Ministry of Foreign Affairs

# *Nexus in Oman*

## *OPPORTUNITIES FOR DUTCH COOPERATION*

*Commissioned by the Netherlands Enterprise Agency*

>> *Sustainable. Agricultural. Innovative. International.*

uniting water energy food

# NEXUS

## IN OMAN

OPPORTUNITIES FOR DUTCH COOPERATION

Dutch connection in Oman

DUTCH GULF

Holland.

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## DISCLAIMER



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This version of the report has been updated for corrections to some sections following feedback from stakeholders. Please use this version of the report published in July 2019 as the final report, in place of the earlier version of the report published in April 2019.
For further information, to provide feedback or to assist in further validating the report, please contact the Embassy: MUS-EA@minbuza.nl

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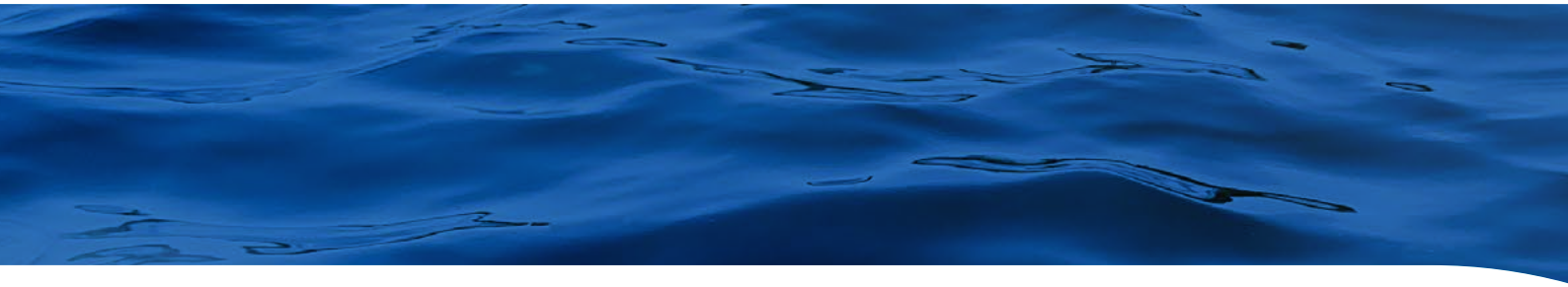
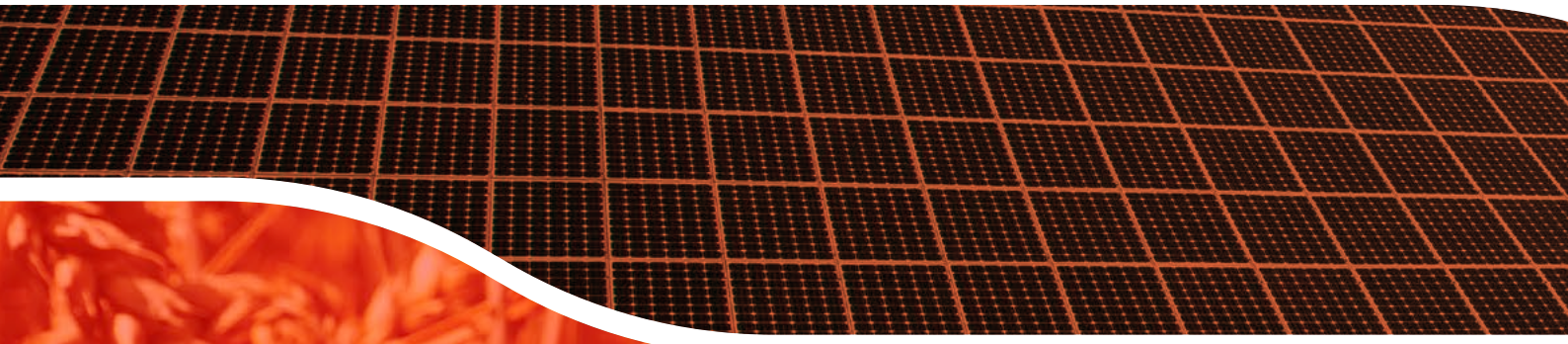




# NEXUS
## IN OMAN

## INTRODUCTION

Water, energy, and food are vital resources on which all living organisms depend for survival. Future demand for these resources will increase significantly in the years to come in response to continued economic development and global population growth. Climate change and environmental stress are also putting further strain on our planet's scarce resources. These challenges affect and should concern us all around the globe, and have led to calls for accelerated, collective action to achieve sustainable development.

It is also my firm belief that today's challenges in the water, energy and food sectors should be faced collectively, so I am delighted that, at a UN summit in 2015, Oman and the Netherlands were among the 193 countries that adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs). 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 such an integrated approach in tackling these SDGs to ensure they are achieved without compromise.

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

By applying an integrated approach to water, energy and food partners can better understand and systematically analyze the interaction between our natural environment and human activities. They can also share additional insights into the complex and dynamic inter-relationship between water, energy and food, so guiding us towards the more sustainable use and management of our limited natural resources.

Around 60% of Oman's food comes from imports, with the agricultural sector accounting for around 80% of Oman's depleting fresh water resources. Oman has set the target of increasing to 20% by 2030 the share of renewable energy in meeting demand. The importance of addressing the water-energy-food nexus is as profound in Oman as it is elsewhere in the Gulf region and, as elsewhere the Netherlands stands ready to cooperate with Oman in this area – uniting water, energy and food.

The Embassy of the Kingdom of the Netherlands in Oman commissioned this report to encourage dialogue, awareness and engagement on the water-energy-food nexus between government, companies and knowledge institutions from both our countries. It explores the current state of play, recent developments and opportunities to advance the water, energy and food nexus in Oman. The report also provides guidance for partners based in the Netherlands on how best to share Dutch innovation, knowhow and skills with Oman. Furthermore it aims to assist in identifying how an integrated approach to the water-food-energy nexus can serve Oman's policy goals, including its Vision for 2040.

Bilateral relations between Oman and the Netherlands have been fruitful for many centuries and are cemented at the highest political levels. I am convinced that dialogue on the water-food-energy nexus will consolidate these relations and enhance further our Strategic Water Partnership. I look forward to the Netherlands and Oman combining forces to take all necessary steps towards sustainable development by addressing the water, energy, food nexus in tandem with other related sectors where we also cooperate, such as logistics. Together we can influence positively one of the most defining issues of our time.

Sincerely,

*Laetitia van Asch*
*Ambassador of the Kingdom of the Netherlands to the Sultanate of Oman*

## Abbreviation List -

| | |
|---|---|
| AWG | Atmospheric Water Generation |
| CAGR | Compounded annual growth rate |
| CCGT | Combined Cycle Gas Turbine |
| CSP | Concentrated Solar Power |
| ED | Electrodialysis |
| ESCO | Energy Servicing Company |
| FDI | Foreign Direct Investment |
| GDP | Gross Domestic Product |
| GMO | Genetically Modified Organism |
| GMOs | Genetically Modified Organisms |
| IoT | Internet of Things |
| LEED | Leadership in Energy and Environmental Design |
| MD | Membrane Distillation |
| MED | Multi-Effect Distillation |
| MSF | Multiple Stage Flash |
| MSW | Municipal Solid Waste |
| MVC | Mechanical Vapour Compression |
| Mwh | Megawatt hour |
| PV | Photovoltaic |
| RAS | Recirculating Aquaculture System |
| RO | Reverse Osmosis |
| T&D | Transmission & Distribution |
| WEF | Water-Energy-Food |
| WtE | Waste to Energy |
| WWTP | Waste Water Treatment Plant |
| YoY | Year-over-Year |

# 1. Objective

The WEF Nexus has risen up on the agenda of various GCC countries. Accordingly, the Dutch government has developed partnerships with GCC governments on this strategically-important topic. Looking at the Sultanate of Oman, the Dutch government is looking to establish a bilateral cooperation on the Nexus, thereby enabling business to business (B2B), knowledge to knowledge (K2K) and government to government (G2G) cooperation.

The objectives of this report are threefold: to support this arrangement by contextualizing the current state of the WEF Nexus in Oman particularly in relation to the availability of primary freshwater, energy and food resources along with the main challenges faced; provide 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; and to highlighting some of the possible investment opportunities for Dutch companies in Oman, and the engagement channels that can be utilized.

Like the 'Shabab Oman II' and the 'Stad Amsterdam': let's sail together towards the future and unite water, energy and food!

## 2. Summary -

# OMAN OVERVIEW

## The Sultanate of Oman

| | |
|---|---|
| **LAND AREA:** | 309,500 km$^2$ |
| **CLIMATE:** | Dry desert; hot, humid along coast; hot, dry interior |
| **TERRAIN:** | Central desert plain, rugged mountains in north and south |
| **ARABLE LAND:** | 0.1% |
| **ENVIRONMENTAL ISSUES:** | Limited natural freshwater resources; high levels of soil and water salinity in the coastal plains; beach pollution from oil spills; aquifer pollution from industrial effluents; desertificaiton |
| **ENVIRONMENT AGREEMENTS:** | Biodiversity, Climate Change, Desertification, Hazardous Wastes, Law of the Sea, Marine Dumping, Ozone Layer Protection, Ship Pollution, Whaling |
| **NATURAL RESOURCES:** | Petroleum, copper, asbestos, some marble, limestone, chromium, gypsum, natural gas |
| **POPULATION:** | 4,613,241 (July 2017 est.), 45% Expatriates |
| **URBANIZATION:** | 84.5% of total population |
| **GDP (PPP):** | USD 186.6 billion (2017 est.)<br>1.7% agriculture, 45.2% industry, 53% service (2017 est.) |
| **GDP - PER CAPITA (PPP):** | USD 45,200 (2017 est.) |
| **INDUSTRIES:** | Crude oil production and refining, natural gas and LNG production; construction, cement, copper, steel, chemicals, optic fiber |

# OMAN WATER-ENERGY-FOOD RESOURCES

### Power generation in Oman

Oman generated 32.3 TWh of electricity in 2017 across its three national power grids. The residential sector is the biggest consumer, followed by the industrial. At the moment, power for the Main-Interconnected-System is generated almost exlusively through natural gas.

| | Natural Gas | Fuel Oil | Renewables (solar, wind etc.) | Waste-to-Energy/ Biogas | Nuclear |
|---|---|---|---|---|---|
| **Power Mix** | ~100% | <1% | <1% | 0% | 0% |
| **Trend** | ▼ | Backup only | ▲ | ▲ | No plans |

### Water production/withdrawal in Oman

Oman's water supply consists of non-renewable groundwater resources, followed by desalination and treated wastewater. In 2015, Oman's water supply amounted to 1721 MCM/year. Agriculture is the largest consumer (83%), followed by residential (10%) and industrial (7%).

| | Thermal Desalination (fossil fuel) | Reverse Osmosis (from Grid) | Treated Wastewater | Surface & Groundwater |
|---|---|---|---|---|
| **Water Mix** | Desalination 16% | | 2% | 81% |
| **Trend** | ▼ | ▲ | ▲ | ▼ |

### Food production and acquisition in Oman

Food Imports

- Food imports in 2016 were worth USD 3.64 billion.
- In 2016, Oman's top food partner was the UAE, followed by Singapore and Somalia.

Foreign Direct Investment in farmland abroad

- While some interest has been shown by Oman over the past few years, FDI in farmland abroad has not taken off or been incorporated into any national food security strategy.

Domestic Food Production

- In 2017, Oman's 1.47 million hectares of agricultural land produced about 1.87 million tonnes of fresh produce, of which 25,600 tonnes were vegetables, 457,660 tonnes were fruits and 972,800 tonnes were fodder crops.

### Food loss in industrialized asian countries across supply chain

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

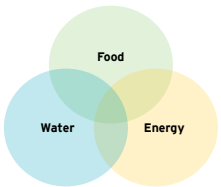
★ Significant opportunities exist to reduce losses at handling & storage, and consumption. Along with biogas opportunities post consumption.

# HIGHLIGHTED INVESTMENT OPPORTUNITIES

### Investment opportunities for Dutch companies (for full list, refer to Chapter 8)

**Water-Food**
- High-tech greenhouses
- Hydroponics & aquaponics
- Urban & vertical 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
- Industrial water discharge management
- Solar water pumps
- Solar water heaters
- District cooling




**Food-Energy**
- Greenhouse and storage cooling systems
- Biogas production from landfills
- Biomass from halophytes
- Route & inventory optimization
- Physical/emergency stockpiling (i.e. food reserves)
- PV for irrigation pumps

# 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.

*Figure 1: Food security tradeoffs in the GCC*[1]

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

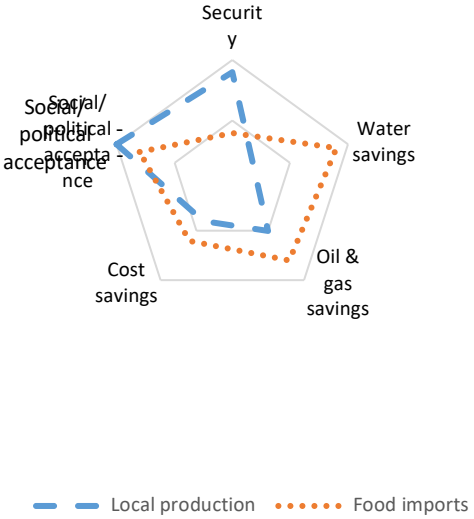
- Food imports are more prone to climate and market shocks as demonstrated by the 2007/2008 Global Food Price Crisis
- Oman has relatively less agricultural bargaining power given its climate conditions and geography

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

- Considerable support is provided to local farmers, and is in line with various strategies/targets, including economic diversification, and food security
- Culturally agriculture is encouraged
- Large trading and bargaining power to secure food imports (long-term contracts to ensure food security)

**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 generally more expensive (when all factors considered) in comparison to food imports, however, food imports are 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 Oman's
- The need to desalinate brackish aquifers makes local food production energy intensive

[1] Figure 1 is based on EY internal analysis

*Figure 2: Water security tradeoffs in the GCC[2]*

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

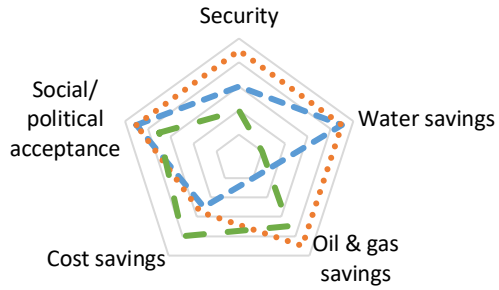
- RE/nuclear desalination is more secure in the long-term, because it decouples water from fossil fuels
- Groundwater extraction is widely prevalent, however aquifers are depleting faster than their regenerative capacity

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

- Government targets to diversify Oman's energy mix inadvertently - support non-fossil fuel desalination -
- Strong government awareness on need to scale back groundwater extraction, through opposition will exist by farmers

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

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




**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 fossil fuel prices go up, - making renewable powered - desalination more attractive -

**How resource intensive is the water production/acquisition method?**

- Renewable powered desalination does not require fossil fuel thereby presenting a large national energy saving

Figures 1 and 2 illustrate conceptual what-if scenarios of various supply side interventions in Oman with respect to food and water security. Local food production refers to the food produced on farms within Oman, using both standard and advanced farming practices. Upon analyzing food security, Oman 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 intensive and energy intensive, as local brackish aquifers require some level of desalination. 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 Oman looks to expand its local food production capacity, it must address the associated constraints of food, water and energy. Strategies, policies and initiatives in place to tackle such constraints are explored in Chapter 6.

