2 Building an environmental aware and supportive society for environmental sustainability.

Programs / Projects: Promoting environmental awareness, especially for future generations

8.4. Low-Carbon Transition in the Built Environment

8.4.1. Ecological Indicators

A. Qatar ecological footprint

Sustainable development represents a commitment to advancing human well-being, with the added constraints that this development needs to take place within the ecological limits of the biosphere and the carrying capacity of the country. Progress in both these dimensions of sustainable development can be assessed using the United Nations Development Programs (UNDP) Human Development Index (HDI) as an indicator of development and the World Wildlife Fund's (WWF) Ecological Footprint as an indicator of human demand on the biosphere.

A HDI of 0.8 or above and a per capita Ecological Footprint of less than the globally available biocapacity per person 1.8 global hectares per capita (WWF, 2012), represents the minimum requirements for sustainable development that is globally replicable (PSA, 2014).

In 2012 Qatar's HDI was the highest amongst Gulf Cooperation Council (GCC) countries and is ranked 36 out of 187 countries globally. WWF's 2012 report shows that Qatar's ecological footprint increased from 10.5 to 11.7 global hectares per capita (gha) from 2007 to 2008. Qatar has the world's highest ecological footprint at 11.7 gha compared to the average footprint of high-income countries which is 5.6 gha and global average footprint of 2.6 gha (Figure 8.4).

Qatar's Human Development Index compares favorably with GCC countries and top 5 HDI countries, but Qatar has the world's highest ecological footprint. The country has launched major initiatives towards environmental sustainability, and these will augur well for reducing our carbon footprint.

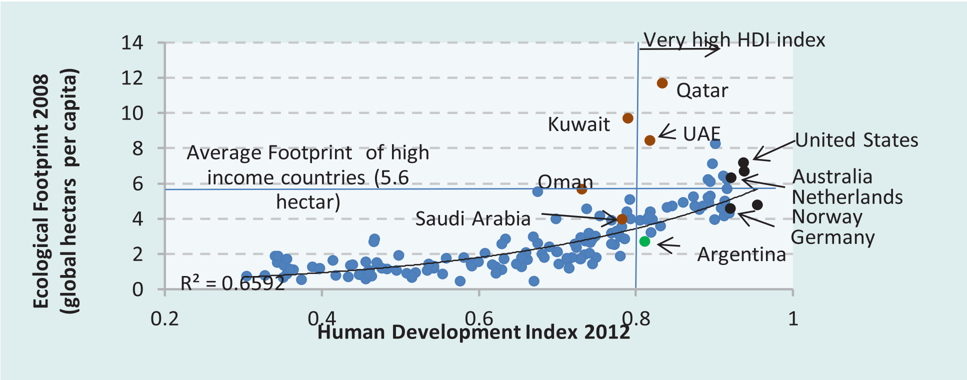

Figure 8.4 Ecological footprint and human development index (Source: NDS-MT, 2014)

B. Environmental Impact (I-PAT)

Increasing population, and the consequent rise in economic activities, exacerbate the environmental challenges. Qatar has also experienced greater affluence. One way to examine the impact of these trends on the environment is through the I-PAT equation, where I (environmental impact) = P (population) x A (affluence) x T (technology).

I-PAT describes the role of multiple factors in determining environmental degradation and has been operationalized here using the multivariate statistical technique of Principal Component Analysis (PCA), whereby PCA transforms a set of correlated variables to a new set of uncorrelated variables called principal components. These are linear combinations of the original variables, derived in decreasing order of importance so that the first component accounts for the largest proportion of variation in the original data.

Below, 4 indicators have been used representing the conceptual variables, population growth, affluence and technology in the IPAT equation to estimate the trend in environmental impact in Qatar. The four standardized indicators are: (i) total population (in millions); (ii) gross domestic product (GDP) per capita (QR ‘000) 2004 prices; (iii) hydrochlorofluorocarbon HCFC-22, (iv) flared volumes (billion cubic meters). The first component of the PCA, accounting for 91% of total variance, is taken to represent the trend in environmental impact. It is an approximately equally weighted average of the 4 variables used in the PCA. The results of the analysis showed that degradation of Qatar’s environment is largely accounted for from the sharp increase in population, rising affluence and the use of technology impacting on the environment (composite indicator trend is shown in Figure 8.5).

