Ministry of Foreign Affairs

Uniting water energy food NEXUS in Qatar

Commissioned by the Netherlands Enterprise Agency

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uniting water energy food

NEXUS

IN QATAR

OPPORTUNITIES FOR DUTCH COOPERATION

Dutch connection in Qatar

Holland.

NEXUS
IN QATAR

ACKNOWLEDGEMENTS

EY MENA team carried out this market overview report related to Water-Energy-Food (WEF) nexus, commissioned by the Embassy of the Kingdom of the Netherlands in Qatar. The report will provide an overview of existing government policies, initiatives and targets pertaining to the Nexus. It will also explore the current dynamics of water, energy and food within the country, along with the challenges and opportunities being looked at by various entities in the country.

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INTRODUCTION

UNDERSTANDING AND MANAGING THE COMPLEX INTERACTIONS BETWEEN WATER, ENERGY AND FOOD

Water, energy, and food are the most vital resources that any living organism needs to survive. Their future demand will significantly increase in the years to come to meet the requirements of continued economic development and global population growth. In addition, climate change and environmental stress are putting further strain on our planet's scarce resources. These challenges affect and concern us all around the globe and therefore we need to call out for accelerated, collective action towards sustainable development.

I am delighted that Qatar and the Netherlands were among the 193 countries that adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) at a UN summit in 2015. Numerous SDGs relate to the areas of water, energy, and food, including zero hunger (SDG2), clean water and sanitation (SDG6), affordable and clean energy (SDG7), sustainable cities & communities (SDG11), responsible consumption and production (SDG12) and climate action (SDG13). The Netherlands strongly advocates for an integrated approach in tackling these SDGs to ensure they are achieved synergistically – without compromise.

By applying an integrated approach on water, energy, and food we can better understand and systematically analyze the interactions between our natural environment and human activities. It can also provide insight into the complex and dynamic inter-relationships between water, energy and food. Accordingly, it guides us towards the sustainable use and management of our limited natural resources.

With more than 80% of Qatar's food coming from imports, 99% of potable water being produced through energy-intense desalination, and the agricultural sector consuming the lion share of Qatar's water resources, nowhere is the water-energy-food nexus more profound than in Qatar and the Gulf region. Qatar and the Netherlands successfully collaborate on water, energy, and food issues. High-level, bilateral visits are giving rise to new joint projects. Our countries also encourage greater dialogue, awareness, and engagement among government, businesses, and knowledge institutions on the water-energy-food nexus.

The report you are about to read on the nexus of water, food, and energy was commissioned by the Embassy of the Kingdom of the Netherlands in Qatar. It explores the state of play, developments and opportunities in Qatar to advance the intersections of water, energy, and food. The report also provides guidance for partners based in the Netherlands on how best to offer Dutch innovations, knowhow and skills to Qatar. It furthermore highlights how the integrated approach of the water-food-energy nexus serves the goals of Qatar's National Vision 2030.

My hope is that the Netherlands and Qatar will jointly step up their forces to take the necessary steps towards sustainable development- including sustainable synergies among water, energy, food and enabling sectors- and influence one of the most defining issues of our time.

Sincerely,
Dr. Bahia Tahzib-Lie
Ambassador of the Kingdom of the Netherlands to the State of Qatar

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DISCLAIMER

- This first version was produced in March 2019 -

Contents

1. Abbreviation List

CAGR	Compounded Annual Growth Rate
CN	Conservation & Energy Efficiency
CSP	Concentrated Solar Power
ESCO	Energy Servicing Company
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GMOs	Genetically Modified Organisms
GSAS	Global Sustainability Assessment System
HLPF	High-level Political Forum
IoT	Internet of Things
LEED	Leadership in Energy and Environmental Design
MD	Membrane Distillation
MED	Multi-Effect Distillation
MSF	Multiple Stage Flash
NBSAP	National Biodiversity Strategy and Action Plan
NDS	National Development Strategy
PV	Photovoltaic
QNFSP	Qatar National Food Security Program
QNRS	Qatar National Research Strategy
QNV	Qatar National Vision
RO	Reverse Osmosis
SDGs	Sustainable Development Goals
TSE	Treated sewage effluent
VNR	Voluntary National Review
WEF	Water-Energy-Food
WtE	Waste to Energy
WWTP	Waste Water Treatment Plant

2. Introduction

2.1 Report Objective

The WEF Nexus has risen on the national agenda as Qatar looks to secure its future and support ongoing development. The Netherlands government is keen to collaborate with Qatar to encourage greater dialogue, awareness and engagement, between the Netherlands government, Dutch companies, and Qatar on the Nexus. This may be achieved through technology transfer, expertise, research and development activities, joint ventures, investments, and other mechanisms.

The objective of this report is to support this arrangement by setting the context of the current state of the WEF Nexus in Qatar. The WEF Nexus is assessed in relation to the availability of primary freshwater, energy and food resources along with the main challenges faced. Thereafter, it provides a snapshot with respect to what national strategies are in place and what technologies/practices are implemented across each intersection of the Nexus, with a particular focus on food. The report concludes by highlighting some of the possible investment opportunities for Dutch companies in Qatar, along with the proposed engagement channels.

2.2 Summary

Understanding Qatar's situation with respect to the Water-Energy-Food (WEF) Nexus helps provide insight on the type of initiatives and investment opportunities that would be applicable to the country.

Figure 1 provides a summary on Qatar including its different resources: power and water mix, food production and acquisition. It also highlights some of the investment opportunities with respect to the different aspects of the WEF Nexus: Water-Food, Water-Energy and Food-Energy. A comprehensive list of investment opportunities can be found in chapter 4.

Figure 1 Qatar Summary

QATAR OVERVIEW

LAND AREA:	11,437 km²
CLIMATE:	Arid; mild, pleasant winters; very hot, humid summers
TERRAIN:	Mostly flat and barren desert
ARABLE LAND:	1.6%
ENVIRONMENTAL ISSUES:	Air, land, and water pollution are significant environmental issues along with limited natural freshwater resources
ENVIRONMENT AGREEMENTS:	Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Ship Pollution
NATURAL RESOURCES:	petroleum, natural gas, fish
POPULATION:	2,639,211 (2017 Est.), 88.4% Expatriates
URBANIZATION:	99.38% of total population
GDP (PPP)	USD 340.6 Billion (2017 Est.)
	0.2% Agriculture, 50.3% Industry, 49.5% Services
GDP - PER CAPITA (PPP):	USD $124,500 (2017 Est.)
INDUSTRIES:	Liquefied natural gas, crude oil production and refining, ammonia, fertilizer, petrochemicals, steel reinforcing bars, cement, commercial ship repair

Qatar

QATAR WATER-ENERGY-FOOD RESOURCES

Power generation in Qatar

Qatar generated 39 TWh of electricity in 2015, the vast majority of which came from fossil fuels, with less than 0.5% from renewables. The residential sector is the biggest consumer, followed by industry.

	Natural Gas	Fuel Oil	Renewables (solar, wind etc.)	Waste-to-Energy/ Biogas	Nuclear
Power Mix	95.5%	<1%	0.5%	0.4%	0%
Trend	▼	Backup only	▲	▲	No plans

Water production/withdrawal in Qatar

Qatar produced and abstracted over 800 million m³ in 2014, consuming around 675 litres of water per capita per day. The residential sector is the biggest consumer, followed by the industry.

	Thermal Desalination (fossil fuel)	Reverse Osmosis (from Grid)	Treated Wastewater	Groundwater Abstraction
Water Mix	Desalination 59%		11%	30%
Trend	▼	▲	▲	▼

Food production and acquisition in Qatar

Food Imports
- Food imports in 2016 were worth USD 1.02 million
- Since the 2017 embargo, Qatar began to reassess its import partners and redraw its food supply chain

Foreign Direct Investment in farmland abroad
- Qatar has made 18 sizeable FDIs (USD ~0.6 billion) in Ethiopia, Sudan and South Sudan
- Qatar's Sovereign Wealth Fund is the primary entity behind such investments, with objective of improving food security

Domestic Food Production
- Qatar produces a variety of crops within the country such as eggplants, pumpkins and cabbages, with the bulk being the growing and harvesting of dates

Food loss in industrialized asian countries across supply chain

Production	Handling & Storage ★	Processing & Packaging	Distribution & Marketing	Consumption ★
17%	23%	2%	11%	46%

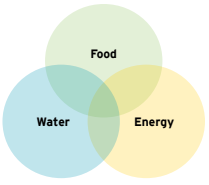
★ Significant opportunities exist to reduce losses at handling & storage, and consumption. Along with biogas opportunities post consumption.

HIGHLIGHTED INVESTMENT OPPORTUNITIES

Investment opportunities for Dutch companies (for full list, refer to Chapter 4)

Water-Food
- High-tech greenhouses
- Hydroponics & aquaponics
- Urban farming
- Aquaculture
- Drip irrigation
- Food monitoring systems
- Food import derisking & early warning systems

Water-Energy
- Renewable powered desalination
- Sewage sludge to biogas
- T&D network efficiency
- Water fixture efficiency
- Solar water pumps
- Solar water heaters
- District cooling



Food-Energy
- Greenhouse and storage cooling systems
- Biogas from landfills
- Biodiesel from food waste
- Biomass from halophytes
- Route & inventory optimization
- Physical/emergency stockpiling (i.e. food reserves)

2.3 The Water-Energy-Food Nexus

The Water-Energy-Food Nexus is the inextricable link between, water, energy and food: the actions in one area often have an impact on the others. For this reason, the WEF-Nexus approach has gained significant traction over the years as a holistic method of resource management and sustainable development. **Fout! Verwijzingsbron niet gevonden.** and **Fout! Verwijzingsbron niet gevonden. Fout! Verwijzingsbron niet gevonden.**have been developed to illustrate the food security and water security tradeoffs for the GCC, respectively. Information specific to Qatar's market and resources was presented where applicable.

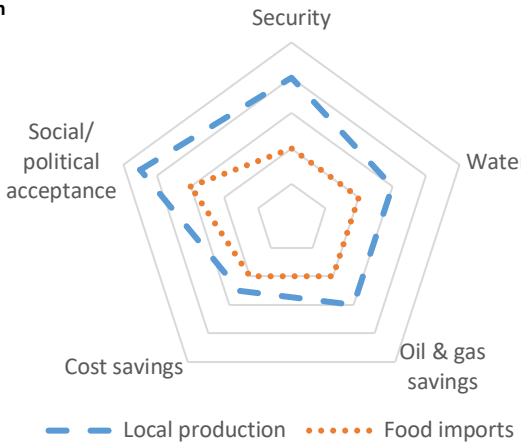
Figure 2 Food Security Trade Offs in the GCC[1]

How secure are the country's food sources? Are they resilient against climate and market shocks?

- Food imports are more prone to climate and market shocks as demonstrated by the 2007/2008 Global Food Price Crisis
- Qatar's local food production is constrained by a number of factors, including its climate conditions, limited arable land, and increasing population
- Qatar has redrawn its food supply chain by diversifying its food imports from a number of countries
- As a small country, Qatar has relatively limited bargaining power in international food markets, especially after the blockade

Is there political and social support for the method of food production and acquisition? Is it in alignment with the strategy and vision of Qatar?

- Government support is provided to farms through loans and guidance
- Culturally agriculture is encouraged



How water intensive is the food production/acquisition method, is the water consumed locally, or is it virtual water?

- Local food production uses non-renewable and limited groundwater aquifers

What is the food production/ acquisition method cost? Are the costs likely to fluctuate?

Local food production is much more expensive (when all factors considered) in comparison to food imports, however, more prone to price fluctuations due to market and climate

How energy intensive is the food production/acquisition method, considering the complete value chain of a food product?

- While food imports require energy, it is not Qatar's
- The need to desalinate local brackish aquifers makes local food production energy intensive

[1] Figure 22 is based on EY internal analysis.

Figure 3 Water Security Trade Offs in the GCC[2]

How secure are the country's water sources? Are they resilient against climate and market shocks?

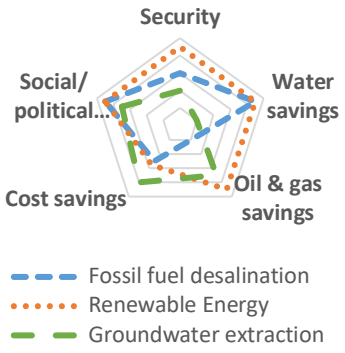
- Renewable powered desalination is more secure in the long-term, because it decouples water from natural gas
- Groundwater extraction is prevalent, however aquifers are depleting faster than their regenerative capacity

Is there political and social support for the method of water production and acquisition? Is it in alignment with the strategy and vision of Qatar?

- Government targets to diversify Qatar's energy mix inadvertently support non-fossil fuel desalination
- Strong government awareness on need to scale back groundwater extraction though opposition will exist

What is the water production/ acquisition method cost? Are the costs likely to fluctuate?

- Desalination is energy-intensive, and the cost will vary as energy prices fluctuate, but likely to decrease with time, as cost of renewables continues to drop, and natural gas prices go up



How does the water production/acquisition method impact domestic water resources?

- Desalination in all forms enhances water availability, while groundwater extraction depletes it

How resource intensive is the water production/acquisition method?

- Renewable powered desalination does not require natural gas, thereby presenting a large national energy saving

When analyzing food security, Qatar has to look at fundamental tradeoffs associated with different food security strategies. For example, a strategy of local food production relative to food importation is signficantly more water and energy intensive, as water used in agriculture results from energy intensive brackwish water treatment or wastewater treatment. Consequently, while local food production provides greater security and potential cost savings, energy and freshwater are major constraints that need to be addressed.

In the case of water security, a strategy of renewable powered desalination relative to traditional cogeneration is more expensive in the immediate term, though providing greater long term security (and potentially lower costs) as it decouples water from fossil fuels. As Qatar looks to expand its local food production capacity, it must address the associated constraints of food, water and energy. Strategies, policies, and initiatives tackling such constraints are explored in section 2.6.

[2] Figure 3 is based on EY internal analysis.

2.4 Background Context

Qatar is a small country located in Southwest Asia with a total area of about 11,437 km^2 that occupies the peninsula that extends Northward from the larger Arabian Peninsula. Qatar shares its southern border with Saudi Arabia and a maritime border with Bahrain and Iran. The area has been continuously but sparsely inhabited from prehistoric times to this day[3]. Qatar is a sovereign and independent state, with Doha as its capital, which has enjoyed complete independence since 1971.

Figure 4: Geographical map of Qatar

Before World War II, Qatar was economically dependent on pearling activities, fishing and trade. Oil was first discovered in Qatar in 1939, four years after the exploration activities had started. However, oil production in Qatar was not on a commercial scale until 1949 when the revenues from the oil company (currently Qatar Petroleum Company) started to rise dramatically. By the 1970s, Qatar enjoyed a boom in its economy which has been contributing to Qatar's position as one of the countries with a high-income economy in the region[4]. The disruptive transformation brought about by the trade of petroleum and natural gas has been accompanied by a growth in Qatar's population and Gross Domestic Product (GDP) as depicted in Figure 5 and Figure 6[5] below.

[3] Rasoul Sorkhabi, *The Qatar Oil Discoveries*, 2010.
[4] Encyclopedia Britannica, *Qatar| Geography & History*, 2018.
[5] The world Bank, *Population growth and GDP in Qatar,* 2018.

Figure 5: Population growth in Qatar since 1960

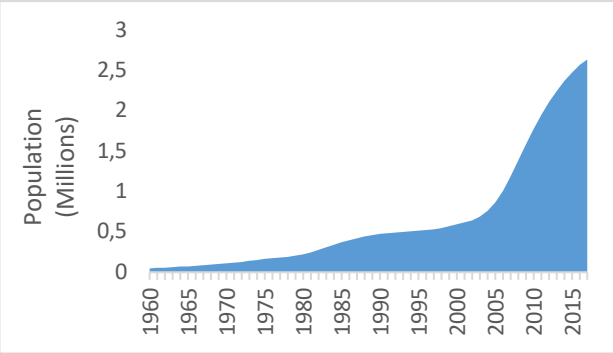
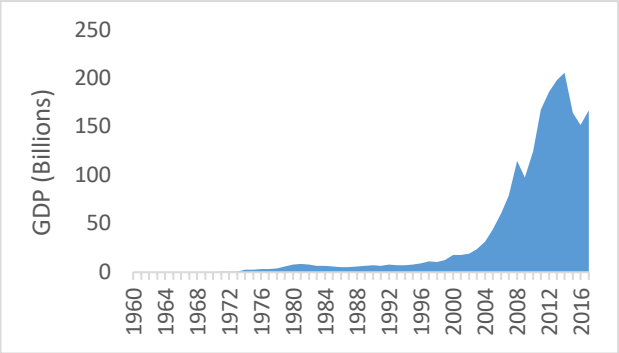


Figure 6: GDP trends in Qatar since 1970 in USD currency



Qatar's population has also been on the rise, almost tripling in the decade leading up to 2011, and showing no signs of slowing down. Qatar's population is expected to increase by 40% by 2050 compared to 2018, putting it under pressure to maintain associated demands and its resource security for continued future development[6].

Although Qatar is considered as the richest economy in terms of GDP per capita[7] (based on Purchasing Power Parity) according to IMF's 2018 figures, the journey towards maintaining its economic status in ever-changing global conditions has not been without its challenges. Qatar's economy has been highly dependent on oil and natural gas revenues, contributing to more than 50% of the GDP, 85% of export earnings, and 70% of government revenues in 2018[8]. Such wealth has allowed Qatar to maintain its water and food security through fossil fuel powered desalination, and food imports.

