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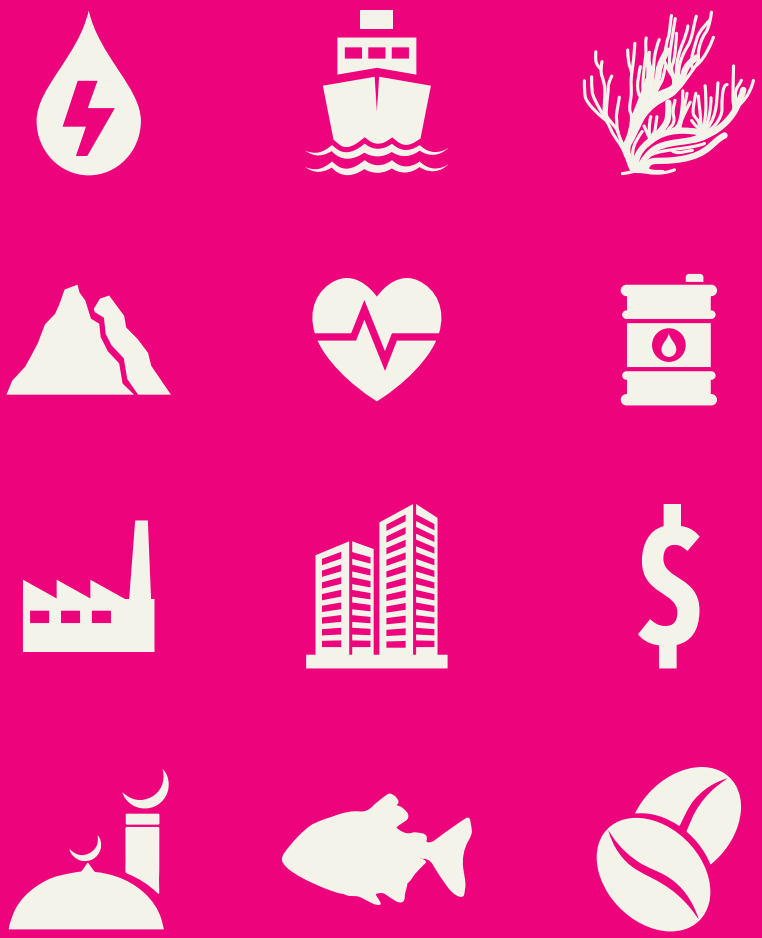

UAE Climate Change Risks & Resilience:

An overview of climate change risks to 12 key sectors

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ABOUT EMIRATES WILDLIFE SOCIETY IN ASSOCIATION WITH WWF (EWS-WWF)

Emirates Wildlife Society is a national (UAE) environmental non-governmental organisation established in 2001 under the patronage of HH Sheikh Hamdan bin Zayed Al Nahyan, Ruler's representative in the western region and Chairman of Environment Agency-Abu Dhabi.

Emirates Wildlife Society works in association with WWF, one of the world's largest and most respected independent conservation organisations, with offices in 100 countries. The association is commonly known as EWS-WWF.

Our vision is to build a future where humans live in harmony with nature.
Our mission is to conserve nature and reduce the most pressing threats to the environment. We work with people and institutions in the UAE and region, to implement conservation solutions through science, research, policy, education and awareness.

For more information, please visit uae.panda.org

ABOUT ACCLIMATISE

Acclimatise is a specialist consulting, communications and digital application company providing world-class expertise in climate change adaptation and resilience. Founded in 2004, our mission is to help our clients understand and adapt to climate risk, and take advantage of the emerging opportunities that climate change will bring.

With offices in the UK, US, India, Barbados and mainland Europe, Acclimatise has worked in over 60 countries worldwide. Working with national and local governments, multilateral organisations, and major corporations, Acclimatise has been at the forefront of climate change adaptation for over a decade. Our experience spans a wide range of sectors including government, finance, insurance, water, energy, transport, mining, agriculture, defence, food and beverages, and development.

Our continued success is based on successful engagement with our clients, taking the time to understand their individual needs, processes and operations. In this way, we help bridge the gap between the latest climate science and the realities of day-to-day decision-making.

For more information, please visit: www.acclimatise.uk.com

ACKNOWLEDGEMENTS

EWS-WWF would like to acknowledge the following stakeholders for supporting and providing valuable insights to the development and completion of this report.

Firstly, we would like highlight the role of the Abu Dhabi Global Environment Data Initiative's (AGEDI) in inspiring us to develop this important summary of risks thanks to their Local, Regional and National Climate Change Programme (LNR-CCP). Secondly, we would like to thank those who have provided valuable insights during and outside of the stakeholder roundtable sessions hosted in March 2016:

Abu Dhabi Farmers Services Centre (ADFSC)	Etihad Energy Service Company (Etihad ESCO)
Abu Dhabi Food Control Authority (ADFCA)	Food & Agriculture Organisation (FAO)
Abu Dhabi Global Environment Data Initiative (AGEDI)	Food Security Centre - Abu Dhabi
Abu Dhabi Water & Electricity Company (ADWEC)	HSBC Bank Middle East Limited
Agriprocity	Insurance Authority UAE
Baringa Partners LLP	International Centre for Biosaline Agriculture (ICBA)
Department of Transport - Abu Dhabi (DoT)	Jumeirah Group
Diamond Developers	Ministry of Climate Change & Environment - UAE
Dubai Electricity & Water Authority (DEWA)	Ministry of Energy - UAE
The Department of Tourism and Commerce Marketing (DTCM)	Ministry of Foreign Affairs & International Cooperation - UAE
Dubai Supreme Council of Energy (DSCE)	Sharjah Electricity and Water Authority (SEWA)
Emirates Diplomatic Academy (EDA)	Tourism Development & Investment Company (TDIC)
Emirates Global Aluminium (EGA)	Urban Planning Council - Abu Dhabi (UPC)
Emirates Green Building Council (EGBC)	Emirates Group
Energetics Incorporated	Masdar Institute
Environment Agency - Abu Dhabi (EAD)	Regulatory & Supervision Bureau - Dubai (RSB)

EWS-WWF would also like to thank the Ministry of Climate Change and Environment for co-hosting the roundtable sessions in March 2016 and in supporting raising awareness about climate change risks in the UAE. We are also very grateful to AGEDI and the International Centre for Biosaline Agriculture (ICBA) for hosting our roundtables in their venues and being tremendously supportive of our initiative and in stakeholder consultations.

We would also like to thank Rehana Jiffrey, from Taka Solutions for providing insightful case studies on climate change impacts on UAE buildings, our volunteers Laura Keeley and Laura Fitzpatrick for their support on research highlighting key climatic events in the region and to Sultan Mollov, from EWS-WWF for supporting the development of this final report.

FOREWORD FROM IDA TILLISCH

Ida Tillisch,
Director General

Global and regional climate change is a reality; it is occurring now and is driven by increasing greenhouse gas emissions, most notably carbon dioxide, which is increasing global temperatures. 2016 was confirmed as the warmest year on record globally since 1880, beating previous records set in 2015 and 2014.

But even powerful global headlines of record breaking extreme weather events, coastal flooding and heat-waves often fail to resonate with policy makers and the public. The reason is these headlines usually don't highlight the tangible risks or the opportunities that a changing climate poses to our society, environment and economy.

The UAE has always endured harsh environmental conditions, successfully thriving in the face of scarce water supplies and intense heat. However, the scale of impacts that are expected from climate change may exceed the coping capacities of many sectors. Consequences will be felt across the country including the national economy, ecosystems, biodiversity, and society. For example, desalination costs are likely to rise due to warmer and more saline intake water; an energy demand-supply gap associated with increased demand for cooling is likely to occur due to increased temperatures and humidity; the simple act of cleaning up after extreme weather patterns will be costlier as their occurrences and intensities increase; and finally our coral reefs' ability to prevent coastal erosion and inundation will be severely impacted under future climate change conditions.

Essentially, the UAE's continuing efforts towards achieving economic diversification and overall wellbeing of the population will be slowed down by climate change impacts if left unmanaged. The country therefore has an important stake in seeing the rapid and successful implementation of the Paris Agreement. Without deep cuts in emissions, the severity and occurrence of climate change impacts are set to increase. At the same time, adaptation actions will be needed to cope with the unavoidable impacts of climate change.

A golden opportunity now exists for the country to take a leading role in the region to make the goals of the Paris Agreement truly meaningful. This report distills the increasing wealth of scientific research carried out in the UAE and the region in order to paint a compelling picture of how climate change has, and will, impact the country. These critical insights aim to encourage increased action toward achieving the Paris Agreement, boost momentum in identifying robust adaptation solutions and support in taking advantage of opportunities presented by climate change.

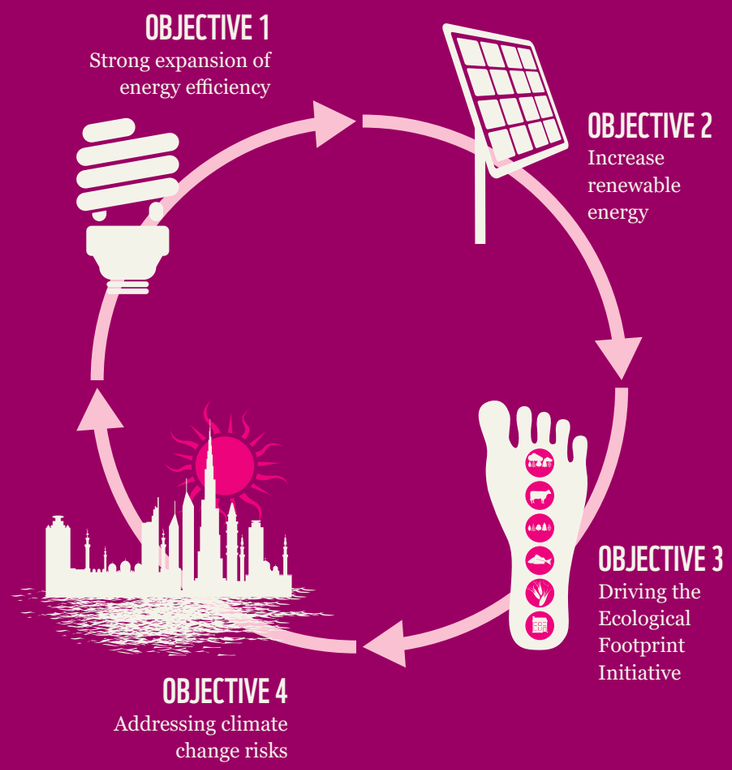
Ida Tillisch
Director General
EWS-WWF

[a]NASA, 2017

CALL FOR SUPPORT

WITH STRONG PARTNERS, WE CAN SCALE UP OUR IMPACT

EWS-WWF wants to see the UAE economy embrace low-carbon development and resilience to climate change. Our five-year Climate Change & Energy Programme focuses on the following:



To find out how your organisation can become part of the solution, contact:

Asif Mugloo
Corporate Partnerships Manager

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amugloo@ewswwf.ae

REPORT SPONSOR

We are grateful for the organizations who support our mission to work with people and institutions within the UAE and the region, to conserve biodiversity, tackle climate change and reduce the ecological footprint through education, awareness, policy, and science-based conservation initiatives.

These types of partnerships, support in driving ambition and progressive thinking, in order to rise to the challenge of ensuring a sustainable future for generations to come.

FARNEK
TOTAL FACILITIES MANAGEMENT

As a leading facilities management company, Farnek is committed towards building a culture of environmental responsibility in partnership with our stakeholders and beyond. However, we believe that there are three basic elements to make this a far-reaching and enduring reality.

First, we must lead by example, ensuring that we minimise our own carbon footprint and look to offset the remaining carbon emissions wherever possible. Secondly, we must engage with our clients to reduce the environmental impact of the buildings that we manage, through the implementation of systematic methodologies and innovative solutions to reduce water and energy consumption and waste volume sent to landfill. Finally, we must create awareness both at the corporate level and collectively throughout the wider UAE community.

It is this last point that brings me appropriately on to our sponsorship of this report. It is essential that the corporate world supports tireless organisations such as the EWS WWF, which shares our values through the invaluable work it does, broadcasting factual accounts of the risks facing our climate, why it matters and what must be done about it.

Markus Oberlin,
CEO, Farnek.

UAE CLIMATE CHANGE RISKS & RESILIENCE:

An overview of climate change risks to 12 key sectors.

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EXECUTIVE SUMMARY

The UAE's continuing efforts towards achieving economic diversification and overall wellbeing of the population will be slowed down by climate change impacts if left unmanaged. Direct impacts of extreme weather events as well as slow-onset phenomena such as sea level rise, will cause disruption in the everyday functioning of transport and infrastructure, impact the value of real estate and damage the tourism industry, to name a few. Consequences will be felt across the national economy and financial services.

The UAE's society and economy have always endured harsh environmental conditions, successfully thriving in the face of scarce water supplies and intense heat. However, the scale of impacts that are expected from climate change may exceed the coping capacities of many sectors. This report demonstrates that significant changes in air and sea temperature, increased variability of precipitation and unpredictable patterns of extreme events will lead to a multiplicity of impacts in all sectors of the economy. Compounded with demographic pressure and fast socio-economic transformation, impacts on critical assets such as water resources, coastal areas and energy will propagate rapidly across sectors.