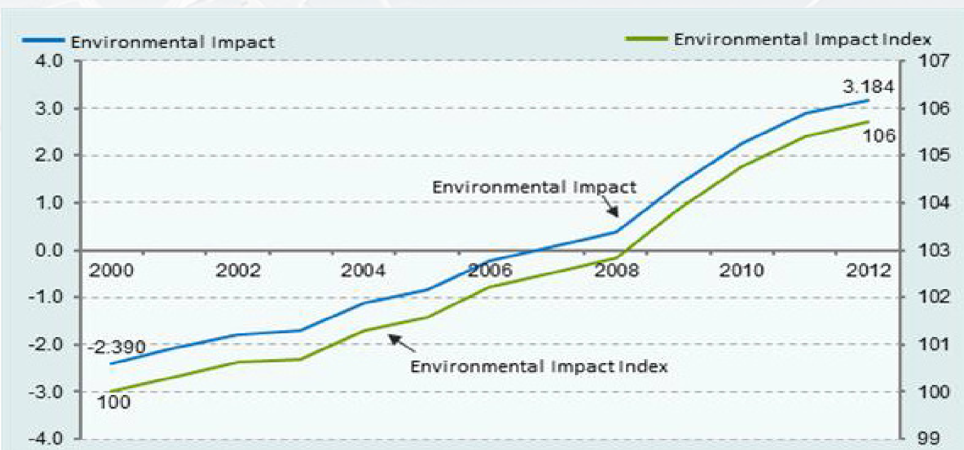

Figure 8.5 Qatar’s Environmental Impact 2000 to 2012 (Source: NDS-MT, 2014)

C. Development of new indicators

It should be recognized that as Qatar develops with increasing external pressures such as climate change and as domestic programs begin to take shape, the development of relevant indicators should be pursued. This should include but not limited to: (1) resilience indicators which consider the country's ability to withstand shocks, and (2) resource productivity to indicate that extent to which waste management programs have reduced the consumption of finite resources.

8.4.2. Measures in the Built Environment

A. Green Technology

One of the outcomes outlined in the QNV 2030 is preserving the environment through:

"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"

Green technology is a new trend worldwide and in Qatar's environmental policy. In Qatar, there are efforts to adopt and work within green technology in such a desert arid country. In addition to plans and initiatives to minimize the waste and consumption of energy and water, there is a complete section in Qatar Construction Specification 2014 (QCS, 2014). This section is called Green Constructions. However, there is another system called Global Sustainability Assessment System (GSAS) for granting certification of constructed buildings as green buildings (by Gulf Organization for Research & Development, GORD).

B. Green Construction (QCS 2014)

Many countries have developed their own standards for green building or energy efficiency for buildings and Building Environmental Assessment tools. Many of building rating systems tools and guidelines exist worldwide. Green building is the process through which buildings are designed, constructed and operated to reduce natural resources consumption, eliminate environmental degradation and enhance social and economic aspects of humans

The contents of this green construction section (Section No 7) in QCS 2014 are:

01. Miscellaneous
02. Qatar Sustainability Assessment System – QSAS
03. Energy
04. Water
05. Indoor Environment
06. Cultural & Economic Value

QCS (2014) Green Building Requirements:

- Engineer s shall specify the applicable Green Building Assessment System for the QCS's Building typologies and to assess compliance with QCS's Green Building Requirements.
- The minimum environmental performance requirements specified in QCS have been derived from the Global Sustainability Assessment System (GSAS) v2.1-2013.

• QCS (2014) encourage the use of any environmental or sustainability performance criteria in addition to those environmental performance criteria specified to help design, construct and operate better buildings.

Types of Buildings:

• Commercial: with built up area of 10000 m2 or more.

• Governmental Buildings

• Public Buildings: Types include: Rail Buildings, Sports, Education Buildings Mosques and other Religious Buildings, Hospitals and Health Centers Buildings, Light Industries Buildings

QCS Green Building Categories & Criteria: The minimum QCS's requirements unless other values specified by the relevant authorities. Table 8.1 shows those categories and criteria used in QCS (2014).

Table 8.1 Categories and criteria of green building used in QCS (2014)			
الفئات حسب مواصفات قطر للإنشاء	المعايير	الحد الأدنى من المتطلبات	نماذج البناء
ENERGY	Energy Demand Performance	EPC ≤ 1.0	Commercial, Governmental Education, Mosques & other religious buildings, Light Industry, Health Centers, Railways, Sports
	Energy Delivery Performance		
ENERGY	Water Consumption	WPC ≤ 1.0	Education, Mosques, Light Industries, Health Centers,
INDOOR ENVIRONMENT	Thermal Comfort	PMV ≤ 2.0	Commercial, Light Industry, Governmental
		80 ≤ ADPI	Education, Mosques
		Comply with ASHRAE Standards	Health Centers
		Comply with ASHRAE Standards	Railways