However, such high reliance on the country's fossil fuel and national wealth for maintaining water and food security, makes Qatar particularly vulnerable to stresses like fluctuating oil prices, population growth, increasing standards of living, and climate change. Although fossil fuel and food price linkages are a global phenomena, the interdependence of the two is even more severe and critical in Qatar. For Qatar, adopting a water-energy-food (WEF) nexus (the Nexus) approach to manage these three vital sectors is a critical step to ensure its continued future development.

[6] World Population Review, *Qatar Population 2018*, 2018.
[7] Statistics Times, *List of Countries by Projected GDP per capita 2017 (based on IMF World Economic Outlook Database, April 2017)*, 2017.
[8] Trading Economics, *Qatar GDP Growth Rate | 2004-2018,* 2018.

2.5 Qatar Resources

2.5.1 Freshwater

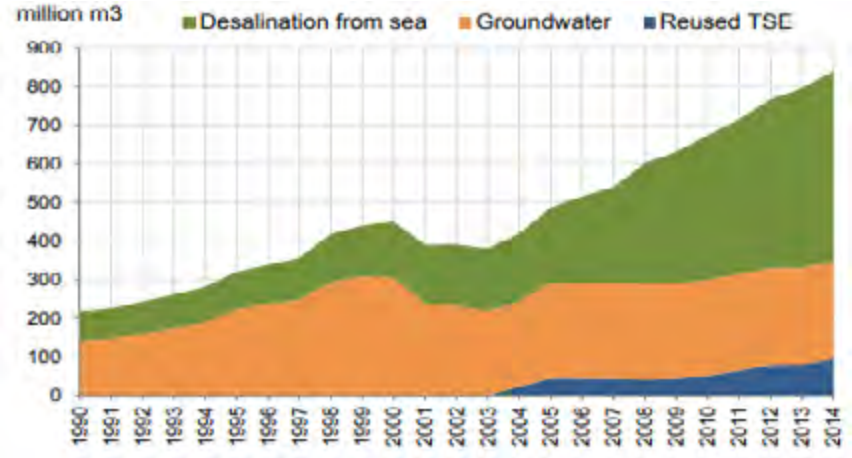
2.5.1.1 Current State

Qatar lies in the arid Arabian Peninsula, surrounded mostly by the waters of the Arabian Gulf with its only land border being Saudi Arabia. Despite its status as a water scarce country, Qatar has one of the highest water per capita consumptions in the world, at 675 litres of water per capita per day[9]. Qatar meets its water demand through its conventional and non-conventional water resources. In 2015, Qatar's water mix, presented in Figure 7, comprised of seawater desalination, groundwater abstraction and treated wastewater.

Qatar's historic, and main conventional water resource is groundwater which recharges through the Rus and Umm er Rhaduma aquifers via Saudi Arabia[10]. However, Qatar's groundwater abstraction, which currently meets 30% of total water demand is far above natural recharge levels[11]. In 2014, Qatar abstracted 252.1 million m^3, a value more than 5 times the sustainable rate, leading to reduced groundwater levels, seawater intrusion, water quality deterioration and increased aquifer salinity[12].

To supplement the limited conventional water resources under population and economic stresses, Qatar began to rely on non-conventional water resources to meet its water demand, primarily seawater desalination, and to a lesser extent treated wastewater[13]. Qatar's first desalination plant 'Ras Abu Aboud' was built in 1962. Since then, Qatar has invested in and built a number of desalination plants across the country, with an installed capacity of around 1.5 million m^3/day[14]. Desalinated water is mainly utilized for municipal and industrial water needs, where it currently meets around 99% of the potable water needs.

Figure 7 Qatar's Water Supply Mix 1990 to 2014[11]



[9] Gulf Intelligence, The future of Qatar's Water Security, 2016
[10] Hukoomi, Water and Desalination
[11] Ministry of Development Planning & Statistics, Water Statistics in the State of Qatar 2015, 2017
[12] Water Statistics, Ministry of Development Planning and Statistics, 2015
[13] Hanan O. Ali et al., Current and future water resources for agriculture in Qatar State, 2017
[14] KAPSARC, GCC Energy System Overview 2017, 2017

In addition to desalination, treated wastewater is becoming a significant non-conventional water resource in Qatar since its introduction in 2004. In 2014, it contributed 11% to Qatar's total water mix, being used primarily for agriculture and landscaping/ green spaces[11]. Water use has increased by almost 81% in the decade leading up to 2014. As can be seen in the below Figure 8, the agriculture sector was the highest consumer of water followed by residential, government, commercial and industry sectors, in that respective order. However, the total use of water by the agriculture sector has remained lower than 300 million m^3 throughout the period with a total growth rate of only 14%, as can be seen in Figure 9. The government and commercial sectors have the highest growth rates of 340% and 205%, respectively[15].

Figure 8 Water Use per Economic Activity

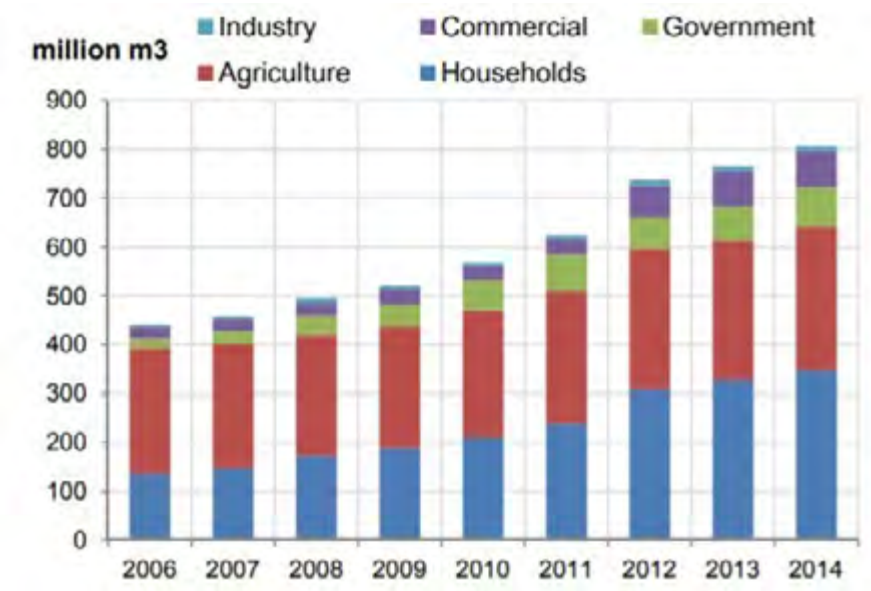
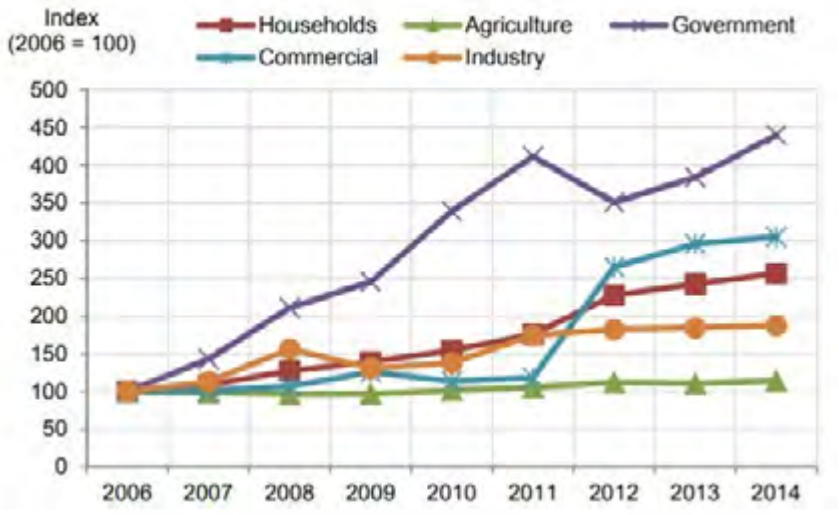


Figure 9 Growth Rate of Water Use per Economic Activity



[15] Ministry of Development Planning & Statistics, Water Statistics in the State of Qatar 2015, 2017

Another area of concern for Qatar and other countries in the region whom lack conventional water resources and rely heavily on desalination is water storage. Qatar only has around 48-hour storage supply of water on hand at any given time in case of emergencies. As such, Qatar is investing in potable water storage capacity by developing the Water Security Mega Reservoirs Project. The first phase of the project, which started in 2015 consists of constructing 24 large concrete reservoirs by 2026, providing 2.3 billion gallon water storage capacity and seven days of potable water within its network system[16].

2.5.1.2 Future Outlook

Spurred by economic development and population growth, Qatar's water demand has been growing significantly over the past years, and is expected to increase by 69% from 2015 to 2025. For Qatar to ensure water security in the future, an adoption of a combination of the below measures and initiatives is proposed to overcome the existing and speculated future challenges[17].

How will Qatar maintain its water security in the future?

Supply: As the demand for domestic and agricultural water increases, renewable-powered desalination is one option being considered as a replacement for current fossil fuel powered technologies. In addition, the use of treated wastewater use will increase to limit the depletion of groundwater aquifers.

Demand: Qatar has implemented a number of strategies and programs that encourage and implement a greater demand side management effort across all sectors – a trend that is expected to continue and expand. Efforts to limit the depletion of groundwater will increasingly be employed including the replacement of water intensive crops with higher value and more water efficient ones. Behavioural changes, application of new technologies (i.e. monitoring systems and increasing the efficiency of the T&D systems and solar systems in the desalination sector), removal/phasing out of subsidies and increasing tariffs will also reduce the overall demand for water.

In addition to supply and demand side initiatives, Qatar will need to improve their response to climate risks, such as sea level rise.

[16] Oxford Business Group, Capacity increase in power and water ultities key to supporting Qatar's economic expansion, 2018

[17] Based on EY internal analysis.

2.5.2 Energy

2.5.2.1 Current State

Qatar's economy relies mainly on its energy resources. It is the worlds' largest exporter of liquefied natural gas (LNG) and has the world's third largest proven natural gas reserves at 24.5 trillion m^3 [18]. The bulk of its gas reserves are found in its North Field, which is the world's largest non-associated gas field. Its natural gas production in 2017 stood at 175 billion m^3, a production rate that can be sustained for the next 138 years[19]. As such, Qatar stands as one of the world's wealthiest and most energy independent nations.

Given it natural gas abundance, Qatar's power generation and desalination in the country is fuelled almost exclusively by natural gas. However, Qatar has taken some initiative toward diversifying its energy mix through renewables, along with improving energy efficiency. The country's recent visions and national strategies, discussed further in Section 2.6, are centred on increasing its renewable energy investment and diversifying its national energy mix with a target of generating 20% of its electrical demand through solar by 2030[20]. Under this long term target, Qatar plans to set up to 10 GW of solar power capacity by 2030[21]. A series of public and private investments are driving new developments in Qatar's solar energy sector to meet the 2030 targets. Qatar Petroleum (QP) and Qatar Electricity and Water Company (QEWC) signed a Memorandum of Understanding (MoU) for the formation of a solar energy joint venture – Siraj Power – in 2016. The two companies have announced that they will invest USD $500 million of start-up capital to the joint venture to develop a 200 MW solar power plant to be fully operational by 2020. There are plans to expand the plant's capacity to 500 MW in the future[22]. This is in support of Qatar's plans of setting up 1,800 MW of power capacity by 2020, which is expected to contribute up to 16% of Qatar's total power production. Other initiatives by the private sector include the announcement by Qatar Solar Technologies (QSTec) – a joint venture between Qatar Solar (a subsidiary of Qatar Foundation), Germany's SolarWorld AG, and Qatar Development Bank – to build a PV technologies producing plant[23].

It is also worth highlighting Qatar's proactive regional research and development role. Its many universities and research institutes, some of which are highlighted in Chapter 0 are engaged in a myriad of renewable energy research and pilot projects that aim to adapt cutting edge technology to the region's unique geography and climate.

In terms of utilizing waste for energy generation, Qatar is ahead of its regional neighbours. Completed in 2011, Qatar's Domestic Solid Waste Management Centre in Mesaieed processes up to 2,300 tonnes of waste per day[24]. Post separation, the facility incinerates non-organic waste, generating and exporting up to 30 MW of electricity to the grid. The separated organic fraction is also anaerobically treated to produce biogas that then generates up to 8MW of electricity. Collectively, the plant diverts up to 95% of incoming waste from the landfill and contributes to the country's renewable energy targets. However, with Qatar

[18] The Oil & Gas Year, Qatar Overview, 2018
[19] Alsheyab Mohammad, Qatar's effort for the deployment of carbon capture and storage, 2017
[20] Saur Energy International, Qatar to adopt first renewable energy strategy, 2017
[21] Renewable Energy Magazine, Qatar to begin construction of 200 MW solar project this year, 2017
[22] Trade Arabia, Qatar to start work on major solar power plant in June, 2017
[23] Oxford Business Group, Qatar gets serious about solar, 2017
[24] Keppel Seghers, Domestic Solid Waste Management Centre, 2014

producing more than 2.5 million tonnes of municipal solid waste each year (6,850 tonnes/daily), there is still great potential for waste to energy, biogas and/or landfill gas.

From a demand perspective, Qatar is one of the world's highest per capital electricity consumers, with each inhabitant consuming an average of 15.3 MWh in 2014, almost 5 times the global average[25]. In light of the country's growing population, economic development and upcoming 2022 FIFA World Cup, the country is experiencing profound increases in its power demand. The country has an electrical demand growth rate of around 10% annually for the past decade and is projected to increase by 6.25% between the years 2018 to 2022, with a total projected consumption of 60 TWh by 2022[26].

Figure 11 highlights Qatar's 2014 electricity consumption by sector, with the residential sector being the biggest consumer, followed by industry[27]. Buildings consume most of the total generated electricity in the country, with 70% [28]going towards cooling.

Figure 11 2014 Electricity Consumption by sector[27]

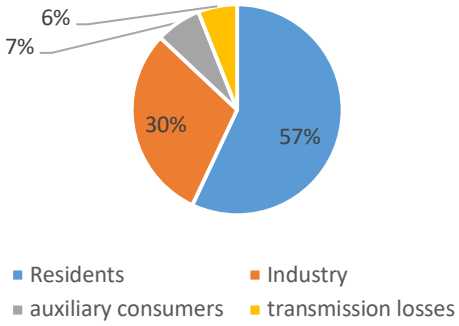
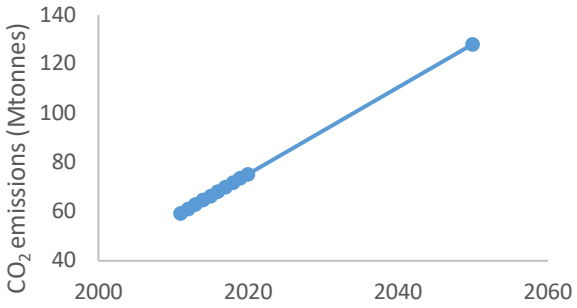


Figure 10 Qatar's Projected GHG Emissions by 2050



[25] World Bank Data, Electrical Power Consumption (kWh/Capita), 2014
[26] Tarsheed, Kahramaa Sustainability Mission 2030
[27] Qxford Business Group, Qatar: Industry
[28] PeninsulaQatar, 70% of electricity consumption is from ACs

2.5.2.1 Future Outlook

Based on the current electricity generation infrastructure, the increase in energy demand will also result in higher greenhouse gas emissions. Figure 10 displays the GHG emissions in Qatar with a projected increase of 116% in 2050 from a 2011 baseline[29]. For Qatar to ensure energy security in the future, an adoption of a combination of the below measures and initiatives is proposed to overcome the existing and speculated future challenges[30].

How will Qatar maintain its energy security in the future?

Supply: Qatar will continue to rely on its natural gas reserves for the foreseeable future to maintain its own energy security. However, the country will also push to diversify its energy mix, primarily through solar power and to a much lesser extent waste to energy. As per Qatar's Vision 2030, Qatar aims to increase its share of solar power generation to 20% of total demand by 2030. Qatar will work to improving the efficiency of its energy generation processes, by monitoring the operational performance of all independent power and water producers and adopting efficient economic operations.

Demand: Qatar is undergoing major revisions to utilities tariffs and subsidies to encourage rationalized consumption. New policies and regulations will encourage greater demand side management efforts across all sectors. Initiatives will increase in the form of distributed energy resources (i.e. solar cooling and power), mandatory green building codes (i.e. GSAS), ESCO markets, as well as the greater adoption of energy saving smart technologies and systems across sectors. Behavioural changes, brought on by awareness (i.e. Kahramaa's Tarsheed program) and tariff reform will also reduce the overall demand for energy.

[29] Forecasting CO_2 emissions in the Persian Gulf States, 2017
[30] Based on EY internal analysis

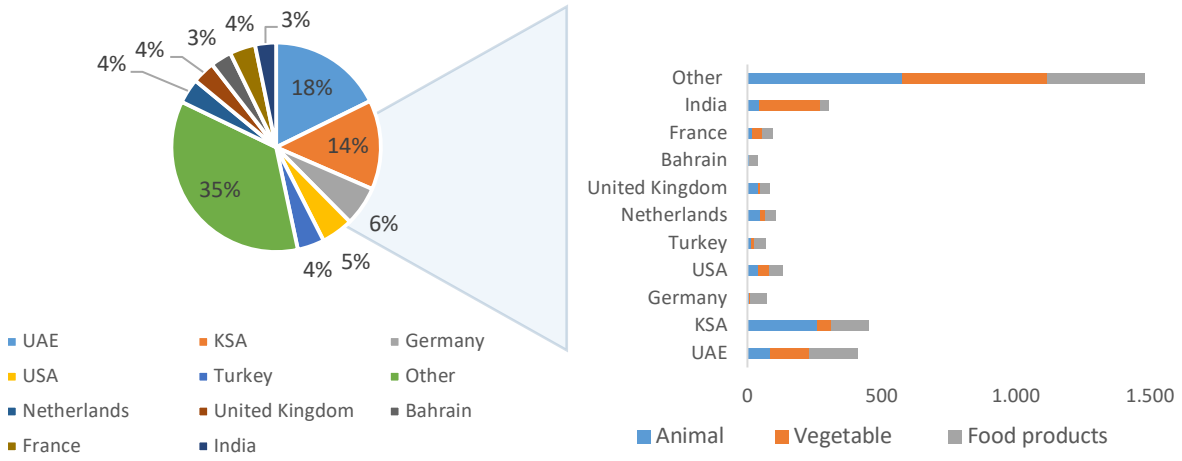
2.5.3 Food

2.5.3.1 Current State

Qatar's arid climate and limited arable land (1.6%)[31] prevents it from achieving food independence for its growing population. Currently, less than 1% of the land is cultivated and agriculture contributed less than 0.2% to the country's GDP in 2016[32]. Although domestic agricultural production exists, its capacity is limited and the country has historically leveraged its economic stability and wealth to import the majority of its food requirements. According to the Global Food Security Index (GFSI), Qatar is ranked 29th globally with a score of 73.3[33].