The recently adopted Paris Agreement is broadly considered a historical breakthrough in multilateral climate change policy. The UAE has made significant steps forward on climate change mitigation (reducing greenhouse gas (GHG) emissions) and green development in recent years, both at national and emirate level. This is reflected in the establishment of the federal Ministry of Climate Change and Environment (MoCCAE) and the Ministry's commitment to develop a UAE National Climate Change Plan. A golden opportunity now exists for the country to take a leading role in the region to make the content of the Paris Agreement truly meaningful and definitive.

The Emirates Wildlife Society - in association with the World Wide Fund for Nature (EWS-WWF) recognises the urgent need to increase awareness and understanding of climate risks in the UAE, as it is critical to promoting action on both mitigation and adaption. This report distils the increasing wealth of scientific research carried out in the UAE and wider region to paint a compelling picture of how climate change has and will in the future impact the country across the following themes:

Infrastructure & Utilities:
1. Energy & Water,
2. Transport & Logistics

Ecosystems & Biodiversity
3. Marine
4. Terrestrial

5. Health & Well-being

Economy & Business:
6. Oil & Gas
7. Industry
8. Buildings, Construction & Real Estate
9. Financial Services
10. Cultural Heritage, Hospitality and Tourism

Food Security:
11. Domestic Agriculture, fishing and aquaculture
12. International Food Imports

Interconnected risks posed by climate change are particularly evident in the water-energy-food nexus, where the increasing use of and stress on these resources are bound to represent a challenge to the national agenda. Water is at the core of most strategic sectors in the UAE. Warmer seawater used for cooling in power generation processes and other industrial functions will result in a loss of efficiency in energy production and higher costs for business. At the same time, water desalination is an energy-intensive activity, carrying a high environmental burden, and is likely to be affected by higher costs. Declining water quantity will have direct impacts on agricultural output and food production costs. In addition, most food supply in the UAE is reliant on agricultural production abroad, in countries prone to climate risks.

The UAE's objectives of GHG emission reduction, clean energy and energy and water efficiency will be impossible to achieve without considering climate change risks. An energy demand-supply gap associated with the combination of increased energy demand for cooling for residential and industrial purposes and marginal losses in power supply may hamper energy security and GHG emissions reduction policies. Energy efficiency measures in the building and construction sector will have to deal with changing, uncertain climate conditions, requiring further adjustments in regulations, standards, designs and materials. Finally, reducing water overuse would require the country to consider future climatic pressures in the efficient management of both the demand and the supply side.

The UAE government is beginning to take action on climate adaptation under the guidance of the MoCCAE through the development of the National Climate Change Plan. This report sets the scene for helping private firms and governments identify robust adaptation solutions associated with climate change risks. It also highlights the opportunities of climate change, such as the development of innovative markets for climate change mitigation and adaptation-related products and services.

It is critical for adaptation policy planning and implementation to occur at the national, sub-national and local level at the public and private sector level. This report concludes by summarising the principles to consider when planning for adaptation, as well as the processes for developing robust climate change adaptation policy frameworks and action plans.

THE UAE'S CONTINUING EFFORTS TOWARDS ACHIEVING ECONOMIC DIVERSIFICATION AND OVERALL WELLBEING OF THE POPULATION WILL BE **SLOWED DOWN BY CLIMATE CHANGE IMPACTS IF LEFT UNMANAGED.**

THIS REPORT SETS THE SCENE FOR HELPING PRIVATE FIRMS AND GOVERNMENTS IDENTIFY ROBUST ADAPTATION SOLUTIONS AND OPPORTUNITIES ASSOCIATED WITH CLIMATE CHANGE RISKS

UAE CLIMATE CHANGE RISKS & RESILIENCE:

AN OVERVIEW OF CLIMATE CHANGE RISKS TO 12 SECTORS

EWS-WWF & Acclimatise's report summarises the impacts and risks from climate change to 12 sectors in the UAE.

BY 2050, THE UAE WILL...

BY 2°C

HUMIDITY UP TO 10%

THESE CHANGES IN THE CLIMATE WILL HAVE IMPORTANT IMPLICATIONS FOR THE ENERGY SECTOR, ESPECIALLY BY DRIVING UP DEMAND FOR COOLING. EXAMPLES OF THESE IMPACTS INCLUDE:

At the building level, this would

INCREASE ENERGY CONSUMPTION BY 11% ANNUALLY

Costs to building owners and end users for the entire UAE building sector* will increase by

+$834 MILLION /YEAR

The energy required to meet this additional demand is equivalent to

18 MASDAR SHAMS 1 SOLAR POWERED PLANTS

This additional demand for energy would produce the Co_2 emissions equivalent to one

CAR DRIVING 17,455 ROUNDTRIPS TO THE MOON

THE UAE'S CONTINUING EFFORTS TOWARDS ACHIEVING ECONOMIC DIVERSIFICATION AND OVERALL WELLBEING OF THE POPULATION WILL BE HINDERED BY CLIMATE CHANGE IMPACTS IF LEFT UNMANAGED. BUT THERE ARE WAYS TO ADAPT...

Learn more about the risks of climate change to the UAE and how countries and companies can adapt in this report.

DEVELOPED IN COLLABORATION WITH: ACCLIMATISE building climate resilience — AND SUPPORTED BY: takasolutions, AGEDI

* Using $0.12/kWh for Dubai as an aggregated total cost of electricity to the utility

Sources: Abu Dhabi Global Environment Data Initiative (AGEDI). DEWA. EWS-WWF. Taka Solutions. UAE Ministry of Energy (State of the Energy Report, 2016). U.S. Environmental Protection Agency (EPA).

مخاطر وتكيّف دولة الإمارات العربية المتحدة لتغير المناخ:

نظرة عامة على تغير المناخ على 12 قطاعاً

يُلخص تقرير جمعية الإمارات للحياة الفطرية بالتعاون مع الصندوق العالمي للطبيعة وأكلاماتايز الآثار والمخاطر الناجمة عن تغير المناخ على ١٢ قطاعاً في دولة الإمارات العربية المتحدة.

ستواجه الدولة بحلول 2050...

ارتفاع 2 درجة مئوية

رطوبة لغاية %10

سيكون لهذه التغيرات من قبل تغير المناخ انعكاسات هامة على قطاع الطاقة، وبشكل خاص في دفع زيادة الطلب على التبريد. بعض من الأمثلة على هذه الآثار:

يعني ذلك على نطاق المباني

زيادة استهلاك الطاقة بنسبة 11% سنوياً

زيادة التكاليف لملاك المباني والمستهلكين لكافة المباني المباني في الدولة* إلى

+$834 مليون/ سنوياً

الطاقة المتطلبة لتلبية هذا الطلب الزائد تساوي

18 محطة "شمس 1" لتوليد الطاقة

سينتج عن زيادة هذا الطلب على الطاقة انبعاثات غاز ثاني أوكسيد الكربون تساوي

قيادة 17,455 مركبة للقمر ذهابً وإياباً

ستعيق آثار تغير المناخ إذا لم يتم إدارتها جهود دولة الإمارات العربية المتحدة المستمرة في تحقيق التنوع الاقتصادي ورخاء العيش للأهالي. ولكنه يوجد دائماً طرق للتأقلم...

تَعرّف على المزيد عن مخاطر تغير المناخ لدولة الإمارات العربية المتحدة، وكيفية تأقلم الدول والشركات في هذا التقرير.

طور التقرير بالتعاون مع: EWS WWF — وبمساعدة فنيّة من قبل: takasolutions, AGEDI, ACCLIMATISE building climate resilience

* استخدام $0,12 / KWh لإمارة دبي كتكلفة إجمالية لخدمة الكهرباء.

المصادر: مبادرة أبوظبي العالمية للبيانات البيئية. هيئة كهرباء ومياه دبي. جمعية الإمارات للحياة الفطرية بالتعاون مع الصندوق العالمي للطبيعة. طاقة سوليشون. وزارة الطاقة في الإمارات العربية المتحدة (من صمن تقرير حالة الطاقة، 2016). وكالة حماية البيئة الأمريكية

1. INTRODUCTION

Global and regional climate change is a reality; it is occurring now and is driven by increasing greenhouse gas (GHG) emissions which are increasing global temperatures. The largest contribution to this warming is the increase in the atmospheric concentration of carbon dioxide (CO_2) since the 1870s due to industrialisation. Concentrations of CO_2 in the atmosphere are higher now than at any time during the past 650,000 years.[1] In the Northern hemisphere, in spring 2015 the three-month global average concentration of CO_2 crossed the 400 Parts Per Million (ppm) level for the first time.[2]

The year 2016 was recently confirmed as the hottest year globally since records began in 1880, at 0.99°C above those in the pre-industrial era.[3]

Climate change is already altering the availability of, and demand for resources, the supply and demand for products and services, the performance of physical assets, and the need for innovation. If changing climate risks are not considered in policy-making and decision-making, this may lead to objectives not being realised. In contrast, ensuring that policies, strategies and decisions are climate resilient, can help to ensure that economies will thrive in the future, that new opportunities are developed, and that environmental and social objectives are met.

NATIONAL OBJECTIVES MIGHT BE AT RISK IF CLIMATE CHANGE IS NOT CONSIDERED

A catastrophe caused by climate change is seen as the biggest potential threat to the global economy in 2016 according to the 'Global Risks Perception Survey' presented in the recent Global Risks Report by the World Economic Forum[4] and remains a top 5 risk in the 2017 version of the report. The same survey also suggests there is a growing realisation in the UAE that the country faces these risks too. In a related measure of "risk for doing business", the survey ranked 'failure to mitigate or adapt to climate change' as number 18 out of 28 risks for the country[5].

1.1 INTERNATIONAL CLIMATE CHANGE FRAMEWORK AND IMPLICATIONS FOR THE UAE

The recently adopted Paris Agreement is broadly considered an historical breakthrough in multilateral climate change policy, involving enhanced contributions with respect to climate change mitigation and adaptation for all countries. The Agreement adopted by the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) in Paris in December 2015 establishes the new regime to curb global GHG emissions from 2020 onwards. At the core of the agreement is an 'ambition mechanism' that lays out a process to regularly increase climate change mitigation targets and actions by States through national climate plans, the so-called Nationally Determined Contributions (NDCs) (see Box 1). By addressing all Parties, the Paris Agreement has outlined that to address climate change all countries need to act together with different responsibilities. Although no direct reference to the traditional differentiation between developed and developing

DEVELOPING COUNTRIES THAT ARE READY AND CAPABLE, SUCH AS EMERGING ECONOMIES LIKE THE UAE, ARE ENCOURAGED TO MOVE TOWARDS MORE COMPREHENSIVE MITIGATION EFFORTS

countries is made in the Agreement, this distinction remains, for example, in provisions about finance, capacity building and technology transfer. In fact, the Agreement takes into consideration 'common but differentiated responsibilities and respective capabilities' and different national circumstances allowing flexibility for developing countries. In practice, developing countries that are ready and capable, such as emerging economies like the UAE, are encouraged to move towards more comprehensive mitigation efforts, and join developed countries in putting forward economy-wide absolute emission reduction targets[6], as well as undertake national adaptation efforts. Developing countries are also encouraged to provide climate finance to support the most vulnerable ones, in addition to developed countries' contributions.

© ARNAUD BOUISSOU / COP PARIS / FLICKR

The Paris Agreement represents the best possible compromise to tackle climate change today and its effective implementation will imply a rapid economic transformation in the next decades[7]. To address the worst risks related to climate change, the Paris Agreement aims to limit temperature increase to well below 2°C and to pursue effort to limit the increase to 1.5°C above pre-industrial levels in line with the latest climate science. Failing to do so will put the world at risk of increasingly adverse climate impacts. In order to have a chance to stay below the temperature goal, peaking of GHG emissions should be reached 'as soon as possible' and net zero emissions should be achieved in the second half of this century[8]. This can be achieved through the rapid decarbonisation of the global economy and changing the global energy supply, with renewables anticipated to become a growing source of power.[9,10] Collective temperature and emissions goals serve as political signals to markets, as a major economic transformation will be needed for all countries to achieve those goals, mainly through scaling up of low-carbon energy[11]. The UAE has a clear interest in avoiding the most dangerous consequences of climate change and benefitting from potential economic opportunities opened up by the Agreement (see Box 1).

THE UAE HAS AN **INTEREST IN AVOIDING** THE IMPACTS OF CLIMATE CHANGE AND BENEFITTING FROM THE OPPORTUNITIES OF THE PARIS AGREEMENT

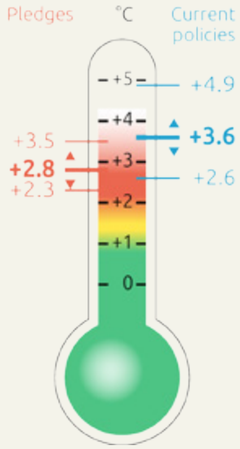

Image 1: Climate Action Tracker Thermometer: Displays the level of warming of current pledges by 2100 (2.8°C) as of November 2016.