INDOOR ENVIRONMENT		PMV ≤ 2.0 office spaces	Sports
		worst case heat load ≤ 1.6 Exposed Spectator Seating	
	Natural Ventilation	Natural Ventilation Can be Utilized (x) 0 < X (month of the year)	Commercial, Education, Mosques, Light Industry
		Comply with ASHRAE Standard	Health Centers
		Natural Ventilation Can be Utilized (x) 0 < X (month of the year)	Sports
		Comply with ASHRAE Standard	Railways (above ground)
	Mechanical Ventilation	no existence of equipment with efficiency less than specified in ASHRAE 90.1 - 2010	Commercial, Governmental, Education, Mosques, Light Industry, Health Centers, Sports, Railways
	Low-Emitting Materials	VOC_emi_total ≤100%	Commercial, Governmental, Education, Mosques, Light Industry, Health Centers, Sports, Railways
CULTURAL & ECONOMIC VALUE	Support of National (GCC) Economy	% of Construction Expenditure Benefiting National Economy (x) 20 ≤ X	Commercial, Governmental Education, Mosques, Light Industry, Health Centers, Railways
	Cultural Identity & Heritage	To be defined & assessed by Certification Authority	Commercial, Governmental Education, Mosques, Light Industry, Health Centers, Sports, Railways
MANAGEMENT & OPERATION	Recycling Management	Recycling Management Plan demonstrates Compliance	Commercial, Governmental Education, Mosques, Light Industry, Health Centers, Railways, Sports
MATERIALS	Regional Materials	Performance Indicator (X) X < 30	

Qatar Green Building Council (QGBC): While urban development is essential to the progress of any country, quite often the natural environment is the first casualty of population growth. Even if this cannot be entirely prevented, it can be managed through a sustainable urban development plan. "Green Building" practices aim to reduce the impact of buildings on the environment by adopting techniques throughout the built environment taking into account factors like energy efficiency, use of environment-friendly materials, waste reduction etc.

QGBC is a non-profit, membership-driven organization providing leadership and encouraging collaboration in conducting environmentally sustainable practices for green building designs and development in Qatar. QGBC also aims to support the overall health and sustainability of the environment, the people, and economic security in Qatar for generations to come. The council, a member of Qatar Foundation, was formally established in 2009 by a decree signed by H.H. Sheikha Moza Bint Nasser and is helping Qatar on its journey to establish a post-hydrocarbon, knowledge economy and progressive society.

QGBC is led by its accomplished expert founders, an executive team and committees with diverse experience and a broad industry network. QGBC is committed to demonstrate that applying sustainably built standards not only helps in reducing energy and utility consumption, but it can also reduce costs, improve life quality of people and be more profitable with long term benefits.

QGBC collaborates with the design and building industry and liaises with the government to promote sustainable development. Additionally, QGBC aims to establish strategic partnerships, performs educational and market transformation activities, researchs projects, conferences and workshops, andothers.

C. Waste Reuse and Recycling

Minimizing the waste will enhance the environmental sustainability and green building. Two outcomes of NDS, is reducing waste, apllying more recycling and efficient reuse together with a more environmentally aware population, have been identified in the NDS program for Environmental Management to be achieved by 2016. Significant work for implementation and progress towards achieving these two outcomes for solid waste were done. However, the main policy for solid waste in Qatar ispresented in Figure 8.6.

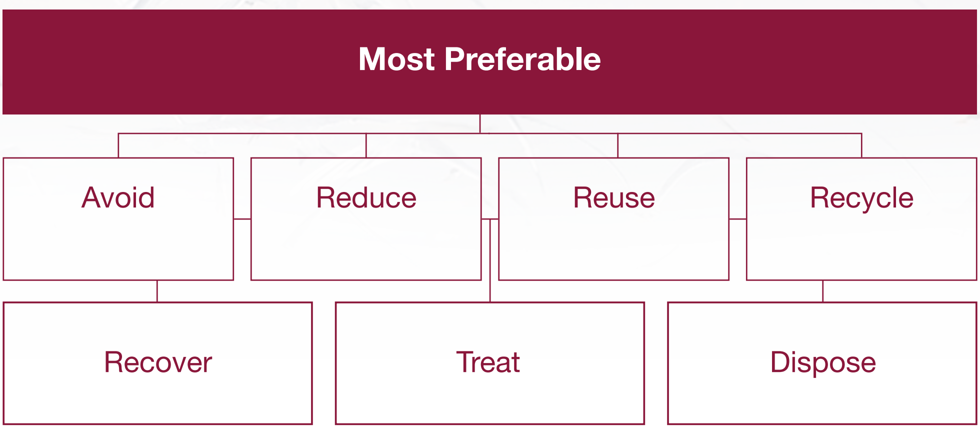

Figure 8.6 Waste Management Hierarchy in Qatar.
(Source: MME internal reports)

8.5 Climate Change Adaptations

In the following section, the adaptations to climate change in the State of Qatar are given according to the Intended Nationally Determined Contributions (INDCs) Report issued by MoE (2015).