[2] Figure 2 is based on EY internal analysis

## 4. Oman: background and context

Upon the discovery of oil in 1962 at Yibal, coinciding with marked socio-political developments, the Sultanate of Oman began its transformation from tribal administrative regions to a modern unified nation. This transformation resulted in major socio-economic and environmental changes, which continue to this day. The population and economic growth that followed, depicted in Figures 3 and 4[3], led to an increase in demand for resources that far exceeded the country's natural carrying capacity. By 2040, the population is estimated to grow by a further 33.75%, reaching 5.35 million, further straining the country's scarce natural resources.

*Figure 3: Population growth in Oman since 1960[3]*

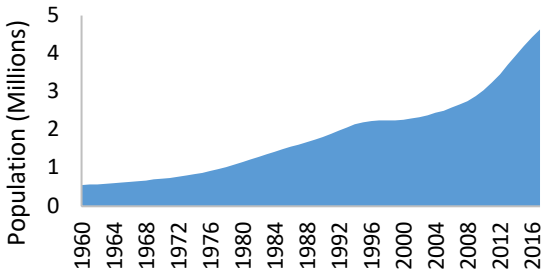
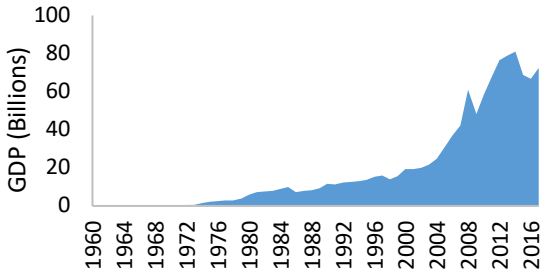



*Figure 4: GDP in Oman since 1960 in USD current[3]*




The country's economy is also significantly dependant on its natural gas reserves. In 2016, Oman held 23 trillion cubic feet (Tcf) of proved natural gas reserves and produced 1.16 Tcf of natural gas, out of which, approximately 70% was consumed domestically and 358 Bcf has been exported[4]. Demand for natural gas continues to grow as it is becoming a key source of energy to the Omani economy, in line with the country's efforts to diversify its economy away from oil.

With 0.3%[5] of the world's proven oil reserves, Oman's oil wealth is markedly less than some of its Gulf neighbours. This has informed Oman's need to diversify its economy early on, though still relying on oil exports.

Oman's oil and gas revenues have enabled the dry and arid country to meet much of its food security needs through imports and local agriculture. Its energy resources have also been utilized to increase its water supply via fossil fuel powered seawater desalination.

The result is that Oman is heavily reliant on its fossil fuel and fossil aquifer resources for maintaining water and food security. This makes it 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 phenomenon, the interdependence of the two is particularly severe and critical in Oman and highlights the importance of adopting a water-energy-food, WEF, nexus (the Nexus) approach when considering and addressing the country's future development.

The Sultanate of Oman comprises of 11 governorates: Muscat, Dhofar, Musandam, Buraymi, the Dakhiliyah, the North Batinah, South Batinah, South Sharqiyah, North Sharqiyah, Dhahirah and Wusta. Each governorate is further divided into provinces (welayat). Its 3,165 kilometre coastline runs northwards from the Arabian Sea and the entrance to the Indian Ocean in the far south-west to the

[3] The World Bank, *Population growth and GDP Oman*, 2018. -
[4] EIA, Country Analysis Brief: Oman, 2017 -
[5] Oman Observer, *Sultanate's oil reserve at 5.115 billion barrels*, 2017. -

Sea of Oman and Musandam, where it overlooks the strategic Strait of Hormuz at the entrance to the Arabian Gulf.[6] Muscat is the Sultanate's capital, seat of government and the centre of the nation's administration. Muscat is the most densely populated Governorate with a population of 2,395,412.

# 5. Resources in Oman

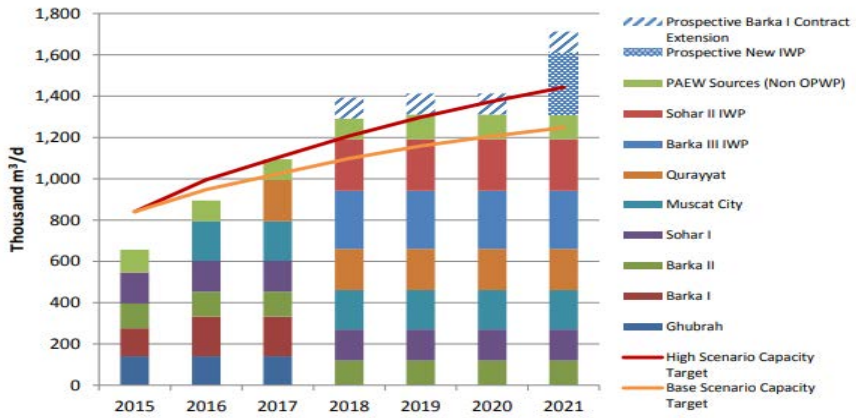
## 5.1 Freshwater

### *5.1.1 Current outlook*

Compared with its other GCC neighbours, Oman is relatively more water abundant – though highly reliant on non-renewable groundwater resources (i.e. fossil aquifers). Oman contains some surface water, primarily through dams such as the Wadi Dayqah Dam, with a capacity of around 100 MCM[7]. A distinct feature of Oman's water infrastructure is the 'Aflaj' system. Aflaj are a wide network of ancient water channels that transport surface/groundwater by gravity – with an average national water supply of 552 MCM/year[7]. Groundwater is found in most parts of the country, with variable quality and storage.

In addition to surface and groundwater, non-conventional sources of water such as desalination (seawater and brackish water) and treated wastewater are growing significantly within the country. While desalination as a percentage of the total water mix in Oman (16%[4]) is lower than other GCC countries, it plays a pivotal role in addressing the country's water needs and has shown a significant increase in supply as shown in Figure 5. This is also supported by the fact that 90% of potable water is obtained from desalination[8]. This energy intensive process results in carbon emissions and in brine and chemical discharge to the sea, exacerbating the Oxygen Minimum Zone (OMZ) off the coast of Oman[9].

*Figure 5: Desalinated Water Capacity Requirements – Interconnected Zone[10]*




Recently, treated wastewater has been given greater attention as an alternative to groundwater abstraction[11]. Oman has 44 wastewater treatment plants controlled by the Ministry of Regional

[6] Sultanate of Oman Ministry of Information, *Oman info*, 2014. -
[7] Fanack, *Water Resources in Oman*, 2018. -
[8] International Decade for Action "Water for Life" 2005-2015 -
[9] The National, *World's largest 'dead zone' in Gulf of Oman has dramatically grown*, 2018. -
[10] Authority for Electricity Regulation Oman, *2017 Annual report*, 2018. -
[11] Rachel McDonnell, *Groundwater Use and Policies in Oman*, 2016. -

Municipalities & Water Resources (MRMWR) – producing around 11.5 MCM/year[7] whereas the private sector controls the remaining wastewater treatment plants. The share of treated wastewater is expected to significantly increase in Oman as the Haya WWTP in Muscat is expected to treat 100 MCM/year by 2030[7]. Treated wastewater is primarily used for landscaping and aquifer recharge as it is prohibited to be used for agriculture in Oman[11].

Figure 6 illustrates Oman's water supply mix, with groundwater being the main water resource - utilized for domestic, industrial and agricultural purposes. Water consumption by sector is illustrated in Figure 7.

*Figure 6: Oman's water supply mix (2015)[7]*

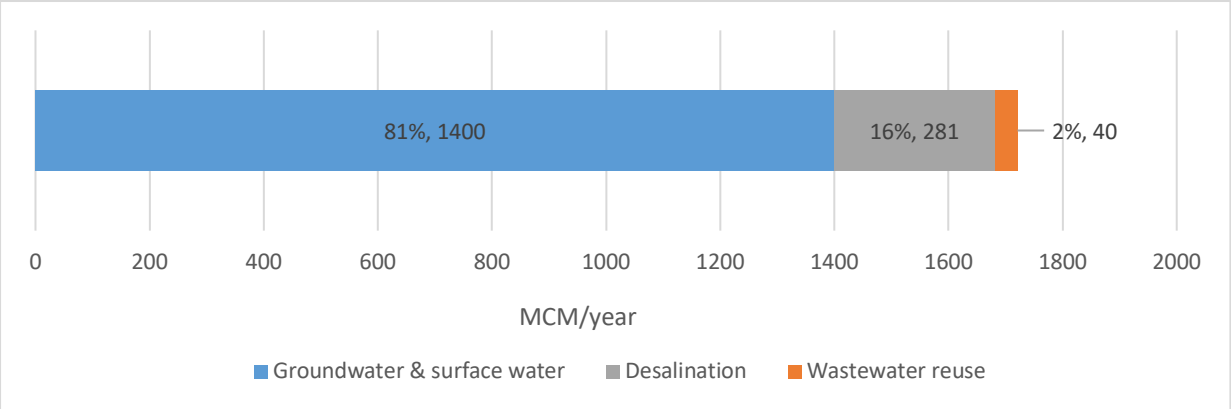
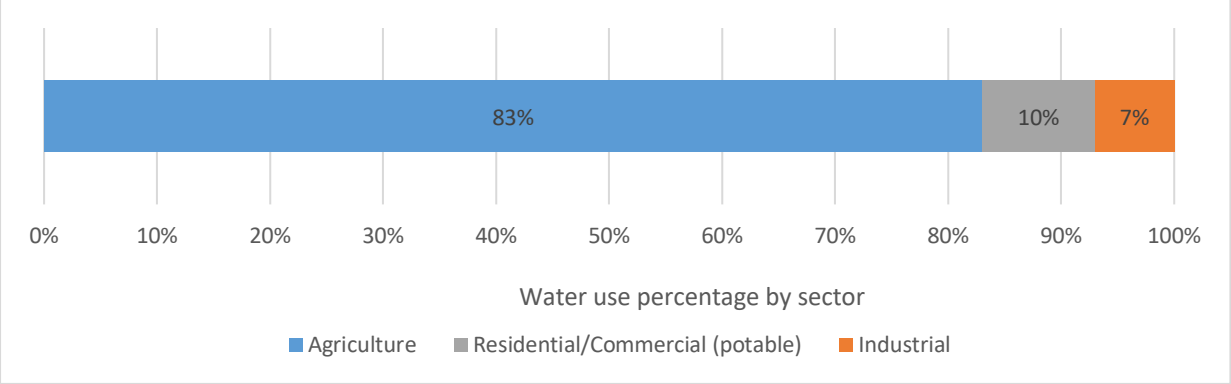
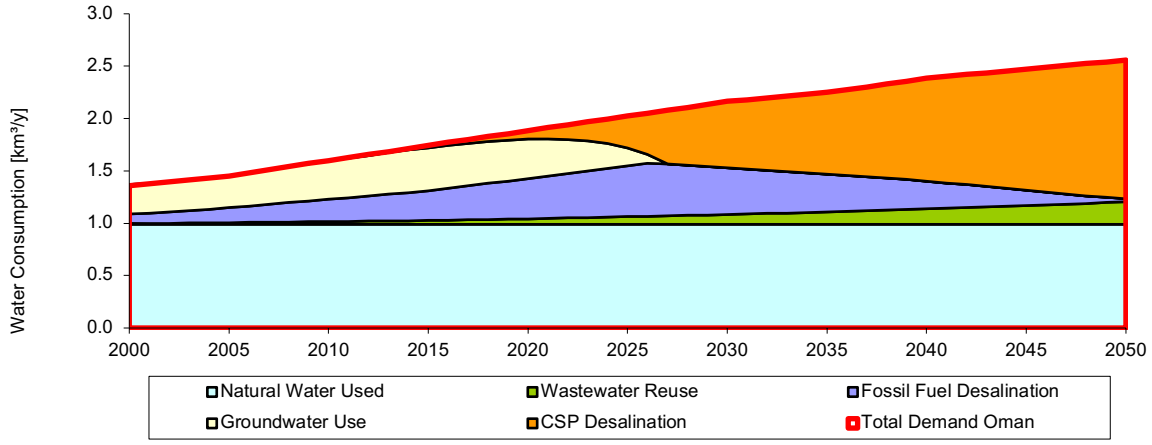



*Figure 7: Oman's water consumption by sector (2013)[7]*




Oman's water demand has been growing significantly and is expected to double by 2050[6]. Figure 8 forecasts the water demand by source, presenting a potential water mix that shifts away from groundwater and fossil fuel desalination to focus more on renewable powered desalination and wastewater reuse.

*Figure 8: Projected scenario of water demand by source[12]*




### 5.1.2 *Future outlook*

As highlighted in Figure 8, water demand is continuously growing and is expected to double by 2050[6]. In order for Oman to ensure water security in the future, an adoption of a combination of the below measures and initiatives is required to overcome the existing and speculated future challenges.

**How can Oman maintain its water security in the future?**

Supply: As the demand for domestic and agricultural water increases, renewable-powered desalination will begin to replace conventional fossil fuel powered technologies. In addition, the use of treated wastewater will increase to limit the depletion of groundwater. Oman will also look towards expanding and reinforcing the country's water storage, transmission and distribution infrastructure.

Demand: Oman has begun to implement a number of strategies and programs that encourage greater demand side management efforts 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. Behavioral changes, application of new technologies (i.e. smart monitoring systems, T&D efficiency increases, and use of renewables), removal/phasing out of subsidies and increasing tariffs will see the overall demand for water reduced.

In addition to supply and demand side initiatives, Oman will work toward improving its response to climate risks, particularly those that threaten its coasts, and marine environment.

[12]Saif et al., *Water Security in the GCC Countries: Challenges and Opportunities,* 2014.

## 5.2 Energy

### 5.2.1 *Current outlook*

Oman's total primary energy supply in 2015 was comprised of 83.7% natural gas and 16.3% oil[13]. Natural gas accounts for 97.1% of Oman's power generation, with the remaining being generated mostly by oil[13]. While Oman is an LNG exporter, it has relied to some extent on natural gas imports from Qatar (via UAE) for its domestic power generation[14]. Such imports are expected to reduce as Oman develops its Khazzan gas field, which will serve both domestic and international markets[14].

With the country's recent visions and national strategies, discussed further in chapter 6, centred on diversifying its energy mix represented in Figure 9, Oman is investing in developing its renewable energy capacity.

*Figure 9: Oman's power generation mix (2015 vs. 2025) [15]*

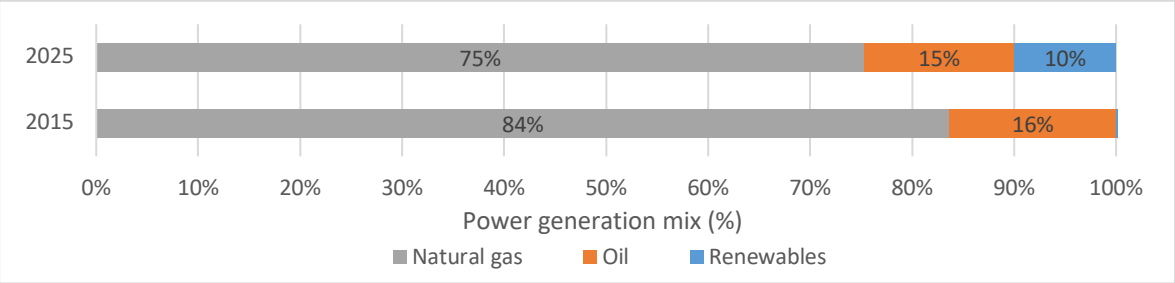



Table 1 summarizes Oman's power consumption for 2017 across its three power systems: the Main Interconnected System Currently (MIS), the RAEC Rural System, and the Dhofar Power System. Across all three systems, the greatest consuming sector is residential, followed by commercial/industrial and lastly government.