There are significant challenges to be tackled at the national level and important aspects to be settled under the UNFCCC to make the content of the Paris Agreement truly meaningful and definitive. The large 'emissions gap'[12,13] between domestic emission cuts presented through the Intended Nationally Determined Contributions (INDCs) before Paris and the mitigation levels that would be consistent with limiting warming below 2°C and pursuing effort to limit the temperature increase to 1.5°C, will have to be filled by more ambitious national climate plans, including by the UAE and other countries with previously no responsibility under the Kyoto Protocol. It is estimated that the current pledges to reduce emissions globally fall short of about 11-13 $GtCO_2e$ in 2025, growing to about 15-17 $GtCO_2e$ in 2030 towards the 2°C path[14]. The emissions gap for the 1.5°C pathway is about 3 $GtCO_2e$ larger than the 2°C gap in 2025, and 6 $GtCO_2e$ larger in 2030. In other words, under such pledges it is extremely likely (>90% probability) that warming will exceed 2°C, and it is only likely (>66% probability) that the temperature increase will remain below 3°C by the end of this century. Limiting warming below 1.5°C seems much more uncertain (with ≥50% probability)[15]. The UAE submitted its INDC in late October 2015, signed the Paris Agreement in April 2016 and ratified the agreement in September 2016 (see Section 1.2.3).

Open issues with respect to the definition of the rules, methodologies and institutions as set out in the Paris Agreement need to be secured in the next rounds of negotiations to allow actual implementation of actions. The success of the Paris Agreement will ultimately depend on the ability of the negotiators to refine, in the next five years, the architecture of the post-2020 climate regime with a robust system that will incentivise countries to submit increasingly ambitious mitigation, adaptation and finance plans, through the NDCs, the transparency mechanism and the global stocktake together (see Box 1)[16]. The UAE has a role to play to ensure that the Agreement is effectively designed and implemented by all countries.

The government of UAE is committed to achieve global objectives related to sustainable development and disaster risk reduction. The UAE has endorsed the Sustainable Development Goals (SDGs) of the 2030 Sustainable Development Agenda adopted by world leaders at the historical UN summit held in New York in September 2015.[17] Furthermore, the UAE is supporting the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 adopted at the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan, on March 18, 2015, aimed at preventing and substantially reducing disaster risk and losses.[18]

Box 1 The UAE and the Paris Agreement

The Paris Agreement entered into force on November 4th 2016, one month after the threshold of 55 Parties representing at least 55% of global emissions was achieved on October 5th 2016. All Parties now have the obligation to communicate their NDCs, starting before 2020, and regularly every 5 years. Although leaving flexibility to define the content and the emission reduction targets, successive NDCs are expected to represent a progression and the highest possible ambition for each country. While achieving the targets set in the NDCs is not legally-binding, countries must report biennially on national GHG emissions and their progress in implementing those targets through a 'transparency mechanism'. The overall implementation of national climate plans will be informed by periodic 'global stocktakes' that will assess progress on a variety of aspects including mitigation, adaptation and financial support, starting in 2023[19].

The UAE had a strong interest in COP21 resulting in a global but flexible climate deal, and for the first time all the Gulf countries had pledged to mitigate and tackle climate change together.[20]

As the UAE has now ratified the Paris Agreement, it will now need to integrate its NDCs in the national development agenda, and put in place a robust system of national reporting on its GHG emissions[21]. Importantly, mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification plans, as well as the impacts of the measures taken in response to climate change are recognised in the Agreement. The UAE also has an opportunity to actively engaging in the UNFCCC negotiations over the coming years to ensure that its national priorities are represented in the process defining the institutional architecture of the Agreement[22].

The agreement falls in line with the existing economic diversification plans UAE already has at national and emirate-level. In the Gulf, the UAE is well positioned to take advantage of the potential economic opportunities created by the Paris Agreement in the medium-term, enabling more predictable investments on low-carbon and climate-resilient technologies and solutions especially in the energy and sustainable infrastructure sectors, both at home and abroad[23]. Long-term impacts of the Paris Agreement for the UAE and other countries in relation to the global demand for oil are yet unclear.[24]

Picture: Dr. Thani Al Zeyoudi, UAE Minister of Climate Change and Environment and Ban Ki-moon, Secretary General of the United Nations after the UAE ratified the Paris Climate Agreement in New York. (credit WAM in Gulf Today)[25]

1.2 KEY FEDERAL POLICY OBJECTIVES IN THE UAE

Economic, social and environmental policy objectives imply consequences in terms of climate change mitigation and adaptation objectives and their degree of success. In turn, the effects of climate change will be economic, social, and environmental and will alter people's lives. An overview of such policies for the UAE sets the scene for the risk assessment contained in this report.

1.2.1 Economic and social development policies

The focus of the UAE economy, primarily based on oil production, has recently shifted to other strategic sectors.[26] The UAE is committed to achieve economic liberalisation and boost growth by expanding key sectors such as clean energy, advanced manufacturing, tourism, real estate and construction, transport and logistics, and financial services, moving away from dependence on oil. Economic diversification is high on the ministerial agenda as showed by the UAE leaders' retreat held at the end of January 2016 to discuss initiatives with a focus on human capital, economy, government policies, and communities[27].

ECONOMIC DIVERSIFICATION IS HIGH ON THE UAE'S AGENDA

The goals set forth in the national strategy, *Vision 2021*[28] aim at reaching a balanced, sustainable growth that is largely based on technological innovation and energy efficiency, and include consideration of climate change concerns.[29] Priorities for the national development agenda include increasing social cohesion and collective identity; achieving progress in the areas of security, emergency preparedness, reliability of police services and road safety; transitioning to a knowledge-based economy that is attractive to foreign investments; reinforcing the current education system; achieving world-class healthcare; and ensuring a sustainable environment and infrastructure. A number of quantitative indicators serve to measure progress continuously against 2021 targets.[30,31]

In line with the Vision 2021 objectives, the UAE has adopted accompanying policies aimed at a more sustainable and competitive economy. These include the 2012 *Green Growth Strategy*[32], and a *National Innovation Strategy*[33], showing engagement in the area of environmentally sustainable technology development and R&D. Also, the Abu Dhabi Plan[34], as well as the Dubai Plan 2021[35] and the recently launched Dubai Clean Energy Strategy 2050[36] are likely to significantly impact on the economic diversification and sustainable development of the Union. Diversification policies are also being considered as a strategy to tackle climate change under a 'co-benefit perspective' contributing to mitigation actions (see Section 1.2.3).

1.2.2 Environmental policies and initiatives

Sustainability and environmental safeguard issues rank high on the policy agenda of the UAE.[37,38] Environmental programmes and policies are being carried out especially on biodiversity conservation (with a focus on the coastal environment), fresh water resource management, and air pollution monitoring.[39] Other initiatives, such as the *Abu Dhabi Global Environmental Data Initiative* (AGEDI)[40], the *UAE Ecological Footprint Initiative*[41,42,43] and the ministerial *Environmental Performance Card* programme to promote green products[44] to name a few, have contributed to raising overall national environmental awareness and ultimately impacted on policy and regulatory frameworks.

The federal Ministry of Climate Change and Environment, in collaboration with local agencies, academia and civil-society, provides for research and policy implementation, prioritising action on integrated management of ecosystems and natural resources.[45] In addition to the Ministry of Climate Change and Environment (MoCCAE) (former Ministry of Environment and Water) which is tasked with environmental action at the federal level, there are also environmental authorities in each emirate including: the Environment Agency – Abu Dhabi (EAD); Dubai Municipality (DM); Environment & Protected Areas Authority – Sharjah (EPAA); Environment Protection and Development Authority - Ras Al Khaimah (EPDA); Ajman Municipality; Umm Al Quwain Municipality; Fujairah Municipality.[46] Abu Dhabi's *Environment Vision* 2030[47] was a catalyst to incorporating climate change mitigation strategies into Emirate-level planning. Furthermore, MoCCAE established the Emirates Committee for Sustainable Environment Research, comprised of representatives from a range of different public and private research organisations, entities and universities. It aims at overseeing the development of a research strategy and integrated work streams on environmental sustainability and climate change in line with the country's key development priorities.[48]

© MOCCAE

Image 2: The Emirates Committee for Sustainable Environment Research

1.2.3 Climate change policies

The UAE is fully committed to the international climate change regime under the UNFCCC and proactive on domestic renewable and energy efficiency strategies and policies, as well as cooperation initiatives. The UAE ranks second in the number of Clean Development Mechanisms (CDM) projects (14) registered under the Kyoto Protocol in the Middle East and North Africa (MENA) region.[49] The main responsibility for such international policies and projects was previously spearheaded by the Directorate of Energy & Climate Change (DECC) within the UAE Ministry of Foreign Affairs (MoFA).[50] In February 2016, the UAE Ministry of Environment and Water was renamed Ministry of Climate Change and Environment (MoCCAE), and all international negotiations under the UNFCCC process now falls under MoCCAE's remit, signalling an enhanced role of this ministry in this field. The UAE hosts the International Renewable Energy Agency (IRENA)[51], and is looking with interest at economically attractive investments in the clean energy industry[52] through the Masdar initiative[53], both based in Abu Dhabi. The UAE is considered to be the most active, forward-thinking countries within the Gulf Cooperation Council (GCC) with regard to climate change approaches, focusing on economic diversification and positive synergies for a low-carbon transition.[54,55]

THE UAE'S INDC WAS RATED "INADEQUATE" BY INTERNATIONAL ANALYSTS

The UAE's INDC to address climate change in the post-2020 UNFCCC framework, however, was rated "inadequate" by international analysts[56]. Climate Action Tracker, an independent scientific analysis produced by four renowned research organisations, have expressed their concern about the UAE's INDC[b] submitted to the UNFCCC in October 2015 to inform the Paris Agreement, as it presents an emission reduction scenario that corresponds to the current projections, and it does not provide complete and transparent data and information.[57] The only measurable element of the INDC remains the Vision 2021 clean energy target of 24% of the total energy mix[c], to be achieved by 2021 through renewables and nuclear. In October 2016, the target was increased to 27% clean energy[58]. In fact, the INDC contains a qualitative description of economic diversification actions and plans yielding co-benefits in mitigation in various sectors, without indications on abatements in terms of GHGs.[59] Besides the clean energy target, initiatives in the energy, buildings and transport sector are listed in the INDC. Currently, the UAE, as other GCC states, does not employ any quantified economy-wide emission reduction instruments such as carbon taxes or markets.[60] To contribute its *"fair share"* of global efforts to limit warming below 2°C, *"the UAE should have pledged to reduce its emissions by 42% relative to 2010"*, according to the Climate Action Tracker review.[61]

TO CONTRIBUTE ITS "FAIR SHARE" "THE UAE SHOULD HAVE PLEDGED TO REDUCE ITS EMISSIONS BY 42% RELATIVE TO 2010"

[b]INDCs are referred to as NDCs as the "intended" is dropped once countries sign and ratify the Paris Agreement.
[c]It is understood that the clean energy target is referring to installed capacity of electricity.

While the emphasis has previously been on mitigation policies, the UAE is now also focusing on adaptation to the impacts of climate change. Adaptation had been overall neglected by the GCC states in the past years[62], with the UAE representing a positive example, planning and undertaking research on climate impacts, vulnerability and adaptation since 2009 as reported by the government in the National Communications to the UNFCCC[63,64,65,66]. Twelve assessment studies were planned for the 2013-2016 period on key themes such as regional climate change, blue carbon, biodiversity and ecosystems, water resources, coastal zones as well as socio-economic systems[67]. The UAE has invested a lot in research and development (R&D) for sustainability in general and for adaptation in particular, specifically with Abu Dhabi's establishment of AGEDI's *Local, National, Regional Climate Change Assessment Programme* that contributes to gathering data on climate change and vulnerability across the wider region[68]. Also, the government has funded education initiatives, training and public awareness campaigns that cover climate change[69].

With regard to concrete adaptation actions, alongside its national contribution to global GHG emission cuts, the UAE INDC presents its most recent and significant adaptation initiatives with an emphasis on those that bring mitigation co-benefits.[70] For instance, the UAE is undertaking measures in the areas of water management (such as water conservation and efficient, energy-saving desalination plant), coastal and marine protection (with potential for coastal carbon sequestration and storage known as 'blue carbon') and food security (research and technological innovation). Furthermore, climate change concerns are integrated in the UAE's natural resource management policies, and are increasingly being addressed through other sectoral policies.

A more comprehensive strategy for tackling climate change mitigation and adaptation is currently being developed for the country, led by the MoCCAE. The plan will include strategies on emission reduction, data management, economic diversification, national adaptation planning and will build on the programmes under the Green Agenda Strategy, in line with the UAE Vision 2021[71,72]. The Green Agenda Strategy[73], aims to reduce vulnerability of human and natural systems while safeguarding economic prosperity, also includes assessments of climate change risk and adaptation measures to ensure climate resiliency. In 2014, a UAE Climate Action Policy Agenda was drafted for the period 2015-2021 in collaboration with several entities including MOFA, EAD, and the Prime Minister's Office (PMO). The policy agenda also aims to address mitigation and adaptation while building on the strategic pillars of the UAE Vision 2021 and the UAE Green Growth Agenda[74]. In 2015, the MoCCAE also drafted a National Adaptation Strategy 2100.

1.3 PURPOSE AND AUDIENCE FOR THIS REPORT

The UAE has made steps forward on climate change mitigation and green development in recent years, both at national and Emirate level. However, to date, national and local plans do not specifically address climate change adaptation. Effectively developing and implementing adaptation actions and measures requires strengthening the capacities and knowledge base on climate change impacts and risks, as well as improving the accessibility and sharing of climate data and information.

Working within this context, the Emirates Wildlife Society - in association with World Wide Fund for Nature's (EWS-WWF) five-year strategy (2014) identified that 'making climate change a national priority by increasing the level of understanding on the projected risks' is critical to promoting mitigation and adaptation actions. In 2016, EWS-WWF is promoting the development of research on climate risks in the country. This strategy includes leveraging the increasing wealth of scientific research carried out in the UAE and wider region to assist decision-makers respond to risks and opportunities associated with a changing climate.