8.5.1 Geographical Conditions of Qatar

The nature of Qatar peninsula is very harsh as it suffers from a scarcity in fresh water supply and local food supply, with low annual rainfall. The State of Qatar is highly dependent on the desalination of the saline seawater from the Arabian Gulf as its main source of water, in addition to ground water.

Qatar is extremely vulnerable to sea level rise as it is liable to inland flooding of 18.2% of its land area, at less than 5m rise in sea level, along with the associated adverse impacts on the population as 96% are living on the coastal areas. Furthermore, climate change would cause the extinction of species such as whales, dolphins and turtles in addition to causing coral bleaching and other several impacts on the migration of some marine species and sea birds.

Although the essential living resources are rare, Qatar is blessed with oil and gas ,which are being used to overcome the living difficulty on the land. Since the exploration of hydrocarbons in Qatar, oil and gas in addition to their associated petrochemical industries,have been contributing to the economic and social growth of the state. Qatar's ecological and human systems are vulnerable to the adverse impact of climate change as well as the impact of response measures due to its unique circumstances.

The international climate change measures and policies shall be in line with the provisions of the of the United Nations Framework Convention on Climate Change in particular, Article 3 paragraph 2 and Article 4 paragraph 8(h) and 10 and shall ensure the developing countries› eligibility for finance, technology transfer and capacity building.

8.5.2. Economic Diversification with Mitigation Co-benefits

Economic diversification is crucial to Qatar in order to maintain a steady and robust economy. Qatar seeks to enhance the diversification of its economy away from hydrocarbons consistent with decision no.24/CP.18. Qatar has been contributing indirectly to the global efforts to mitigate climate change by exporting Liquefied Natural Gas as a source of clean energy.

A. Energy Efficiency

According to Qatar National Vision 2030, the energy industry is taking into consideration the impacts of its development and growth on the environment. Many programs and projects in the country are pursuing energy efficiency and process optimization. Although the existing capacity and technology are not enough to support improvement and upgrade, Qatar is in the process of employing available resources to achieve energy efficiency.

B. Clean Energy and Renewables

Despite the abundance of gas which is considered clean energy, Qatar is heavily investing in other natural resources. Attempts have been made to utilize clean energy and renewable resources such as solar and wind power. Efforts have been made into solar energy generation with a view to becoming a regional supplier of solar-generated electricity. However, based on the harsh environment and weather conditions, utilizing such renewables as reliable power sources is very challenging due to the lack of access to high technology, which is necessary for using these resources effectively and efficiently. Yet, some national entities started considering solar and wind resources to generate electricity for small buildings aiming to open a new market, in the hope of strengthening the economic diversification. Utilizing clean energy and renewables is an adaptive precaution to climate change impacts that would open a window to diversify the economy and reduce emissions to the atmosphere from the fuel combustion. Some of clean energy and renewable sources are available, however, they cannot be utilized without the needed support; especially, technology transfer.

C. Research and Development

Qatar is highly committed to advancing research and development. Qatar has invested heavily in research and development in various areas including sustainable energy, in line with its National Research Strategy. Many research activities are being carried out in various fields, improving the environment to adapt with climate change impacts, utilizing clean energy and renewables, reducing emissions to the atmosphere and developing technologies that convert emissions into useful products. These research efforts consider economical validation, economic-diversification and efficiency.

Local entities are actively promoting sustainable development within their research programs and addressing Qatar's grand research challenges which include solar energy, energy storage, smart grids, energy efficiency and innovative cooling methods, air quality, innovative waste recycling to produce value added products, the energy, water and food nexus, biofuel production from algae, CO2 sequestration using algae for the production of useful products, utilization of CO2 for Methanol production and also the development of novel isolation materials to reduce buildings' energy requirements.. These entities are addressing many of the issues related to Qatar, the region and the world, and developing local solutions with the potential for global impact.