*Table 1: Electricity supply by power system and sector in Oman (2017)[10]*

| | **Main interconnected System** | | | **RAEC Rural System** | | | **Dhofar Power System** | | |
|---|---|---|---|---|---|---|---|---|---|
| Sector | MWh | % of total | YoY % | MWh | % of total | YoY % | MWh | % of total | YoY % |
| Residential | 13,268,328 | 46% | 6% | 451,348 | 49% | 13% | 1,172,414 | 43% | 10% |
| Industrial | 4,487,503 | 16% | -3% | 38,516 | 4% | -19% | 494,587 | 18% | -1% |
| Commercial | 6,827,412 | 24% | 17% | 144,120 | 16% | 8% | 460,204 | 17% | -18% |
| Agriculture & Fisheries | 371,048 | 1% | 6% | 44,646 | 5% | 36% | 9,228 | 0% | 3% |
| Hotels / Tourism | 173,392 | 1% | 453% | 30,508 | 3% | 6% | 13,784 | 1% | 517% |
| Government | 3,143,282 | 11% | -4% | 169,214 | 19% | -2% | 501,433 | 18% | 23% |
| Ministry of Defence | 311,219 | 1% | 37% | 35,618 | 4% | 6% | 102,464 | 4% | -15% |
| **Totals** | **28,582,184** | **100%** | | **913,970** | **100%** | | **2,754,114** | **100%** | |

It is worth noting that in 2017, tourism saw an almost 5% year-on-year growth, which is in line with Oman's efforts to diversify its economy through different sectors[16]. As a result, there has been a

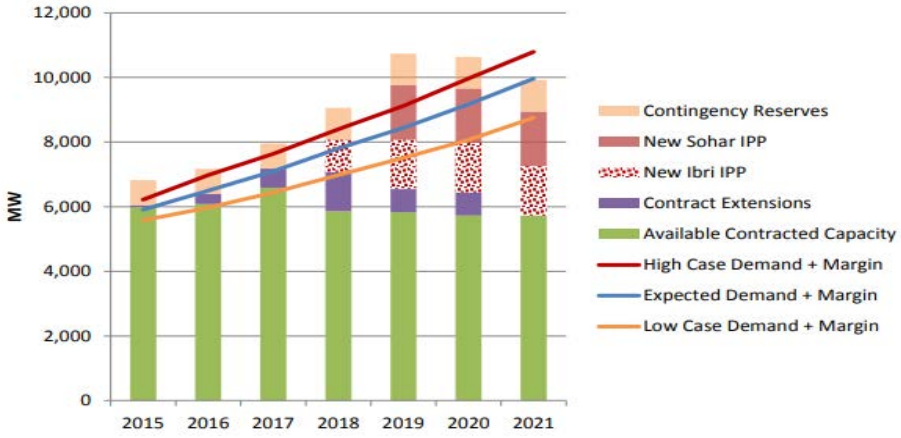
[13] International Energy Agency, *Oman Energy Balance,* 2015. -
[14] Arab News, *Oman ramps up gas production*, 2018. -
[15] Oman Observer, *Oman to target 3,000 MW power from renewables by 2025*, 2017. -
[16] Times of Oman, More Than 3 Million Tourists Visited Oman in 2017, 2018 -

significant year-on-year growth for urban power systems (MIS and Dhofar Power system) – reflecting Oman's economic plans of growing the tourism sector.

### 5.2.2 *Future Outlook*

As Oman continues to develop key sectors, its electricity consumption will continue to increase with the growth and forecasts highlighted in Figure 10.

*Figure 10: Future Power Generation Capacity Requirements of Main Interconnected System[10]*




As highlighted in Figure 10, Oman's electricity consumption will continue to increase as it focuses on developing its key sectors. In order for Oman 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.

**How can Oman maintain its energy security in the future?**

Supply: Renewable energy will steadily increase in contribution to Oman's energy mix with some projects either complete or in the pipeline. As per Oman's Energy Master Plan 2040, renewables will constitute 10% of the national power mix by 2025. Oman will also see adoption of distributed energy systems (DER) particularly residential grid solar power systems that will feed into the grid.

Demand: Oman is undergoing significant revisions and changes to its tariffs, subsidies, policies and laws that will encourage greater demand side management efforts across all sectors. Initiatives will increase in the form of mandatory green building codes, ESCO markets, as well as the greater adoption of energy saving smart technologies and systems across sectors. Behavioral changes, brought on by awareness and tariff reform will also reduce the overall demand for energy.

## 5.3 Food

### 5.3.1 *Current outlook*

Despite Oman's relatively arid climate, it has a rich agricultural history, showcased by its ancient Aflaj irrigation systems. In 2017, Oman's 1.47 million hectares of agricultural land[17] produced about 1.87 million tonnes of fresh produce, of which 25,600 tonnes were vegetables, 457,660 tonnes were fruits and 972,800 tonnes were fodder crops[18]. Nevertheless, Oman is highly reliant on food imports (around 60%)[19] to maintain its food security, sustained by its capacity to finance imports. Amongst the GCC countries, Oman has the 2nd highest food security score according to the Global Food Security Index (GFSI), it ranks 28th globally with a score of 73.9%[20].

*Figure 11: Food import mix of Oman ( 2016, by region )*[21]

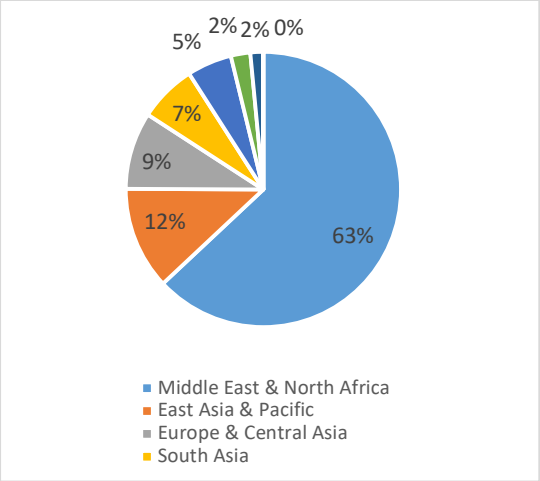
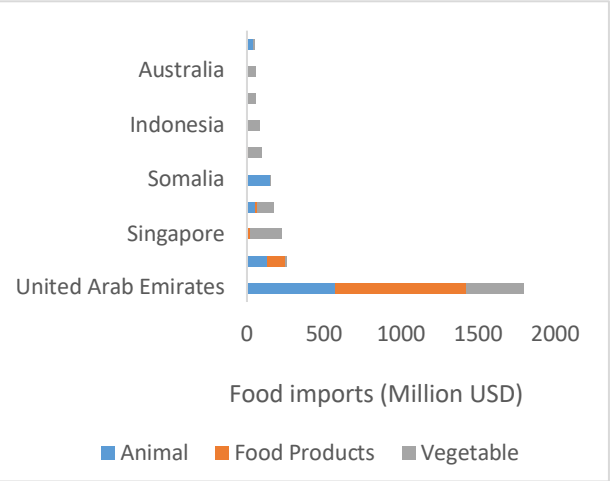



*Figure 12:* Oman's import breakdown of the top 10 trading partners (2016, million USD)[21]




In 2016, food imports to Oman totalled USD 3.64 billion, with more than 2.5% of its food (animal, fruits/vegetables and food products) coming from the Netherland directly or through re-export[21]. These imports amounted to USD 39.85 million and were dominated by animal products, with a smaller portion of food products and fruits/vegetables[21]. It is worth noting that while the UAE constitutes Oman's largest food trading partner (as per Figure 12), the food does not originate from the UAE, but is largely re-exported through their ports.

While Figure 22 would suggest that the Oman's food imports are relatively diversified, specific crops tend to be dominated by specific food exporting countries. For example, the majority of rice in 2016 was imported from Pakistan and India, while wheat was imported from Germany, Russia, Australia and Canada[22].

Currently, Oman has developed the National Water Resource Management Master Plan and the Oman Food Security Strategy to develop sustainable solutions to the threats of food and water insecurity[23].

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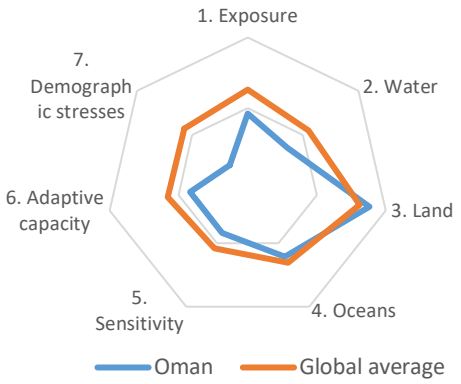
[17] Food Agricultural Organization, *Oman Country Profile*, 2018. -
[18] Times of Oman, *Oman second most food-secure country in GCC*, 2017. -
[19] Times of Oman, *Dependent on imports, Oman takes steps for food security*, 2018. -
[20] EIU and The Economist, *Global Food Security Index,* 2018. -
[21] World Integrated Trade Solution, *Oman Imports,* 2016. -
[22] Observatory of Economic Complexity. *Oman Country Profile* (2018). -
[23] Future Directions International, *The Sultanate of Oman: Food and Water Security to 2025*, 2015. -

However, no clear efforts have been made to address the climate and market risks related to its food imports and partners.

Despite its current Food Security Index score, Oman will be prone to food insecurity in the future. Based on the Global Food Security Index[20], Figure 13 highlights the country's poor resilience to food security pressures, particularly with respect to demographic stresses, reflecting the challenges facing the country as its population continues to increase and urbanize.

*Figure 13: Food Security Index pressures for Oman[20]*



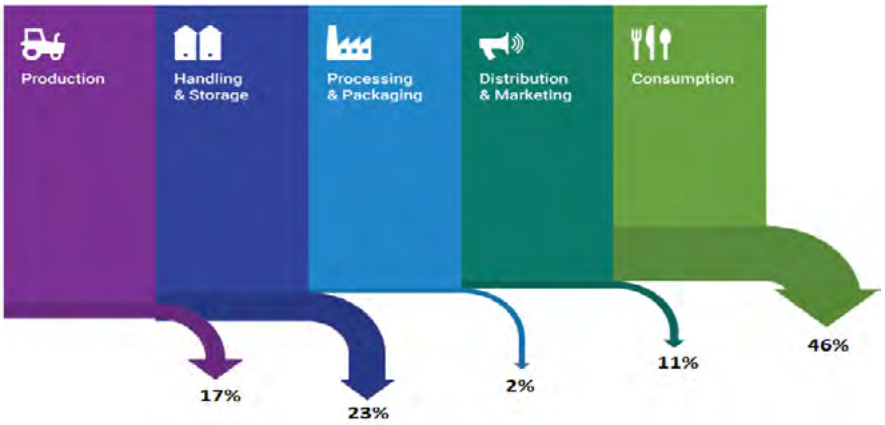

| Pressure | Food Security pressure components |
|---|---|
| 1. Exposure | Temperature rise, sea level rise, drought, flooding, storm severity |
| 2. Water | Agricultural water availability, water quality |
| 3. Land | Soil erosion, soil salinity |
| 4. Oceans | Eutrophication/hypoxia, marine biodiversity 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, food waste and loss in Oman is significant. It is estimated that throughout the supply chain, Oman loses 24% of fisheries and 40% of farm output[19]. There is an intention to tackle such losses by reducing them down to 6% and 10% respectively with the support of the Oman Food Investment Holding Company (OFIC) [19]. Figure 14 highlights the percentages of food waste lost across the supply chain in industrialized Asia, which Oman's profile falls under. The majority of losses occurs at handling and storage and at the consumption level (23% and 46%, respectively). In an effort to raise awareness on food wasted during consumption Be'ah, the company responsible for waste management in the country, revealed statistics suggesting that 27% of municipal waste consists of food items, accounting for approximately $150 million annually[24].

Furthermore, food waste is an untapped resource for fertilizer and energy generation. Currently, it is ending up in the landfills and has many associated negative effects such as increased amounts of emitted landfill gas. In an effort to tackle this issue and as a part of its strategy, Be'ah is planning to develop biogas plants in order to divert 60% of the municipal solid waste from all landfills across the Sultanate by 2030 and 80% by 2040 through the introduction of recovery activities[25].

[24] Muscat Daily, Amount of food wasted enough to meet 18% annual demand, 2018
[25] Muscat Daily, Be'ah issues feasibility study tender to develop biogas plant, 2018

*Figure 14: Food waste across supply chain in industrialized Asia[26]*




### 5.3.2 *Future outlook*

As Oman's population continues to increase and urbanize, it will face the challenge of meeting future demand and maintaining food security. In order for Oman 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.

**How can Oman maintain its food security in the future?**

Supply: Food imports, supplemented by agricultural Foreign Direct Investment (FDI) projects, will remain pivotal in Oman's food security strategy. Oman will look to consider climate and market risks more rigorously in its international food import strategy and adopt national risk management strategies such as early warning systems and expand its physical stockpiling. Oman will secure a wide range of global trading partners for a variety of shipping routes to avoid any further restrictions with regards to food import. Furthermore, domestic food production will shift away from animal feed and significantly modernize and leverage smarter and more efficient technologies along with more climate suitable crop variations (particularly fruits and vegetables) as a result of depleting aquifers.

Demand: Efforts to curb food wastage and spoilage will continue through better education/awareness and logistics. Water efficient technologies and solutions are being explored and adopted for agricultural practice in which seaweed could potentially play a significant role.

The future of Oman's food security relies on initiatives in the areas of efficient irrigation systems, water-saving greenhouses, salt-water agriculture, multi-trophic systems, healthy food healthy lifestyle, post-harvest solutions, biofuel and organic waste management.

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

# 6. National strategies, visions and objectives of Oman

The run up to 2040 will witness a series of reforms and investments aimed at implementing the myriad visions and strategies of Oman. Although these strategies target different sectors, they all share similar overarching components: diversification of the economy, employment, agriculture, the environment, education, technology and health.

*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 15: Strategies and visions on the national level in OmanFigure 15 summarizes some main strategies, visions and plans being available prior to the presentation of the draft overall Vision Oman 2040 (scheduled for January 2019).

*Figure 15: Strategies and visions on the national level in Oman*


## 6.1 Paris Agreement (Intended Nationally Determined Contributions)[27]

Oman, 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, Oman communicated the country's mitigation contributions with respect to energy efficiency, renewable energy, gas flaring, development of climate change legislation, and technology. It also communicated its adaptation contributions in energy security, food security, flood protection, sea level rise, marine environment, water scarcity and desertification.

[27] Submission on Intended Nationally Distributed Contributions (INDCs).