Qatar meets most of its food demands through food imports from various countries. Figure 12 highlights Qatar's dependency on food imports with a total of USD 1.02 million in 2016, representing a compounded annual growth rate (CAGR) of 9.9% from 2010. In 2016, Qatar imported 3.84% of its food from the Netherlands. These imports amounted to USD 39 million and were dominated by food products, with a smaller portion of animal, fruits and vegetables[34].

Figure 12 Qatar's food import mix and import breakdown of the top 10 trading partners in 2016 (million USD) [16]



While Figure 12 illustrates the different food products Qatar imports, the country does produce a variety of crops within the country. Figure 13 highlights some of the fruits and vegetables Qatar grows such as eggplants, pumpkins and cabbages with the bulk being the growing and harvesting of dates[35]. One of Qatar's food security initiatives is to secure agricultural land abroad through foreign direct investment (FDI). Qatar has done so in several countries including Sudan[36].

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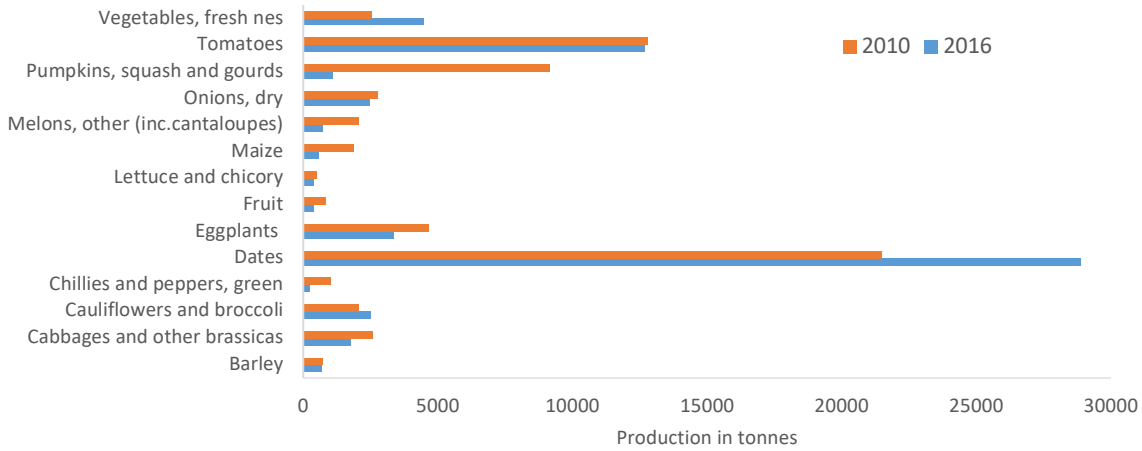
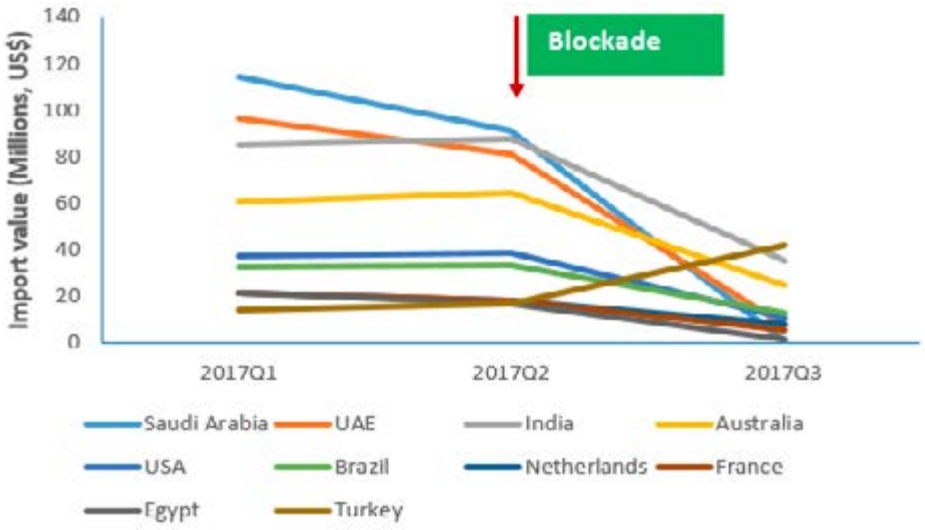
[31] Nik-Othman Abdullah,Hydroponic farming for domestic food production, 2016
[32] The Global Economy, Qatar: GDP Share of Agriculture, 2018
[33] EIU and The Economist, *Global Food Security Index,* 2017
[34] WITS, Qatar Food Products Imports by Country and Region, 2016
[35] FAO, Qatar Crops
[36] Dabanga, Qatar to invest in Sudan agriculture, 2018

Figure 13 Comparison of Qatar's produce production



Although Figure 12 suggests that KSA and UAE are Qatar's largest food trade partners, food imported from the two countries constitutes re-exports from their ports rather than originating from there. Additionally, given the current diplomatic crisis between Qatar and some of its GCC neighbours, Qatar no longer imports food from KSA and the UAE. It is worth highlighting the tremendous impact that the recent regional political disputes have had on Qatar. Since the start of the diplomatic rift in June of 2017, Qatar has had to majorly redraw its food supply chain, which relied heavily on KSA and UAE. This has pushed Qatar to consider its food security more seriously than most, highlighting the need to diversify its food imports from a number of countries such as Turkey and Vietnam[37]. Figure 14 illustrates how Qatar's food imports changed before and after the blockade began.

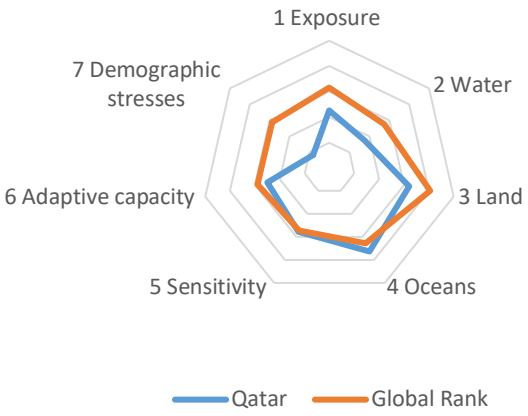
Figure 14: Food imports in Qatar before and after blockade[38]



[37] Investvine, Vietnam to corporate with Qatar on food security, 2018
[38] National University of Singapore, Insight 185: Contemporary Issues in Qatar's Food Security, 2018

As Qatar remaps and configures its food security strategy it must also consider its resilience to certain food security pressures as highlighted in Figure 15, particularly with respect to water, exposure and demographic stresses[39].

Figure 15: Qatar Food Security Index Pressures

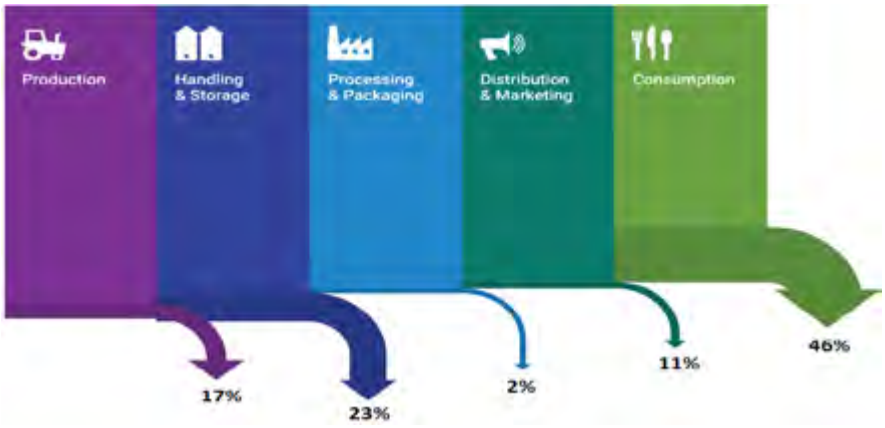


Pressure	Food Security pressure components
1. Exposure	Temperature rise, sea level rise, drought, flooding, storm severity
2. Water	Agricultural water availability, water quality
3. Land	Soil erosion, soil salinity
4. Oceans	Eutrophication/hypoxia, marine biodiversity and protected areas
5. Sensitivity	Food import dependency, disaster risk management, natural capital dependence
6. Adaptive capacity	Early warning measures, climate smart agriculture, National agricultural risk management system
7. Demographic stresses	Population growth, urbanization

On the demand side, much food is ultimately lost throughout the supply chain in Qatar, estimated at around 30% [40]. Food loss in Industrialized Asia, which Qatar's profile falls under is presented in Figure 16, with the majority of losses occurring during handling and storage and later at consumption. In 2018, a combined research effort by multiple universities led by Georgetown University under the banner of 'SAFE-Q' conducted a detailed analysis of the causes of food waste occurring during the handling, distribution, transportation, and storage of food, as well as during food preparation, cooking, and consumption[41]. The initiative aims to "provide businesses, policy makers, and members of the public with greater insight into the problem as well as the information they need to take practical steps to limit food waste". As such, significant opportunities exist to reduce food loss at the handling and storage phase, consumption phase and handling of the final waste through areas such as biogas and compost production.

[39] EIU and The Economist, *Global Food Security Index,* 2017
[40] EcoMENA, *Food Waste Woes in Qatar*, 2016
[41] Georgetown University of Qatar, Researchers Share Findings of Study on Food Waste in Qatar, 2018

Figure 16: Food waste across supply chain in industrialized Asia[42]



[42]M. Kummu et Al., L*ost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use*, 2012

2.5.3.2 Future Outlook

As Qatar's population continues to increase, it will face the challenge of a growing demand coupled with a lack of sufficient arable land for growing fruits and vegetables domestically. For Qatar to ensure food security in the future, an adoption of a combination of the below measures and initiatives is proposed to overcome the existing and speculated future challenges[43].

How will Qatar maintain its food security in the future?

Supply: Food imports will remain important in Qatar's food security strategy. Qatar will continue to ensure its food security through varying its food import sources, investing in agricultural farmland abroad and the further development of its agricultural industry. Qatar will also look to consider climate and market risks more rigorously in its international food import strategy and adopt national risk management strategies such as physical stockpiling and early warning systems.

Domestic food production will also shift towards modernizing the agricultural sector across the value chain. Food production will become smarter and less resource intensive, leveraging more efficient approaches and technologies such as climate suitable crop selection, hydroponics, aeroponics and aquaponics. All of which will be supplemented with production in the sea, through aquaculture developments.

Demand: Qatar's efforts to reduce food loss across the supply chain will intensify, leveraging technologies such as IoT to improve handling and storage. Additionally, more food waste will be diverted from landfills to more productive uses, such as fertilizer production and power generation through bio-gas.

[43] Based on EY internal analysis.

2.6 National Strategies, Visions and Objectives

2.6.1 Federal level

The run up to the year 2030 will witness a series of reforms and investments aimed at implementing the myriad visions and programs of Qatar under the Qatar National Vision 2030. Although these strategies target different sectors, they all share similar overarching components: sustainable use of resources, diversification of the economy and sources of water, energy and food security, innovation, education and awareness.

National strategies, visions and objectives are detailed below, consisting of both supply side and demand side elements. WEF security is ultimately about building resilience. This requires diversifying the supply and demand strategies that complement one another and engaging the population in a meaningful way to change their current behaviours. Figure 17 summarize the main strategies, visions and plans.

Figure 17: National level strategies and visions

2.6.1.1 Paris Agreement (Intended Nationally Determined Contributions)

Qatar, among other parties to the UN Framework Convention on Climate Change (UNFCCC), have formally submitted their Intended Nationally Determined Contributions (INDCs), outlining their national circumstances and the post-2020 climate actions they intend and plan to take. The INDCs came in advance of the Paris Agreement, which is a universal climate change agreement that required all parties to put forward their best efforts through nationally determined contributions and to strengthen these efforts in the coming years. The main aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise for this century well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

Through their INDCs, Qatar communicated the country's economic diversification with mitigation co-benefits in energy efficiency, clean energy and renewables, research and development, education, and tourism. It also communicated adaptation actions with mitigation co-benefits in water management, infrastructure and transport, waste management, and awareness.

2.6.1.2 The UN Agenda 2030 for Sustainable Development

The UN Agenda 2030 for Sustainable Development is the central UN action plan that embeds 17 Sustainable Development Goals (SDGs) and 169 targets that are critical for humanity and the planet. The

successful implementation of Agenda 2030 is founded on efficient peer learning and knowledge sharing between nations.

In 2017, Qatar submitted the first Voluntary National Review (VNR) of the State of Qatar with regards to the UN Agenda 2030 to the High-level Political Forum (HLPF)[44]. The VNR submission outlined how the UN's Sustainable Development Goals were integrated in Qatar's Second National Development Strategy (NDS-2) 2018 – 2022. Ministries, government entities as well as the private sector, civic society, research and academic centres are supporting the implementation of the strategy.

2.5.1.3 Qatar National Vision (QNV) 2030[45]

Launched in 2008 by the General Secretariat for Development Planning in Qatar, the QNV 2030 serves as a roadmap towards driving Qatar's growth forward by balancing the accomplishments that achieve economic growth with the human and natural resources. The vision aims at transforming Qatar into an advanced country by 2030, capable of sustaining its own development and providing for a high standard of living for all of its people for generations to come. Qatar's national vision rests on four pillars – human development, social development, economic development and environmental development.

2.5.1.4 Qatar National Food Security Program (QNFSP)[46]

The Qatar National Food Security Program is a taskforce consisting of 17 relevant departments and institutions from the government and private sectors that was established in response to the 2008 global food crisis with the aim of increasing self-sufficiency from 10% to 70% by 2023. The QNFSP lays out a growth plan that seeks to make Qatar's water and food secure by balancing the relationship between economic and population growth, reduce overall risk to the country and foster a diversified economy. The four key sectors that the program focuses on are agriculture, water, renewable energy and food manufacturing. The QNFSP plays a major role in advising relevant government agencies on legislation and regulations for food and water, while leveraging investment opportunities in the areas of infrastructure, education, and technology to drive improvements and diversify Qatar's economy.

2.5.1.5 Qatar National Research Strategy[47]

The Qatar National Research Strategy (QNRS) first published in 2012, provided the basis for the national research program to develop the capabilities of Qatar's people and institutions. The QNRS 2014 builds on the achievements and focusses in detail on Qatar's current challenges. It provides a structured framework for Qatar Foundation's research and development objectives and helps in driving the program plans and measures of performance by guiding decision makers in identifying investment opportunities in R&D programs that address critical national priorities and progress towards QNV 2030. The Qatar Foundation R&D Enterprise has instigated an annual forum to discuss key issues with stakeholders and drive the QNRS forward. The forum has identified four Grand Challenges to be assigned to relevant Qatar Research Institutes to drive the stakeholder community to take action. The Grand Challenges focus on the need for enhanced water security, energy security, cyber security, and healthcare.

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[44] The United Nations, *Qatar Voluntary National Review 2017*, 2017.
[45] Ministry of Development Planning and Statistics, *Qatar National Vision 2030*, 2017.
[46] Qatar National Food Security Program, 2018.
[47] Qatar National Research Strategy, 2018.

2.5.1.6 The National Development Strategy[48]

The first National Development Strategy for Qatar 2011-2016 was developed to provide guidance on the goals and objectives of the QNV 2030 and pave the way for Qatar's economic, social, cultural, and environmental development. Thus leading to an even more prosperous Qatar and setting the pace for future national strategies to drive the progress further.

The second National Development Strategy for Qatar 2018 – 2022 builds on the achievements and lessons learnt of the first strategy and continues to support towards implementing QNV 2030, in addition to improving economic performance and future aspects. The strategy pledges to rationalize energy consumption and encourage development of renewable energy while raising the self-sufficiency for farming and fishing production, among other key aspects.

2.5.1.7 Tarsheed Strategies and Projects[49]

The Conservation & Energy Efficiency (CN) Department was created in 2011 with the vision of maximizing the efficient and effective management of resources to make Qatar a regional leader in terms of electricity and water consumption reduction per capita, while maintaining a high standard of conservation in building construction. Thus, the National Campaign for Conservation and Efficient Use of Water and Electricity, Tarsheed, was launched. Tarsheed encompasses numerous strategies and projects to meet the targets of the national campaign that focuses on efficiency in consumption, conservation, awareness and community development, and law enforcement and regulations.

2.5.1.8 Qatar National Biodiversity Strategy and Action Plan[50]

In order to control the impact of rapid development and industrialization, Qatar has formed the National Biodiversity Strategy and Action Plan (NBSAP) 2015-2025 which is in line with the Vision 2030. The emphasis of the plan is sustainable development through a mix of socio-economic benefits with the conservation of biodiversity and natural heritage. The plan is an update from the National Biodiversity Strategy and Action Plan formed during 2004. The main purpose of this update is to revisit the 11 strategic goals set out in Qatar's original NBSAP, and set out a more focused path.