D. Education

Qatar is investing heavily in education. Great steps have been taken to create a world-class education system that aims to build an environmental aware society. Universities and research institutions have programs that center around environmental studies, including climate change. All in all, Qatar's emphasis on education is expected to produce graduates who are specialized in knowledge-based services, healthcare and green technologies. On the same grounds, young Qataris are always motivated to take advantage of the various opportunities for post-secondary education and training. These generations are encouraged to increase their involvement in the private sector by launching business training and capacity building programs. This involvement will, in turn, strengthen the new generation's capabilities and improve their analytical thinking, innovation and entrepreneurship to contribute to climate change efforts and sustainable development. Educational programs related to environmental sciences, sustainable energy and sustainable environment at masters and doctoral level have been launched within Qatar to raise the human capacity to undertake many of the global challenges. The programs attract students locally and internationally along with faculty and scientists to address many of the issues challenging Qatar and the rest of the world.

E. Tourism

Qatar has a long-term strategy towards advancing its tourism industry through a series of well-defined plans, programs, and policies developed according to international best practices, and following a nation-wide consultative process. The aim of this strategy is to reduce dependence on hydrocarbon resources by promoting sustainable tourism strategies, as well as to protect the country's economy from market fluctuations that can significantly affect its economic growth.

8.5.3 Adaptation Actions with Mitigation Co-benefits

A. Water Management

According to Qatar National Vision 2030, efforts initiated to place Qatar's resources management on a sustainable path for future generations. Qatar aims to use upgraded wastewater treatment plants to improve the treated water quality and further support using it for agricultural purposes to reduce the demand on fresh water and accordingly decrease the fuel consumption in water desalination and associated gaseous emissions. In addition, Qatar is undertaking the following key initiatives in relation to water management:

- Water Conservation: Qatar will enact a comprehensive National Water Act establishing an integrated system of quality requirements, discharge controls and incentives for conservation.

- Desalination: Qatar is moving towards more efficient forms of desalination and is investing in research and development of new technologies, including the usage of renewable energy to power desalination plants.

These new technologies will minimize the environmental impacts of the desalination projects. Significant research and development activities about developing innovative desalination technologies and utilizing renewable energy for desalination and water treatment have been established at Qatar.

B. Infrastructure and Transport

Currently, Qatar's infrastructure is being improved and directed towards an efficient adaption and mitigation measure for reducing climate change impacts. Several projects are serving the goal. Qatar introduced public transportation to reduce the demand on private vehicles and direct the nation towards the use of public transportation and expressway programs that would enhance the traffic flow and divert it outside the cities. Hence, local roads and drainage programs are expected to enhance the network of drinking water, wastewater and treated sewage effluent. In Qatar, Vehicles Inspection Services regulates the emissions of vehicles. Qatar continues to improve the emission standards for new motor vehicles, in accordance with regional and global emission standards.

C. Waste Management

Qatar uses state-of-the-art waste treatment technologies which treat most of the collected waste, generating significant amount of clean energy. Efforts are focused on adopting a strategy to contain the levels of waste generated by household, commercial sites and industries.

To improve waste management, the government recognizes a hierarchy of actions to alleviate the pressure on the environment and to reduce, reuses or recycle generated waste in addition to the reduction of methane emissions. The waste management facilities will have the capability to convert waste to energy. Awareness programs are planned to encourage a sense of shared responsibility towards the environment.

D. Awareness

A sustainable environment could be achieved through public involvement. Therefore, awareness programs are being carried out to spread the idea of using less energy consumption devices and energy efficient building structures through thermal insulation systems. These programs are meant to adapt with climate change impacts that would bring down the emissions as a co-benefit, through encouraging the sense of shared responsibility towards the environment, along with the development of positive environmental attitudes and values.

8.5.4 Response Measures

Due to Qatar's dependence on the export of oil and gas, there is an uncertainty from the potential impact of the implementation of response measures to climate change that may negatively impact the strength of Qatar's economy and potentially the quality of life of its residents. Therefore, measures must be assessed in order to avoid potential impacts of their implementation on Qatar, along with the necessity of international cooperation in this regard to achieve the objectives of sustainable development in line with the principles and provisions of the convention article 4.8.

8.5.5 Timeframe

The intended voluntary contributions in this climate change adaption activities are planned to cover the periodstarting from 2021 to 2030 in line with the national vision.

8.5.6. Monitoring and reporting progress

A dedicated department for climate change within the Ministry of Environment (currently: Ministry of Municipality and Environment) has been established to strengthen the governance of climate change on national level and to implement standardized data collection and reporting. This national Monitoring, Reporting and Verification system could be used to track the progress of the actions and projects that may accelerate the process of achieving the aims of these INDCs.

8.5.7 Fairness and Ambition

This INDC is based on the provisions and principles on the convention and in particular article 3 paragraph 2 and article 4 paragraph 1, paragraph 8(h) and 10.

All national actions and plans described in this INDCs are voluntary and the means of implementation and support will be in accordance with the principles and provisions of the United Nations Framework Convention on Climate Change in particular Articles 4.7, 12.4.