As part of the EWS-WWF strategy, this report aims to contribute to understanding preliminary implications of physical impacts and risks brought about by climate change in the UAE. The report draws on the latest global and regional science to paint a compelling picture of how climate change has and may in the future impact the country's efforts towards the achievement of economic diversification and overall social wellbeing. Case studies of previous climate impacts from news reports are used to help contextualise the science and bring home to the reader how the UAE may be affected in the near term as well over longer time periods.

THIS REPORT CALLS ON A WIDE RANGE OF STAKEHOLDERS IN THE UAE GOVERNMENT, PRIVATE SECTOR, ACADEMIA, AND CIVIL SOCIETY **TO ADOPT AND PROMOTE INFORMED DECISION MAKING** WITH REGARD TO CLIMATE CHANGE

This report calls on a wide range of stakeholders in the UAE government, private sector, academia, and civil society to adopt and promote an informed decision making with regard to climate change. While this study is primarily aimed at policy makers at the federal and emirate level to support decision making in the face of climate change, executives in private sector and governmental organisations operating in the sectors covered in the report are also considered as a key audience expected to manage the risks arising from climate change. Scientists and non-governmental organisations also play a significant role in building the knowledge base for climate adaptation action and need to be involved at all levels.

Relevant stakeholders and sectoral experts were invited to provide their contribution to this study, including through a series of thematic roundtables held in Dubai and Abu Dhabi between 29th February and 3rd March 2016. The full list of involved organisations is contained in the Acknowledgments section.

2. OVERVIEW OF CLIMATE IN THE UAE – NOW AND IN THE FUTURE

The United Arab Emirates lies in one of hottest and driest regions on the planet.[75] Summers are very hot, stretching from April through the month of September, and temperatures can rise to about 48˚C in coastal cities – with humidity levels reaching as high as 90% (Figure 1). In the southern desert regions, temperatures can climb to 50°C with very low humidity. Rainfall is sparse and inconsistent with the country averaging between 140- 200 mm of rainfall per year, with some mountainous areas along the north-east coast experiencing up to 350 mm per year. Most of this rainfall occurs between December and April.

Temperature					
Month	Max	Mean Max	Mean	Mean Min	Min
January	30.3	22.3	19.9	17.5	12.9
February	36.2	24.1	21	18.8	13.2
March	40.2	27.1	23.6	20.7	13.4
April	43	31.4	27.5	24.5	18.2
May	45.7	35.4	31.3	28.3	24
June	46.7	36.5	33	30.2	25.3
July	47.9	38.4	34.7	32.2	28.5
August	48	40	35.4	32.8	29.1
September	45	37.1	33.6	30.9	27.4
October	41.6	33.7	30.8	27.9	24
November	37.4	29.5	26.8	24.1	19
December	31.6	24.4	22.3	19.9	12.6

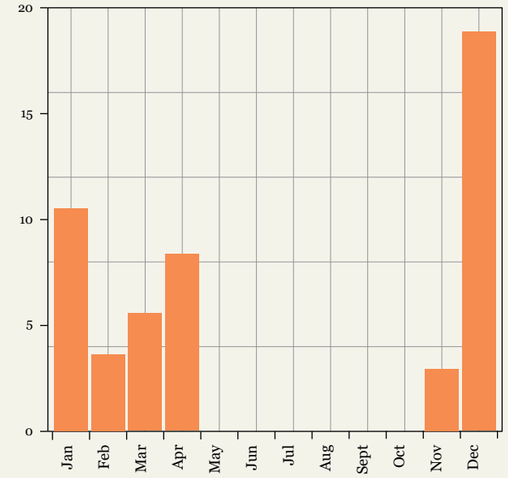

Figure 1 Average and extreme monthly temperature in °C (left) and rainfall in mm (right) for Abu Dhabi from 2003 to 2014 (Ministry of Presidential Affairs, 2015).[76]

2.1 PAST CLIMATE TRENDS IN THE UAE

TEMPERATURES HAVE BEEN INCREASING OVER THE LAST 100 YEARS TO PRESENTLY AROUND 0.5-1°C ABOVE THE 1986-2005 AVERAGE

Already facing extreme climatic conditions, even small long-term variations in temperature, precipitation and marine conditions could have an impact on the environment and the people living in the UAE. There is already a clear trend towards a warmer climate in the country. Observations show maximum temperatures have been increasing over the last 100 years to presently around 0.5-1°C above the 1986-2005 average (see Figure 2, left). There is not such a clear trend in precipitation, but there is significant inter-annual variation and a tendency towards drier conditions since 2000 (see Figure 2, right).

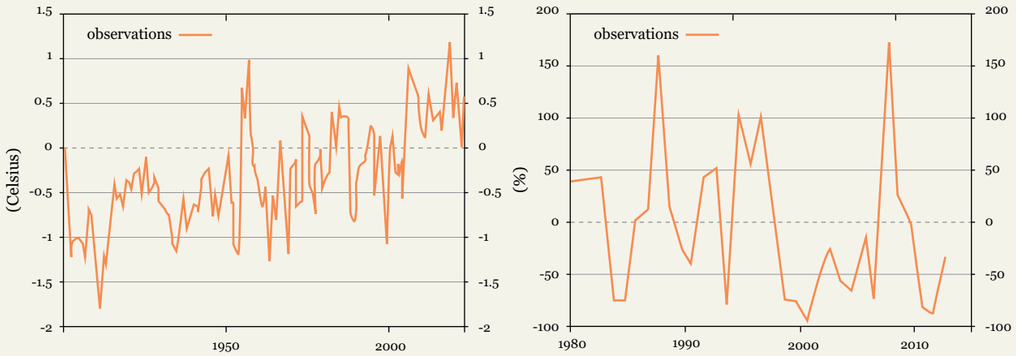

Figure 2 Trend in observed maximum monthly temperature (left) and precipitation (right) from 1980 to 2014 in the UAE (relative to 1986-2005). Temperature data from CRU 3.22 and precipitation data from GPCC v 6 (via KNMI, 2016).[77]

THERE IS EVIDENCE OF RELATIVE SEA LEVEL RISE OF 2.2 MM (± 0.5 MM) PER YEAR BETWEEN 1979 AND 2007

Measurements from tide gauges in the region have confirmed that the level of the Arabian Gulf has been steadily rising. These changes are associated with a concurrent rise in sea temperature causing thermal expansion as well as contributions from global ice melt. There are no published data from tide gauges along the UAE coastline which can provide a long enough record (i.e. 20+ years), to detect such trends[78] and so for now we are reliant on using nearby data. Relative sea level (RSL) variations in the north-western region of the Arabian Gulf have been measured using a comprehensive record of tide gauge data (Figure 3).

Researchers found evidence of relative sea level rise of 2.2 mm (± 0.5 mm) per year between 1979 and 2007 (1.5 ± 0.8 mm per year when accounting for ground movement measured using GPS).[79] A further assessment of sea level records from 1990 to 1999 from tide gauges at two stations along the north coast of the Arabian Gulf, (Bandar Abbas and Bushehr in Iran) reported a rise at the rate of 2.8 mm per year (1990-1999). Figure 4 shows strong seasonal variation in the sea level height at Bandar Abbas, although there is also a clear upward trend over time.[80] The reported rates in both instances are close to but slightly less than the global average of ~3.1 mm per year since the early 1990s.[81]

THE ARABIAN GULF IS BECOMING INCREASINGLY ACIDIC AT A FASTER RATE THAN MOST OTHER OCEANIC WATERS AROUND THE WORLD

The Arabian Gulf is becoming increasingly acidic at a faster rate than most other oceanic waters around the world. When carbon dioxide (CO_2) is absorbed by seawater, chemical reactions occur that reduce seawater pH. There is less scope for the removal of CO_2 by photosynthesis in the region, which means aquatic uptake of CO_2 is more likely.[82] Globally, oceans and seas have already absorbed about 30% of the emitted anthropogenic CO_2, causing ocean acidification.

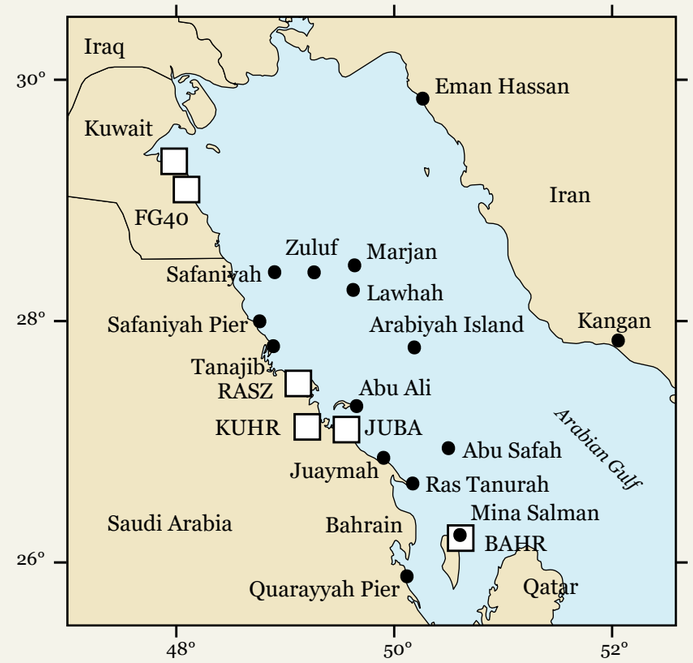

Figure 3 The location of the tide gauges (black dots) and GPS stations (white squares) used to estimate sea level changes between 1979 – 2007.

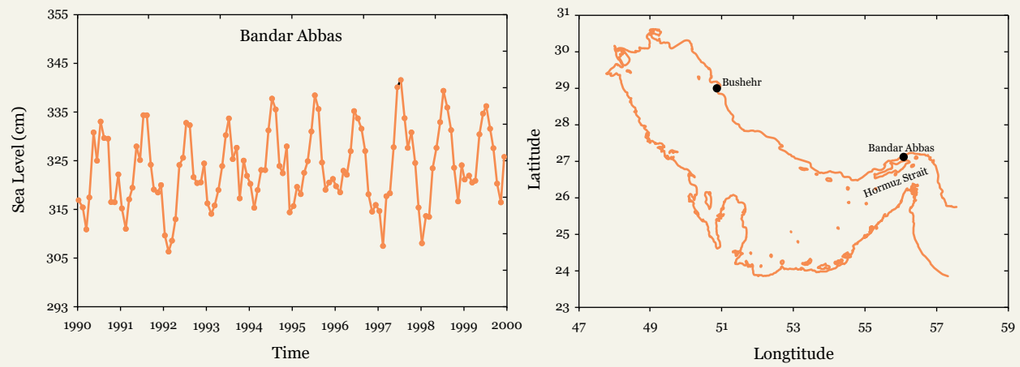

Figure 4 Sea level at Bandar Abbas between 1990 – 1999 (left) and location of Bandar Abbas tide gauge (right).

THE REGION IS CHARACTERISED BY HIGH TO "EXTREMELY" HIGH WATER RISK

2.2 CURRENT CLIMATE EXTREMES AND HAZARDS FACING THE UAE

Current climate hazards already facing the UAE include heat and water stress. The region is characterised by extremely high temperatures especially in the summer as well as "high" to "extremely" high water risk. Figure 5 shows current levels of water risk in the region which is based on an aggregated measure of Physical Quantity, Quality and Regulatory & Reputational Risk.[83] Climate change has already had an impact in the region – for example it has been estimated that the recent drought in the Southern Levant region was "around 45% more likely" due to anthropogenic climate change.[84]

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Heavy rainfall can occasionally lead to disruption from flash flooding, particularly along wadis in the mountainous east.[85] For example, the heavy rainfall experienced in February and March 2016 saw considerable disruption due to a series of intense thunderstorms in the country which resulted in extensive flash flooding.[86,87,88] Figure 6 shows a flood risk map showing the extent and depth of the 1 in 100-year event (due to heavy rainfall) across the country. Lower lying coastal areas can also be affected, where there have been reports of flash flooding in urban areas where heavy rain is compounded by a lack of drainage associated with roads and buildings. Tropical cyclone Gonu passed nearby in 2007, although the exposure to such events is currently regarded as minimal.[89]

The Middle East is well-renowned for frequent dust and sand storms, particularly during the dry summer months. The primary source of such events in the UAE, sometimes known as 'heat cyclones', is the Empty Quarter (Rub' al Kali) which is the world's largest contiguous sand desert. The north-westerly 'Shamal' winds can also contribute to such events as well as coastal flooding (see Section 2.4.3)[90] . Cooler winter mornings can also bring reduced visibility and associated disruption due to fog.