[48] Ministry of Development Planning and Statistics, *Qatar National Development Strategy*, 2017.
[49] Tarsheed: Strategies & Projects, 2013.
[50] Qatar National Biodiversity Strategy and Action Plan 2015 – 2025, 2014.

3. Qatar WEF Nexus Snapshot

This chapter aims to provide a snapshot of the current state of the WEF Nexus within Qatar. The chapter is structured according to the Nexus intersects of Water-Food, Water-Energy and Energy-Food. Though not exhaustive, the way in which WEF security is achieved in the country is captured through the Nexus Maps illustrated in Figure 18, Figure 19 and Figure 20. The Nexus Maps help structure the complex interactions and interlinkages of the Nexus, providing a high level understanding of WEF dynamics and security. Meanwhile, Table 2, Table 3, and Table 4 outline the various technologies and approaches currently utilized in Qatar for each Nexus intersect in detail, coupled with corresponding initiatives and programmes within the past 5 years. The references for the initiatives can be found in Appendix A.

Table 1: Scoring criteria of WEF Nexus approaches/technologies

Approach/technology maturity	
Score	Description
1	Non-existent
2	Interest/awareness present
3	Pilot project or significant research on the area exists
4	Emerging in the market
5	Well established

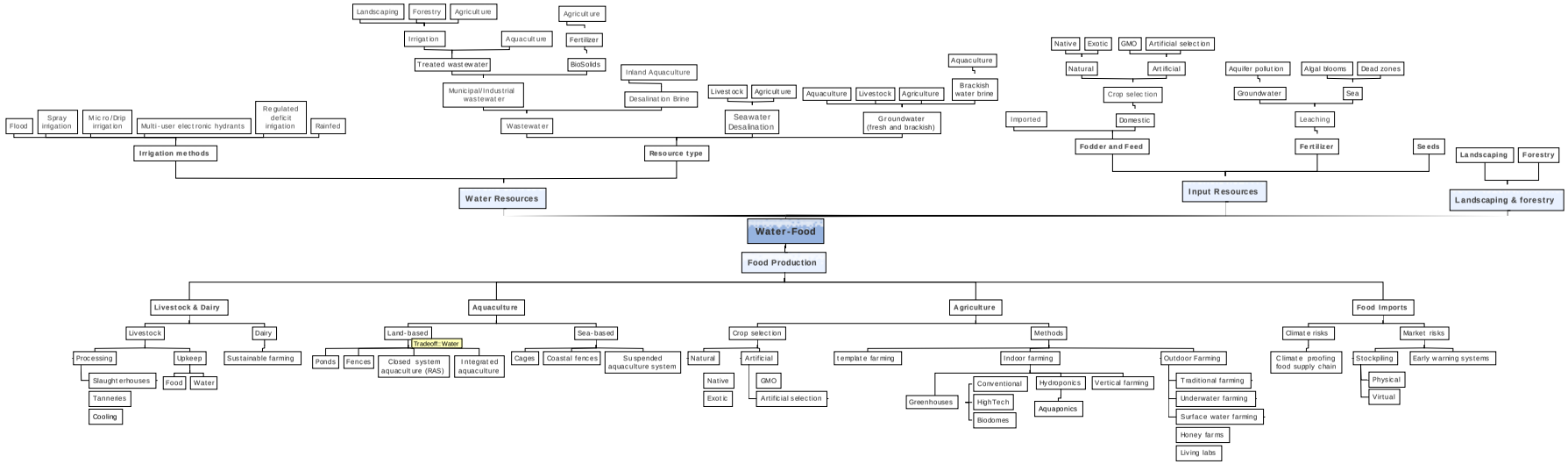
Approach/technology growth potential	
Score	Description
1	Declining growth
2	No growth
3	Low growth
4	Medium growth
5	High growth

The strengths and limitations of each approach/technology are outlined and scored as per the criteria in Table 1. The criteria is based on maturity level and growth potential. Maturity level relates to how well-established a particular approach/technology is in the country while growth potential considers strengths and limitations (i.e. environment, laws and regulations, consumer preferences etc.). The scoring for each criteria were based on extensive research of the different initiatives and programs carried out across Qatar. The scores are presented in Tables 2, 3 and 4.

3.1 Water-Food

Figure 18 shows the Water-Food Nexus Map in the GCC which explores food production and its various inputs from the perspective of water. Various food production/acquisition methods are captured, including: livestock and dairy, aquaculture, agriculture and food imports. These categories are further broken down by practice of production. The required input resources includes the material used in food production such as fodder and feed, fertilizer and water. Water resources are covered in a separate section of the map due to the extensive consideration of water resources ranging from irrigation methods, wastewater, seawater desalination and groundwater. The below figure is based on EY internal analysis.

Figure 18: Water-Food Nexus Map for GCC[51]



[51] Figure 188 is based on EY internal analysis.

Table 2: Qatar Water-Food Nexus Initiatives

SN	Category 1	Category 2	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
WF -1	Livestock, Poultry & Dairy	Livestock (cow, sheep, goat and camel)	Livestock protection & development	- Improved licensing and monitoring of veterinary products/medicine results in higher product quality, lower disease outbreaks and therefore higher yields	- No significant limitations	3	3	- Livestock Production Research Plant, The Ministry of Municipality and Environment
WF -2			Sustainable breed selection	- Particular breeds can be less resource intensive (i.e. water) and more heat tolerant	- Consumers may prefer particular breeds based on quality - Farmers are inclined to raise those with the highest profit margins	3	3	- The Animal Production Research Station in Al Shahaniya, The Ministry of Municipality and Environment
WF -3			Production systems	- The design and choice of particular production systems (meat or dairy production) can reduce costs, disease outbreaks, environmental impact and resource requirements	In Qatar, certain production systems are constrained by: - Climate (i.e. temperature, rainfall etc.) - lack of natural shrub/vegetation for grazing	2	4	- Agriculture research strategy, The Ministry of Municipality and Environment
WF -4			GMOs	- Opportunities to improve yields through disease resistance, saline water tolerance and heat tolerance	- Public hesitation/resistance towards GMOs	2	3	- GM food labelling under consideration
WF -5		Poultry	Farming of poultry	- Suitable for the climate conditions - Less resource intensive than livestock - Relatively low maintenance costs	- Prone to disease outbreaks due to poor ventilation - Low profit margin on poultry -Requires large supply of feeds and medicines	4	4	- Poultry production, Arab Qatari Company for Poultry productions
WF -6	Agriculture	Crop Selection	Native and climate compatible species	- Salt and heat tolerant crops - Reduced need for freshwater - Synergy with voluntary and mandatory green building standards	- Limited variety of crops - Legal challenges in registering new crop varieties	4	3	- Date production, National Food Co., Hassad Food
WF -7			Seaweed and macro-algae farming for animal feed	- Low input requirement - High in nutrients	- Requires controlled conditions - May prove difficult to scale up - Significant investments (QR 45 million) have already been made in a Green Fodder Project, which will meet 90% of fodder needs in Qatar by end of 2018	3	3	-Algal Technologies Program (ATP) and Food & Water Security Programs at Qatar University
WF -8			Domestic production of Fodder and feed	- High demand for fodder - Reduced reliance on imports - Emergence of fodder irrigated by saline waters	- Fodder cultivation competes with other crops for water resources - Fodder crops are generally water intensive (such as Rhodes grass)	4	3	- Umm Ghuwailina Green Fodder Project, Al-Baidaa Group & The Ministry of Municipality and Environment
WF -9			Artificial (Artificial Selection & GMOs)	Opportunities for improved yields, and disease, draught, heat and salt resistance	- Public hesitation/resistance towards GMOs	2	3	- GM food labelling under consideration
WF -10		Greenhouses and	High-tech greenhouses	- Increased crop productivity & growth rate - Improved water and energy efficiency	- High CAPEX	4	5	- Distribution of 73 greenhouses to local farms

SN	Category 1	Category 2	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
		Hydroponics		- Increased crop variety - Self-sufficiency of food production through the available fruits and vegetables	- In extreme heat, acts as a heat trap killing crops - Does not facilitate pollination			- Greenhouses run by a computerized pad fan cooling system, Arab Qatari Agricultural Production Co., Hassad Food - MoU between AgroQatar and Gulf Petroleum for the development of high-tech greenhouses
WF -11			Seawater greenhouses	- Creates ideal growing conditions for crops while producing fresh water for irrigation	- High CAPEX - Fine tuning of complex system - Potential aquifer contamination from seawater	2	3	- Sahara forest pilot project (2009), Yara International and QAFCO (Project no longer seems to be active)
WF -12			Bio-domes	- Energy & cost efficient - Synergies with voluntary & mandatory green buildings standards - Can serve educational purposes - The government, in partnership with Qatar Development Bank, is also offering local farms subsidies and loans to encourage them to convert to hydroponics.	- High CAPEX - Systems need to be thoroughly studied, designed, and fine-tuned as the approach is still in early stages in Qatar - Significant maintenance is required	1	3	- No initiatives
WF -13			Hydroponic farming	- High irrigation efficiency compared to traditional methods - Increased crop productivity - Reduced use of pesticide & fertilizer - Strong government support and financing	- High CAPEX - Risk of water microorganisms contamination - Does not facilitate pollination	4	5	- Closed hydroponic systems, AGRICO - Zulal Oasis hydroponics project, Primaflor Group & Hassad Food
WF -14			Aquaponics	- Reduced water consumption - No addition of fertilizer required - When combined with hydroponics, reduces overall water requirements of system	- High CAPEX - Needs to be coupled with hydroponic systems, which may be difficult or not feasible at times	2	5	-Ministry of Municipality and Environment is in talks with various global firms to work on the latest aquaponics methods in Qatar
WF -15		Farming	Urban Farming	- Controlled growing environment - Maximize resource efficiency - Can be integrated and adapted into existing buildings - Increase variety of crops - Synergies with voluntary & mandatory green building standards - Strong support and financing by government	- High CAPEX - Maintenance of systems may be more complicated than traditional farming	4	5	-Agricultural farm with 38 hectares open fields for vegetable crops, Arab Qatari Agricultural Production Co., Hassad Food - Home-Farming Hydroponics initiative, Qatar Development Bank
WF -16			Surface Water Farming	- Extensive coastline and access to sea	- Uncontrolled conditions - Dependent on availability of salt and heat tolerant crops	1	5	-No initiatives

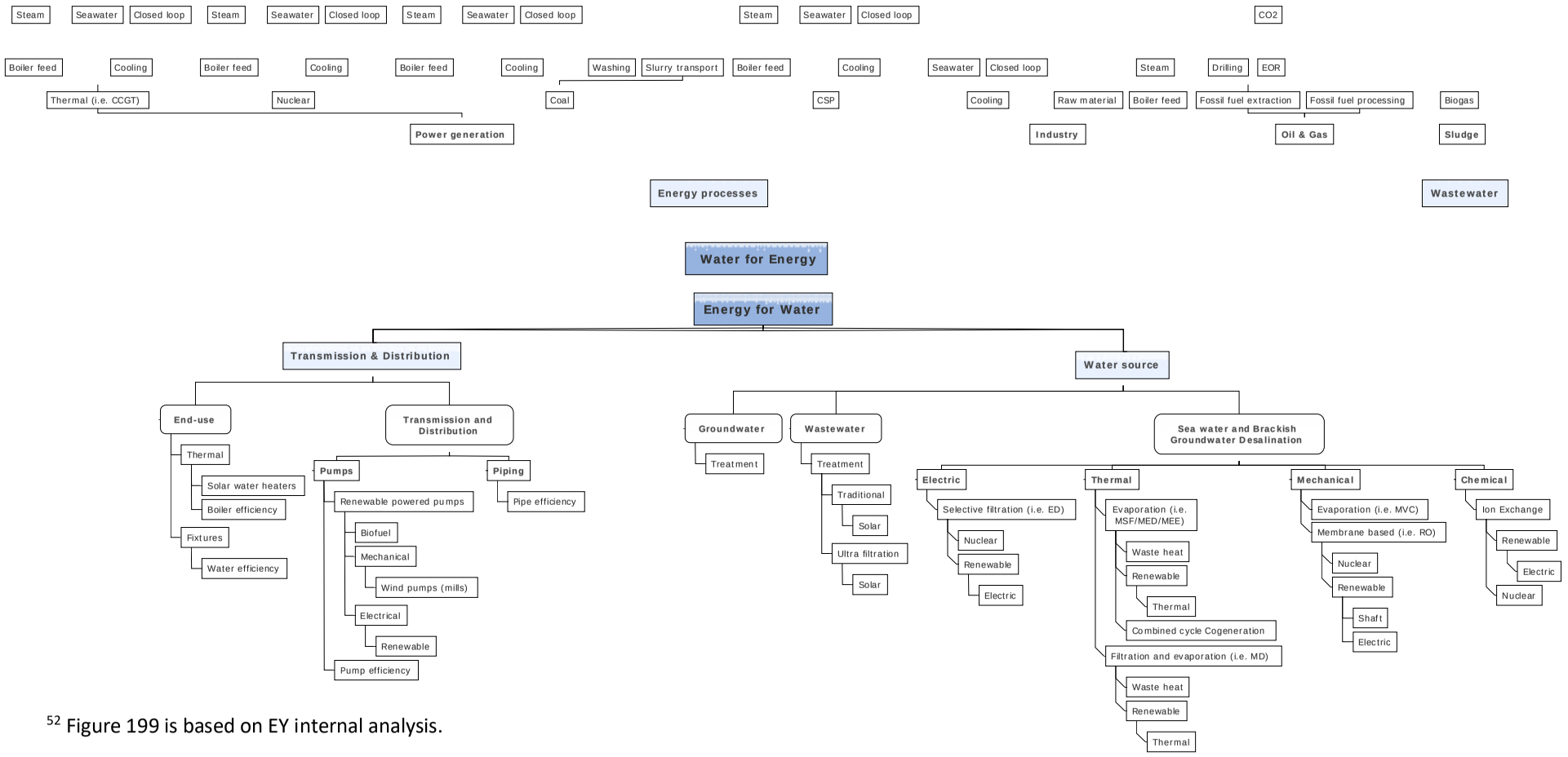
SN	Category 1	Category 2	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
WF -17			Honey Farms	- Opportunities for coupling for pollination -Strong cultural interest & demand	-Weather conditions, including temperatures, dust and humidity - Relatively small country size	4	3	- Bu Saif Apiaries - Distribution of hives and honey colonies along with pesticides and tools, The Ministry of Municipality and Environment.
WF -18			Organic Fertilizers	- Reduced environmental damage caused by eutrophication and leaching into aquifers	- Potentially more expensive - Potentially more difficult to collect and process	3	5	- Tadweer Initiative, The Ministry of Municipality and Environment
WF -19			Vertical Farming	- Controlled growing environment - Maximize resource efficiency - Can be integrated and adapted into existing buildings - Increase variety of crops - Synergies with voluntary & mandatory green building standards	- High CAPEX - Requires high level of maintenance and fine tuning of system	3	4	- Vertical farming potential in Qatar through the cooperation with South Korea - AGRICO for agricultural development
WF -20			Organic Farming	- Reduced environmental damage - Strong public interest and commercial appeal	-Could result in reduced yields and higher disease outbreaks if not properly managed	3	4	-Plan to set up 5 organic farms, Ministry of Municipality and Environment
WF -21	Aqua-culture	Integrated multi-trophic aquaculture (IMTA)	Land-based aquaculture	- Usage of existing brackish water - Utilization of brine discharge from onsite brackish water reverse osmosis - Declining fish stocks	- Temperature may be too harsh for certain species - Risk of disease and contamination in closed systems, if not properly managed	3	5	- 10 fish farms to be built at a marine life research centre in Ras Matbakh with a capacity of 500 metric tons/year over
WF -22			Sea-based aquaculture	- Extensive coastline available for coastal aquaculture - Declining fish stocks	- Heat and salinity threat - Risk of invasive species	4	5	- Aquatic Fisheries and Research Centre - 2 fish farming projects with a capacity of 2,000 tons each
WF -23	Land-scaping & Forestry	Landscaping & Forestry	Landscaping	- Widespread landscaping across Qatar - Opportunities for improvements in soil, irrigation efficiency and crop selection (water, heat and salt tolerance)	- Landscaping directly competes for food production water resources unless properly managed and maintained	5	3	- The Qatari-Turkish Flower Gardens Forum, The Ministry of Municipality and Environment
WF -24			Forestry	- Opportunity for eco-tourism - Supports local biodiversity and conservation - Carbon sequestration	- High water use with no tangible benefit towards food security	4	3	- 8.3 km^2 forest near Umm Salal Ali
WF -25	Water Resources	Smart Irrigation	Drip irrigation	- High water efficiency - Smart monitoring and scheduling	- Relatively high maintenance and replacement cost	5	5	- Guidance on benefits of irrigation systems provided in Qatar National Development Strategy, General Secretariat for Development Planning
WF -26			Spray irrigation	- Ease of installation, use and maintenance - Smart monitoring and scheduling	- Less water efficient than some other irrigation methods (high evapotranspiration)	5	3	
WF -27		Cooling	Misting fans for animal cooling	- Widespread on farms	- High water use	5	3	- Misting fans use in Baladna's dairy farm

SN	Category 1	Category 2	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
WF -28		Wastewater	Treated/ recycled wastewater	- Conservation of freshwater sources - Reduced use of synthetic fertilizer - Current research promoting usage of treated wastewater in agriculture and fodder crops production - Some WWTP in Qatar such as Umm Salal Ali, currently producing high quality water (utilizing ultrafiltration and ultra-violet technology) that can be used for agricultural purposes	- Risks of heavy metal contamination to soil, crops & groundwater - Some cultural/public backlash to practice	4	4	- High quality reclaimed water at Umm Salal Ali WWTP - Research on the use of treated sewage effluent for fodder crops production, Ministry of Municipality and Environment, Public Works Authority (Ashghal) & National Food Security Program
WF -29			Aquaculture effluent	- Use effluent with salt tolerant crops - Cultivation of otherwise barren lands	- Salt tolerant crops are not widespread	3	3	- Studies being conducted by Qatar University
WF -30			Brine	- Potential for redirection towards aquaculture - Potential for mining of minerals in brine through Solar ponds, WAIV, brine concentrators, ohmic evaporators, MD & ZLD - Availability of technologies for dealing with the environmental impacts of brine discharge to sea	- Brine discharge is a by-product of the desalination process in Qatar, which can negatively impact marine ecosystems and fisheries through thermal, chemical and saline pollution.	3	3	-Brine recirculation pumps for seawater desalination plants, Torishima -Experiment to recycle desalination by-product brine, Inhabitant
WF -31	Food imports	Food import	Food import diversification and de-risking	- Ability to import food from various countries based on quality, price, availability etc. thereby constantly balancing Qatar's supply-demand gap - Qatar is significantly remapping its current food supply chain due, giving greater emphasis to food security and diversification	- Significant market and climate risks associated with over dependence on imports - As a relatively small country/market, Qatar has a lower bargaining power in global food markets	3	5	- Not formalized through a program or documented strategy, but Qatar is remapping its food supply chain and imports since the blockade began
WF -32		Food monitoring systems	Food safety monitoring systems	- Ability to track and monitor the value chain of food products from "farm to fork", thereby protecting public health and safety from possible foodborne disease outbreaks - Reduce food loss and wastage through monitoring	- Requires continuous stakeholder buy in across the food supply chain to maintain the system	4	5	- Electronic system launched to register information on all imported food, Ministry of Public Health and General Authority of Customs
WF -33			Early warning systems	- Ability to monitor and forecast market and climate related risks of major food import partners, offering resilience in case of price shocks, droughts, natural disasters etc.	- Will require government support and buy in - Requires dedicated task force to own the early warning system.	1	5	-No initiatives in place, or research into the matter

3.2 Water-Energy

Figure 19 shows the Water-Energy Nexus Map in the GCC. This was developed based on two main aspects: the use of energy for water production and treatment and the use of water in energy production. The use of energy in water production/treatment was classified based on two main areas of use, the transmission and distribution of water and the treatment of different sources of water. The sources included were groundwater, wastewater and desalinated water (segmented by technology type). The water used in the energy value chain was classified based on its predominant areas of consumption, namely power generation, industry/ oil and gas activities and wastewater treatment facilities.