## 6.2 The National Program for Enhancing Economic Diversification (TANFEEDH)[28]

TANFEEDH was initiated by the government to diversify Oman's national income resources through linking essential sectors to each other, which include: Transport and Logistics, Manufacturing, Tourism and Mining and Fisheries. The various solutions and necessary interventions are identified through the TANFEEDH labs which involves stakeholders, partners, and participants from the relevant sectors. In addition, the initiative focuses on encouraging Public Private Partnerships (PPP), through the identification of government projects and community opportunities and challenges.

## 6.3 Oman Vision 2020[29]

Oman's Vision 2020 aims to provide a roadmap for the country's economic and social development by 2020. This vision sets key targets for the nation that includes economic and financial stability, the expansion of private sector participation, the diversification and globalization of the Omani economy as well as the development of the Omani Nation's skills in the workforce.

## 6.4 Oman's Five-Year Development Plan 2020[30]

Oman's 9th Five-Year Development plan is the last of the series of 5-Year Plans for the Vision 2020 and was established in 2016 for the economic diversification and social development of the Sultanate of Oman by 2020. This plan focuses on the creation of jobs of the Nation, the enhancement of the national economy through private sector involvement and economic diversification. This plan identifies five main sectors that display promise towards the economic diversification strategy of the Sultanate. The five sectors are: Manufacturing, Transport and Logistic Services, Tourism, Fisheries and Mining.

## 6.5 National Water Resources Master Plan[31]

Oman's National Water Resources Master Plan was established in 2000 for the development of a strategy aimed towards attaining the sustainable development of Oman's water resources by 2020. This Master plan is set for an improved understanding of the water availability and demand for water in the Sultanate of Oman to ensure meeting future demand as well as restoring existing deficit during this time period through management and conservation practices. One of the major objectives of this government Master Plan is to increase irrigation efficiency of localized systems for water conservation practice in agricultural development. Standards and calculations of crop water requirements for different areas have been set for these systems by the Ministry of Agriculture and Fisheries (MAF). Furthermore, the assessment of water resources in the country determined that there is a need for regulatory support to achieve sustainable levels of water consumption in the Sultanate.

## 6.6 Oman Energy Master Plan 2040[32]

The Oman Energy Master Plan 2040 Draft Report sets innovative energy solution recommendations for Oman on improving Oman's long-term energy security. Oman plans to reduce its dependence on hydrocarbons by diversifying its energy mix through the increased reliance on renewables. Furthermore, Oman aims to reduce the load on its non-renewable underground water resources by

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[28] Tanfeedh, *The National Program for Enhancing Economic Diversification (TANFEEDH),* 2016. -
[29] Salalah Free Zone, *Vision 2020,* 2018. -
[30] Government of the Sultanate of Oman, *A brief of the Ninth Five-Year Development Plan (2016-2020),* 2016. -
[31] FAO, *Oman Environment and Health*, 2009. -
[32] The Gulf Intelligence, *Oman Energy Master Plan 2040 Draft Report,* 2016. -

shifting towards desalination for its potable water. Collaboration with more developed countries and regional institutes to strengthen the research and development of the Nation is also considered for the country's future security.

## 6.7 New National Energy Strategy[33]

Oman's national energy strategy sets out the necessary guidelines and policies for securing the country's energy needs, through energy source diversification i.e. the ratio of renewable energy, with focus on solar and wind energy, in the national energy mix.

## 6.8 National Food Security Strategy[34]

Oman's Food Security Strategy has been set for the development and improvement of the nation's food supply chain with main focus on food security with regards to agriculture, fisheries, GDP (gross domestic product) levels and research and development. This strategy further focuses on identifying food security challenges of the Sultanate of Oman. This includes the limited availability of water for irrigation as well as the country's shortage of fertile land. The strategy further extends to include University research sponsorships as a method of supporting the domestic food production of drought-resistance and salt tolerant crops.[35]

## 6.9 Sustainable Agriculture & Rural Development (SARD) 2040[36]

The Ministry of Agriculture and Fisheries in Oman in collaboration with the Food and Agriculture Organization of the United Nations (FAO) developed a national strategy for sustainable agriculture and rural development in Oman. This strategy is being developed in alignment with Oman's National Vision 2040 and Five-Year Development Plan 2020 in order to unlock the potential of Oman's agriculture sector. This development program mainly focuses on contributing to the country's GDP as well as its employment for an improvement in the agricultural sector's trade balance. Oman aims to attain that goal through the efficient and sustainable use of its natural resources as well as its resilience to natural disasters and crisis management.

## 6.10 Oman Fisheries Development Strategy 2020[37] and Vision for 2040[38]

Oman Fisheries Development Strategy was developed in 2013 in line with Oman's Five-Year Development Plan 2020. The main objectives of this plan include upgrading the fishing fleet and infrastructure of the fisheries industry, research and resource management, the development of fish marketing and exports and the advancement of commercial aquaculture. This is to create an overall world-class competitive fishing industry that contributes to the country's GDP and job market where Oman aims to become a leader in aquaculture in the Gulf Region.

In addition, a Vision for 2040 has been established for the development of a profitable world-class fisheries sector for the sustainable contribution to Oman's economy. Oman's Ministry of Fisheries and Aquaculture has set out targets as part of this vision including the development of partnerships on

[33] Oman Economic Review, *New National Energy Strategy,* 2015. -
[34] Times of Oman, *Oman makes good progress in food security,* 2016. -
[35] Future Directions International, *The Sultanate of Oman: Food and Water Security to 2025,* 2015. -
[36] FAO, *A Sustainable Agriculture and Rural Development Strategy for Oman.* -
[37] Ministry of Agriculture and Fisheries Wealth, *Projects and Policies creating investment opportunities in the Fisheries Sector enhancing "Blue Growth",* 2013. -
[38] Iamena, *MENA Visions,* 2018. -

programs in collaboration with the World Bank. The commitment of this Omani Vision towards the fisheries industry aims to support Oman's economy using its natural resources.

# 7. Snapshot of the Water-Energy-Food Nexus in Oman

This chapter aims to provide a snapshot of the current state of the WEF Nexus within Oman. 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 Figures 16, 17 and 18. The Nexus Maps help structure the complex interactions and interlinkages of the Nexus, providing a high level understanding of WEF dynamics and security. Meanwhile, Tables, 3, 4 and 5 outline the various technologies and approaches currently utilized in Oman for each Nexus intersect in detail, coupled with corresponding initiatives and programs within the past 5 years. The references for the initiatives can be found in Appendix A.

*Table 2: Scoring criteria of WEF Nexus approaches/technologies*

| Approach/technology maturity | | Approach/technology growth potential | |
|---|---|---|---|
| Score | Description | Score | Description |
| 1 | Non-existent | 1 | Declining growth |
| 2 | Interest/awareness present | 2 | No growth |
| 3 | Pilot project investments/contracts or significant research on the area exists | 3 | Low growth |
| 4 | Emerging in the market | 4 | Medium growth |
| 5 | Well established | 5 | High growth |

The strengths and limitations of each approach/technology are outlined and scored as per the criteria in Table 2. 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 all eleven governorates in The Sultanate of Oman. The scores are presented in Tables 3, 4 and 5.

## 7.1 Water-Food

Figure 16: Water-Food Nexus Map for the GCC16 shows GCC's Water-Food Nexus Map which explores food production and its various inputs from the perspective of water and Table 3 highlights Oman's initiatives with respect to the Water-Food Nexus map. 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 include the material used in food production such as fodder and feed, fertilizer and water. Water resources were 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.

*Figure 16: Water-Food Nexus Map for the GCC[39]*

[39] Figure 16 is based on EY internal analysis

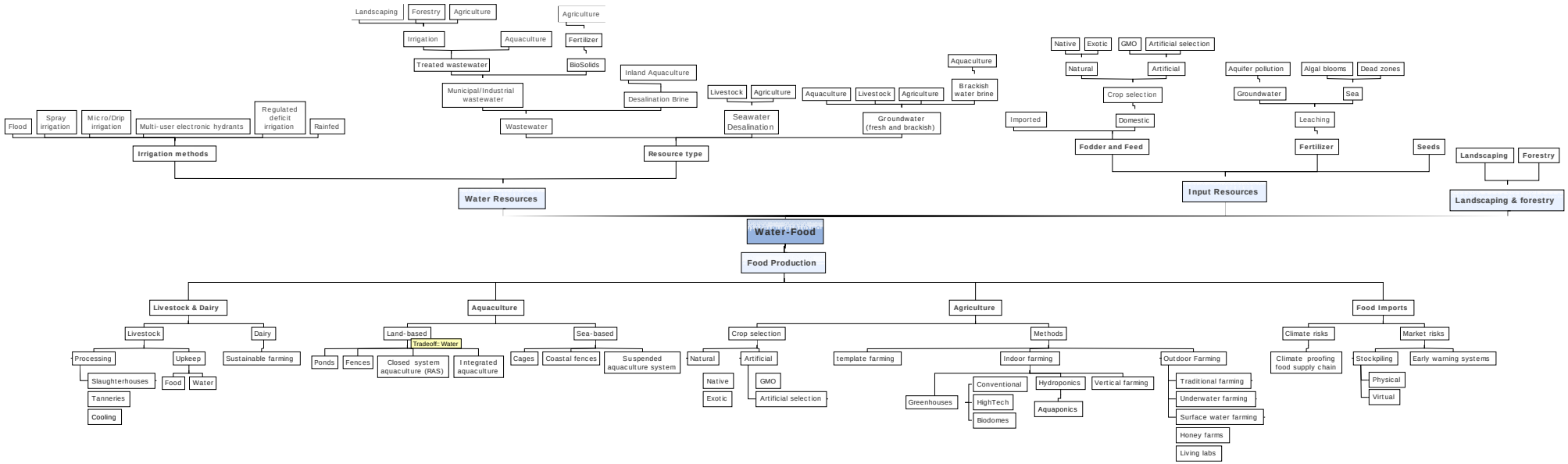



*Table 3: Water-Food Nexus Initiatives in Oman*

| SN | Category 1 | Category 2 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | 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 | 4 | 3 | - Regulated by the Ministry of Agriculture and Fisheries, Oman<br>- Safety and hygienic measures deployed by Oman LNG, Sur |
| 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<br>- Farmers are inclined to raise those with the highest profit margins | 3 | 4 | - Research on animal genetic resources in the Sultanate of Oman, Seeb<br>- Livestock research center, Oman |
| 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 Oman, certain production systems are constrained by:<br>- Climate (i.e. temperature, rainfall etc.) | 3 | 3 | - No initiatives |

| SN | Category 1 | Category 2 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | - lack of natural shrub/vegetation for grazing | | | |
| WF-4 | | | GMOs | - Opportunities to improve yields through disease resistance, saline water tolerance and heat tolerance | - Public hesitation/resistance towards GMOs | 3 | 3 | - Research on GMOs is being conducted by the College of Agricultural & Marine Sciences at SQU |
| WF-5 | | Poultry | Farming of poultry | - Suitable for present climate conditions<br>- Less resource intensive than livestock<br>- Relatively low maintenance costs | - Prone to disease outbreaks due to poor ventilation<br>- Low profit margin on poultry | 5 | 3 | - Poultry farms are widespread throughout Oman with various setup types (i.e. commercial farmed eggs vs. free-range organic eggs) |
| WF-6 | Agriculture | Crop Selection | Native and climate compatible species | - Salt and heat tolerant crops<br>- Reduced need for freshwater<br>- Synergy with voluntary and mandatory green building standards | - Limited variety of crops<br>- Legal challenges in registering new crop varieties | 3 | 5 | - Date palm salinity tolerance, Sultan Qaboos University<br>- Quinoa initiative, Oman |
| WF-7 | | | Seaweed farming for animal feed | - Low input requirement<br>- High in nutrient content | - Requires controlled conditions<br>- May prove difficult to scale up | 2 | 4 | - MoU between Oman Centre for Marine Biotechnology and Oman Authority for Partnership and Development to support micro algae cultivation |
| WF-8 | | | Domestic production of fodder and feed | - High demand for fodder<br>- Reduced reliance on imports<br>- Emergence of fodder irrigated by saline waters | - Fodder cultivation competes with other crops for water resources<br>- Fodder crops are generally water intensive (such as Rhodes grass) | 5 | 2 | - Barakat Feeds for feeding cattle, sheep and goats, Salalah<br>- National Feed, Salalah |
| WF-9 | | | Artificial (Artificial Selection & GMOs) | Opportunities for improved yields, and disease, draught, heat and salt resistance | - Public hesitation/resistance towards GMOs | 2 | 3 | - Biosaline services in Oman on crop diversification and genetic improvement<br>- No initiatives. A research has been conducted regarding attitudes on GMOs, Sultan Qaboos University |
| WF-10 | | Greenhouses and Hydroponics | High-tech greenhouses | - Increased crop productivity<br>- Improved water and energy efficiency<br>- Increased crop variety | - In extreme heat, acts as a heat trap killing crops<br>- Does not facilitate pollination | 3 | 5 | - Al Hosn Investment Co, Barka<br>- Research funded by the Research Council to develop greenhouses in the Sultanate<br>- The Australia-based Sundrop Farm is set to develop greenhouses in Oman |
| WF-11 | | | Seawater greenhouses | - Creates ideal growing conditions for crops while producing fresh water for irrigation | - Fine tuning of complex system<br>- Potential aquifer contamination from seawater | 3 | 4 | - Research on seawater greenhouse in Oman<br>- Seawater Greenhouse, Muscat, Oman<br>- Model at SQU |
| WF-12 | | | Bio-domes | - Energy & cost efficient<br>- Synergies with voluntary & mandatory green buildings standards<br>- Can serve educational purposes | - Systems need to be thoroughly designed and fine-tuned<br>- Significant maintenance is required | 3 | 4 | - Oman Botanic Garden, Muscat |

| SN | Category 1 | Category 2 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|---|
| WF-13 | | | Hydroponic farming | - High irrigation efficiency compared to traditional methods<br>- Increased crop productivity<br>- Reduced use of pesticide & fertilizer | - High CAPEX<br>- Risk of water microorganisms contamination<br>- Does not facilitate pollination | 3 | 5 | - Mazaya Agro, Muscat<br>- Gardinia Hydroponic Farming, Barka<br>- Global Energy United, Muscat<br>- Al Hosn Investment Co, Barka |
| WF-14 | | | Aquaponics | - Reduced water consumption<br>- No addition of fertilizer required<br>- When combined with hydroponics, reduces overall water requirements of system | - High CAPEX<br>- Needs to be coupled with hydroponic systems, which may be difficult or not feasible at times | 3 | 5 | - Global Energy United, Muscat<br>- Al Arfan Farms, Ar Rumays<br>- Urban Oasis, Oman |
| WF-15 | | Farming | Urban Farming | - Controlled growing environment<br>- Maximize resource efficiency<br>- Increase variety of crops<br>- Synergies with voluntary & mandatory green building standards | - High CAPEX<br>- Maintenance of systems may be more complicated than traditional farming | 2 | 4 | - Research on potential urban agriculture in Oman, Muscat |
| WF-16 | | | Vertical Farming | -Less demand for land<br>-less water intensive<br>-high yield | - High CAPEX<br>- Requires high level of maintenance and fine tuning of system | 2 | 4 | - Project by Sultan Qaboos University students to grow crops using vertical farming |
| WF-17 | | | Surface Water Farming | - Extensive coastline and access to sea | - Uncontrolled conditions<br>- Dependent on availability of salt and heat tolerant crops | 1 | 5 | - No initiatives. |
| WF-18 | Aqua-culture | Integrated multi-trophic aquaculture (IMTA) | Land-based | - Usage of existing brackish water<br>- Utilization of brine discharge from onsite brackish water reverse osmosis<br>- Declining fish stocks | - Temperature may be too harsh for certain species<br>- Risk of disease and contamination in closed systems, if not properly managed | 4 | 5 | - USD 2 bn investments worth on aquaculture investments, Oman<br>- 3 projects are planned to be developed by Oman Aquaculture Development Company in 2018<br>- 3,000 tonnes capacity aquaculture project launched by the Ministry of Agriculture and Fisheries, Quriyat<br>- MOU signed by Oman Food Investment Holding Company for the development of a fish centre, Special Economic Zone in Duqm |
| WF-19 | | | Sea-based | - Extensive coastline available for coastal aquaculture<br>- Declining fish stocks | - Heat and salinity threat<br>- Risk of invasive species | 3 | 5 | - World Bank Group support on sea-based aquaculture in Oman |
| WF-20 | Land-scaping & Forestry | Landscaping & Forestry | Landscaping | - 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 | - No specific initiatives. Landscaping is widespread throughout Oman |
| WF-21 | | | Forestry | - Opportunity for eco-tourism<br>- Supports local biodiversity and conservation<br>- Carbon sequestration | - High water use with no tangible benefit towards food security | 4 | 3 | - Green Wadis Initiative, Muscat<br>- Environment Society of Oman plans to plant 20,000 native trees, with |