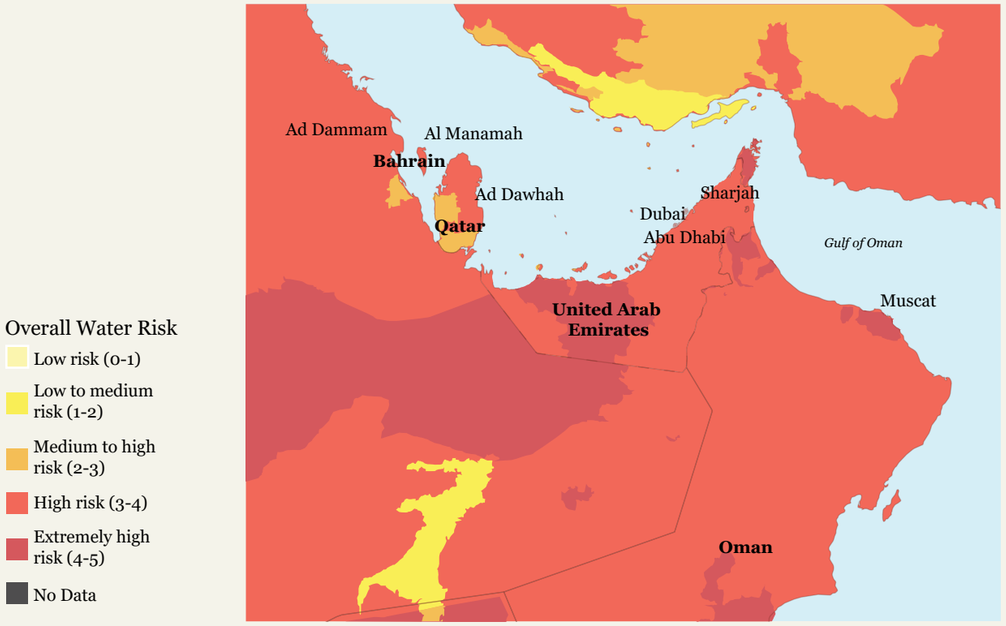


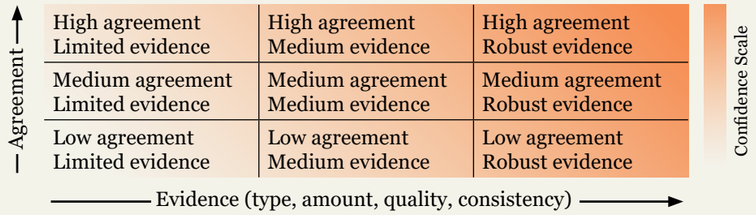
Figure 5 Overall water risk in the UAE and surrounding region. Water risk is an aggregated measure of Physical Quantity, Quality and Regulatory & Reputational Risk categories (Aqueduct, 2016).[91]

Figure 6 100 year flood depth due to heavy rainfall in the UAE. Darker blue shading indicates a greater depth of flood (UNEP, 2016).[92]

2.3 GLOBAL CLIMATE CHANGE

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC AR5) indicates that warming of the global climate system is 'virtually certain'.[93] 2016 was recently confirmed as the hottest year globally since records began in 1880, at 0.99°C above those in the pre-industrial era.[94] In addition to changes in temperature, there have also been recorded changes in the global water cycle. Some areas of the world have seen an increase in precipitation (mid-latitude northern hemisphere) whilst others have seen a decrease. Trends in how precipitation has changed are less clear than with temperature.

The IPCC uses two measures to communicate how certain or robust scientific findings are – *likelihood* and *confidence*. Likelihood refers to the probability of something occurring and confidence is a measure of how good the evidence is to support that conclusion (see Figure 7).



Term	Likelihood of the Outcome
Virtually certain	99-100% probability
Very Likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% % probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

Figure 7 Scales of confidence (top) and likelihood (bottom) used by the IPCC to communicate uncertainty[95]

LIMITING CLIMATE CHANGE WILL REQUIRE SUBSTANTIAL AND SUSTAINED REDUCTIONS OF GREENHOUSE GAS EMISSIONS

MAN-MADE CLIMATE CHANGE IS ALREADY UNDERWAY AND FURTHER CHANGE IS NOW INEVITABLE

In addition to 'gradual' changes in temperature, precipitation, sea level and ice extents, there have been observed changes in extreme climate events since the 1950s. There is variation in the assessment of how much human induced climate change has contributed to these trends. For example, it is 'very likely' that CO_2 emissions have already contributed to an increased occurrence of extreme hot days and nights over most land areas.[96] It is also 'likely' that regions of the world have seen increases in heavy precipitation, droughts, cyclone activity and sea level although there is less scientific confidence in whether these trends can be directly attributed to anthropogenic climate change.

Continued emissions of CO_2 and other greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.[97] Evaluating how the climate may change in future is primarily achieved by running General Circulation Models (GCMs). GCMs[d] are global scale climate models that apply a series of equations based on established laws of physics and chemistry to the earth's atmosphere and oceans. Increasingly, Regional Climate Models (RCMs) are being used alongside GCMs to help improve the understanding of the climate in more detail in specific parts of the world (including the Arabian Gulf region).

The level of future climate change depends to some extent on the amount of GHG emissions (primarily CO_2) that are emitted in the future. GHG emissions are, in turn, dependent on demographic development, socio-economic development and technological change. All of these factors carry levels of uncertainty about how the future will develop. Some of this uncertainty is captured by the use of RCP (Representative Concentration Pathways) scenarios which represent different future GHG emission levels (we are currently on the RCP8.5 trajectory). The result of using multiple RCPs (and GCMs/ RCMs) is that projections of future climate change are usually provided as ranges rather than specific, single values.

Adapting to climate change is important because historical emissions mean that man-made climate change is already underway and further change is now inevitable. Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. Although global temperatures are expected to continue to increase over the course of the century, Figure 8 shows the emissions pathway that the world follows (i.e. RCP) has an impact on how severe this will be. The difference between RCPs is less pronounced during the first half of the century but widens towards 2100. Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6. When multiple RCPs and GCMs agree that certain trends or benchmarks will occur, it is common to label these projections as 'likely' or 'very likely'.

[d]Higher resolution climate models nested within GCMs are called Regional Climate Models (RCMs). RCMs are complementary to GCMs by adding further details to global climate projections, or to study climate processes in more detail than global models allow.

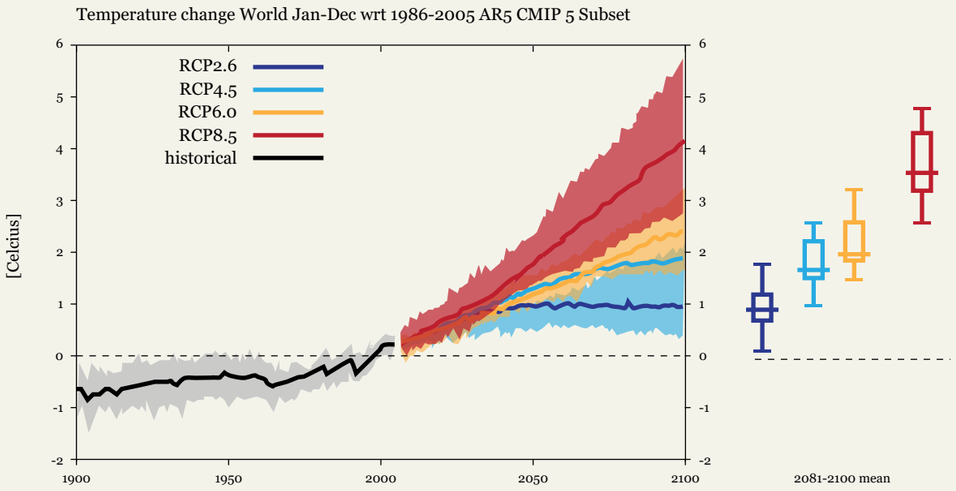


Figure 8 Projections of global temperature over the 21st century relative to 1986–2005 for a range of RCP scenarios.[98]

2.4 CLIMATE CHANGE IN THE UAE

The GCMs used as the basis for the IPCC AR5 indicate significant changes in the future climate around the Arabian Peninsula. However, these projections can be unreliable in regions such as the Gulf due to its complex terrain, surface winds and sea surface temperatures.[99] There are ongoing efforts to translate or 'downscale' this information using RCMs, which are capable of accounting for local complexities. These efforts include:

1. The Coordinated Regional Downscaling Experiment (CORDEX), which is a program sponsored by World Climate Research Program (WCRP) to develop an improved framework for generating regional-scale climate projections for impact assessment and adaptation studies worldwide. There is a MENA (Middle East North Africa) domain.
2. The Weather Research and Forecasting (WRF) and Regional Ocean Model (ROM) models developed as part of the Local, National and Regional Climate Change Programme (LNRCCP) by the Abu Dhabi Global Environmental Data Initiative (AGEDI) launched by the Environment Agency - Abu Dhabi (EAD) in conjunction with United Nations Environment Programme (UNEP).
3. Other regional studies, for example;
    a. The Masdar Institute[100],
    b. NYU Abu Dhabi's Centre for Prototype Climate Modelling (CPCM)[101] and
    c. International Centre for Biosaline Agriculture (ICBA)'s Modelling and Monitoring Agriculture and Water Resources for Development (MAWRED) project[102].

The AGEDI Weather Research and Forecasting (AGEDI WRF) model and Regional Ocean Model (AGEDI ROM) provide useful insights into the potential future climate of the UAE. The models are a valuable addition to the portfolio of evidence which should be looked at when making decisions based on an uncertain future (see Box 13 for more information on exploring the 'envelope of uncertainty'). As part of any evidence gathering process it is important to critically consider the relative merits of each data source. For example, low resolution GCM data can be unreliable at the local scale, whilst the AGEDI WRF and ROM models can simulate finer scale physical climate processes with greater precision (see Box 2 for a technical summary of the AGEDI WRF and ROM). Generally, there are some model outputs should be treated with particular caution – salinity, circulation patterns, turbulence, currents and wind for example, are notoriously uncertain in all climate models.

Box 2 The Abu Dhabi Global Environmental Data Initiative (AGEDI): Downscaling climate data for decision making in the UAE

Below is brief technical summary of the AGEDI Regional Climate Models:

AGEDI WRF (Atmospheric) model:

- Validated against a 30-year historical baseline.
- 36, 12, and 4-km spatial resolution.
- RCP 4.5 and 8.5 emission pathways.
- Projections are provided for the future time period 2060-2079 (2065 to 2075 for 4km resolution).
- Boundary conditions provided by a single GCM: Community Earth System Model, Version 4 (CCSM4).
- The AGEDI WRF projections are 'wetter' than the IPCC AR5 average which may be largely due to precipitation increases from a few events in the AGEDI model e.g. a tropical cyclone.
- It has been noted by AGEDI that further work is warranted to quantify uncertainty, particularly around extreme events (see Section 4.1 for more information on making decisions in the face of uncertainty).

AGEDI ROM (Marine) model:

- Validated against Gulf salinity and temperature records (2000 – 2012).
- 1.1 km spatial resolution.
- Single RCP 8.5 emission pathway.
- Boundary conditions provided by a single GCM: Max Planck Institute mixed resolution ESM (MPIMR).
- Early 2000-2020 and late 2080-2100 future scenarios modelled (with 5 year 'time slices' reported).
- See Section 4.1 for recommendations for future research.

TEMPERATURES ARE PROJECTED TO INCREASE BETWEEN **2 AND 3°C** DURING THE SUMMER BY 2060-2079

HUMIDITY IS PROJECTED TO INCREASE BY ABOUT **10%** OVER THE ARABIAN GULF BY 2060-2079

Below is a brief assessment of the preliminary findings of the AGEDI WRF model in conjunction with the IPCC AR5 GCMs (known as the Coupled Model Intercomparison Project Phase 5, CMIP5) and other regional studies where available.

2.4.1 Temperature and humidity

The results from the AGEDI WRF suggest a strong upward trend in average temperature in the UAE. For example, Figure 9 (left panel) shows an increase of between 2 and 3°C during the summer months by 2060-2079.[103] This pattern is consistent with nearer term CMIP5 GCM projections for the region, which suggest an increase in annual average temperature in the country of around 1°C by 2020 and between 1.5 and 2°C by the 2040s (Figure 9, right panel). The CMIP5 GCMs also indicate a substantial increase in extreme daily temperatures which indicate a rise in the risk of severe heatwaves (Figure 10).[104]

The AGEDI WRF also suggests an increase in humidity of about 10% over the entire Arabian Gulf by 2060-2079. This modelled change in humidity is particularly pronounced in the summer months in the north of the UAE. More recently a study based on a different RCM of the Arabian Peninsula suggested extremes of wet bulb temperature (a combination of temperature and humidity) will increase in the country to such an extent that it is likely to "severely impact human habitability in the future" by the end of this century. As an illustration, the authors suggest that a plausible analogy of future climate for many locations in the region is the current climate of the desert of Northern Afar on the African side of the Red Sea, which is a region with no permanent human settlements owing to its extreme climate.[105]

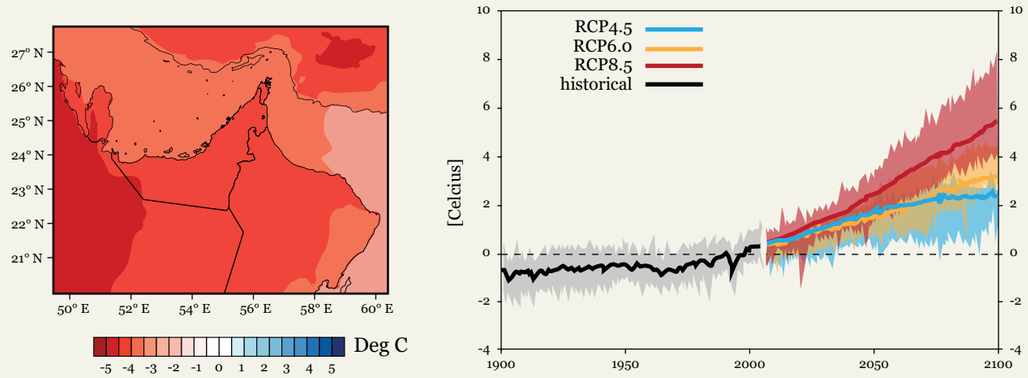


Figure 9 Left: Average change in temperature during June, July and August across the UAE by 2060-2079 relative to 1986-2005 according to the WRF AGEDI RCM based on RCP8.5. Right: Projected change in average annual temperature in the UAE over the coming century relative to 1986-2005 based on CMIP5 models, for RCPs 4.5, 6.0 and 8.5 (KNMI, 2015).