Figure 19: Water-Energy Nexus Map for GCC[52]



[52] Figure 199 is based on EY internal analysis.

Table 3: Qatar Water-Energy Nexus Initiatives

SN	Category 1	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
WE-1	Waste to Energy	Bio-gas from sewage sludge	- Significant sewage generated across Qatar -Anaerobic digestion of sludge is a net energy producing process, in the form of biogas - Nutrient recovery (phosphate and nitrogen) can be used in agriculture/industrial applications - Local climate favourable to technology	- High investment cost for anaerobic digestion tanks and system	4	4	-Using waste sludge to produce methane gas, PROTEC
WE-2	Renewable energy powered desalination	MED/MSF/MEE with solar thermal	- High solar irradiance in Qatar - Opportunity for dropping costs of CSP brought on by largescale national projects in the region	- Higher CAPEX of systems (MSF/MED compared to RO and CSP compared to PV) - High energy requirement - Solar thermal systems (such as CSP) are yet to be integrated with desalination commercially - Slowing adoption of thermal desalination in Qatar and region, in favour of RO	3	4	-- As Qatar diversifies its energy mix, RO plants will be supplied more and more by renewable energy via the grid -Independent Water and Power Plants with desalination using RO, Qatar General Electricity and Water Corporation (KAHRAMAA). - Qatar Petroleum (QP) and Qatar Electricity and Water Company (QEWC) signed a Memorandum of Understanding (MoU) for the formation of a solar energy joint venture – Siraj Power. -Plans to set up a green desalination plant with Sweden that relies on solar and wind energy, Ministry of Energy and Industry.
WE-3		Reverse Osmosis with PV/ storage	- High solar irradiance in Qatar - Opportunity for dropping costs of PV brought on by largescale national projects in the region - RO has lower CAPEX compared to thermal desalination and is gaining market share in total installed capacity - Combining PV directly with RO addresses the intermittency issue as it allows for addition of RE into energy mix without the associated challenges	- Reduced RO membrane lifetime due to high salinity and high temperature of Arabian gulf seawater - High OPEX (associated with membrane replacement) - PV is yet to be directly combined with RO	3	5	
WE-4	Cogeneration	Combined cycle - MSF/MED	- Cogeneration (combined cycle with MSF/MED) is the predominant technology utilized in Qatar - Availability of coastline makes power and water generation coupling easy - Low natural gas costs (Less than 2 USD/MMBTU) - Use of by-product steam from power generation for thermal desalination - Energy storage (i.e. batteries), can be used to optimize the cogeneration process, thereby reducing the energy requirements for thermal desalination	- High CAPEX - Inherent risks associated with coupling water supply to natural gas - Cogeneration facilities are designed for an optimal MW to MGD generation ratio, which often don't match water and electricity demand, leading to inefficient burning of natural gas	5	3	-Independent Water and Power Plants with combined cycle MSF technology
WE-5	Industrial water discharge	Water discharge management	- Availability of technologies for managing the environmental impacts (i.e. chemical, thermal and saline pollution) associated with water use for industrial, power and desalination processes	- High CAPEX - Technical challenges related to the Arabian Gulf (depth, high temperature and salinity)	4	3	- Current discharge is regulated by the Supreme Council for the Environment & Natural Reserves (SCENR)

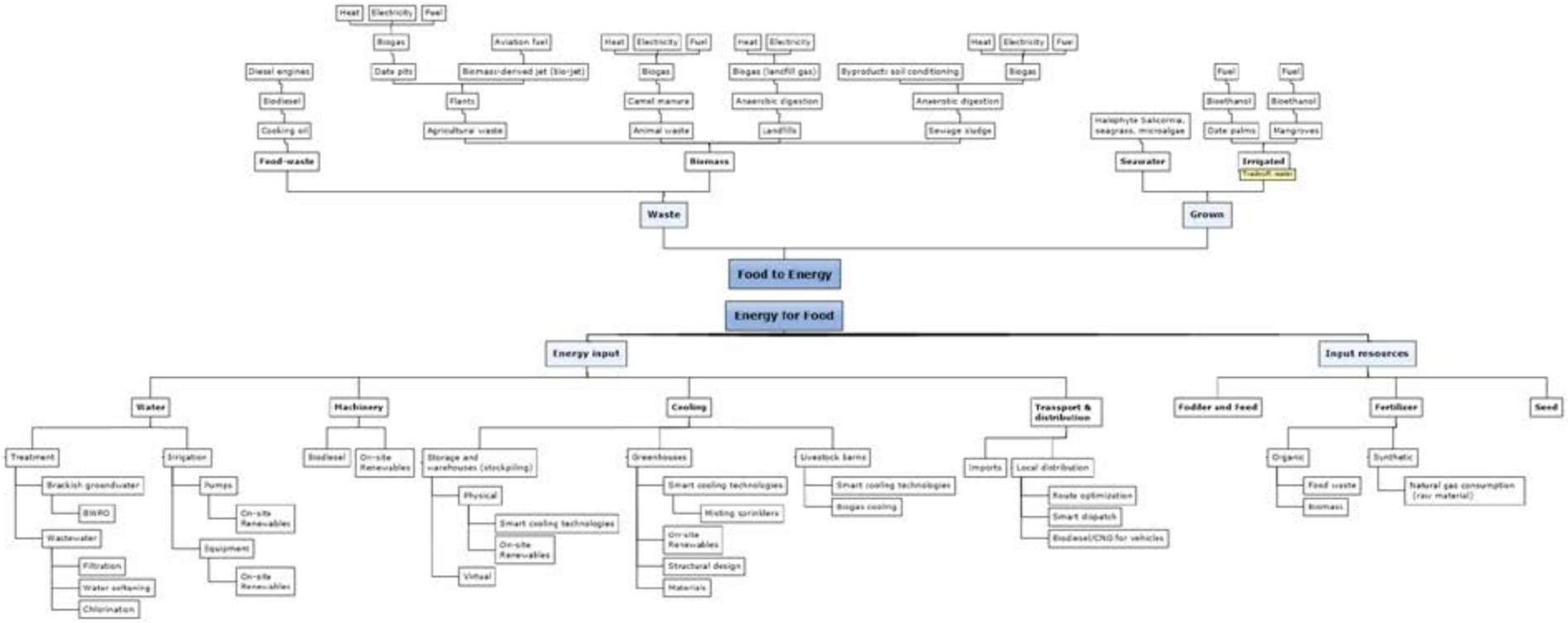
SN	Category 1	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
			- Proper water discharge management would improve marine biodiversity, fisheries and boost eco-tourism				- Discharge into the sea is allowed for non-contact cooling, desalinization unit brine and cooling towers
WE-6	RE powered WWTP	Solar powered WWTP	- High solar irradiance in Qatar	- Intermittency, unless a hybrid system - Currently, higher cost than grid connection	1	4	-As the national energy mix is diversified, the share of renewables used in WWTP will naturally increase.
WE-7	Water pumping and transport	Solar water pumps	- High solar irradiance in Qatar - Off-grid usage makes system mobile, and avoids electrification costs	- Intermittency, unless a hybrid system	4	5	-Providing solar technologies, solutions and products, Solar solutions. -Providing solar technologies, solutions and products, AL Emadi Solar -Plant for producing solar PV technologies and products, Qatar Solar Technologies (a joint venture between Qatar Solar (a subsidiary of Qatar Foundation), Germany's SolarWorld AG, and Qatar Development Bank).
WE-8		Biofuel water pump	- Carbon neutral energy source - No intermittency issues	- Dependent on maturity of biofuel technology	1	3	-No initiatives
WE-9		Piping efficiency and T&D monitoring	- Water system savings - Identification of system nodes requiring maintenance and/or replacement through monitoring system (i.e. SCADA)	- Pipe replacement and/or maintenance can be costly and disruptive - High marginal cost of improvement due to existing high network efficiency - Qatar already has a relatively high T&D network efficiency	4	4	-Water Security Mega Reservoirs Project, KAHRAMAA.
WE-10	Water heating & cooling	Solar-water heaters	- High solar irradiance in Qatar well suited for technology -High cost savings and quick ROI - Emerging supporting regulations at national level - High growth market	- Higher installation costs than conventional water heating systems - High requirement for proper insulation	4	5	-Providing solar technologies, solutions and products, Solar solutions. -Providing solar technologies, solutions and products, AL Emadi Solar. -Plant for producing solar PV technologies and products, Qatar Solar Technologies (a joint venture between Qatar Solar (a subsidiary of Qatar Foundation), Germany's SolarWorld AG, and Qatar Development Bank).
WE-11		Solar-Cooling systems	- High solar irradiance in Qatar - High cooling load in Qatar - Dropping PV and other solar technology costs - Interest in system for FIFA 2022 world cup stadiums	- Intermittency, unless a hybrid system - Higher CAPEX compared to traditional systems	3	5	- Prototype made to test the feasibility of implementing solar cooling systems in stadiums hosting FIFA 2022

SN	Category 1	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
WE-12	Cooling	District Cooling	- District cooling reduces energy consumption to about 40% compared to traditional cooling - Strong market growth and interest, with well-established regional players	- Highly linked to booms and busts of real-estate sector	4	5	- The Pearl Qatar, West Bay districts of Doha and seven stations of Qatar Rail are serviced by Qatar Cool, a district cooling company
WE-13	Water fixtures	Water fixture efficiency	- Market adoption of existing voluntary green building codes such as LEED - Emergence and adoption of mandatory green building practices through Construction Specifications - Rising water tariffs among all sectors after cutting on subsidies	- No significant constraints	4	5	- New "Green Building" chapter in Qatar Construction Specification which includes quantitative standards relating to energy, water, materials and the internal environment, Qatar General Organization for Standardization.
WE-14	Water use in Oil & Gas	Fossil fuel extraction	- Water steam savings from EOR process by CO_2 injection substitution - Reduced aquifer pollution compared to using produced water - Form of carbon sequestering	- Risk of CO_2 contamination into aquifers - Qatar's demand for EOR is relatively low given its focus on natural gas production opposed to oil (with most of its natural gas reserves being non-associated fields)	2	3	- Several research laboratories at Texas A&M in Qatar exploring CO_2 injection for EOR
WE-15		Monitoring systems	- Ability to monitor and analyse water and energy consumption and losses across Oil & Gas value chain - Oil & Gas is the primary and most resource consuming industry within Qatar	- Challenges in data collection and integration of assets across value chain	3	5	- Data Monitoring Systems are being developed across Qatar Petroleum subsidiaries in Qatar to varying levels, though no centralization exists to date

3.3 Energy-Food

Figure 20 shows the Energy-Food Nexus Map in the GCC. This was developed based on two main aspects: the use of energy for food production and the use of organic material in the production of energy. The use of energy in food production was categorized based on inputs of energy and resources required for production. The energy inputs were categorized based on the energy used to operate water treatment and irrigation systems, machinery, cooling systems as well as the transport and distribution of the energy for the production of food. The organic material used in energy production was classified into two types: organic waste and grown food. For the organic waste, the map presents the different sources of waste, i.e. food-waste, agricultural waste, animal waste and waste from landfills. On the other hand, grown food was grouped based on method of production (i.e. seawater grown or freshwater irrigated). Seawater grown includes microalgae and seagrass production while irrigated includes the cultivation of date palms and mangroves for the production of bioethanol.

Figure 20: Energy-Food Nexus Map for GCC[53]



[53] Figure 2020 is based on EY internal analysis.

Table 4: Qatar's Food-Energy Nexus Initiatives

SN	Category 1	Category 2	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
FE-1	Biofuels	Grown biofuels	Biomass from halophytes	- Salt tolerant (use of Salicornia Halophyte) - Wide availability of seawater and avoided use of freshwater - Strong demand and support by local airlines for green/renewable jet fuel	- Commercialization and scaling up - More expensive than conventional fuels	3	5	- Studies by Qatar University
FE-2			Bioethanol	- Strong market interest in sustainable fuels in the region	- Unless resulting from a waste stream or introduction of speciality plants (i.e. Jatropha), the process will be water intensive - Limited number of native species that can be used at commercial scale - More expensive than conventional fuels	4	3	- Phase 2 of Qatar Biofuel Project, Qatar University
FE-3		Biofuels from Waste	Biogas from animal waste	- Animal waste is a significant and un-utilized waste stream in Qatar	- Biomass yield is dependent on the kind of bio-waste (e.g. cattle or camel manure, chicken droppings etc.) and whether animals are held in stables or not - Not feasible for all farms given size	3	4	- Research on the combustion process of biogas, University of Newcastle & Qatar University
WE-1			Biogas from sewage sludge	Please refer to WE-1 for the details of this approach as it is categorized under Water-Energy as well as Food-Energy				
FE-4			Biogas or Waste to Energy from Landfills	- Large potential for waste to energy and landfill bio-gas in Qatar - Both waste to energy and biogas already existing at DSWMC - Organic fraction of MSW may provide a source for organic fertilizer/soil improver depending on waste stream purity - Growing population and economic growth resulting in increasing waste within the country	- Large infrastructural investments required	4	5	- Domestic Solid Waste Management Centre, Operated for Ministry of Municipal Affairs & Agriculture by SMEC
FE-5			Biodiesel from food waste	- Significant food waste exists in the Qatar, such as waste cooking oil - Hotels/restaurants are a major source of food waste in the country, offering potential food waste collection partnerships	- Limited by ability to collect food waste at commercial scale - More expensive than conventional fuels	4	4	- Phase 2 of Qatar Biofuel Project, Qatar University
FE-6	Onsite energy inputs for	Smart Cooling Technologies	Cooling of animal farms	- Growing number of farms in the country - High energy requirement for cooling to maintain optimal range for animals	- Lack of proper cooling can result in loss of livestock, disease or decreased output	3	4	- Misting fans use in Baladna's dairy farm

SN	Category 1	Category 2	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
FE-7	food production		Cooling of greenhouses	- Large consumers of energy for cooling -Opportunities exist for more energy efficient cooling technologies, coupled with smart systems for monitoring and process optimization	- Cooling systems may present high initial investment cost with a long ROI - Inherent tradeoffs of some cooling systems (i.e. high water efficiency but high energy or vice versa)	4	5	- Doha Cool and Fog, high pressure fogging systems to regulate greenhouse temperatures. - Greenhouses run by a computerized pad fan cooling system, Arab Qatari Agricultural Production Co., Hassad Food -Sophisticated air conditioned hydroponics facility, AGRICO - MoU between AgroQatar and Gulf Petroleum for the development of high-tech greenhouses - Sahara forest pilot project
FE-8			Cooling of storage			1	5	- No initiatives
FE-9		Greenhouses	Reducing cooling load through design and materials	- Greenhouses consume significant amounts of energy for cooling - Opportunities for synergies with other technologies and setups (i.e. aquaculture)	- Materials must be tolerant to harsh Qatar climate - Potentially higher cost	2	4	- Distribution of 73 greenhouses to local farms
FE-11		Fertilizer	Synthetic fertilizer production	- Improves crop yields - Haber process is net CO_2 consuming	- Can result in eutrophication of water bodies - Haber process is natural gas consuming	5	2	- Fertilizer production by QAFCO
FE-12		Onsite renewables	PV for irrigation & pumps	- Off-grid solution for water pumps, reducing maintenance and electrical connection	- Low electricity tariffs for agricultural sector - Intermittency, unless a hybrid system	1	4	- No initiatives
FE-13			PV for water treatment	- Off-grid solution for water treatment and onsite brackish water RO	- Low electricity tariffs for agricultural sector - Intermittency, unless a hybrid system	1	4	- No initiatives
FE-14			Biodiesel for equipment	- Renewable source of fuel that can be generated from onsite agricultural waste streams and by-products	- More expensive than conventional fuels if purchased	3	3	- Qatar Biofuel Project, Sustainable Development Centre, Qatar University
FE-15	Energy inputs for transport & distribution of food	Stockpiling	Virtual Stockpiling	- Utilization of warehouses abroad avoid infrastructure investment domestically - Enhanced energy saving initiative for reduced cooling requirements - Cost saving (buying during low prices) - Added food security (emergency preparedness)	- Cost of storage/stockpiling abroad	1	4	- No initiatives

SN	Category 1	Category 2	Approach/ technology	Approach strengths	Approach limitations	Maturity	Growth opportunity	Initiative(s)/Programme(s)
FE-17			Physical/ emergency stockpiling	- Strategic storage reserves allow for release of stockpiles during emergencies or price hikes	- Investment cost and maintenance - Cooling and humidity control	3	5	- Food storage processing plant for only rice, sugar, and oil at Hamad Port
FE-18		Local storage and distribution	Route & inventory optimization	- Route optimization can reduce energy cost of transport and lengthen freshness and lifetime of food products - Reduced inventory time can reduce food wastage and costs for businesses - Emerging technology (i.e. IoT) can enable the above solutions in a cost effective and integrated way	- No significant constraints	3	5	- May exist with private sector companies. However, no initiatives disclosed on the matter

4. Investment and Engagement Opportunities

Investment/engagement opportunities in Qatar were identified for Dutch companies based on the technologies and approaches outlined in Table 2, Table 3, and Table 4 of the previous chapter. The maturity and growth opportunity scoring of each technology/approach was used to identify the most suitable opportunities.