Qatar reserves the right to further elaborate and update this INDCs in line with its special national circumstances and sustainable development imperatives with a view to avoiding adverse effects of the economic and social consequences of response measure.

8.6 Environmental Sustainability Outlook and the Global Agenda

8.6.1 UN Sustainable Development Goals 2015-2030

Qatar's blueprint for sustainable development envisions a country where society is prosperous, peaceful, knowledge-empowered and respectful of environment. The blueprint comprises several strategies for specific actions which can be broadly grouped. Qatar has kept abreast of UN sustainable development initiatives, signed various international conventions that directly and indirectly contribute to SDGs and developed national programs of action to address the pertinent issues. Globally, the concept of sustainable development has continued to evolve, and Qatar is no exception to changing perspectives. However, since the essence of sustainable development has always been to achieve a balanced and stable human relationship with nature,

Considerable efforts have been made due to country's rapid transformation characterized by industrialization and urbanization. Integrating the social, economic and environmental dimensions in ways that offer sustainable solutions for current and future generations,

after the end of the Millennium Development Goals (MDGs) in 2015, UN startsa new era beyond 2015. Currently, UN has the sustainable Development Goals (SDGs) to be achieved by 2030. Among the 17 SDGs, there are some goals which are related to environmental sustainability and performance. Yale Center for Environmental Law and Policy mapped the SDGs whichfollow the Environmental Performance Index (EPI) as shown in Figure 8.7. Those SDGs which are related to environment performance are No 2, 3, 6, 7, 11, 13, and 14. Those targets should be considered in any international report related to sustainable development in environmental area.
Figure 8.7: Mapping the SDGs and Environmental Performance Index of Yale. (Source: EPI, 2016)

Disparity among the countries is so huge that strategies and pathways for achieving all the 17 SDGs cannot be the same despite similar aspirations the harmony of human society with nature, the priorities for environmental, social and economic dimensions of sustainability are expected to be significantly different.

In the context of Qatar which has the highest GDP, the society is affluent, enjoying the benefits of knowledge empowerment, healthcare and many other amenities but the country has to deal with some extreme environmental conditions. The blueprint for attaining SDGs for Qatar takes these ground realities into consideration.

The state of Qatar adopted several strategies for sustainable development and is effective in achieving goals 1-6, 8 - 10. However, for the rest of the goals (7 and 11-16) on-going efforts can be characterized as 'work in progress'. This is backed by the matrix presented in the various chapters of this report. Qatar has several Voluntary National Reviews on the SDGs' implementations to the High-Level Political Forum on Sustainable Development.

Sustainable Development Goal Targets	EPI Metric
SDG-2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture → By 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality	• Nitrogen Use Efficiency and Nitrogen Balance
SDG-3: Ensure healthy lives and well-being → By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	• Environmental Risk Exposure • Air quality • Water and Sanitation • Wastewater Treatment
SDG-6: Ensure availability and sustainable management of water and sanitation for all → ... halving the proportion of untreated wastewater by 2030 → ensure[s] access to water and sanitation for all	• Wastewater Treatment • Drinking Water Quality and Access to Sanitation
SDG-7: Ensure access to affordable, reliable, sustainable and modern energy for all → ... halving the proportion of untreated wastewater by 2030 → ensure[s] access to water and sanitation for all	• Access to Electricity • Trend in CO_2 per kWh • Trend in Carbon Intensity
SDG-11: Make cities and human settlements inclusive, safe, resilient and sustainable → Strengthen efforts to protect and safeguard the world's cultural and natural heritage → By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	• Air quality • Terrestrial Habitat Protection • Species Protection
SDG-13: Take urgent action to combat climate change and its impacts	• Access to Electricity • Trend in CO_2 per kWh • Trend in Carbon Intensity
SDG-14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development → By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts → By 2020, conserve at least 10 per cent of coastal and marine areas → By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies	• Fish Stocks • Marine Protected Areas

Figure (8-7): Yale University Sustainable Development Goals Plan and Environmental Performance Indicator. (Source: Environmental Performance Index (EPI), 2016)

8.6.2 Environmental Multilateral Agreements

Qatar engages in international environmental development initiatives and has committed to improvements in environmental and sustainability policies and indicators. Until 2010, Qatar has signed 13 out of 14 Multilateral Environmental Agreements (MEAs) - the Cartagena Convention which relates to marine environments in the Caribbean Region is excluded (Figure 8.8). After 2010, Qatar signed one more international agreement in 2016 which is Paris agreement about Climate Change. Table 8.2 shows all regional and international environmental agreements whichwas signed by the State of Qatar.