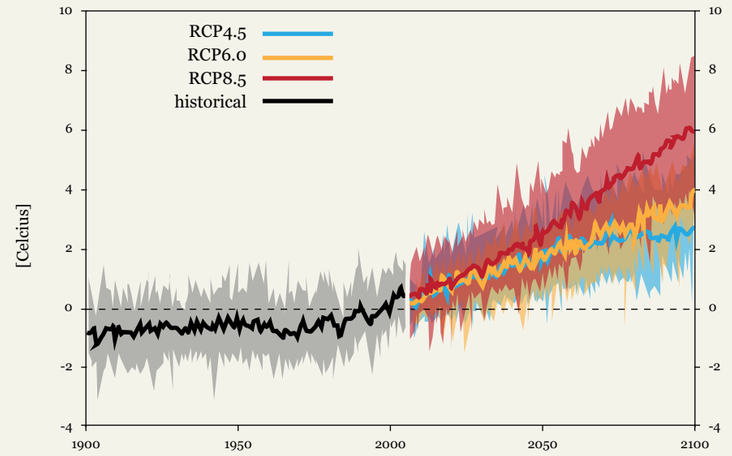


Figure 10 Projected change in annual maximum value of daily maximum temperature in the UAE over the coming century relative to 1986-2005 based on CMIP5 models, for RCPs 4.5, 6.0 and 8.5 (KNMI, 2015).

2.4.2 Precipitation

The results from the AGEDI WRF suggest an increase in average annual precipitation (see Figure 11). This trend is stronger during the usually drier summer months and is, associated with a reduction in the number of 'wet days' i.e. days where any rainfall is recorded.[106] This may suggest an increase in heavier rainfall events when they do occur. Projections of precipitation, more so than temperature, are uncertain and should be treated with caution. To illustrate this, Figure 11 shows the range of CMIP5 GCM outputs across the country. There is a large amount of inter-model variation i.e. 'noise', around whether average precipitation will increase (or decrease) and by how much.

The IPCC reports that it is likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe. For the West Asia region, the same report indicates that a heavy rainfall event previously expected to occur once every 20 years will occur around every 15 years by the 2050s.[107] Figure 11 shows projections of precipitation extremes in the UAE specifically. Despite considerable 'noise' amongst the results, these projections include possible increases of up to 200% in the annual maximum 1-day precipitation total (RCP 8.5, top 95th percentile of model results by 2050s – see Figure 12).

THE UAE COULD SEE INCREASES OF **UP TO 200% IN ANNUAL** MAXIMUM 1 DAY RAINFALL BY 2050

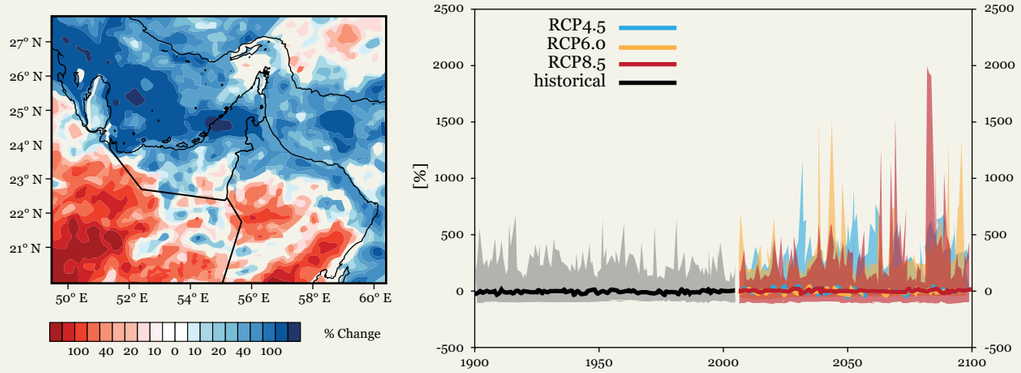


Figure 11 Left: Average change in annual precipitation across the UAE by 2060-2079 relative to 1986-2005 according to the WRF AGEDI RCM based on RCP8.5. Right: Projected change in annual precipitation over the coming century in the UAE relative to 1986-2005 based on RCPs 4.5, 6.0 and 8.5 (KNMI, 2015).

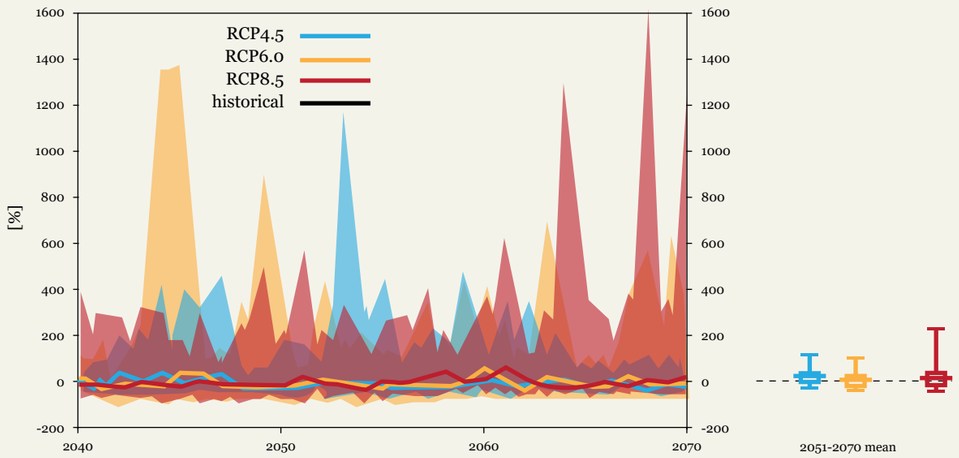


Figure 12 Projected change in annual maximum 1-day precipitation total in the UAE between 2040 and 2070 relative to 1986-2005 based on CMIP5 models, for RCPs 4.5, 6.0 and 8.5 (KNMI, 2015).

SEA SURFACE TEMPERATURES OF THE ARABIAN GULF COULD WARM BY ABOUT

1°C - 2°C

BY THE END OF THE CENTURY

2.4.3 Marine and coastal

The results from the AGEDI ROM suggest that the Sea Surface Temperatures (SST) of the Arabian Gulf could be warmer by about 1°C to 2°C by the end of the century[108], which is broadly in line with the trends expected globally (Figure 13). Even in the medium-term (2050s) the changes could be up to 1°C. Changes in sea surface salinity are expected in response to changes in precipitation, evaporation and runoff as well as ocean circulation. By mid-century, the AGEDI ROM suggests an increase in the salinity of the UAE coastal waters[109], although significant patterns in global projections of salinity are notoriously difficult to identify and should be considered relatively uncertain.[110]

The Arabian Gulf is already becoming increasingly acidic at a faster rate than most other oceanic waters around the world and this is likely to increase in the future.[111]

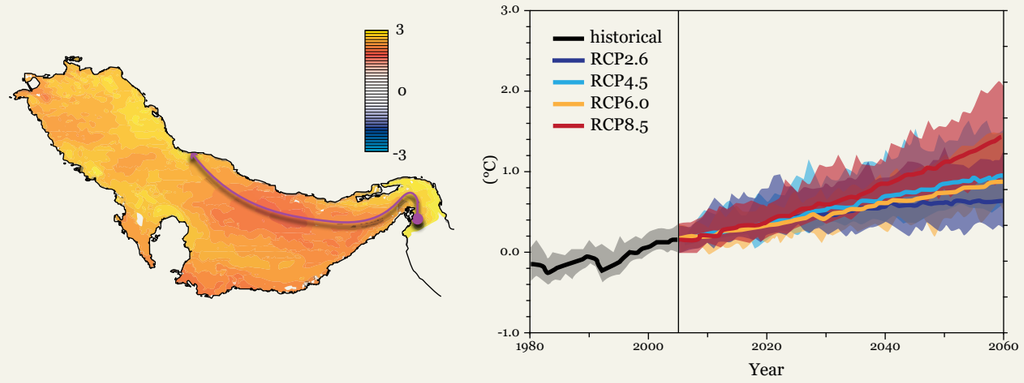


Figure 13 Left: Difference between late (2080-2100) and early (2000-2020) 21st century Sea Surface Temperature projections (°C) from AGEDI ROM simulations. Right: Projected changes in annual averaged, globally averaged, surface ocean temperature based on 12 models from the CMIP5 (KNMI, 2016).

SEA LEVEL GLOBALLY IS LIKELY TO RISE BY BETWEEN

0.26 M AND 0.98 M

BY THE END OF THE CENTURY

Sea level globally is likely to rise by between 0.26 m and 0.98 m by the end of the century (relative to 1986 – 2005) according to the latest IPCC projection.[112] This accounts for thermal expansion of the ocean and increased loss of mass from glaciers and ice sheets. Some experts suggest that it is possible these projections underestimate ice sheet melting, with some recent upper estimates of between 1.8 and 9 m by 2100.[113,114] Even the most conservative estimate assumes an accelerated rate of rise, relative to that already recorded nearby the UAE (see Section 2.1).

Sea level change impacts along the UAE coastline will be dependent on local conditions such as the direction and strength of prevailing winds (e.g. the 'Shamal'), tidal and storm surges which could propagate through the Strait of Hormuz and relative land movement (Figure 14). As a low-end estimate, if the rates of sea level rise in the UAE are consistent with those observed nearby, and continue linearly into the future, the UAE could experience sea level rise of around 0.06 m by mid-century (1.5 mm per year over the next 40 years). Regional models (e.g. the AGEDI WRF) will be useful for shedding more light on the issue but there will always be a degree of uncertainty. These can then be used to refine inundation maps for some coastal areas which currently exist for between 0.5 and 9 meters of sea level rise.[115,116,117] (see Box 15 for more information on climate change and uncertainty). The Abu Dhabi Urban Planning Council's coastal and marine framework uses a 3 meter estimate of projected sea level rise combined with a 1 in 100 year storm surge level for the year 2100 as the baseline standard for the planning and design for climate change adaptation[118].

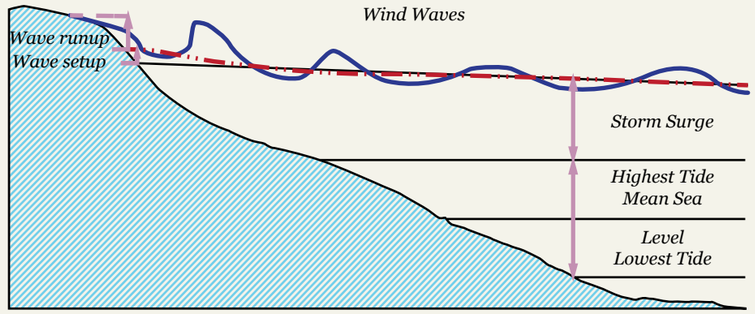


Figure 14 various contributions to sea level at any given time (note that land movements are not shown on this figure).[119]

2.4.4 Storms, sandstorms and fog

There is some evidence that the Arabian Gulf coast of the UAE could be exposed to tropical cyclones in the future. The AGEDI WRF simulated a cyclone passing much further west over the Arabian Peninsula than has previously been experienced.[120] Other regional modelling studies have found a growing risk for 'grey swan' cyclones to hit the UAE – a reference to their low-likelihood but high impact – generating storm surges of between 4-7 meters in Dubai.[121] Globally, by the end of the century, tropical cyclones could be less frequent but more intense (2-11% increase) and produce substantially higher rainfall rates (10-15%). Fujairah on the Gulf of Oman has already been adversely affected by Cyclone Gonu in 2007 and potentially could face repeated events.

REGIONAL MODELLING STUDIES HAVE FOUND A GROWING RISK FOR 'GREY SWAN' CYCLONES TO HIT THE UAE

Changes in the incidence and severity of sandstorms and heavy fog are significant areas of uncertainty and require further research. (See Section 4.1 for more recommendations for future research areas). A late 2015 climate outlook from the World Meteorological Organisation (WMO) suggested that El Niño's above average sea-surface temperatures in the Indian and Pacific tropical ocean waters could result in unpredictable weather events across the Middle East, including dust storms[122]. IPCC's Working Group II Second Assessment Report contained a specific chapter on deserts and climate change. The chapter suggested that some coastal deserts may have more dew and fog associated with El Niño Southern Oscillation (ENSO) events due to the effect of changes in sea surface temperatures on humidity[123].