Table 5: Investment/engagement opportunity type for Dutch companies

Opportunity Category	Category description	Maturity	Growth opportunity
Category 1	High growth potential and mature market, ready for entry	>3	≥4
Category 2	High growth potential market, but requires knowledge partner(s)	≤3	5

The technologies/approaches identified in the previous chapter are categorized into two opportunities; Category 1 or Category 2 as per Table 5. Category 1 represents well established technologies/approaches with good growth potential, as such Dutch companies can engage with those markets directly as technology/solution providers.

Category 2 technologies/approaches demonstrate high growth potential but are considered less mature commercially (still in research/ testing phase within Qatar). For Dutch companies, Category 2 presents good growth potential, but will require knowledge partner(s) (Dutch and/or local) to further develop such markets within Qatar. Knowledge partnerships can include more than one local or Dutch partner. The WEF stakeholder groups in Qatar identified in

Table 8 are to be considered for these potential partnerships.

Applying the criteria in Table 5 to the technologies/approaches in the previous chapter yields a prioritized list of investment opportunities for Dutch companies presented in Table 6 and Table 7. It is worth noting that such opportunities often comprise of two parts which Dutch companies can contribute towards. Such opportunities consist of technical solutions and complimentary knowledge sharing/expertise. Taking hydroponics as an example, Dutch companies can deliver technical solutions with respect to irrigation, cooling, system automation etc., while also providing knowledge sharing/expertise on the most suitable choice of crops, best practices in system maintenance, analysis of data and so forth. The latter can be delivered via training, consulting, joint research projects etc.

Table 6: Category 1 approaches and technologies

SN	Category	Approach or Technology	Maturity	Growth opportunity
WF-5	Livestock, Poultry & Dairy	Farming of poultry	4	4
WF-10	Agriculture	High-tech greenhouses	4	5
WF-13	Agriculture	Hydroponic farming	4	5
WF-15	Agriculture	Urban Farming	4	5
WF-22	Aquaculture	Sea-based aquaculture	4	5
WF-25	Water resources	Drip irrigation	5	5
WF-28	Water resources	Treated/ recycled wastewater	4	4
WF-32	Food imports	Food safety monitoring systems	4	5
WE-1	Waste to Energy	Bio-gas from sewage sludge	4	4
WE-7	Water transport	Solar water pumps	4	5
WE-9	Water transport	Piping efficiency and T&D monitoring	4	4
WE-10	Water heating & cooling	Solar-water heaters	4	5
WE-12	Cooling	District Cooling	4	5

SN	Category	Approach or Technology	Maturity	Growth opportunity
WE-13	Water fixtures	Water fixture efficiency	4	5
FE-4	Biofuels	Biogas or Waste to Energy from Landfills	4	5
FE-5	Biofuels	Biodiesel from food waste	4	4
FE-7	Smart Cooling Technologies	Cooling of greenhouses	4	5

Table 7: Category 2 approaches and technologies

SN	Category	Approach or Technology	Maturity	Growth opportunity
WF-14	Agriculture	Aquaponics	2	5
WF-16	Agriculture	Surface Water Farming	1	5
WF-18	Agriculture	Organic Fertilizers	3	5
WF-21	Aquaculture	Land-based aquaculture	3	5
WF-31	Food imports	Food import diversification and de-risking	3	5
WF-33	Food imports	Early warning systems	1	5
WE-3	Water heating & cooling	Reverse Osmosis with PV/ storage	3	5
WE-11	Water heating & cooling	Solar-Cooling systems	3	5
WE-15	Water use in Oil & Gas	Monitoring systems	3	5
FE-1	Biofuels	Biomass from halophytes	3	5
FE-8	Cooling	Cooling of storage	1	5
FE-17	Storage	Physical/ emergency stockpiling	3	5
FE-18	Storage	Route & inventory optimization	3	5

5. Success through Engagement

The success of the Netherlands in the area of food production has placed them as the second largest global exporter of food in terms of dollar value after the United States. The Netherlands is currently the 2nd in the Global Innovation Index 2018, while Qatar is the 51st country, with a minor decline in rank when compared to the previous year. There is a timely opportunity for the two countries to collaborate on developing and implementing innovative solutions for their mutual benefit.

Qatar has the opportunity to drive major advancements in the region due to its abundant wealth and growing economy. In line with Qatar's National Vision Strategy 2030, the development of the economy will be steered towards a path that enables Qatar to sustain its growth and development, while still maintaining a high standard of living for its people. Qatar has forged key successful global partnerships and established feasible action plans that have increased the country's resilience and allowed Qatar to mitigate the impact of shortage of certain resources at troubled times.

Furthermore, the need for a water-energy-food nexus approach in Qatar, has never been timelier, particularly in light of recent events and the embargo. Starting with the fall in global oil prices, Qatar's public sector had to undergo major restructuring in 2016 by taking austere measures to cut back on wasteful spending and subsidies, overstaffing and lack of accountability[54]. Moreover, the situation was further aggravated by recent tensions in Qatar's diplomatic ties with GCC countries in the region[55]. The blockade that has been enforced due to political differences has put Qatar's resource security at risk.

One of the main areas that Qatar can adopt from the Netherlands is their Dutch Triple Helix approach that strengthens synergies between government, industry, academia and society.

For Dutch companies looking to enter the Qatar WEF market, engaging with the right stakeholders is pivotal. Doing business in Qatar and the wider region requires a certain level of adaptiveness and fluidity – brought on by sharp climatic, regulatory and cultural contrasts when compared to Europe and other regions. With the current spike in Qatar's food demand, coupled with a need to maintain energy and water consumption levels, there exists a significant scope for collaborations with Dutch companies as the government is seeking global best practices, solutions and expertise. The government is driving the move towards ensuring resource security, improving efficiency, conservation and diversification in relation to the WEF Nexus. Therefore, it is an opportunity for Dutch companies to fill the market gap by extending their support through active engagement with the local entities and cultivating close relationships with them in the long term.

[54] World Bank. *How is Qatar Reacting to Low Oil Prices?*, 2018.
[55] The World Bank. *Qatar's Economic Outlook - October 2017*, 2017.

5.1 Direct Engagement with Local Entities

Though by no means exhaustive,

Table 8 and Figure 21 illustrate some of the key WEF stakeholders in Qatar. Briefs about the entities and website links can be found in Appendix B. The level to which they should be engaged will vary dramatically from one organization to the other, based on the support required, value proposition, etc. For each category of approaches and technologies, Dutch companies can engage with any of the interested stakeholders that correspond to the respective Nexus areas indicated in Figure 21. Additionally, Table 8 identifies the high level engagement strategies by stakeholder group.

Figure 21: Qatar's Water Energy Food Nexus Stakeholder Map

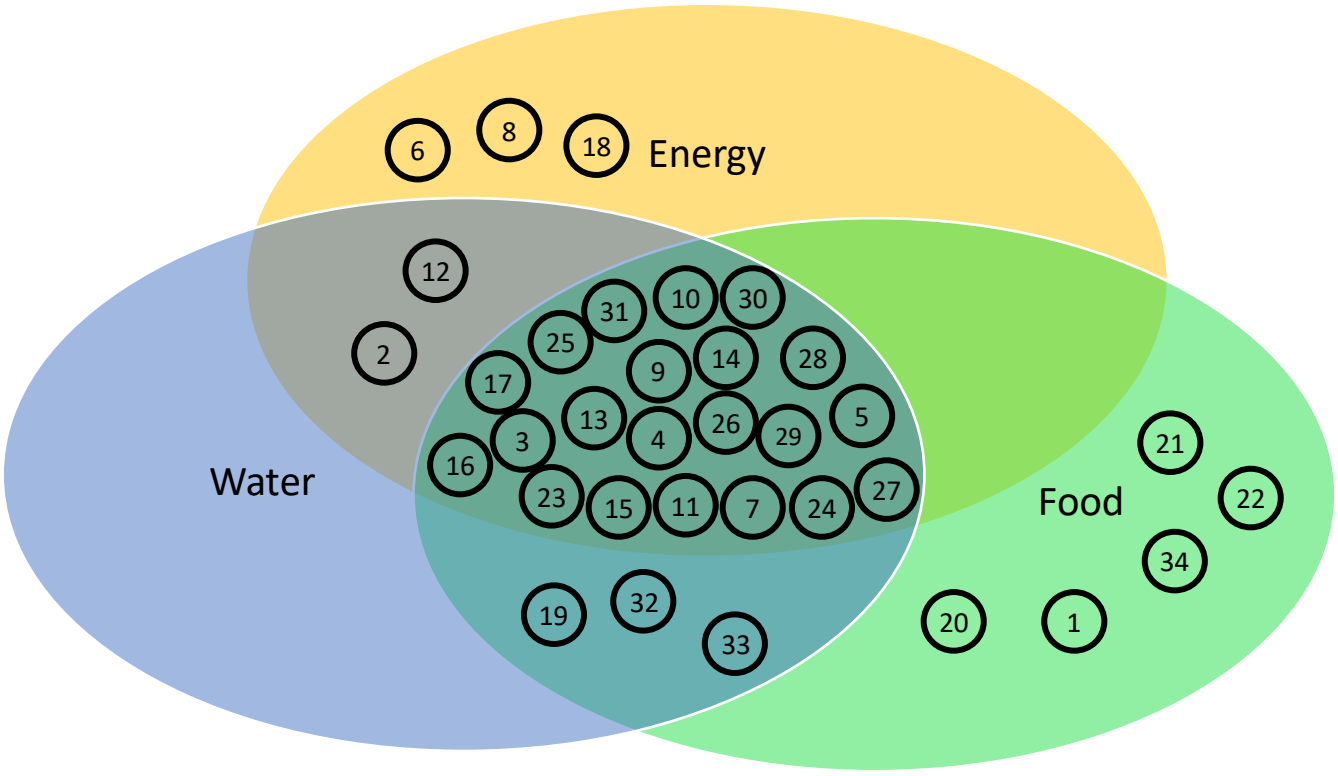


Table 8: Engagement strategy of WEF stakeholder groups in Qatar

Entity Type	Engagement Strategy
Government operator entities 1. Hassad Food Investment Fund by Qatar Investment Authority 2. KAHRAMAA (Water & Electricity company) 3. ASHGHAL (Public Works Authority) 4. Qatar Investment Authority	1. Information collection: Dutch Companies need to form a solid understanding of the strategies, objectives and operations of the various government operators Qatar if they wish to collaborate successfully 2. Involve senior management: Dutch companies need to utilize the information collected in their research to connect with government operators based on their most pressing issues. Dutch companies should employ their senior management to connect with government operators and capitalize on the Qatar-Dutch diplomatic channels (i.e. the Dutch embassy) for introductions where relevant/possible. 3. Share insights: Dutch Companies need to share their insights and experiences with government operators. This is best done in an interactive manner that emphasizes demonstration. This may include: meetings, conferences, workshops and invitations to see leading best practices abroad etc.
Government regulator entities 5. Ministry of Municipality & Environment 6. Ministry of Energy & Industry 7. Ministry of Development Planning & Statistics	1. Establish focal point: Dutch companies need to establish a key focal point within their organization that will regularly engage with the Qatar government regulator entities to improve communications and access to information. This can be complemented with meetings in person to establish key contact points within priority departments in Qatar government entities to build a trust-based relationship. Dutch companies can capitalize on Qatar-Dutch diplomatic channels (i.e. the Dutch embassy) for introductions where relevant/possible. 2. Consult regularly: Regular consultations are important and should be followed up at regular intervals to help Qatar government regulators familiarize themselves with new information. As Qatar is a dynamic environment in which regulations are regularly updated, Dutch companies can benefit from regular consultations to remain up to date with regulatory changes. 3. Share insights: Dutch entities can share their experience and insights with Qatar regulators with respect to which regulatory enablers would support agricultural sector growth and innovation in Qatar. This will allow Dutch entities to play a proactive role in Qatar. This is best done in an interactive manner that emphasizes demonstration. This may include: meetings, conferences, workshops and particularly invitations to see leading best practices abroad etc. 4. Awareness building: As Dutch companies look to introduce novel ideas and solutions to Qatar, awareness building will play a key part of any engagement strategy. Developing promotional material for regulators is key to refresh memories of officials who are aware of on-going discussions and provide introductory information to those who are not.

Entity Type	Engagement Strategy
Industry 8. Qatar Petroleum and subsidiaries 9. Qatar National Bank 10. Qatar Development Bank 11. Industries Qatar 12. Qatar Electricity & Water Company 13. Aamal Holding 14. United Development Company 15. Salam International 16. Gulf Warehousing Company 17. PROTEC 18. Al Baida Group 19. Arab Qatari Company 20. AGRICO 21. Baladna 22. Al Sulaiteen Agricultural and Industrial Complex (SAIC)	1. <u>Identify industry drivers:</u> Dutch Companies should research and understand the scope and operations of the industries they wish to engage with to identify the key challenges and drivers before engaging. 2. <u>Establish focal point:</u> Companies should nominate a focal point to directly engage with key industry personnel in order to establish a trust based relationship and maintain an open line of communication. 3. <u>Share insight:</u> Dutch Companies should focus on personalizing all pitches to Qatar industry leaders to increase their chances of success. Sharing new insight might be challenging as Qatar companies might initially resist change. However, interactive strategies that emphasize demonstration often work well. This may include: meetings, conferences, workshops and particularly invitations to see leading best practices abroad. Additionally, pilot projects and key collaborations opens the way for greater market acceptance/adoption of new technologies and practices.
Universities and Research Institutes 23. Qatar University 24. Qatar Foundation 25. Qatar Science & Technology Park 26. Qatar Environment and Energy Research Institute 27. Qatar National Research Fund 28. Georgetown University in Qatar 29. Texas A&M in Qatar 30. Carnegie Mellon university in Qatar 31. Northwestern University in Qatar 32. Aquatic Fisheries and Research Centre 33. Agricultural Research and Guidance Centre 34. Animal Production Research Station	1. <u>Building local relationships:</u> Dutch companies may want to engage with local universities and research institutes to gain country/region specific context, which will help them tailor their solutions when engaging with stakeholders such as government regulators/operators and local companies etc. This can be achieved through direct partnership, or by bringing in Dutch universities as well. 2. <u>Nominate a key contact:</u> Dutch companies should ensure there is a champion within the university/research institute who understands the importance of the collaboration to guarantee endorsement for the project and help in securing legitimacy and access to resources

5.2 The Dutch Economic Network in the Gulf

The availability of lucrative trade and investment opportunities in Qatar has increased the interest of Dutch companies in pursuing collaborations and business opportunities in Qatar through a local presence.

The Dutch Economic Network in the Gulf Region, which is established to help Dutch businesses in identifying business opportunities within the Gulf Countries[56], is the only channel that is operational in Qatar. The network advises Dutch businesses on how to enter the Gulf market and set up business in the Gulf as well as offering advice based on the market context and potential partners.

Economic and Trade Affairs Officers are available at each of the 5 Embassies and 1 Consulate-General in the Gulf Region as well as a regionally operating Agricultural Office in Riyadh[57], Saudi Arabia. A newly appointed regionally operating Nexus expert in Abu Dhabi, UAE, is also available to provide support or advice Dutch companies wanting to do business in Qatar.

For more information on the Dutch Economic Network in the Gulf region kindly visit the website

www.dutchgulf.com or https://www.netherlandsworldwide.nl/doing-business-in-the-gulf-region.

[56] Kingdom of the Netherlands, Dutch Economic Network in the GCC, 2018.
[57] Kingdom of the Netherlands, Agricultural Department for the GCC-countries

6. Appendix A

The tables below include the sources of all the initiatives cited in chapter 3, and are listed by initiative number, mirroring Table 2, Table 3, and Table 4.