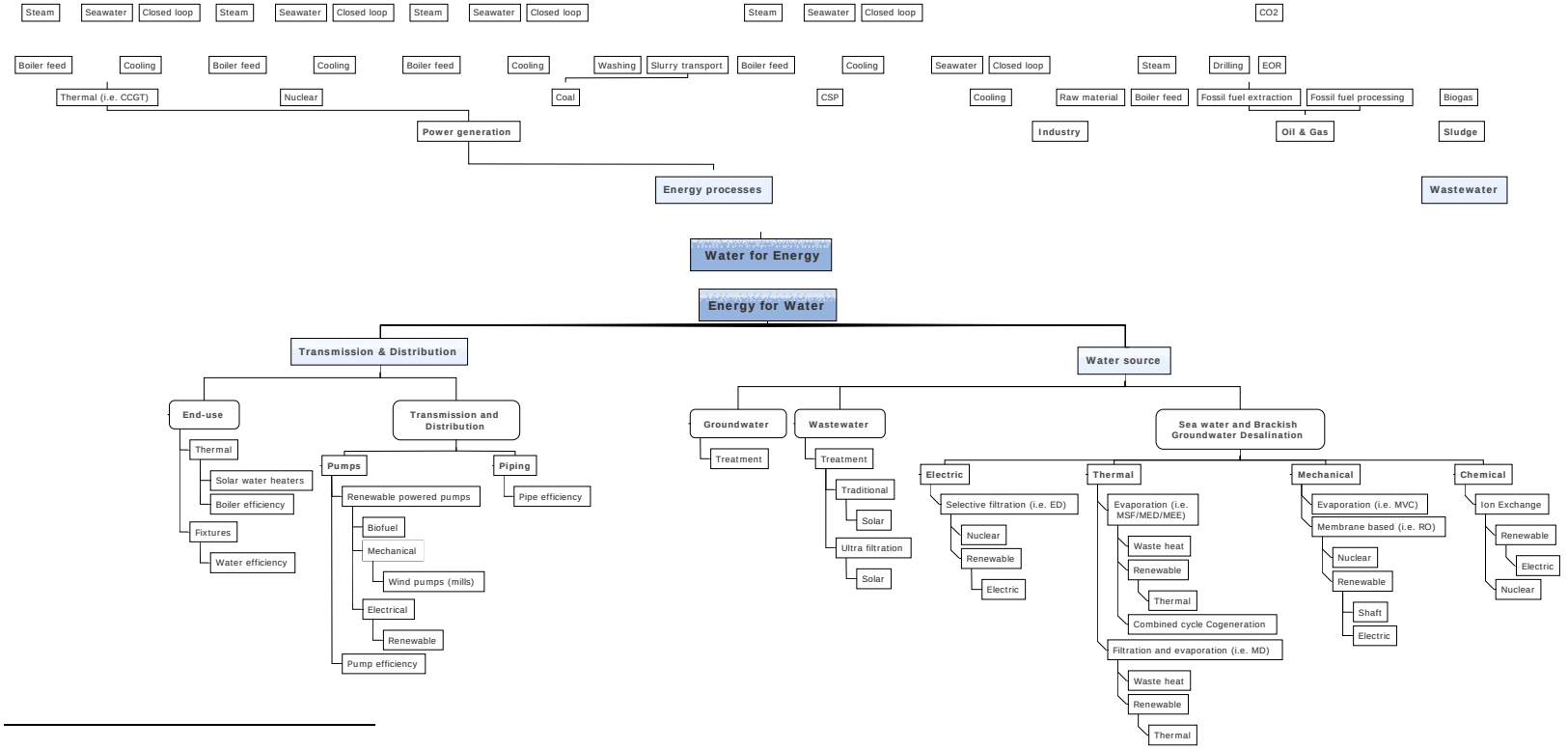
| SN | Category 1 | Category 2 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | more than 7,000 already planted, Dhofar |
| WF-22 | Water Resources | Smart Irrigation | Drip irrigation | - High water efficiency<br>- Smart monitoring and scheduling; reduction of water usage through adopting soil moisture sensors to regulate scheduling<br>- improvement by sub-merged systems | - Relatively high maintenance and replacement cost | 5 | 5 | - Falaj Irrigation System, Oman<br>- Piloting on underground irrigation for date palms conducted by the ministry of agriculture and fisheries<br>- Smart agriculture initiative undertaken by the Government of Oman<br>- Partnership between Kalhat serives and US irrigation products firm, Oman |
| WF-23 | | | Spray irrigation | - Ease of installation, use and maintenance<br>- Smart monitoring and scheduling; reduction of water usage through adopting soil moisture sensors to regulate scheduling | - Less water efficient than some other irrigation methods (high evapotranspiration) | 5 | 2 | - Spray irrigation widely used across farms in Oman.<br>- Muna Noor, Muscat |
| WF-24 | | Cooling | Misting fans for animal cooling | - Widespread on farms | - High water use | 4 | 3 | - EMergyKool misting systems, Oman |
| WF-25 | | Wastewater | Treated/ recycled wastewater | - Conservation of freshwater sources<br>- Reduced use of synthetic fertilizer<br>- No tertiary treatment of wastewater required<br>- Current policies promoting usage of treated wastewater in agriculture | - Risks of heavy metal contamination to soil, crops & groundwater<br>- Some cultural/public backlash to practice<br>- Law initiated by the ministry of agriculture and fisheries prohibits the use of treated wastewater for agriculture | 4 | 4 | - Muscat waste-water project (Al-Ansab and Al Seeb), Oman waste water services<br>- Collaboration between Haya Water and the ministry of agriculture and fisheries on a reuse of treated waste water pilot project across 5 farms, Al Barka |
| WF-26 | | | Aquaculture effluent | - Use effluent with salt tolerant crops<br>- Cultivation of otherwise barren lands | - Salt tolerant crops are not widespread | 2 | 5 | - Biosaline center services Oman on aquaculture effluent |
| WF-27 | | | Brine | - Potential for redirection towards aquaculture<br>- Potential for mining of minerals in brine through Solar ponds, WAIV, brine concentrators, ohmic evaporators, MD & ZLD<br>- 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 Oman, which can negatively impact marine ecosystems and fisheries through thermal, chemical and saline pollution. | 2 | 4 | - Dilution/dispersion already exists in Oman at many desalination plants.<br>- No initiatives for brine use |
| WF-28 | Food imports | Food import | International trade partnerships | - Ability to import food from various countries based on quality, price, availability etc. thereby constantly balancing Oman's supply-demand gap | - Significant market and climate risks associated with over dependence on imports<br>- As a relatively small country/market, Oman has a lower bargaining power in global food markets | 4 | 5 | - Represents the major mechanism for food acquisition in Oman<br>- No initiatives for de-risking food imports |
| WF-29 | | Food monitoring systems | Food safety monitoring systems | - Ability to track and monitor the value chain of food products from "farm to fork", thereby | - Not well established yet, and will require significant stakeholder buy in across the food supply chain. | 3 | 5 | - Alfarsi, Muscat |

| SN | Category 1 | Category 2 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | protecting public health and safety from possible foodborne disease outbreaks<br>- Reduce food loss and wastage through monitoring | | | | |
| WF-30 | | | 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<br>- Requires dedicated task force to own the early warning system. | 2 | 5 | - There is no current system in place |

## 7.2 Water-energy

Figure 17 shows GCC's Water-Energy Nexus Map and Table 4 highlights Oman's initiatives with respect to the Water-Energy Nexus map. This was developed based on two main aspects: the use of energy for water production and the treatment and use of water in energy generation. 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. The different forms of water used are also identified, be it for steam, cooling, cleaning or as a raw material.

*Figure 17: Water-Energy Nexus Map for the GCC[40]*




[40] Figure 17 is based on EY internal analysis

*Table 4: Water-Energy Nexus Initiatives in Oman*

| SN | Category 1 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|
| WE-1 | Waste to Energy | Wastewater sludge to methane based biogas | - Significant sewage generated across Oman<br>- Anaerobic digestion of sludge in the form of biogas is a net energy producing process<br>- Recovered nutrients (phosphate and nitrogen) can be used in agriculture/industrial applications<br>- Local climate favourable to technology | - High investment cost for anaerobic digestion tanks and system | 2 | 5 | - No biogas initiatives in place for the existing WWTP;<br>- Muscat Wastewater Project, Governorate of Muscat<br>- A'Seeb Wastewater Project, Muscat |
| WE-2 | Renewable energy powered desalination | Thermal desalination (i.e. MED/MSF/MEE) with solar thermal (i.e. CSP) | - High solar irradiance in Oman<br>- Reduced GHG emissions<br>- Decoupling from natural gas results in greater national savings and/or opportunities for natural gas export | - High energy requirement<br>- Solar thermal systems (such as CSP) are yet to be integrated with desalination commercially<br>- Higher CAPEX of systems (MSF/MED compared to RO and CSP compared to PV)<br>- Slowing adoption of thermal desalination in Oman | 3 | 4 | - Ministry of Agriculture and Fisheries cell, producing 3,000 gallons/d solar desalination project (PV-RO), Muscat |
| WE-3 | | Reverse Osmosis with PV/ storage | - High solar irradiance in Oman<br>- Reduced GHG emissions<br>- RO has lower CAPEX compared to thermal desalination and is gaining market share in total installed capacity<br>- Combining PV directly with RO addresses the intermittency issue as it allows for addition of RE into energy mix without the associated challenges<br>- High adoption of RO in Oman enables the integration of renewable energy as a power source | - High OPEX (associated with membrane replacement) | 3 | 5 | |
| WE-4 | Cogeneration | Combined cycle - MSF/MED | - Availability of coastline makes power and water generation coupling easy<br>- Low natural gas costs<br>- Use of by-product steam from power generation for thermal desalination<br>- Energy storage (i.e. batteries) can be used to optimize the cogeneration process, thereby reducing the energy requirements for thermal desalination | - Inherent risks associated with coupling water supply to natural gas<br>- High CAPEX<br>- 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 | - Various plants across Oman.<br>- Sohar Power and Desalination Plant, Sohar |

| SN | Category 1 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|
| 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<br>- Proper water discharge management would improve marine biodiversity, fisheries and boost eco-tourism<br>- Laws on water reuse and discharge management are in place and regulated by the Ministry of Regional Municipalities, Environment & Water Resources | - Current regulations on discharge may not be conducive to technology/solution adoption<br>- Cost of systems | 4 | 4 | - All industries, power plants and desalination plants on the coast that discharge cooling water, treated wastewater or brine into the sea are regulated by the Ministry of Regional Municipalities, Environment & Water Resources<br>- No initiatives on zero-liquid discharge for brine |
| WE-6 | RE powered WWTP | Solar powered WWTP | - High solar irradiance in Oman | - Intermittency, unless a hybrid system<br>- Currently, higher cost than grid connection | 1 | 4 | - No initiatives |
| WE-7 | Water pumping and transport | Solar water pumps | - High solar irradiance in Oman<br>- Off-grid usage makes system mobile, and avoids electrification costs | - Intermittency, unless a hybrid system | 3 | 5 | - Solar pumps in Samail, Dakhiliyah Governorate |
| WE-8 | | Biofuel water pump | - Algae biofuel production and application being researched in Oman | - Dependent on maturity of biofuel technology | 2 | 4 | - No initiatives |
| WE-9 | | Piping efficiency and T&D monitoring | - Water system savings<br>- 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<br>- High marginal cost of improvement due to existing high network efficiency | 4 | 4 | - SCADA remote control & monitoring systems, Public authority for water (PAW), Muscat<br>-Development of a wireless irrigation control system in the coastal aquifers of Oman |
| WE-10 | Water heating & cooling | Solar-water heaters | - High solar irradiance in Oman well suited for technology<br>- High cost savings and quick ROI<br>- Emerging supporting regulations at national level<br>- High growth market | - Higher installation costs than conventional water heating systems<br>- High requirement for proper insulation | 3 | 5 | - Solar hot water system implemented at Sultan Qaboos University, Eco-house |
| WE-11 | | Solar-Cooling systems | - High solar irradiance in Oman<br>- High cooling load in Oman<br>- Dropping PV and other solar technology costs<br>- Lower OPEX compared to traditional system | - Intermittency, unless a hybrid system<br>- Higher CAPEX compared to traditional systems | 3 | 5 | - Solar powered air conditioning being sold in the Omani market |
| WE-12 | Cooling | District Cooling | - District cooling reduces energy consumption to about 40% compared to traditional cooling<br>- Strong market growth and interest, with well-established regional players | - Highly linked to booms and busts of real-estate sector | 4 | 5 | - Muscat District Cooling Company, Muscat<br>- Tabreed (District cooling company), Seeb |
| WE-13 | Water fixtures | Water fixture efficiency | - Market adoption of existing voluntary green building codes such as LEED<br>- Emerging green building codes<br>- Increasing water tariffs and changing tariffs structure | - No significant constraints | 5 | 5 | - The Green Building Information Gateway in Oman, Muscat<br>- Evaluating benefits of energy efficiency programs in Oman, KAPSARC<br>- Green building regulation in the pipeline for Oman<br>- Public Authority for Electricity and Water, Muscat |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| WE-14 | Water use in Oil & Gas | Fossil fuel extraction | - Water steam savings from EOR process by CO2 injection substitution<br>- Reduced aquifer pollution compared to using produced water<br>- Form of carbon sequestering | - Risk of CO2 contamination into aquifers | 4 | 4 | - Mukhaizna oilfield, Al Wusta<br>- The Nimr Oilfield, Al Wusta |
| WE-15 | | Water recycling | - Opportunities for water saving along oil and gas value chain, especially in extraction<br>- Treatment | - High treatment costs | 3 | 5 | - Adoption of the RecyClean Hydro-Pod technology<br>- Research on use of wastewater from oil production in agriculture, Petroleum Development Oman |
| WE-16 | | Monitoring systems | - Ability to monitor and analyze water and energy consumption and losses across Oil & Gas value chain | - Challenges in data collection and integration of assets across value chain | 2 | 4 | - No initiatives |
| WE-17 | Water production | Atmospheric Water Generation (AWG) | - While water scarce, Oman is hot and humid many parts of the year, ideal conditions for AWG<br>- Fog harvesting is already established in the Dhofar region of Oman<br>- Oman has a large rural population, that can benefit from off-grid water systems<br>- Can reduce water T&D infrastructure investments, and costs associated with T&D losses<br>- Synergies possible with Seawater Greenhouses (see WF-11)<br>- AWG can occur passively, or with an energy input (such as solar) for higher production | - Challenges in scaling up (ideal for low to medium capacity usage)<br>- Can be an expensive investment for non-passive systems (depends largely on the cost of other alternatives) | 3 | 4 | Environment and Climate Affairs Ministry, Fog harvesting pilot, Salalah, Oman |