3. CLIMATE IMPACTS AND RISKS FACING THE UAE

The following section of the report examines the impacts and risks climate change poses for the UAE across the following themes:

Infrastructure & Utilities:
1. Energy & Water,
2. Transport & Logistics

Ecosystems & Biodiversity
3. Marine
4. Terrestrial

5. Health & Well-being

Economy & Business:
6. Oil & Gas
7. Industry
8. Buildings, Construction & Real Estate
9. Financial Services
10. Cultural Heritage, Hospitality and Tourism

Food Security:
11. Domestic Agriculture, fishing and aquaculture
12. International Food Imports

THIS REPORT PROVIDES A COMPREHENSIVE STARTING POINT FOR ASSESSING **RISKS AND VULNERABILITIES** TO CLIMATE CHANGE FOR THE UAE

Figure 15 summarises the IPCC definition of where risk lies at the intersection of vulnerability and exposure to hazards. When these risks occur, they are said to have an impact on socio-economic systems. The implications of these impacts and risks on the UAE's visions, strategies and policies for development are explored in Section 3.6. This report provides a comprehensive starting point for assessing risks and vulnerabilities to climate change. It does not represent an in-depth climate change risk and vulnerability assessment, for which new dedicated research at the national scale would be necessary. Uncertainty about how the future climate will evolve globally, regionally and in the UAE is inevitable. Section 4 details key areas of future research and principals for making decisions in the face of such uncertainty.

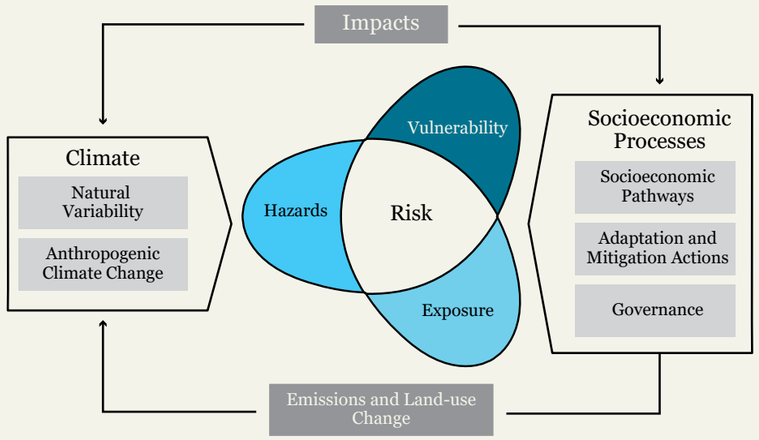
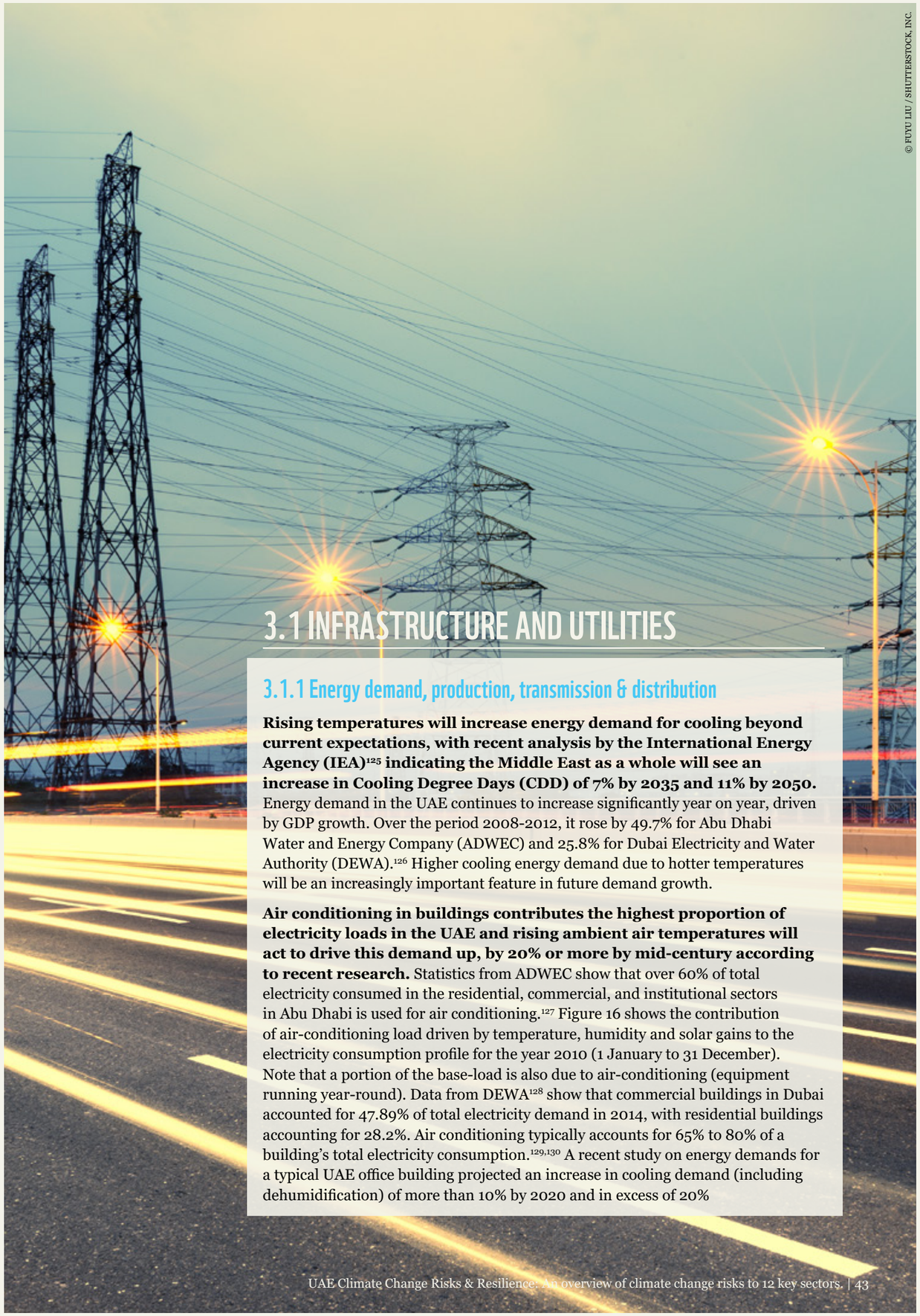


Figure 15 The IPCC framework for defining climate change risks and impacts[124]



3.1 INFRASTRUCTURE AND UTILITIES

3.1.1 Energy demand, production, transmission & distribution

Rising temperatures will increase energy demand for cooling beyond current expectations, with recent analysis by the International Energy Agency (IEA)[125] indicating the Middle East as a whole will see an increase in Cooling Degree Days (CDD) of 7% by 2035 and 11% by 2050. Energy demand in the UAE continues to increase significantly year on year, driven by GDP growth. Over the period 2008-2012, it rose by 49.7% for Abu Dhabi Water and Energy Company (ADWEC) and 25.8% for Dubai Electricity and Water Authority (DEWA).[126] Higher cooling energy demand due to hotter temperatures will be an increasingly important feature in future demand growth.

Air conditioning in buildings contributes the highest proportion of electricity loads in the UAE and rising ambient air temperatures will act to drive this demand up, by 20% or more by mid-century according to recent research. Statistics from ADWEC show that over 60% of total electricity consumed in the residential, commercial, and institutional sectors in Abu Dhabi is used for air conditioning.[127] Figure 16 shows the contribution of air-conditioning load driven by temperature, humidity and solar gains to the electricity consumption profile for the year 2010 (1 January to 31 December). Note that a portion of the base-load is also due to air-conditioning (equipment running year-round). Data from DEWA[128] show that commercial buildings in Dubai accounted for 47.89% of total electricity demand in 2014, with residential buildings accounting for 28.2%. Air conditioning typically accounts for 65% to 80% of a building's total electricity consumption.[129,130] A recent study on energy demands for a typical UAE office building projected an increase in cooling demand (including dehumidification) of more than 10% by 2020 and in excess of 20%

RISING TEMPERATURES WILL DRIVE UP DEMAND FOR COOLING **BY 20%** OR MORE BY MID-CENTURY

by 2050, due to climate change.[131] Another climate change study found that air conditioning demand (for cooling and fans) in typical UAE residential villas will increase by between 10% - 35% by 2050, depending on the future CO_2 emissions scenario.[132] The government in Abu Dhabi, where 53% of electricity costs in 2012 were paid directly by government through subsidies[133], stands to be hard hit by these increases. It should be noted that Abu Dhabi has reformed their subsidies in January 2015, again lightly in January 2016 and in January 2017 so more of the burden will now be placed on the end-user than the government than before.[134]

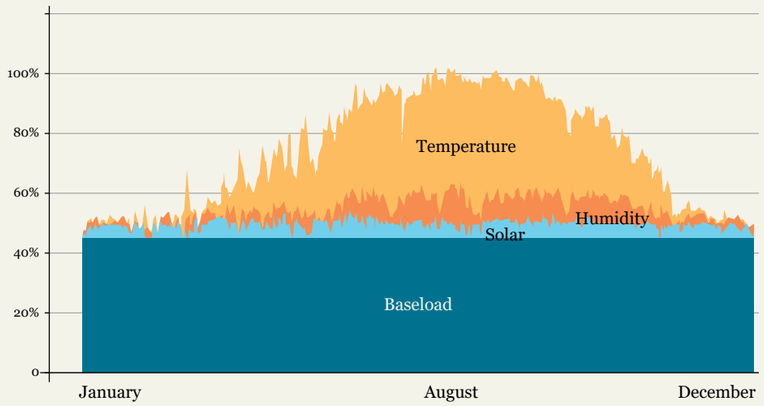


Figure 16 Contribution of cooling to electricity load in Abu Dhabi throughout the year.[135]

Without further action on energy efficiency and conservation, higher temperatures will increase electricity costs for consumers and governments, create a need for additional generation capacity and impact on the UAE's goals to reduce GHG emissions. Improving air conditioning efficiency could generate significant fuel savings and help to offset expensive peak fuel sources such as diesel and liquid natural gas (LNG).[136] Local governments have taken measures to encourage building energy efficiency through legislation, subsidy reform, guidelines and other actions such as the Estimada programme in Abu Dhabi, and the Green Building Code and Etihad ESCO (Energy Service Company) in Dubai. Looking forward, rising temperatures will increase the imperative for energy efficiency, as targeted by the UAE's Green Growth Strategy, to ensure emissions reduction targets can be achieved.

Box 3 – Case Study: Impacts of Climate Change on Energy Consumption of Building

In order to showcase the impacts of a changing climate in the UAE, Taka Solutions conducted a modelling exercise to quantify the impacts of increased temperature and humidity on energy consumption in a typical UAE building. Using the eQUEST building energy simulation software, the actual energy consumption of a Dubai building in 2015 was used to analyse four scenarios to understand changes in energy demand and impact on emissions.

The scenarios included an increase in wet bulb (WB) and dry bulb (DB) temperature of 1°C and 2°C and a relative humidity (RH) increase of 5% and 10%. The building is a 17-story high-quality residential building with 168 units and a total floor area of 27,000m². The baseline accounted for variations in the schedule for occupancy, lighting, thermostat set points, and HVAC system operation over the course of a year for 8,760 hours.

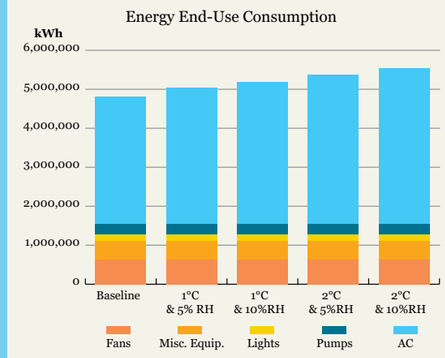
Conclusion

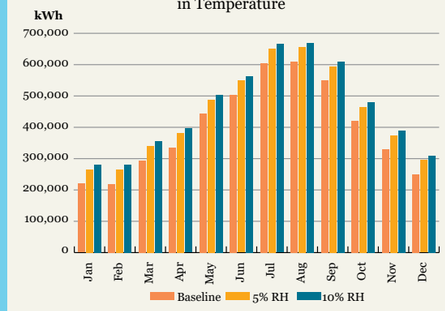
The result of the simulation showed a marked increase in energy consumption for cooling in response to increases in temperature and humidity. It also showcased that while the seasonal variations of the energy consumption in the building continue to occur due to heavy usage of cooling in the summer, the scenarios show a proportionate increase in energy consumption consistently across the year.

Changes in global temperature and relative humidity will cause significant impacts in the consumption of a building, with most impact in the demand for cooling. This will naturally increase the carbon emissions of the building (in this case between 4.8% – 15.2% depending on the scenario) as well as increase utility costs for residents and building owners.

In the 2°C/5% RH scenario, the 11% increase in energy resulted in an rise of **AED 248,625 ($67,745) per year for the building for the additional energy consumption.**

takasolutions





Increase in Carbon Footprint and Energy Consumption*

#	Description		Annual Increase in Carbon Footprint kg CO_2e	Annual Increase in Energy Consumption %
1	1°C	5%RH	114,950	4.8
2		10%RH	185,000	7.7
3	2°C	5%RH	276,250	11.5
4		10%RH	365,650	15.2

*using DEWA's emission factor of 0.5 kg CO_2e/kWh

At the national level, these changes would result in an increase of 6.95 TWh in energy consumption[e] and AED 3.06 billion ($834 million)/year[f] in costs for end-users.

Author: Rehana Jiffrey, Taka Solutions, www.takasolutions.com - Taka Solutions is a UAE-based 'smart-building technology and engineering company that uses quality engineering, financing and management to optimize building energy use through efficiency to reduce costs, carbon impact and increase asset profitability and value using paid-from-savings ESCO model.