SN	Initiative(s)/Programme(s)	Links
WF-1	Livestock Production Research Plant at Al Shahaniya aims at developing the quality, minimizing the proliferation of diseases, increasing production whether in terms of the number of born calves or the produced quantity of milk and maintaining the process of fighting diseases and livestock resistance.	http://www.mme.gov.qa/cui/view.dox?id=702&siteID=2&contentID=5446
WF-2	An initiative of The Ministry of Municipality and Environment (MME), The Animal Production Research Station in Al Shahaniya is involved in research on animal production and artificial insemination technology to increase the animal production in the country.	http://www.mme.gov.qa/cui/view.dox?id=702&siteID=2&contentID=5492
WF-3	The Ministry of Municipality and Environment (MME) has adopted a new agriculture research strategy to increase both livestock and agriculture production	http://www.gulf-times.com/story/577754/New-research-strategy-to-raise-livestock-agricultu
WF-4	Supreme Council for Environment and Natural Reserves (SCENR) is seeking approval to form a committee that will address the flow of genetically modified organisms (GMOs) and related health concerns.	https://gulfnews.com/news/gulf/qatar/qatar-considers-introducing-gm-food-labelling-law-1.206661
WF-5	Arab Qatari Company for Poultry productions is one of ACOLID Group (Arab company for livestock development) in partnership with Hassad food as a major poultry products supplier for the Qatari market	http://aqpoultry.com.qa
WF-6	Date production, National Food Co., Hassad food	http://www.hassad.com/English/Pages/NAFCO.aspx
WF-7	-Algal Technologies Program (ATP) and Food & Water Security Programs at Qatar University	http://brc.qu.edu.qa/research/sustainable-development-center/research-programs/algal-Technologies-Program-(ATP) http://brc.qu.edu.qa/research/sustainable-development-center/research-programs/food-&-Water-Security-Program
WF-8	Umm Ghuwailina project - initiated by State in collaboration with the Private Sector represented by Al-Baidaa Group which developed it. The project is a part of the efforts exerted by the Government to realize self-sufficiency with respect to green fodder.	http://www.mme.gov.qa/cui/view.dox?id=702&siteID=2&contentID=5447
WF-9	Supreme Council for Environment and Natural Reserves (SCENR) is seeking approval to form a committee that will address the flow of genetically modified organisms (GMOs) and related health concerns.	https://gulfnews.com/news/gulf/qatar/qatar-considers-introducing-gm-food-labelling-law-1.206661
WF-10	Greenhouses run by a computerized pad fan cooling system, Arab Qatari Agricultural Production Co., Hassad Food Distribution of 73 greenhouses to local farms AgroQatar, has signed a memorandum of understanding (MoU) with Gulf Petroleum for the development of a system of high-tech greenhouse production of fresh fruit and vegetables.	http://www.qt-fa.com/about.html http://www.hortidaily.com/article/31255/Qatar-Government-invests-in-greenhouses-for-local-farmers http://www.gulf-times.com/story/574533/AgroQatar-Gulf-Petroleum-sign-MoU-for-greenhouse-p
WF-11	A project to "green" desert areas with an innovative mix of technologies—producing food, biofuel, clean water, energy, and salt. The Qatar plant—which is supported by Qatari fertilizer companies Yara International and QAFCO—is 1 hectare in extent with 600 square meters of growing area in the greenhouse.	http://www.sciencemag.org/news/2013/11/desert-farming-experiment-yields-first-results
WF-12	No Initiatives	Not applicable
WF-13	Air conditioned hydroponic systems, AGRICO Zulal Oasis hydroponics project	http://www.agrico.qa/about-agrico http://ngsystem.com/en/inicio/zulal_oasis
WF-14	The ministry is in talks with various global firms to work on the latest aquaponics methods in Qatar. Ministry in working on a comprehensive strategy to encourage and support local farmers to	http://www.qatar-tribune.com/news-details/id/112841

SN	Initiative(s)/Programme(s)	Links
	adopt aquaponics in order to maintain the levels of fish stock in the country	
WF-15	Agricultural farm with 38 hectares open fields for vegetable crops, Arab Qatari Agricultural Production Co., Hassad Food Home-Farming Hydroponics initiative, Qatar Development Bank	http://www.qt-fa.com/about.html https://www.thepeninsulaqatar.com/article/30/01/2018/Qatar-to-promote-%E2%80%98home-farming%E2%80%99-using-hydroponics
WF-16	No Initiatives	Not applicable
WF-17	Bu Saif Apiaries – is a leading honey producer in Qatar with production up to 15 tonnes of honey per year Department of Agricultural Affairs in the Ministry of Municipality and Environment that supports local beekeepers as part of a national project. They provide them with hives and honey colonies along with pesticides and tools to help them develop their apiaries	http://www.qatar-tribune.com/news-details/id/100855 https://www.qatarliving.com/forum/qatar-living-lounge/posts/saving-bees-qatar-s-burgeoning-honey-industry
WF-18	National Recycling Awareness (Tadweer), is being implemented by the Ministry in collaboration with Ras Laffan Power Company (RLPC) and Al Tayyar Company for Marketing and Event Management. Under the initiative, the food waste and tree leaves will be turned into high quality organic compost and fodders.	https://www.thepeninsulaqatar.com/article/18/04/2018/MME-launches-initiative-to-turn-organic-waste-into-fertiliser
WF-19	Vertical farming potential in Qatar through cooperation with South Korea AGRICO, A private Qatari agricultural development company, Agrico was established in 2011 with the aim of helping the country achieve food security. Agrico operates a 120,000sqm (12 hectare) organic farm in Al Khor	http://www.hortidaily.com/article/32639/South-Korea,-Qatar-join-hands-in-vertical-farming http://agrico.qa/
WF-20	Plan to set up 5 organic farms, Ministry of Municipality and Environment	http://www.hortidaily.com/article/23183/%20qatar-environment-ministry-to-set-up-five-organic-farms
WF-21	10 fish farms to be built at a marine life research centre in Ras Matbakh with a capacity of 500 metric tons/year	https://www.undercurrentnews.com/2017/12/29/44atar-targets-fish-self-sufficiency-with-14-new-farms/
WF-22	Aquatic Fisheries and Research Centre is set to become one of the most important productive research centres in the field of aquaculture. 2 fish farming projects with a capacity of 2,000 tons each	http://www.mme.gov.qa/cui/view.dox?id=702&siteID=2&contentID=5492 https://aquaculturemag.com/2018/01/03/new-fish-farming-projects-to-save-strategic-reserve-in-qatari/
WF-23	The Qatari-Turkish Flower Gardens Forum, organized by the Ministry of Municipality and Environment, with participation of more than 50 companies from Qatar and Turkey engaged in the production of trees and decorative flowers	http://www.mme.gov.qa/cui/view.dox?id=702&siteID=2&contentID=5566
WF-24	8.3 km^2 forest near Umm Salal Ali	https://nricafe.com/biggest-man-made-forest-in-gcc-coming-up-in-qatar/
WF-25 WF-26	As part of Qatar National Vision 2030 government is encouraging newer irrigation methods such as drip irrigation systems, which use much less water for a given yield	https://www.mdps.gov.qa/en/knowledge/HomePagePublications/Qatar_NDS_reprint_complete_lowres_16May.pdf
WF-27	Misting fans use in Baladna's dairy farm	https://www.reuters.com/article/us-gulf-qatar-cows/qatar-builds-dairy-industry-in-desert-as-it-defies-arab-boycott-idUSKBN1DT2E9
WF-28	QR3.63 billion sewage treatment plant in Umm Salal Ali to process 245,000 cubic meters of sewage per day Research on the use of treated sewage effluent for fodder crops production, Ministry of Municipality and Environment, Public Works Authority (Ashghal) & National Food Security Program	https://dohanews.co/qatar-opens-new-sewage-treatment-plant-as-it-ups-wastewater-usage/ http://www.journalrepository.org/media/journals/JSRR_22/2015/Dec/Osman962015JSRR21807.pdf
WF-29	Study conducted by Qatar university on screening for local halophytes to quantify their level of tolerance to saline environment	http://www.qscience.com/doi/pdf/10.5339/qproc.2016.qulss.28
WF-30	Brine recirculation pumps for seawater desalination plants, Torishima	https://www.torishima.co.jp/en/2015/12/10/torishima-receives-order-for-brine-recirculation-pumps-for-

SN	Initiative(s)/Programme(s)	Links
	Experiment to recycle desalination by-product brine, Inhabitat	seawater-desalination-plant-in-qatar-from-hitachi-zosen-corporation/ -https://inhabitat.com/new-desalination-method-from-qatar-recycles-waste-brine-and-excess-co2-at-the-same-time/
WF-31	Not formalized through a program or documented strategy, but Qatar is remapping its food supply chain and imports since the blockade began	https://mei.nus.edu.sg/publication/insight-185-contemporary-issues-in-qatars-food-security/
WF-32	Electronic system launched to register information on all imported food, Ministry of Public Health and General Authority of Customs	http://www.hukoomi.qa/wps/portal/media-center/news/news-details/mophlaunchesswebsiteforfoodregistration
WF-33	No Initiatives	Not applicable

SN	Initiative(s)/Programme(s)	Links
WE-1	Using waste sludge to produce methane gas, PROTEC. The waste material (sludge) from the treatment of sewage can be anaerobically digested to produce methane gas (amongst others), which can be used to supply energy to the process and be used to produce electricity. The digested sludge can be further treated by drying, for use as a fertilizer, or be a fuel source for power generation.	https://www.protecind.com/solutions12/waste-to-energy
WE-2	Independent Water and Power Plants with desalination using RO, Qatar General Electricity and Water Corporation.	https://www.power-technology.com/projects/umm-al-houl-combined-cycle-power-plant/
WE-3	Qatar Petroleum (QP) and Qatar Electricity and Water Company (QEWC) signed a Memorandum of Understanding (MoU) for the formation of a solar energy joint venture – Siraj Power. Plans to set up a green desalination plant with Sweden that relies on solar and wind energy, Ministry of Energy and Industry.	https://www.renewableenergymagazine.com/pv_solar/qatar-to-begin-construction-of-200-mw-20170322 https://www.thepeninsulaqatar.com/article/16/05/2017/Qatar-Sweden-plan-eco-friendly-desalination-plant
WE-4	Independent Water and Power Plants with combined cycle MSF technology	https://www.wsp.com/en-GL/projects/ras-laffan-c-iwpp https://www.venturesonsite.com/projects/projects-in-qatar/power-and-water-projects-in-qatar
WE-5	Discharge into the sea is allowed for non-contact cooling, desalinization unit brine and cooling towers. Waters used as cooling water for once through non-contact cooling or desalinization unit brine or cooling tower blowdown may be discharged to cooling water outfall provided that the chemical characteristics of the water are not altered above the background characteristics except for temperature, dissolved solids and residual chlorine	http://www.qpic.qa/PoliciesAndRegulations/QPICRLCProcedure/old/RLC%20Environmental%20Regulations.pdf
WE-6	As the national energy mix is diversified, the share of renewables used in WWTP will naturally increase.	https://www.mdps.gov.qa/en/qnv1/pages/default.aspx
WE-7	Solar solutions, Qatar Plant for producing solar PV technologies and products, Qatar Solar Technologies (a joint venture between Qatar Solar (a subsidiary of Qatar Foundation), Germany's SolarWorld AG, and Qatar Development Bank). AL Emadi Solar, Qatar	http://solarsolutionsqatar.com/ https://oxfordbusinessgroup.com/news/qatar-gets-serious-about-solar http://www.alemadisolar.com/en/Services-solarpumping.htm
WE-8	No initiatives	Not applicable
WE-9	The objective of the Water Security Mega Reservoirs Project is to provide the 7 days of potable water storage in the new mega reservoirs and the existing and future secondary reservoirs preserving the water quality. At five different sites around greater Doha area, new mega reservoirs are being built along with integrated pumping stations including more than 650 km of interconnecting water pipelines	https://www.gkw-consult.com/en/projects/water/single/article/qatar-water-mega-reservoirs-project/
WE-10	Providing solar technologies, solutions and products, Solar solutions. Plant for producing solar PV technologies and products, Qatar Solar Technologies (a joint venture between Qatar Solar (a subsidiary of Qatar Foundation), Germany's SolarWorld AG, and Qatar Development Bank). Providing solar technologies, solutions and products, AL Emadi Solar.	http://solarsolutionsqatar.com/ https://oxfordbusinessgroup.com/news/qatar-gets-serious-about-solar http://www.alemadisolar.com/en/Services-solarpumping.htm
WE-11	The state developed a small, solar-powered prototype stadium seating 500 during the bid process but wants to develop more efficient technologies ahead of 2022.	https://www.aljazeera.com/sport/football/2013/04/201341815028187915.html
WE-12	Qatar Cool is the leading commercial provider of district cooling services in Qatar. Qatar Cool currently owns and operates three cooling plants covering the West Bay and The Pearl-Qatar districts with the combined refrigeration capacity of 197,000 tons of, with a fourth cooling plant under the commissioning stage.	http://www.qatarcool.com/about-qatar-cool/#tabs-3

WE-13	New “Green Building” chapter in Qatar Construction Specification by Qatar General Organization for Standardization, which includes quantitative standards relating to energy, water, materials and the internal environment.	http://www.saurenergy.com/solar-energy-news/qatar-adopt-first-renewable-energy-strategy
WE-14	- Several research laboratories at Texas A&M in Qatar exploring CO_2 injection for EOR	https://www.qatar.tamu.edu/programs/petroleum-engineering/research/research-laboratories
WE-15	- Data Monitoring Systems are being developed across Qatar Petroleum subsidiaries in Qatar to varying levels, though no centralization exists to date	https://www.qp.com.qa/en/QPActivities/QPOperations/Pages/EnvironmentandSocietyDetails.aspx?EID=2

SN	Initiative(s)/Programme(s)	Links
FE-1	No major initiatives, Qatar University has conducted studies in the past on this.	http://qspace.qu.edu.qa/bitstream/handle/10576/10002/070222-0009-fulltext.pdf?sequence=10
FE-2	Phase 2 of Qatar Biofuel Project, Qatar University. A research project, initiated at Qatar University, is looking at the use of biofuels sourced from indigenous natural resources. The project aims to produce clean and environmentally-friendly alternative energy from locally-available natural resources, specifically for use in Qatar's aviation industry.	https://www.biofuelsdigest.com/bdigest/tag/qatar/
FE-3	- GBP 400,000 fund for research on the combustion process of biogas, University of Newcastle & Qatar University	https://renewablesnow.com/news/uk-qatar-biogas-research-project-wins-gbp-400000-grant-560197/
WE-1	Please refer to WE-1	
FE-4	Domestic Solid Waste Management Centre (DSWMC) in Mesaieed, houses the largest composting facility in the country and one of the largest in the world. The waste that enters the plant initially goes through anaerobic digestion, which produces biogas that can power the facility’s gas engine and generators.	https://www.bioenergyconsult.com/tag/domestic-solid-waste-management-center/
FE-5	Phase 2 of Qatar Biofuel Project, Qatar University. The Ministry of Municipality and Environment launched a project to produce biogas from wastes with Qatar University’s College of Engineering with the goal of using that biogas as a clean energy to power the motor vehicles. The project will study various techniques for producing biogas from waste and aims to convert vehicles from diesel to biofuel and compressed gas to utilize the waste from the solid waste management centre.	https://www.biofuelsdigest.com/bdigest/2017/12/22/biogas-fuel-exploration-launched-in-qatar/
FE-6	Misting fans use in Baladna’s dairy farm	https://www.reuters.com/article/us-gulf-qatar-cows/qatar-builds-dairy-industry-in-desert-as-it-defies-arab-boycott-idUSKBN1DT2E9
FE-7	Doha Cool and Fog, high pressure fogging systems to regulate greenhouse temperatures. Greenhouses run by a computerized pad fan cooling system, Arab Qatari Agricultural Production Co., Hassad Food MoU between AgroQatar and Gulf Petroleum for the development of high-tech greenhouses Sahara Forest Project - The intention of the project is to demonstrate technologies, such as saltwater-cooled greenhouses, concentrated solar power and algae production that can enable restorative growth in desert areas.	http://www.dohacoolfog.com/greenhouse-cooling/ http://www.qt-fa.com/about.html http://www.gulf-times.com/story/574533/AgroQatar-Gulf-Petroleum-sign-MoU-for-greenhouse-p https://www.greenhomegnome.com/qatar-saltwater-cooled-greenhouses/
FE-8	No initiatives	Not applicable
FE-9	Distribution of 73 greenhouses to local farms	http://www.hortidaily.com/article/31255/Qatar-Government-invests-in-greenhouses-for-local-farmers
FE-11	Fertilizer production by QAFCO	http://www.qafco.qa/Satellite/Qafco/en/OurProducts/Urea
FE-12	No initiatives	Not applicable
FE-13	No initiatives	Not applicable
FE-14	Qatar University launched in 2012 research into the development of sustainable biofuels	http://www.qu.edu.qa/newsroom/Qatar-University/Qatar-University-reveals-Qatar-Biofuel-project

FE-15	No initiatives	Not applicable
FE-17	- Food storage processing plant at Hamad Port	http://www.tradearabia.com/news/IND_327639.html
FE-18	It may exist. However, no initiatives disclosed on the matter.	Not applicable

7. Appendix B

The table below elaborates on the stakeholder entities identified in Chapter 5, providing entity descriptions and links.