Qatar hosted the 2012 United Nations Climate Change Conference (COP18) attended by delegates from governments, business, international organizations, NGOs and youth organizations. This reflects the national commitment to proactively address climate challenges stated in international agreements and to adapt and to help mitigate its negative impacts.

These international and regional agreements have some obligations and commitments that have to be carried out by Qatar, either by reporting or follow-ups. This must be considered in the national strategies of environmental sector.

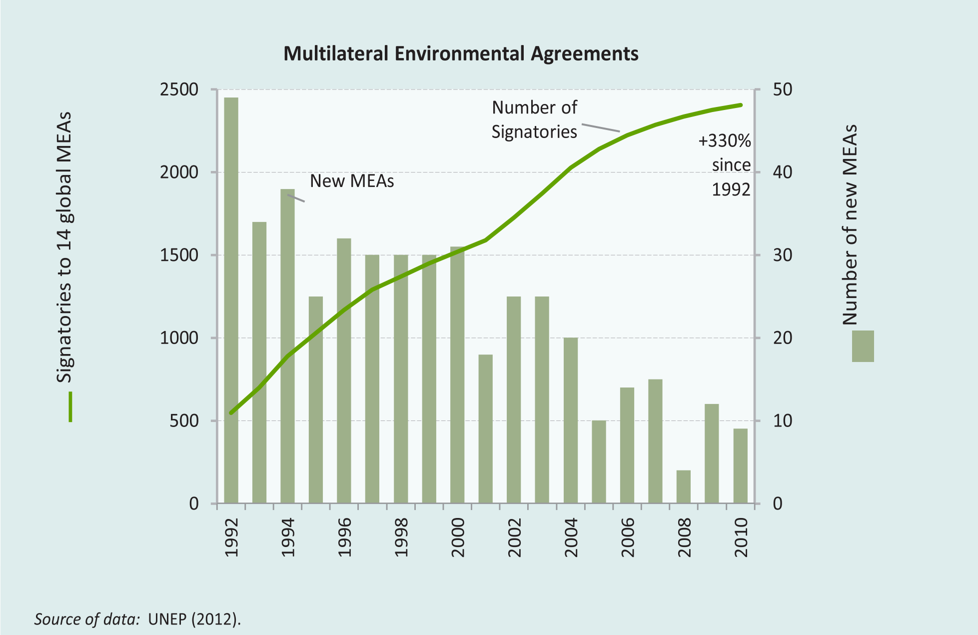

Figure 8.8: Multilateral Environmental Agreements signed by Qatar (Source: PSA, 2014)

Cooperation and an openness to learning is essential to ensure that people and organizations are engaged,together with regional and international stakeholders responsibility for managing global development, as well as threats to international peace and security, must be spreadamong nations.

Qatar›s official development assistance exceeds the average of OECD countries. As part of its commitment to the global partnership for development, Qatar allocates 0.55% of its GDP to official development assistance – an amount that is higher than the OECD countries average of 0.31% of GDP. Of this 79% is allocated to development.

Table 8.2: Environmental agreements signed by Qatar				
No	Agreement Name	Type	Signed By	Singed Year
1	World Cultural and Natural Heritage Convention (1972)	International	-	1984 “Decree (21) 1985”
2	Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES (1973)	International	Supreme Council of Environment and Protected Areas	2001 “Decree (19) 2001”
3	Kuwait Regional Convention for Cooperation on The Protection of The Marine Environment From Pollution (1978)	Regional	State of Qatar	Law (55) 1978
4	UN Convention on the Law of the Sea (1982)	International		2002
5	Vienna Convention for the Protection of the Ozone Layer (1985)	International	Ministry of Foreign Affairs	1996
6	Montreal Protocol on Substances that Deplete the Ozone Layer (1987) and its Amendments of 1990-1992	International	State of Qatar	Law (23) 1999
7	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)	International	Ministry of Foreign Affairs	1995 “Decree (15) 1996”
8	Decision no (1/3) of 3rd parties meeting of Basel Convention (Ban Amendment)	International	Ministry of Foreign Affairs	Law (22) 2003
9	Protocol for the Protection of the Marine Environment Against Pollution from Land-Based Sources (1990)	Regional	State of Qatar	1992
10	International Convention on Oil Pollution Preparedness, Response and Cooperation (1990)	International	State of Qatar	Law (36) 2007
11	The Arab Declaration on Environment and Development and Future Prospects (1991)	Regional	League of Arab States	1991
12	Agenda 21 and the Rio Declaration on Environment and Development, UNESCO (1992)	International	State of Qatar	1999
13	UN Convention on Biological Diversity (1992)	International	Ministry of Municipality Affairs and Agriculture	1996 “Decree (90) 1996”
14	UN Framework Convention on Climate Change (UNFCC) (1992)	Multilateral Environmental Agreements	State of Qatar	1996 “Decree (47) 1996
15	UN Convention to Combat Desertification (UNCCD) (1994)	International	Ministry of Municipality Affairs and Agriculture	1999