## 7.3 Energy-Food

Figure 18 shows the Oman Energy-Food Nexus Map and Table 5 highlights Oman's initiatives with respect to the Energy-Food Nexus map. This was developed based on two main aspects: the use of energy for food production and the use of organic material in the generation 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 generation 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 18: Energy-Food Nexus Map for the GCC region*[41]

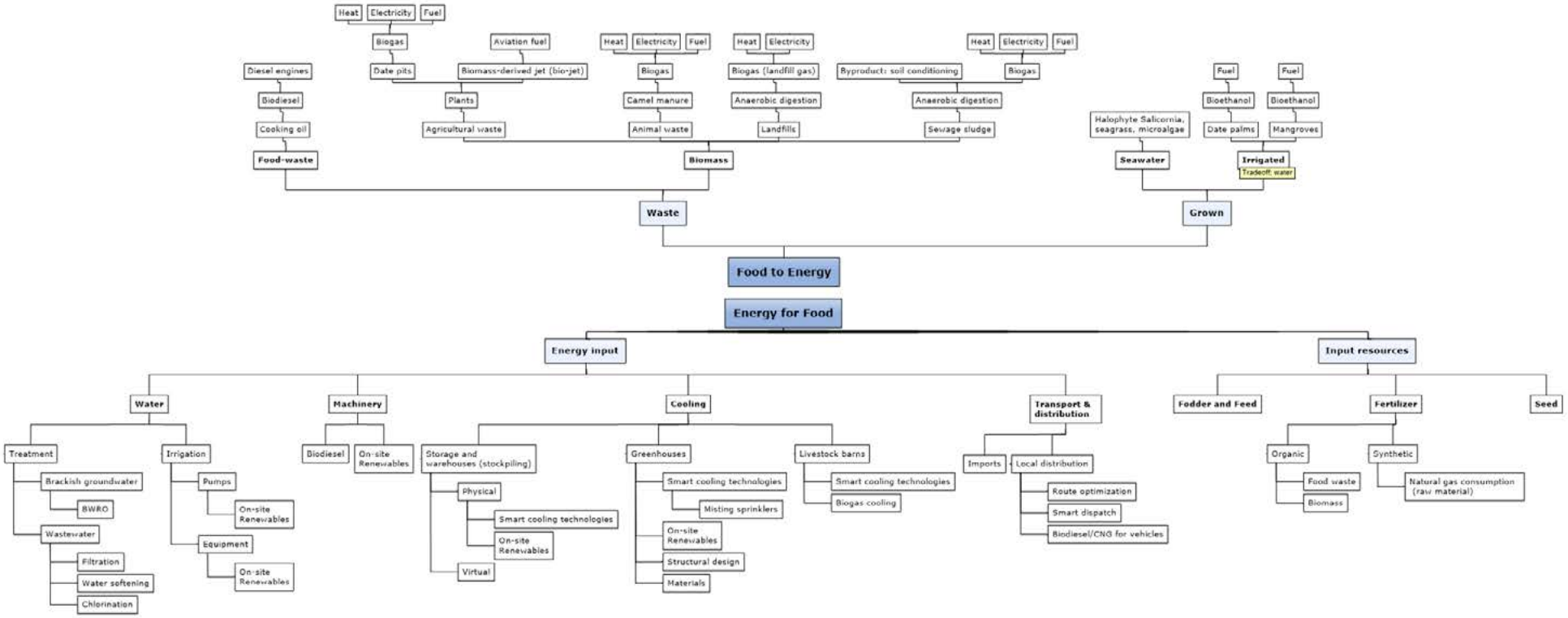


*Table 5: Food-Energy Nexus Initiatives in Oman*

| SN | Category 1 | Category 2 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|---|
| FE-1 | Biofuels | Grown biofuels | Biomass from seaweed and halophytes | - Salt tolerant (use of Salicornia Halophyte)<br>- Wide availability of seawater and avoided use of freshwater | - Commercialization and scaling up<br>- More expensive than conventional fuels | 2 | 5 | - Research on producing biofuel from biological and agricultural waste , Sultan Qaboos University |
| FE-2 | | | Bioethanol | - Strong market interest in sustainable fuels<br>- First studies testing Jatropha in Omani conditions showed positive and encouraging results | - Unless resulting from a waste stream or introduction of speciality plants like Jatropha, process will be water intensive<br>- Limited number of native species that can be used at commercial scale<br>- More expensive than conventional fuels | 3 | 3 | - The Research Council in collaboration with the Department of Biology, Sultan Qaboos University have converted fermentable sugars by enzymatic hydrolysis into bioethanol<br>- College of Agricultural & Marine Sciences, Sultan Qaboos University has tested Jatropha plant growth under different conditions<br>- Jatropha plant testing in arid climates by German scientists |
| FE-3 | | Biofuels from Waste | Biogas from animal waste | - Animal waste is a significant and un-utilized waste stream in Oman | - 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<br>- Not feasible for all farms given size | 2 | 4 | (refer to FE-4) |
| 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 from Landfills | - Large potential of landfill gas in Oman<br>- Organic fraction of MSW may provide a source for organic fertilizer/soil improver depending on waste stream purity | - Depending on the conditions of the landfill (sanitary landfill vs. unregulated landfill) Large infrastructural investments may be required | 3 | 5 | - Be'ah (MoU) with The (GUtech) on implementation of a biogas plant in the university's premises, Muscat<br>- Be'ah waste diversion strategy (multiple waste streams including green and agricultural/animal waste), Oman<br>- Biogas recovery project in Barka landfill |
| FE-5 | | | Biodiesel from food waste | - There is significant food waste in Oman, such as waste cooking oil<br>- Hotels 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<br>- More expensive than conventional fuels | 2 | 4 | - Refer to FE-4<br>- Studies are being conducted by Be'ah on WtE projects, Oman<br>- Research on using date palm pits to produce biodiesel, Sultan Qaboos University<br>- Research on biodiesel production from agricultural waste, Sultan Qaboos University |

| SN | Category 1 | Category 2 | Approach/ technology | Approach strengths | Approach limitations | Maturity | Growth Opp. | Initiative(s)/Programme(s) |
|---|---|---|---|---|---|---|---|---|
| FE-6 | Onsite energy inputs for food production | Smart Cooling Technologies | Cooling of animal farms | - Large number of farms (cow, camel, goat, sheep) in the country<br>- 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 | 2 | 4 | - No initiatives |
| FE-7 | | | Cooling of greenhouses | - Large consumers of energy for cooling<br>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<br>- Inherent trade-offs of some cooling systems (i.e. high water efficiency but high energy or vice versa) | 3 | 5 | - No initiatives |
| FE-8 | | | Cooling of storage | | | 3 | 4 | - No initiatives |
| FE-9 | | Greenhouses | Reducing cooling load through design and materials | - Greenhouses are widespread in Oman<br>- Greenhouses consume significant amounts of energy for cooling<br>- Opportunities for synergies with other technologies and setups (i.e. aquaculture) | - Materials must be tolerant to harsh Oman climate<br>- Potentially higher cost | 3 | 5 | - No initiatives |
| FE-10 | | Fertilizer | Synthetic fertilizer production | - Improves crop yields<br>- Haber process is net CO2 consuming | - Can result in eutrophication of water bodies<br>- Haber process is natural gas consuming | 5 | 2 | - OMIFCO fertilizer complex has setup ammonia and urea plants, OMIFCO |
| FE-11 | | Onsite renewables | PV for irrigation & pumps | - Off-grid solution for water pumps, reducing maintenance and electrical connection | - Low electricity tariffs for agricultural sector<br>- Intermittency, unless a hybrid system | 3 | 4 | - PV Irrigation System for Omani Farmers, Ad Dakhiliyah Region |
| FE-12 | | | PV for water treatment | - Off-grid solution for water treatment and onsite brackish water RO | - Low electricity tariffs for agricultural sector<br>- Intermittency, unless a hybrid system | 2 | 4 | - No initiatives |
| FE-13 | | | 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 | 1 | 4 | - No initiatives |
| FE-14 | Energy inputs for transport & distribution of food | Stockpiling | Virtual Stockpiling | - Utilization of warehouses abroad avoid infrastructure investment domestically<br>- Enhanced energy saving initiative for reduced cooling requirements<br>- Cost saving (buying during low prices)<br>- Added food security (emergency preparedness) | - Cost of storage/stockpiling abroad | 1 | 4 | - No initiatives |
| FE-15 | | | Physical/ emergency stockpiling | - Strategic storage reserves allow for release of stockpiles during emergencies or price hikes<br>- Oman food security strategy promotes physical stockpiling/emergency reserves | - Investment cost and maintenance<br>- Cooling and humidity control | 3 | 5 | - Sohar Port and Free Zone -Sohar Flour Mills, Sohar<br>- Public Authority for Stores & Food Reserve, Oman Government |
| FE-16 | | Local distribution | Route & inventory optimization | - Route optimization can reduce energy cost of transport and lengthen freshness and lifetime of food products<br>- Reduced inventory time can reduce food wastage and costs for businesses<br>- 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 |

# 8. Investment and Engagement Opportunities in Oman

Investment/engagement opportunities in Oman were identified for Dutch companies based on the technologies and approaches outlined in Tables 3, 4 and 5 of the previous chapter. The maturity and growth opportunity scoring of each technology/approach was used to identify the most suitable opportunities.

*Table 6: 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 6. 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 Oman). 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 Oman. Knowledge partnerships can include more than one local or Dutch partner. The WEF stakeholder groups in Oman identified in Table 9 are to be considered for these potential partnerships.

Applying the criteria in Table 6 to the technologies/approaches in the previous chapter yields a prioritized list of investment opportunities for Dutch companies presented in Table 7 and Table 8. It is worth noting that such opportunities often comprise of two parts towards which Dutch companies can contribute. Such opportunities consist of technical solutions and complementary 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 7: Category 1 Identified technologies and approaches for partnership opportunities*

| **Nexus Code** | **Category** | **Approach/ technology** | **Scoring** | |
|---|---|---|---|---|
| | | | **Maturity** | **Growth Opportunity** |
| WF-18 | Aqua-culture | Land-based | 4 | 5 |
| WF-22 | Water Resources | Drip irrigation | 5 | 5 |
| WE-5 | Industrial water discharge | Water discharge management | 4 | 4 |
| WE-9 | Water pumping and transport | Piping efficiency and T&D monitoring | 4 | 4 |
| WE-12 | Cooling | District Cooling | 4 | 5 |
| WE-13 | Water fixtures | Water fixtures efficiency | 5 | 5 |
| WE-14 | Water use in Oil & Gas | Fossil fuel extraction | 4 | 4 |

*Table 8: Category 2 Identified technologies and approaches for partnership opportunities*

| Nexus Code | Category | Approach/ technology | Scoring | |
|---|---|---|---|---|
| | | | Maturity | Growth Opportunity |
| WF-6 | Agriculture | Native and climate compatible species | 3 | 5 |
| WF-10 | Agriculture | High-tech greenhouses | 3 | 5 |
| WF-13 | Agriculture | Hydroponic farming | 3 | 5 |
| WF-14 | Agriculture | Aquaponics | 3 | 5 |
| WF-17 | Agriculture | Surface Water Farming | 1 | 5 |
| WF-19 | Aqua-culture | Sea-based | 3 | 5 |
| WE-1 | Waste to Energy | Wastewater sludge to methane based biogas | 2 | 5 |
| WE-3 | Renewable energy powered desalination | Reverse Osmosis with PV/ storage | 3 | 5 |
| WE-7 | Water pumping and transport | Solar water pumps | 3 | 5 |
| WE-10 | Water heating & cooling | Solar-water heaters | 3 | 5 |
| WE-11 | Water heating & cooling | Solar-Cooling systems | 3 | 5 |
| WE-15 | Water use in Oil & Gas | Water recycling | 3 | 5 |
| FE-1 | Biofuels | Biomass from seaweed, algae and halophytes | 2 | 5 |
| FE-4 | Biofuels | Biogas from Landfills | 3 | 5 |
| FE-7 | Onsite energy inputs for food production | Cooling of greenhouses | 3 | 5 |
| FE-9 | Onsite energy inputs for food production | Reducing cooling load through design and materials | 3 | 5 |
| FE-15 | Energy inputs for transport & distribution of food | Physical/ emergency stockpiling | 3 | 5 |
| FE-16 | Energy inputs for transport & distribution of food | Route & inventory optimization | 3 | 5 |

# 9. 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. In the Global Innovation Index 2018, the Netherlands was ranked 2nd and Oman ranked 69th, rising from its 77th spot in the prior year[42].

In the Ease of Doing Business Index, which captures various important dimensions of the country's regulatory environment, Oman ranked 71st across 190 economies in 2018, and 4th in the MENA region[43]. Although dimensions such as Getting Credit, Protecting Minority Investors, and Resolving Insolvency with rankings of 133, 124, and 98, respectively negatively impacts Oman's Ease of Doing Business Index , Oman ranked the highest on the dimensions for Starting a Business and Paying Taxes with rankings of 31 and 11, respectively. [44]. In addition to Oman's ranks on the Ease of Doing Business Index, its strategic location, stable economic environment, excellent infrastructure, educated young workforce and free trade and open market present essential reasons to invest in the country.

Moreover, on The Global Competitiveness Index (GCI) for 2017-2018, which assesses 137 economies and ranks them based on their performance against 12 pillars of competitiveness, Oman scored 4.31 points out of 7, ranking it 62nd, moving up four places from the prior year. Although showing promising improvements in terms of its macroeconomic environment and higher education and training, doing business may be challenging due to restrictive labour regulations, inadequately educated workforce, access to financing, and inefficient government bureaucracy[45].

[42] Soumitra Dutta et al., Global Innovation Index 2018, 2018 -
[43] The World Bank, Doing Business, 2018 -
[44] The World Bank, Doing Business 2018, 2018 -
[45] World Economic Forum, The Global Competitiveness Report 2017-2018, 2018 -

In line with its National Strategy for Innovation, Oman has the opportunity of becoming a global innovation hub benefiting from its human and financial capital to drive innovative research and development in addition to attracting foreign investments. With Oman's well established regional and global partnerships, ease of doing business and strong national commitment towards food security, innovation and sustainability, Oman can focus on creating an environment of innovation for food production technologies in arid climates.