Entity type		Entity Responsibility	Link
Government operator entities			
1	Hassad Food	Hassad Food is an investment arm of the Qatar Investment Authority with a primary focus on the field of agriculture	http://www.hassad.com/English/Pages/default.aspx
2	KAHRAMAA	The public water and electricity authority charged with regulating and maintaining the supply of electricity and water for the population of Qatar.	https://www.km.qa/
3	Ashghal Public Works Authority	The Public Works Authority 'Ashghal' is responsible for the planning, design, procurement, construction, delivery, and asset management of all infrastructure projects and public buildings in Qatar.	http://www.ashghal.gov.qa
4	Qatar Investment Authority	The Qatar Investment Authority is Qatar's state-owned holding company that can be characterized as a National Wealth Fund.	https://www.qia.qa/
Government regulator entities			
5	The Minister of Municipality & Environment	MME is a service Ministry directly related to the general public, in order to meet the many requirements of their daily life, and contribute through its subsidiary departments, municipalities and centres, to the rapid development of the State of Qatar.	http://www.mme.gov.qa
6	Ministry of Energy & Industry	Responsible for the development and regulation of Qatar's industrial sector, with the objective of diversifying national income sources and increasing the industrial sector's contribution to gross domestic product.	https://mei.gov.qa
7	Ministry of Development Planning & Statistics	The Ministry of Development Planning & Statistics is responsible for the development of the overall vision for the state, in cooperation with the concerned authorities; preparation of national development strategies; follow-up of their implementation; preparation of studies and population policies related to such strategies; supporting the planning process in government agencies; working on linking development priorities to the state budget; monitoring the progress of implementation of plans.	www.mdps.gov.qa
Industry			
8	Qatar Petroleum and subsidiaries	Qatar Petroleum is a state owned petroleum company in Qatar. The company operates all oil and gas activities in Qatar, including exploration, production, refining, transport, and storage.	https://www.qp.com.qa/en/Pages/Home.aspx
9	Qatar National Bank	Qatar National Bank is a Qatari commercial bank headquartered in Doha, Qatar and the largest financial institution in the Middle East and Africa region.	https://www.qnb.com/
10	Qatar Development Bank	QDB was established with the objective of diversifying Qatar's economy by promoting developmental projects across a wide range of sectors.	https://www.qdb.qa/en
11	Industries Qatar	Industries Qatar Q.S.C. is a Qatari conglomerate with subsidiaries and investments in the petrochemicals, fertilisers and steel industries. IQ is a 51% subsidiary of Qatar Petroleum.	https://www.iq.com.qa/

12	Qatar Electricity Water Company	The second largest utility company in the MENA region. QEWC is the main supplier of electricity and desalinated water in Qatar with a market share of 62% of electricity and 79 % of the water.	www.qewc.com
13	Aamal Holding	Aamal Holding is one of Qatar's largest and most diversified holding companies, operating in industrial manufacturing, trading and distribution, property and managed services.	http://www.aamal.com.qa
14	United Development Company	United Development Company (UDC) is a leading Qatari public shareholding company with a mission to identify and invest in long-term projects contributing to Qatar's growth and providing good shareholder value.	http://www.udcqatar.com
15	Salam International	Salam International Investment Ltd. QSC is a publicly-listed Qatar shareholding company that operated across four main areas including energy and industry; contracting; luxury retail and hospitality; and technology.	http://www.salaminternational.com
16	Gulf Warehousing Company	GWC is by far Qatar's biggest pure-play logistics operator, offering express services, warehousing and freight solutions to its clients. The firm is based in Logistics Village Qatar, the country's new supply chain hub.	http://www.gwclogistics.com/
17	PROTEC	Privately owned company established in Doha, Qatar engaged in the fields of Engineering, Supply, Construction, Installation, Commissioning, Operation and Maintenance of various types of equipment for the Water, Waste Water, Energy, and Industrial markets.	https://www.protecind.com
18	Al Baida Group	Al Baida Group is one of the leading Business conglomerate in the State of Qatar. Activities include Engineering consultancy, Construction, Heavy Equipment Rental, Logistics, Freight forwarding, Real Estate, Infrastructure, Customs Clearance and Consumer products.	https://www.albaidagroup.com/index.php?option=com_k2&view=itemlist&layout=category&task=category&id=1
19	Arab Qatari Company	Part ACOLID Group (Arab company for livestock development) in partnership with Hassad food as a major poultry products supplier for the Qatari market and meets the needs of the Qatari citizen of white meat and eggs as well as fodder for productive processes.	http://aqpoultry.com.qa/users/aboutus
20	AGRICO	AGRICO is a private local Qatari Agricultural Development Company that was founded on the principle of sustainable long term agricultural production with an eye on the National target of achieving food security.	http://www.agrico.qa/about-agrico
21	Baladna	Baladna is an agricultural company that raises livestock and produces dairy products	https://baladna.co/
22	Al Sulaiteen Agricultural and Industrial Complex (SAIC)	SAIC is the leading landscaping & agriculture company in Qatar with operations ranging from turnkey landscaping projects to supply of flowers and fresh fruits & vegetables to the local market.	http://saic.com.qa/saic/
Universities and Research Institutes			
23	Qatar University	The first, largest, and most prominent institution for higher education in Qatar.	http://www.qu.edu.qa/
24	Qatar Foundation	Qatar Foundation for Education, Science and Community Development is a private, non-profit organization that serves the people of Qatar by supporting and operating programs in three core mission areas: education, science and research, and community development. The Foundation strives to nurture the future leaders of Qatar. By example and by sharing its experience, the Foundation also contributes to human development nationally, regionally, and internationally. In all of its activities, the Foundation promotes a culture of excellence in Qatar and furthers its role in supporting an innovative and open society that aspires to develop sustainable human capacity, social, and economic prosperity for a knowledge-based economy.	https://www.qf.org.qa/
25	Qatar Science Technology Park	Part of Qatar Foundation, Qatar Science & Technology Park is a home for international technology companies in Qatar, and an incubator of start-up technology businesses.	https://qstp.org.qa/

26	Qatar Environment and Energy Research Institute	Part of Qatar Foundation, Qatar Environment & Energy Research Institute's (QEERI's) mission is to conduct and co-ordinate long-term and multidisciplinary research that addresses critical national priorities concerning energy and the environment.	https://hbku.edu.qa/QEERI
27	Qatar National Research Fund	The Qatar National Research Fund (QNRF) is a governmental funding body that supports original, competitively selected research by both local and international researchers for projects that fit with Qatar's national research strategy, and that incorporate a Qatar-based partner	http://www.qnrf.org/
28	Georgetown University in Qatar	Georgetown University in Qatar (GU-Q) is a satellite campus of Georgetown University, based in Education City in Doha.	https://www.qatar.georgetown.edu/
29	Texas A&M University in Qatar	Texas A&M University in Qatar is a satellite campus of Texas A&M University, based in Education City in Doha.	https://www.qatar.tamu.edu/
30	Carnegie Mellon university in Qatar	Carnegie Mellon university in Qatar is a satellite campus of Carnegie Mellon University, based in Education City in Doha.	https://www.qatar.cmu.edu/
31	Northwestern University in Qatar	Northwestern University in Qatar is a satellite campus of Northwestern University, based in Education City in Doha.	https://www.qatar.northwestern.edu/
32	Aquatic Fisheries and Research Centre	Research centre in the field of aquaculture.	Website still under construction
33	Agricultural Research and Guidance Centre	Research centre in the field of agriculture.	http://www.mme.gov.qa/cui/view.dox?id=583&siteID=2
34	Animal Production Research Station	Research development on animal production and artificial insemination technology.	http://www.mme.gov.qa/cui/view.dox?id=583&siteID=2

8. Endnotes

[1] EY internal analysis.

[2] EY internal analysis.

[3] Rasoul Sorkhabi, P. (2010).The Qatar Oil Discoveries. GEO ExPro. Retrieved August 8, 2018, from https://www.geoexpro.com/articles/2010/01/the-qatar-oil-discoveries [Accessed 8 Aug. 2018].

[4] Encyclopedia Britannica. (2018). Qatar | Geography & History. Retrieved August 8, 2018, from https://www.britannica.com/place/Qatar

[5] World Bank. (2018). Qatar population growth and GDP. Retrieved August 9, 2018, from https://data.worldbank.org/country/qatar?view=chart

[6] World Population Review. (2018). Qatar Population 2018. Retrieved August 9, 2018, from http://worldpopulationreview.com/countries/qatar-population

[7] Statistics Times. (2017). List of Countries by Projected GDP per capita 2017 (based on IMF World Economic Outlook Database, April 2017). Retrieved August 9, 2018, from http://statisticstimes.com/economy/countries-byprojected-gdp-capita.php.

[8] Trading Economics. (2018). Qatar GDP Growth Rate | 2004-2018 | Data | Chart | Calendar | Forecast. Retrieved August 9, 2018, from https://tradingeconomics.com/qatar/gdp-growth

[9] Gulf Intelligence. (2016). The future of Qatar's Water Security. Retrieved on August 15 2018 from https://www.flandersinvestmentandtrade.com/export/sites/trade/files/attachments/WATER%20SECURITY%20Special%20Report%202016%20-%20Web%20Edition.pdf

[10] Hukoumi. Water and Desalination. Retrieved on August 15 2018 from http://www.hukoomi.qa/wps/portal/topics/Environment+and+Agriculture/wateranddesalination

[11] Ministry of Development Planning & Statistics (2017). Water Statistics in the State of Qatar 2015. Retrieved on August 5, 2017 from https://www.mdps.gov.qa/en/statistics/Statistical%20Releases/Environmental/Water/2015/Water-Statistics-2015-En.pdf

[12] MDPS (2015). Water Statistics in the State of Qatar. Retrieved on August 15 2018 from https://www.mdps.gov.qa/en/statistics/Statistical%20Releases/Environmental/Water/2015/Water-Statistics-2015-En.pdf

[13] Hanan O. Ali et al. (2016). Current and Future Water Resources for Agriculture in Qatar State. British Journal of Applied Science & Technology, Vol.18, No.4, pp. 1-13. Retrieved on August 15 2018 from http://www.journalrepository.org/media/journals/BJAST_5/2017/Jan/Ali1842015BJAST17881_1.pdf

[14] KAPSARC (2017), GCC Energy System Overview 2017. Retrieved on August 15 2018 from https://www.kapsarc.org/wp-content/uploads/2017/11/KS-2017-MP04-GCC-Energy-Overview-2017.pdf

[15] Ministry of Development Planning & Statistics (2017). Water Statistics in the State of Qatar 2015. Retrieved on August 5, 2017 from https://www.mdps.gov.qa/en/statistics/Statistical%20Releases/Environmental/Water/2015/Water-Statistics-2015-En.pdf

[16] Oxford Business Group (2018). Capacity increase in power and water ultities key to supporting Qatar's economic expansion. Retrieved August 5, 2018 from https://oxfordbusinessgroup.com/overview/poised-growth-capacity-increases-power-and-water-are-key-supporting-continued-economic-expansion

[17] EY internal analysis.

[18] The Oil & Gas Year (2018), Qatar Overview. Retrieved on August 5 2016 from https://www.theoilandgasyear.com/market/qatar/

[19] Alsheyab, M. (2017). Qatar's Effort for the Deployment of Carbon Capture and Storage. Global NEST Journal, Vol. 19, No. 3, pp 453-457. Retrieved on August 15 2018 from https://journal.gnest.org/sites/default/files/Submissions/gnest_02269/gnest_02269_published.pdf

[20] Saur Energy (2017). Qatar to Adopt First Renewable Energy Strategy. Retrieved on August 15 2018 from http://www.saurenergy.com/solar-energy-news/qatar-adopt-first-renewable-energy-strategy

[21] Renewable Energy Magazine (2017). Qatar to begin construction of 200 MW solar project this year. Retrieved November 7, 2018 from https://www.renewableenergymagazine.com/pv_solar/qatar-to-begin-construction-of-200-mw-20170322

[22] Trade Arabia (2017). Qatar to start work on major solar power plant in June. Retrieved November 7, 2018 from http://www.tradearabia.com/news/OGN_321642.html

[23] Oxford Business Group (2017). Qatar gets serious about solar. Retrieved November 7, 2018 from https://oxfordbusinessgroup.com/news/qatar-gets-serious-about-solar

[24] Keppel Seghers (2014). Domestic Solid Waste Management Centre. Retrieved on August 15, 2018 from http://www.keppelseghers.com/en/news_item.aspx?sid=3039&aid=4715

[25] World Bank Data (2014). Electrical Power Consumption (kWh/Capita). Retrieved on August 15, 2018 from https://data.worldbank.org/indicator/eg.use.elec.kh.pc

[26] Kahramaa. Sustainability Mission 2030. Retrieved on August 15 2018 from auptde.org/Article_Files/Qatar.pptx

[27] Oxford Business Group. Qatar: Industry. Retrieved on August 15 2018 from https://oxfordbusinessgroup.com/overview/expand-rationalise-capacity-increases-keep-sector-ahead-demand-while-lower-oil-revenues-prompt-new

[28] The Peninsula Qatar. (2017). ACs consume up to 70 % of electricity in houses. Retrieved on August 15 2018 from https://www.thepeninsulaqatar.com/article/04/07/2017/ACs-consume-up-to-70-of-electricity-in-houses-Kahramaa

[29] G.I. Danmaliki et al. (2017). Forecasting CO2 emissions in the Persian Gulf States, Global J. Environ. Sci. Manage., Vol. 3, No. 1, pp. 1-10, doi: 10.22034/gjesm.2017.03.01.001

[30] Based on EY internal analysis.

[31] N.O., Abdullah. (2016). Vertical-Horizontal Regulated Soilless Farming via Advanced Hydroponics for Domestic Food Production in Doha, Qatar. Research Ideas and Outcomes, doi: 10.3897/rio.2.e8134

[32] The Global Economy (2018). Qatar: GDP share of Agriculture. Retrieved August 15, 2018 from https://www.theglobaleconomy.com/Qatar/Share_of_agriculture/

[33] EIU and The Economist. (2018). The Global Food Security Index. Retrieved August 15, 2018, from http://foodsecurityindex.eiu.com/

[34] WITS. (2016). Qatar Food Products Imports by Country and Region. Retrieved on August 15 2018 from https://wits.worldbank.org/CountryProfile/en/Country/QAT/Year/2016/TradeFlow/Import/Partner/all/Product/16-24_FoodProd

[35] FAO. (2016). Qatar Crops. Retrieved on August 15 2018 from http://www.fao.org/faostat/en/#data/QC

[36] Dabanga. (2018). Qatar to Invest in Sudan Agriculture. Retrieved on August 15 2018 from https://www.dabangasudan.org/en/all-news/article/qatar-to-invest-in-sudan-agriculture

[37] Investvine. (2018). Vietnam to Cooperate with Qatar in Food Security. Retrieved on August 15 2018 from http://investvine.com/vietnam-cooperate-qatar-food-security/

[38] National University of Singapore (2018). Insight 185: Contemporary Issues in Qatar's Food Security. Retrieved August 12, 2018 from https://mei.nus.edu.sg/publication/insight-185-contemporary-issues-in-qatars-food-security/

[39] EIU and The Economist. (2018). The Global Food Security Index. Retrieved August 15, 2018, from http://foodsecurityindex.eiu.com/

[40] EcoMENA (2016). Food Waste Woes in Qatar. Retrieved on August 12, 2018 from https://www.ecomena.org/food-waste-in-qatar/

[41] Georgetown University of Qatar (2018). Researchers Share Findings of Study on Food Waste in Qatar. Retrieved on August 12, 2018 from https://www.qatar.georgetown.edu/news-events/news/researchers-share-findings-study-food-waste-qatar

[42] M. Kummu et Al. (2012), Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. Retrieved August 12, 2018, from http://www.sciencedirect.com/science/article/pii/S0048969712011862

[43] Based on EY internal analysis.

[44] The United Nations. (2017). Qatar Voluntary National Review 2017. Retrieved August 12, 2018, from https://sustainabledevelopment.un.org/content/documents/16517Qatar_VNR_2017_En.pdf

[45] Ministry of Development Planning and Statistics. (2017). Qatar National Vision 2030. Retrieved August 12, 2018, from https://www.mdps.gov.qa/en/qnv/Documents/QNV2030_English_v2.pdf

[46] Qatar National Food Security Program. (2018). Retrieved August 12, 2018, from http://www.qnfsp.gov.qa/

[47] Qatar National Research Strategy. (2018). Retrieved August 12, 2018, from https://www.qnrf.org/en-us/About-Us/QNRS

[48] Ministry of Development Planning and Statistics. (2017). Retrieved August 12, 2018, from https://www.mdps.gov.qa/en/knowledge/HomePagePublications/Qatar_NDS_reprint_complete_lowres_16May.pdf

[49] Tarsheed: Strategies & Projects. (2013). Retrieved August 14, 2018, from https://www.km.com.qa/MediaCenter/Publications/webenglish.pdf

[50] Qatar National Biodiversity Strategy and Action Plan 2015 – 2025. (2014). Retrieved August 19, 2018, from https://www.cbd.int/doc/world/qa/qa-nbsap-v2-en.pdf

[51] EY internal analysis.

[52] EY internal analysis.

[53] EY internal analysis.

[54] World Bank. (2018). How is Qatar Reacting to Low Oil Prices?. Retrieved August 8, 2018, from http://www.worldbank.org/en/country/gcc/publication/economic-brief-july-qatar-2016 [Accessed 9 Aug. 2018].

[55] The World Bank. (2018). Qatar's Economic Outlook - October 2017. Retrieved August 9, 2018, from http://documents.worldbank.org/curated/en/930611523635638905/pdf/125261-MEM-April2018-Qatar-EN.pdf

[56] Kingdom of the Netherlands. (2018). Dutch Economic Network in the GCC, 2018. Retrieved August 13, 2018, from https://www.netherlandsworldwide.nl/doing-business-in-the-gulf-region/contact-us/holland-network-in-gcc

[5757] Kingdom of the Netherlands. Agricultural Department for the GCC-countries. Retrieved on November 14 2018 from https://www.netherlandsandyou.nl/your-country-and-the-netherlands/saudi-arabia/about-us/agriculture

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