16	Kyoto Protocol (1997)	Multilateral Environmental Agreements	Ministry of Foreign Affairs	2005
17	Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazards Chemicals and Pesticides in International Trade (PIC) (1998)	International	State of Qatar	2004
18	Regional Organization for the Protection of Marine Environment (ROPME) (1998)	Regional	Supreme Council of Environment and Protected Areas	1998
19	Cartagena Protocol on Biosafety (2000)	International	Supreme Council of Environment and Protected Areas	2007
20	Conservation of Wildlife and their Natural Habitat in the GCC (2001)	Regional	Ministry of Foreign Affairs	2003 "Decree (43) 2003"
21	Stockholm Convention on Persistent Organic Pollutants (2001).	International	-	2004
22	Nagoya Protocol for Sharing the Benefits of Genetic Resources (2010).	International	-	2017
23	Manama Mercury Convention, (2013)	Manama Mercury Convention, (2013)	-	-
24	Paris Agreement under the United Nations Framework Convention on Climate Change (2015)	Paris Agreement under the United Nations Framework Convention on Climate Change (2015)	Ministry of Municipality and Environment	2016

8.7 Summary

Sustainable development depends on three interrelated pillars that are Environmental protection, Social integrity, as well as Economic growth aspects, which all play an important factor in sustainability. As an act to create a balance between the present and future interests and needs through the three aspects of sustainability, the state of Qatar has developed Qatar National Vision 2030 (QNV) to embody that purpose. Ultimately, there is a need to reduce national resource consumption, maintain the integrity of the environment, enhance the social and economic status of the State of Qatar, whilst mitigating the effects of climate change. Climate change adaptation for the State of Qatar has been presented in details throughout this SoE, containing valuable input from the "Intended Nationally Determined Contributions (INDCs)" Report issued by Ministry of Environment (currently: Ministry of Municipality and Environment) in 2015 has been considered (MoE, 2015).

The 1st Qatar National Development Strategy (NDS) 2011-2016 was launched in 2011 to convert the QNV 2030 into implementation/ operational phase. The NDS included 14 sectors, and environmental sustainability is one of those sectors. The 7-outcomes and the 10-projects of the national environmental strategy within this NDS were presented in details. The government of Qatar launched its 2nd NDS 2018-2022. The outcomes for the environmental sustainability sector have been presented.

In this chapter about the status of the environment (SoE) report, several dimensions related to the environment have been considered, such as the general wellbeing and health of national ecosystems. This included Ecosystem components related to air, water, soil and land. Future SoEs perhaps should consider the integration of ecosystem components and explore the inter-linkages between them. Furthermore, the increasing trend in the implementation of green technology and green buildings within the State of Qatar has been explored throughout this chapter and SoE report. This is an addition to the need for effective waste management.

Finally, the blueprint and outlook for sustainable development focusing on environmental sustainability has been provided in line with the UN Sustainable Development Goals 2015-2030. International and regional environmental agreements are other aspects to be considered

in environmental strategies and plans implemented in Qatar. List of multilateral environmental agreements were given

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Acronyms & Abbreviations

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Preparing this report requires effective coordination and sharing of information from various parties. The Monitoring and Environmental Laboratory Department extends its thanks to all the parties that helped with data, information, photos, publications, reports and links to websites for the preparation of this report, and those parties are specifically:

Entities within the Ministry of Municipality:

- Department of Industrial Inspection and Pollution Control.
- Department of protection and wildlife.
- Management of nature reserves.
- Department of Radiation and Chemicals Protection.
- Climate change management.
- Management of waste recycling and treatment.
- Department of Agricultural Affairs.
- Agricultural Research Department.
- Department of public parks.
- Fisheries management.
- Livestock management.
- Public Relations Department.
- Department of International Cooperation.
- Urban Planning Department.
- Geographical information systems management.

Entities Outside the Ministry of Municipality and Environment:

- Qatar General Water and Electricity Corporation “KAHRAMAA”.
- The Public Works Authority “Ashghal”.
- Qatar Institute for Environment and Energy Research “Hamad Bin Khalifa University”.
- Qatar Petroleum Company.
- Qatar University.
- Department of Meteorology.
- Ministry of Commerce and Industry.
- Ministry of Finance.
- Ministry of Culture and Sport.

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