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

For Dutch companies looking to enter the Omani WEF market, engaging with the right stakeholders is critical. Doing business in Oman and the wider region requires a certain level of adaptability and fluidity – brought on by sharp climatic, regulatory and cultural contrasts when compared to Europe and other regions. In Oman, ministries are driving strategies on resource conservation and diversification linked to the WEF Nexus, while pressured to boost economic diversification and employment. While WEF security is high on the government agenda in Oman, Dutch companies will also need to showcase their best practices, solutions and expertise – by actively engaging with local entities and cultivating those relationships in the long term, and integrating elements of local employment and sustainability in their business models. One example of successful engagement among government, industry and academia is the Strategic Water Partnership between the Netherlands and Oman.

## 9.1 Direct engagement with local entities

Though by no means exhaustive, Figure 19 and Table 8 illustrate some of the key WEF stakeholders in Oman. 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 opportunity to opportunity, based on the support required, value proposition etc. Nonetheless, a qualitative prioritization was conducted to showcase the stakeholders whom Dutch companies might find the most relevant. 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 19. Additionally, Table 8 identifies high-level engagement strategies by stakeholder group, listed in no specific order.

*Figure 19: Oman Water Energy Food Nexus Stakeholder Map*

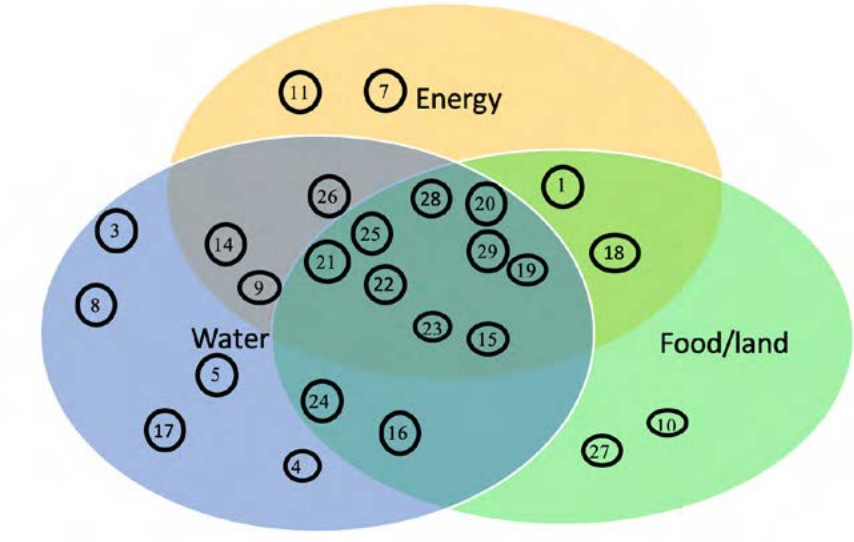


*Table 9: High-level engagement strategies by stakeholder group*

| Entity Type | Engagement Strategy |
|---|---|
| Government operator entities | |
| 1. Be'ah<br>2. Omani Authority for Partnership for Development (OAPFD)<br>3. Oman Aquaculture Development Company (OADC)<br>4. Haya Water<br>5. Oman Power and Water Procurement Co.<br>Salalah Wastewater Services Co | 1. Information collection: Dutch Companies need to form a solid understanding of the strategies, objectives and operations of the various government operators in Oman if they wish to collaborate successfully<br>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 Omani-Dutch diplomatic channels (i.e. the Dutch embassy) for introductions where relevant/possible.<br>Share insights: Dutch Companies need to share their insights and experiences with government operators as technology or knowledge partners 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 | |
| 6. Ministry of Agriculture and Fisheries<br>7. Authority for Electricity Regulation<br>8. Ministry of Regional Municipalities, Environment & Water Resources<br>9. The Public Authority for Water<br>10. The Public Authority for Stores and Food Reserve | 1. Establish focal point: Dutch companies need to establish a key focal point within their organization that will regularly engage with the Omani 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 Oman government entities to build a trust-based relationship. Dutch companies can capitalize on Omani-Dutch diplomatic channels (i.e. the Dutch embassy) for introductions where relevant/possible.<br>2. Consult regularly: Regular consultations are important and should be followed up at regular intervals to help Omani government regulators familiarize themselves with new information. As Oman 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.<br>3. Share insights: Dutch entities can share their experience and insights with Omani regulators with respect to which regulatory enablers would support agricultural sector growth and innovation in Oman. This will allow Dutch entities to play a proactive role in Oman as envisioned by the signed MoU. 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.<br>4. Awareness building: As Dutch companies look to introduce novel ideas and solutions to Oman, 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. |
| Industry | |

| | |
|---|---|
| 11. Oman LNG<br>12. Al Hosn Investment Company<br>13. Agribusinesses<br>14. Sohar Power Company<br>15. Oman Food Investment Holding Company<br>16. Oman Water Treatment Company<br>17. Oman India Fertiliser Company (OMIFCO) | 1. Identify industry drivers: 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.<br>2. Establish focal point: 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.<br>3. Share insight: Dutch Companies should focus on personalizing all pitches to Omani industry leaders to increase their chances of success. Sharing new insight might be challenging as Omani 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. |
| European Commission sponsored programme | |
| 18. Arab Authority for Agricultural Investment & Development<br>19. IRENA<br>20. Food and Agriculture Organization<br>21. International Livestock Research Institute<br>22. World Bank Group<br>23. Environment Society of Oman | 1. Signing a MoU: Companies can establish effective partnerships with international organizations by signing a Memorandum of Understanding (MoU) to develop further cooperation in different areas. For instance, companies can share their know-how but also improve oversight of the Omani market which could support companies in their engagement with government operators/regulators. |
| Universities and Research Institutes | |
| 24. International Center of Biosaline Agriculture<br>25. Sultan Qaboos University<br>26. Oman Center for Marine Biotechnology (OCMB)<br>27. Oman Animal and Plant Genetic Resources Center (OAPGRC)<br>28. The Research Council<br>29. German University of Technology in Oman (GUtech) | 1. Building local relationships: 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.<br>2. Nominate a key contact: 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 |

## 9.2 Engagement with the Dutch Economic Network

The Dutch Economic Network in the Gulf Region, including Muscat, is a useful diplomatic channel of entry for Dutch companies looking to enter Oman's WEF market. It is established to help Dutch businesses in identifying business opportunities within the Gulf Countries.[46] The aim of this network is to provide advice to Dutch businesses in terms of setting up a business in the Gulf where they advise based on the market as well as potential partners. The 5 Embassies and 1 Consulate-General in the Gulf Region each have one or more Economic and Trade Affairs Officers, in addition to a regionally operating Agricultural Office in Riyadh, Saudi Arabia[46,] and a newly appointed regionally operating Nexus expert in Abu Dhabi, UAE, to support or advice Dutch companies that want to do business in Muscat, Oman.

For more information on the Dutch Economic network in the Gulf region kindly visit our website www.dutchgulf.com or https://www.netherlandsworldwide.nl/doing-business-in-the-gulf-region.

[46] Kingdom of the Netherlands, *Dutch Economic Network in the GCC,* 2018.

# 10. Appendix A

The tables below include the sources of all the initiatives cited in chapter 7, and are listed by initiative number, mirroring Tables 3, 4 and 5.

| SN | Initiative(s)/Programme(s) | Links |
|---|---|---|
| WF-1 | - Ministry of Agriculture and Fisheries, Oman | http://www.oman.om/wps/wcm/connect/en/site/home/gov/gov1/gov5governmentorganizations/maf/moa |
| | - National Feed, Salalah | http://www.onld.om/about-us.php |
| | -Safety and hygienic measures deployed by Oman LNG, Sur | https://www.muscatdaily.com/Archive/Oman/Oman-LNG-boosts-safety-and-hygienic-measures-for-livestock-5a0z |
| WF-2 | - Research on animal genetic resources in the Sultanate of Oman, Seeb | https://www.trc.gov.om/TRCWebsite/files/TRC%20Genetic%20Resources%20presentation%202011.pdf |
| | - Livestock research center, Oman | https://oapgrc.gov.om/Documents/The%20Current%20Status%20of%20Animal%20Genetic%20Resources%20in%20Oman_Ihab%20Shaat.pdf |
| WF-3 | - Research on the state of animal genetic resources, Oman | http://www.fao.org/ag/agaInfo/programmes/en/genetics/documents/Interlaken/countryreports/Oman_E.pdf |
| WF-4 | - Research on GMOs is being conducted by the College of Agricultural & Marine Sciences at SQU. | https://www.squ.edu.om/Portals/33/Publication/Horizon/Horizon-302.pdf?ver=2015-04-22-092819-487 |
| WF-5 | - Poultry farms are widespread throughout Oman with various setup types (i.e. commercial farmed eggs vs. free-range organic eggs) | http://pdeza.organic/ |
| WF-6 | - Date palm salinity tolerance, Biosaline institute | http://webcache.googleusercontent.com/search?q=cache:fHfHcx0jF7sJ:www.mdpi.com/1999-4907/8/4/136/pdf+&cd=2&hl=en&ct=clnk&gl=ae |
| | - Quinoa initiative, Oman | https://gulfnews.com/opinion/thinkers/quinoa-harvesting-the-world-s-supergrain-1.2078322 |
| WF-7 | - MoU between Oman Centre for Marine Biotechnology and Oman Authority for Partnership and Development to support algae cultivation | http://www.omanobserver.om/agreement-support-algae-cultivation-oman/ |
| WF-8 | - Barakat Feeds for feeding Cattle, Sheep and goats, Salalah | http://www.omanflourmills.com/product/barakat/ |
| WF-9 | - No initiatives. A research has been conducted regarding attitudes on GMOs, Sultan Qaboos University | http://ijsse.com/sites/default/files/issues/2014/v4-i5-2014/Paper-4.pdf |
| WF-10 | - Research funded by the Research Council to develop greenhouses in the Sultanate | https://timesofoman.com/article/90278 |
| | - The Australia-based Sundrop Farm is set to develop greenhouses in Oman | https://www.muscatdaily.com/Archive/Oman/Revolutionary-greenhouse-farming-to-harness-Oman-s-sunlight-seawater-3qvb/ |
| | - Al Hosn Investment Co, Barka | http://www.hortidaily.com/article/8924/Oman-33ha-hydroponic-greenhouse-project-lauched-to-bridge-demand-gap-for-local-veggies |
| WF-11 | - Research on seawater greenhouse in Oman | https://www.sciencedirect.com/science/article/pii/S1364032115010953 |
| | Seawater Greenhouse Pilot project, Muscat, Oman | https://seawatergreenhouse.com/oman/ |
| WF-12 | - Oman Botanic Garden, Muscat | https://www.designboom.com/architecture/oman-botanical-garden-grimshaw-arup-11-14-2017/ |
| WF-13 | - Mazaya Agro, Muscat | http://www.mazayaoman.com/agro/#varieties-section |
| | - Gardinia Hydroponic Farming, Barka | https://www.gardiniaonline.com/pages/aboutus/ |
| | - Global Energy United, Muscat | http://geuoman.co/divisions/hydroponics-i-aquaponic/ |
| WF-14 | - Global Energy United, Muscat | http://geuoman.co/divisions/hydroponics-i-aquaponic/ |
| | - Al Arfan Farms, Ar Rumays | http://www.omanaquaponics.com/aquaponic.html |
| | - Urban Oasis, Oman | http://urbanoasis.om/aquaponics/ |
| WF-15 | - Research on potential urban agriculture in Oman, Muscat | https://aag.secure-abstracts.com/AAG%20Annual%20Meeting%202018/abstracts-gallery/13449 |
| WF-16 | - SQU students project to grow crops using vertical farming | http://www.hortidaily.com/article/38288/Oman-University-students-grow-crops-using-vertical-farming/ |
| WF-17 | - No initiatives, concept is still in its infancy within Oman | Not Applicable |
| WF-18 | - Oman as allocated an amount of USD 2 bn investments worth on aquaculture investments | https://www.undercurrentnews.com/2017/05/22/oman-plans-aquaculture-investments-worth-over-2bn/ |
| | - 3 projects are planned to be developed by Oman Aquaculture Development Company in 2018 | http://www.omanobserver.om/oman-aquaculture-devt-plans-three-new-projects/ |

| SN | Initiative(s)/Programme(s) | Links |
|---|---|---|
| | - 3,000 tonnes capacity aquaculture project launched by the Ministry of Agriculture and Fisheries, Quriyat | https://www.muscatdaily.com/Archive/Oman/Aquaculture-project-in-Quriyat-with-3-000-tonnes-capacity-launched-54te |
| | - MOU signed by Oman Food Investment Holding Company for the development of a fish center, Special Economic Zone in Duqm | http://www.constructionweekonline.com/article-49331-fish-centre-to-be-developed-in-omans-duqm-economic-zone/ |
| WF-19 | - Reimbursable Advisory Service from the World Bank Group to support sea-based aquaculture in Oman | http://www.worldbank.org/en/news/feature/2017/02/14/plenty-of-potential-for-oman-to-increase-the-value-of-its-catch-in-fisheries |
| WF-20 | - Green Wadis Initiative, Muscat | http://www.omanobserver.om/green-wadis-initiative-launched/ |
| WF-21 | - Workshop on genetic resources information platform, organized by Oman Animal and Plant Genetic Resources Centre in collaboration with Biodiversity International | https://www.bioversityinternational.org/news/detail/big-data-on-biodiversity-in-oman/ |
| | - Plan to plant 20,000 native trees, Dhofar | https://timesofoman.com/article/119024 |
| | - More than 200 trees have been planted in 2016, Muscat | https://timesofoman.com/article/92716 |
| WF-22 | - Falaj Irrigation System, Oman | https://omantourism.gov.om/wps/portal/mot/tourism/oman/home/experiences/culture/aflaj/!ut/p/a0/04_Sj9CPykssy0xPLMnMz0vMAfGjzOItvc1dg40MzAzcA4OcDTyDQ4JNnP3CjM38zPSDU_P0C7IdFQGlrfWE/ |
| | - Smart agriculture initiative undertaken by the Government of Oman | http://www.oman.om/wps/portal/index/iot/!ut/p/a1/hc5NC4JAEAbg39LBY87oimi3TanURKIo3UsobKtgrqhl_ftMugR9zG1mnpcZYBADq9JrIdKukFVaPntmHqONZmqrCAMLiYN07kSGoVHULX0AyQDwS1H8l9_yCg7ARkZwiRjZXhjswmFL9gvfXpvEdY0X-HHGByZKmY0vJ7TKiCWANfzEG96ol2YY511XtzMFFez7XhVSipKrKVfwUyKXbQfxG4T6HN-8KcvuPZ08APVFVKI!/dl5/d5/L0lKQSEvUUt3SS80RUkhL2Vu/ |
| | - Partnership between Kalhat services and US irrigation products firm, Oman | https://www.muscatdaily.com/Archive/Oman/Kalhat-Services-ties-up-with-leading-US-based-irrigation-products-firm-3h6u |
| | - Development of a wireless irrigation control system in the coastal aquifers of Oman | https://ieeexplore.ieee.org/document/7409402/ |
| | - Research on implementation of smart irrigation system for groundwater use at farm scale, Sultan Qaboos University | https://squ.pure.elsevier.com/en/publications/design-and-implementation-of-smart-irrigation-system-for-groundwa |
| WF-23 | - Muna Noor, Muscat | https://www.munanoor.com/product-category/field-irrigation-kit/ |
| WF-24 | - EMergyKool misting systems, Oman | http://oman.emergykool.com/ |
| WF-25 | - Law initiated by the ministry of agriculture and fisheries, prohibiting use of treated waste water to irrigate agricultural lands | https://www.muscatdaily.com/Archive/Oman/Using-treated-wastewater-to-irrigate-agricultural-lands-against-law-MoAF-582n |
| | - Muscat waste-water project | https://www.water-technology.net/projects/muscat/ |
| | - Law initiated by the ministry of agriculture and fisheries, prohibiting use of treated waste water to irrigate agricultural lands | http://www.biosaline.org/sites/default/files/project_brief_benefits_and_risks_of_using_treated_municipal_v3-eng-web.pdf |
| | - Collaboration between Haya Water and the ministry of agriculture and fisheries on a reuse of treated waste water pilot project across 5 farms, Al Barka | https://www.squ.edu.om/Portals/97/Activities/Workshop/WWD2017/HayaWater.pdf |
| WF-26 | - No initiatives available | - |
| WF-27 | - No initiatives available | - |
| WF-28 | - Represents the major mechanism for food acquisition in Oman | https://wits.worldbank.org/CountryProfile/en/Country/OMN/Year/2015/TradeFlow/Import/Partner/by-country/Product/16-24_FoodProd |
| WF-29 | - Alfarsi, Muscat | https://www.alfarsi.me/products/food-safety/ |
| WF-30 | - There is no current system in place | - |

| SN | Initiative(s)/Programme(s) | Links |
|---|---|---|
| WE-1 | - Muscat Wastewater Project, Governorate of Muscat | https://www.water-technology.net/projects/muscat/ |
| | - A'Seeb Wastewater Project, Muscat | https://www.parsons.com/project/aseeb-wastewater-project/ |
| WE-2 | - The Research Council, Sultan Qaboos University, the Omani Ministry of Agriculture and Fisheries and Middle East Desalination Research Centre have installed a desalination unit powered directly by photovoltaic solar panels to treat brackish water irrigation purposes. Each unit consists of 20 solar cell, producing 3,000 gallons of water per day. | https://www.natureasia.com/en/nmiddleeast/article/10.1038/nmiddleeast.2017.170 |
| WE-3 | - Sharqiyah Desalination, Sur Desalination Plant | https://sharqiyahdesalination.com/sur-desalination/sur-desalination-plant |
| WE-4 | - Cogeneration performed at various plants across Oman<br>- Sohar Power and Desalination Plant, Sohar | - https://www.kapsarc.org/wp-content/uploads/2017/11/KS-2017-MP04-GCC-Energy-Overview-2017.pdf<br>- http://www.omanpwp.com/new/Pages.aspx?Pid=24 |
| WE-5 | - All industries, power plants and desalination plants on the coast that discharge cooling water, treated wastewater or brine into the sea | Not Applicable |
| WE-6 | - No initiatives | Not Applicable |
| WE-7 | - Solar pumps in Samail, Dakhiliyah Governorate | https://www.muscatdaily.com/Archive/Oman/Solar-power-to-help-pump-well-water-to-80-homes-in-Samail-5484 |
| WE-8 | - No initiatives | Not Applicable |
| WE-9 | - The Supervisory Control and Data Acquisition (Scada) Centre, affiliated with the Public Authority for Water (PAW) , worth OMR11,485,870, was initiated to use remote control & monitoring systems, Muscat | https://timesofoman.com/article/13806/Oman/Scada-to-help-plug-water-leakage |
| WE-10 | - Solar hot water system implemented at Sultan Qaboos University, Eco-house | http://www.ecohouse.om/solar-energy/ |
| | - Solar water heater system implemented at IRENA, Abu Dhabi | http://www.masdar.ae/assets/downloads/content/4996/irena_hg.pdf |
| WE-11 | - GREE solar powered air conditioning, Entire Oman market | http://www.genetco.net/GREESOLARPOWEREDAIRCONDITIONINGISINOMAN/tabid/829/Default.aspx |
| | AMGE, Muscat | http://www.solaroman.com/about-us.html |
| WE-12 | - Muscat District Cooling Company, Muscat | http://www.bahwanengineering.com/en/district-cooling |
| | - Tabreed, Seeb | http://www.tabreedoman.com/about-us/ |
| WE-13 | - Evaluating benefits of energy efficiency programs in Oman, KAPSARC | https://www.kapsarc.org/wp-content/uploads/2017/05/KS-2017-DP11-Energy-Productivity-Evaluating-Large-Scale-Building-Energy-Efficiency-Programs-in-Oman.pdf |
| | - The Green Building Information Gateway in Oman, Muscat | http://www.gbig.org/search/advanced?search%5Bflat_rating_program_ids%5D=Certification&search%5Bplace_ids%5D=782 |
| | - Public Authority for Water, Muscat | https://timesofoman.com/article/79520 |
| | - Green building regulation in the pipeline for Oman | https://www.zawya.com/mena/en/story/Green_building_regulation_in_the_pipeline_for_Oman-ZAWYA20161005043323/ |
| WE-14 | - Mukhaizna oilfield, Al Wusta | https://www.mottmac.com/oil-and-gas/enhanced-oil-recovery |
| WE-15 | -Recyclean Hydro-pod | https://www.muscatdaily.com/Archive/Features/Recycling-oil-wastewater-41me |
| | - Research on use of wastewater from oil production in agriculture | https://www.muscatdaily.com/Archive/Oman/PDO-Bauer-prove-wastewater-from-oil-production-to-be-suitable-for-agriculture-4za5 |
| WE-16 | - No initiatives in place | Not Applicable |
| WE-17 | Environment and Climate Affairs Ministry, Fog harvesting pilot, Salalah, Oman | - https://gulfnews.com/news/gulf/oman/oman-plans-fog-harvesting-project-to-ease-water-shortage-1.644770 |

| SN | Initiative(s)/Programme(s) | Links |
|---|---|---|
| FE-1 | - Research on biodiesel production from agricultural waste, Sultan Qaboos University | https://www.muscatdaily.com/Archive/Oman/Omani-scientists-working-to-produce-biofuel-from-agricultural-waste-47h8 |
| | - Research on algae collection for biofuel synthesis, Sultan Qaboos University | https://timesofoman.com/article/127621 |
| FE-2 | - The Research Council in collaboration with the Department of Biology, Sultan Qaboos University have converted fermentable sugars by enzymatic hydrolysis into bioethanol | https://www.muscatdaily.com/Archive/Oman/Omani-researchers-convert-wastepaper-into-bioplastic-bioethanol-and-biodiesel-57n9 |
| | Study on bioethanol potential of lignocellulosic biomass such as date palm & mangroves | http://www.scopemed.org/?mno=184787 |
| | - College of Agricultural & Marine Sciences, Sultan Qaboos University has tested Jatropha plant growth under different conditions | https://timesofoman.com/article/22470 |
| | - Jatropha plant testing in arid climates by German scientists | https://www.egu.eu/newsletter/geog/07/pressreleases.pdf |
| FE-3 | - Opportunities discussed by omanobserver on potential biogas plants around the country | https://businessgateways.com/news/2017/12/17/Potential-for-10-biogas-plants-around-Oman |
| | High potential of camel manure in biogas production, Abu Dhabi | http://www.scopemed.org/?mno=184787 |
| WE-1 | Please refer to WE-1 | – |
| FE-4 | - Be'ah has signed a memorandum of understanding (MoU) with The German University of Technology in Oman (GUtech) regarding the formation of a biogas plant in the university's premises.<br><br>- Be'ah targets to divert 60 per cent of the municipal solid waste from all landfills across the sultanate by 2020 and 80 per cent by 2030 through the introduction of value recovery activities | https://www.muscatdaily.com/Archive/Oman/Be-ah-GUtech-pact-to-establish-biogas-plant-4wdi |
| FE-5 | - Studies are being conducted to initiate a number of waste-to-energy and biogas projects. | https://www.arabianbusiness.com/politics-economics/382871-oman-set-to-privatise-waste-management-sector |
| | - Research on using date palm pits to produce biodiesel, Sultan Qaboos University | https://www.muscatdaily.com/Archive/Oman/Omani-scientists-working-to-produce-biofuel-from-agricultural-waste-47h8 |
| | - Biogas recovery project in Barka landfill | http://www.stoffstrom.org/fileadmin/userdaten/dokumente/Veranstaltungen/KWW16/Vortraege/IEC7_Al_Kharusi.pdf |
| FE-6 | - No initiatives | Not Applicable |
| FE-7 | - No initiatives | Not Applicable |
| FE-8 | - No initiatives | http://smartcool.ae/ |
| FE-9 | - No initiatives | Not Applicable |
| FE-10 | - OMIFCO fertilizer complex has setup ammonia and urea plants, OMIFCO | http://www.omifco.com/project.html |
| FE-11 | - PV Irrigation System for Omani Farmers, Ad Dakhiliyah Region | https://www.phaesun.com/references/water-systems/pv-irrigation-system.html |
| FE-12 | - No initiatives | Not Applicable |
| FE-13 | - No initiatives | Not Applicable |
| FE-14 | - No initiatives | Not Applicable |
| FE-15 | - Sohar Flour Mills, Sohar<br>- Public Authority for Stores & Food Reserve, Oman Government | https://businessgateways.com/news/2018/04/16/Sohar-Port-signs-land-pact-for-construction<br>http://www.oman.om/wps/wcm/connect/en/site/home/gov/gov1/gov5governmentorganizations/pasfr/pastoresandfoodreser |
| FE-16 | - No initiatives | Not Applicable |

# 11. Appendix B

The table below elaborates on the stakeholder entities identified in Chapter 9, providing entity descriptions and links.

| Entity type | | Entity Responsibility | Link |
|---|---|---|---|
| Government operator entities | | | |
| 1 | Bee'ah | Environmental management, systematic waste management, renewable energy utilization and community engagement initiatives to set a benchmark for sustainability | https://www.beah.om/ |
| 2 | Omani Authority for Partnership for Development (OAPFD) | Manage and administer the Partnership for Development (PFD/Offset) program | https://oapfd.om/en/Pages/Objectives.aspx |
| 3 | Oman Aquaculture Development Company (OADC) | The company is investing in fish farming projects that lead to the development of aquaculture sector in the sultanate, including shrimp farming, finfish, shellfish and seaweed ventures | http://oadc.om/about-us/ |
| 4 | Haya Water | Develop, design, implement, operate and maintain the wastewater facilities in Muscat Governorate | https://haya.om/en/Pages/VisionMission.aspx |
| 5 | Oman Power and Water Procurement Co. | Single Buyer of power and water for all IPP/IWPP projects within the Sultanate of Oman | http://www.omanpwp.com/new/Pages.aspx?Pid=1 |
| 6. | Salalah Wastewater Services Co | Responsible for providing wastewater services | Not available |
| Government regulator entities | | | |
| 7 | Ministry of Agriculture and Fisheries | Building and developing the agriculture and fisheries fields by developing the technologies used in these fields and implementing new supporting projects | http://www.oman.om/EN/site/home/gov/gov1/gov5governmentorganizations/maf/ |
| 8 | Authority for Electricity Regulation | Responsible for regulating the electricity sector and some aspects of the water sector | http://www.aer-oman.org/aer/aboutUs.jsp |
| 9 | Ministry of Regional Municipalities, Environment & Water Resources | Formulate policies, plans and programs for all sectors and follow up their implementation, assessment and improvement, in accordance with the latest development in related fields. | http://www.oman.om/EN/site/home/gov/gov1/gov5governmentorganizations/mrmewr/ |
| 10 | The Public Authority for Water/DIAM | Providing high quality sustainable and reliable potable water and power services to all people in Oman | https://www.paew.gov.om/About-us/Who-we-are |
| 11 | The Public Authority for Stores and Food Reserve | Providing basic food commodities and ensuring warehouse storage with high technical specifications for local use in case of emergency situations in Oman. | http://www.oman.om/wps/wcm/connect/en/site/home/gov/gov1/gov5governmentorganizations/pasfr/pastoresandfoodreser |
| Industry | | | |
| 12 | Oman LNG | Liquefy, store, transport and market Oman's natural gas and to deliver LNG to customers | http://omanlng.com/en/TheCompany/Pages/OmanLNGInBrief.aspx |
| 13 | Al Hosn Investment Company | HIC investments target vital economic sectors including healthcare, education, aquaculture, industrial and manufacturing, telecom / media / technology. Additionally, HIC may consider other growth sectors, on a case by case basis | https://www.alhosnoman.com/ |
| 14 | Agribusinesses | To provide world-class agricultural products<br>Focuses on sustainable farming practices and investments in agricultural innovation | https://farmfolio.net/articles/oman-agribusiness-heart-indian-ocean/ |
| 15 | Sohar Power Company | Owns and operates the largest power generation and water desalination plant in the Sultanate of Oman | https://www.mubadala.com/en/what-we-do/renewables/masdar |
| 16 | Oman Food Investment Holding Company | Developing partnerships with food companies and other stakeholders to identify project opportunities and building strong business cases for investors. | http://omanfood.om/about-us/who-is-ofic/ |
| 17 | Oman Water Treatment Company | Design, engineering and construction of Water and Wastewater Treatment Plants. | http://www.owatco.com/aboutus.html |

| Entity type | | Entity Responsibility | Link |
|---|---|---|---|
| 18 | Oman India Fertiliser Company (OMIFCO) | An initiative by the Governments of Oman & India, in order to construct, own and operate an ammonia-urea fertiliser manufacturing plant at the Sur Industrial Estate in the Sultanate of Oman. | http://www.omifco.com/about.html |
| International organizations and NGOs | | | |
| 19 | Arab Authority for Agricultural Investment & Development | To invest in agricultural activities for food security in the Arab World | https://www.aaaid.org/en/aaaid-glance |
| 20 | IRENA | To provide data on renewable energy and promote economic, social and environmental benefits of renewables | http://www.irena.org/ |
| 21 | Food and Agriculture Organization | To contribute to the sustainable production of agriculture and fisheries to combat poverty | http://www.fao.org/countryprofiles/index/en/?iso3=ARE |
| 22 | International Livestock Research Institute | Works to improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock | https://www.ilri.org/ |
| 23 | World Bank Group | One of the world's largest sources of funding and knowledge for developing countries, to promote sustainable development | https://www.worldbank.org/en/who-we-are |
| 24 | Environment Society of Oman | Non-profit organization helping to protect Oman's natural heritage | http://www.eso.org.om/index/list.php?categoryId=289 |
| Universities and Research Institutes | | | |
| 25 | International Center of Biosaline Agriculture | Research focused on innovative technologies and non-traditional crops to address food security | http://www.biosaline.org/ |
| 26 | Sultan Qaboos University | To excel in teaching and learning, research and innovation, and community service by promoting the principles of scientific analysis and creative thinking | https://www.squ.edu.om/About/About-SQU/Vision-Mission-Objectives |
| 27 | Oman Center for Marine Biotechnology (OCMB) | Oman's first research and development organization within the field of Marine Biotechnology | http://www.omancmb.com/about/ |
| 28 | Oman Animal and Plant Genetic Resources Center (OAPGRC) | To promote recognition, and valuation of genetic diversity of Oman's animals, plants and microorganisms as a natural heritage resource. | https://oapgrc.gov.om/Pages/Overview.aspx |
| 29 | The Research Council | To provide an enabling environment for research and Innovation | https://www.trc.gov.om/trcweb/about |
| 30 | German University of Technology in Oman (GUtech) | To become a leading university of technology in Oman and the wider region. | https://www.gutech.edu.om/about/profile/#toggle-id-1 |

## 12. Endnotes -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2. EY internal analysis
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