[e]Calculation: Buildings consume 60% of total UAE energy consumption (UAE State of Energy Report 2016), equivalent to 63.24 TWh. 11% of 63.24 TWH is 6.95 TWh

[f]Using $0.12/TWh for Dubai as an aggregated total cost of electricity to the utility

RISING TEMPERATURES WILL SLIGHTLY **REDUCE THE EFFICIENCY** AND OUTPUT FROM THE UAE'S GAS-FIRED POWER PLANT FACILITIES

At the same time, rising temperatures will slightly reduce the efficiency and output from the UAE's gas-fired power plant facilities. The UAE currently relies on a fleet of modern gas-fired thermal power plants with a total installed capacity of more than 27 GW[137], most of which have been constructed in the last decade. The majority of these are combined cycle gas turbine (CCGT) plants. Studies in the Gulf region and elsewhere demonstrate that the thermal efficiency and power output of gas-fired plants is affected by ambient air temperature.[138,139,140] The power output decreases due to a reduction in air mass flow rate as temperature increases, and the efficiency decreases as the compressor requires more power to compress air at higher temperature. Depending on the gas turbine technology, design of the plant, and type of cooling system, power output reductions are reported to be in the range 0.1% to 0.8% for each 1°C increase in air temperature.[141,142,143,144]

+1.5°C IN SEA WATER TEMPERATURE COULD LEAD TO A POWER LOSS **OF 0.5%** IN BARAKAH NPP

Barakah Nuclear Power Plant (NPP) can also expect small reductions in output and efficiency over time, due to rising temperatures of Gulf sea water used for cooling. Barakah NPP (4 x 1,400 MWe) is due to commence generating in 2017, and from 2020, its nuclear power is expected to provide around 20% of the UAE's power.[145] The Arabian Gulf has some of the highest ocean temperatures found globally, which can exceed 35°C in the summer, and designs for industrial facilities made elsewhere in the world require modification to be able to operate successfully. The Barakah NPP therefore includes larger heat exchangers and higher cooling water flow rate than the Korean reference plant (Shin-Kori Units 3 & 4) on which it is based.[146] According to researchers, an increase of cooling seawater temperature of 15°C results in a 2% loss of efficiency and about a 6% power loss for the plant.[147] A 1.5°C increase in sea water temperature due to climate change, which could be seen in the Arabian Gulf by the 2040s, would lead to a power loss of around 0.5%. If the heating effects of thermal plumes from industrial facilities on the coast are combined with the effects of climate change to yield greater sea water temperature increases, the power losses could be higher.

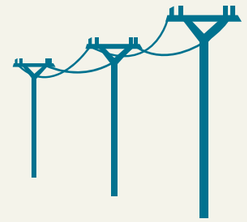
Rising sea levels and increased storm activity could lead to increased risk of flooding of coastal power generation facilities during storm surge events and this is an area where dedicated research is required to better understand the level of risk. Over 90% of power and water infrastructure in the UAE is located in the coastal zone, and is potentially vulnerable to flooding.[148] The flood protection design criteria for these facilities would require investigation to evaluate the level of protection they offer in light of climate change. As already noted, there are considerable uncertainties about the rate of sea level rise that will be experienced in the UAE over coming decades, and on the likelihood of cyclones. Further research is needed to better evaluate this risk.

RISING SEA LEVELS INCREASE THE RISK OF **FLOODING OF COASTAL POWER GENERATION FACILITIES**

Renewable energy technologies, while bringing strong benefits for climate change mitigation, are not immune to the impacts of climate change. As noted in Section 1.2.3, the UAE has set a target of increasing the contribution of clean energy to the total energy mix to 27% by 2021, assumed to be installed capacity, using renewable and nuclear energy technologies. According to analysis by the Masdar Institute and the International Renewable Energy Agency (IRENA), solar generation technologies are the most promising renewables for the UAE and different solar energy technologies could potentially account for more than 90% of renewable energy use in 2030[149]. Solar photovoltaic (PV) is increasingly seen as the most attractive technology in the UAE in the near-term, owing to its lower cost and excellent resource availability in the country. Concentrated solar power (CSP) with thermal energy storage, in turn, has good potential to provide base load power.

Solar energy technologies are sensitive to dust, humidity and high temperatures, all of which are likely to be exacerbated due to climate change. The Masdar Institute/IRENA note that the main challenges in developing large-scale solar in the region are dust particles and humidity which lead to a significant reduction in direct normal irradiance (DNI), primarily affecting CSP technology, together with soiling of panels and mirrors, which require frequent cleaning[150]. Research is ongoing to address these issues. While reliable projections of changes in dust levels are not yet available for UAE, higher temperatures point to the likelihood of higher dust levels in the future. As noted in Section 2.4.1, humidity levels in the Arabian Gulf are also projected to increase. High air temperatures in the region already affect the performance of solar PV[151] compared to cooler climates, leading to lower efficiency of PV cells and reduced PV electrical generation[152]. Increases in air temperature due to climate change will exacerbate these impacts.

Electricity transmission systems are vulnerable to higher temperature extremes[153]. Overhead transmission lines, transformers, switchgear and cables are all negatively affected by heat. Higher temperatures expected under climate change will therefore reduce the current carrying capacity of lines, transformers and switchgear[154]. In practice, this might mean that overhead lines and transformers are de-rated and their losses will increase. Higher ambient air temperatures can also reduce transformer lifetimes, depending on equipment rating and peak system load. Cables located underground and would therefore be less affected.



TRANSMISSION LINES, TRANSFORMERS AND CABLES ARE ALL **NEGATIVELY AFFECTED BY HEAT**

CLIMATE CHANGE IMPACTS, COULD BEGIN TO CREATE A **DEMAND-SUPPLY GAP** OVER TIME

The combination of increased cooling energy demand and small decreases in power generation and transmission efficiency driven by rising temperatures are important considerations for the Ministry of Energy and Utilities when it develops the federal Energy Policy and makes its investment plans to meet demand growth as well as energy utilities. These climate change impacts are directly relevant to several key pillars of the energy policy (which is currently under development[155]) – namely energy security into the future and reductions in greenhouse gas emissions. The increasing demand for energy and water is a defining feature of the UAE energy sector, requiring an investment programme to ensure additional demand is met, and to intensify demand-side management efforts. Climate change impacts, if not accounted for in these programmes, could begin to create a demand-supply gap over time.

3.1.2 Water demand and availability

There are three main sources of fresh water in the UAE; groundwater, desalinated water and treated waste water.[156] Together, groundwater and desalination provide the vast majority of the country's supply (Table 1). Groundwater is typically used for agriculture and is also used in the oil and gas industry.[157] Whilst rainwater harvesting dams are used to facilitate recharge, levels have steadily fallen as extractions have exceeded renewal. Where groundwater levels remain high enough, Falaj (manmade canals) are used as a traditional method of agricultural irrigation in some areas. Treated wastewater is typically used in landscaping, such as irrigation of gardens, green spaces and reforestation trees, especially in the areas surrounding apartment complexes.

Table 1 Water resources by source in the UAE in 2013.[158]

Water Sources 2013 Estimates		
Source	Quantity (million cubic meter)	Percentage
Groundwater	1850	44%
Treated wastewater	584	14%
Desalinated water	1750	42%
Surface water	16	Less than 1%
Total	**4200**	**100%**

The booming economy and industrial development in the country have increased water demand over the last few decades (Figure 17), which has largely been met by desalination.[159] Indeed, seawater desalination plants produce 98% of the water consumed in the municipal sector (which includes potable, industrial and commercial use).[160] According to the UAE National Bureau of Statistics, installed desalination capacity has increased from 5 Million Cubic Meters (MCM) in 2007 to over 7 MCM in 2013 with a total of 40 desalination plants in operation.[161] Desalination technologies of all types are energy intensive. In order to meet these requirements, facilities are usually combined with power plants to meet on-site requirements as well as supplying power to the grid. Releasing hot brine and treatment chemicals into the Arabian Gulf can be damaging for marine ecosystems, particularly for corals (see Section 3.2.1). [162, 163]

RELEASING HOT BRINE AND CHEMICALS INTO THE GULF **CAN BE DAMAGING TO MARINE ECOSYSTEMS**

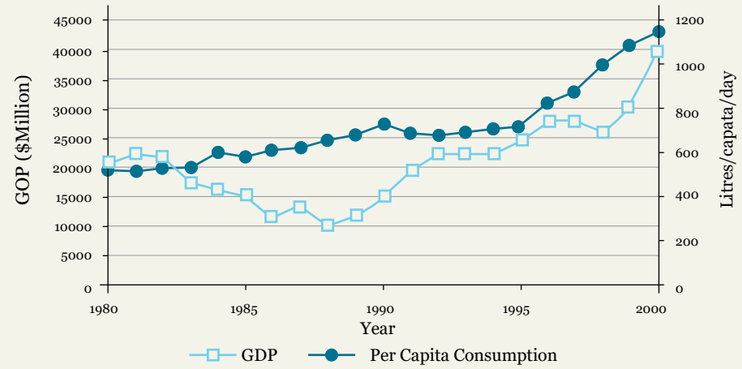


Figure 17 GDP and per capita consumption of water in Abu Dhabi from 1980 to 2000.[164]

The importance of water resource management and creating a reduction in water demand has been a trend in the country over the last decade, with awareness campaigns and demand-side management strategies launched at the local and national levels. Residents of the UAE have enjoyed significant subsidies for water, particularly the UAE nationals who until recently paid nothing for domestic and agricultural water use.[165, 166, 167] This can lead to wasteful use of water as the true costs are 'hidden' from consumers. In 2015, subsidies in Abu Dhabi were reduced and Emiratis began paying for water for the first time.[168] Recent demand side management strategies have been put in place in order to reduce consumption of water by 40 % by 2030 in Dubai.[169]

THE MORE SALINE THE ARABIAN GULF,
THE MORE ENERGY REQUIRED FOR DESALINATION

Climate change, rapid population growth, industrial development, urbanisation and demand for agricultural irrigation will all have an impact on future water resources in the Arab region.[170] In the UAE, there is a degree of concern for even larger growth in agricultural water demand, particularly during the productive winter months which will see higher temperatures and greater rates of evapotranspiration, thus increasing demand, that could further stress scarce groundwater resources.[171] Other reports suggest that ongoing improvements in water resource management techniques can help alleviate the pressure (see Sections 3.5.1 and 3.5.2 for links with domestic agriculture and food security).

The economic and environmental cost of desalination will also increase as the climate changes. Climate projections suggest that the Arabian Gulf – the primary feedstock of desalination plants in the UAE – is likely to become warmer and more saline (see Section 2.4.3). The impact of this is two-fold: firstly, higher air and water temperatures may call into question the safe limits on discharge temperatures.[172] Secondly, the energy requirements of Reverse Osmosis (RO) – which is becoming an increasingly popular method of desalination in the Arabian Gulf – are closely linked to the salinity of the 'feedstock' water. The more saline the feedstock, the more energy is required for desalination. In addition, the efficiency of natural gas power plants that provide the electricity for desalination are reduced as temperatures increase (see Section 3.1.1). On the other hand, higher ambient sea water temperatures would logically lead to lower energy requirements to reach boiling point as required by Multi-Stage Flash Distillation (MSF).

The combination of climate change and the intensification of desalination activity to cope with socioeconomic growth and increasing constraints on fossil groundwater poses a significant policy challenge. Further research is needed to ascertain the impact of climate change on desalination in UAE. This is currently being undertaken by AGEDI in their Socioeconomic Systems: Desalinated Water Supply Report, which models mid-21st Century impacts on Gulf temperature and salinity due to climate change and desalination [173].

EXTREME EVENTS LIKE ALGAL BLOOMS
RISK DISRUPTING THE DESALINATION SUPPLY

The risk of disruption to desalination supply due to extreme events e.g. storms and algal blooms, could also increase with climate change. In 2008, water supplies were cut to homes in parts of the Ras Al Khaimah emirate for several days after a toxic red tide of algae forced the Al Ghalileh desalination plant to be closed.[174] It has been suggested that climate change pressures will influence marine planktonic systems globally, and it is conceivable that harmful algal blooms may increase in frequency and severity, which will drive up the costs for industry to mitigate the risks (see Section 3.2.1 on marine and coastal risks for more information).[175] Strong winds and tidal surges associated with storms could also have a similar impact. Efforts are underway to build redundancy into the system by developing underground storage.[176]

3.1.3 Transport and logistics

TRANSPORTATION AND LOGISTICS ASSETS ARE AT RISK
FROM A CHANGING CLIMATE IF RISKS ARE UNMANAGED

The UAE is considered one of the global leaders in transport infrastructure and its Vision 2021 key indicators show that it aims to be the World No. 1 for the quality of its airport and port infrastructure and among the top 10 countries globally for overall logistical performance.[177] The logistics sector is made up of four key areas; transportation services, warehousing services, freighting forwarding services and value added logistics services (VALS). In 2013, the economic value was reported as $23.4 billion (6% of GDP) and forecast to rise to $27 billion by 2015[178]. Dubai is a major transportation hub in the Middle East due to its air and sea ports, with the main ports of Jebel Ali, Port Rashid, Hamriya and Dubai Creek serving more than 13,000 vessels each year and handling a significant share of the world's shipping cargo. Abu Dhabi and Sharjah also have major ports, which are used for export.[179] The UAE is investing in transport sector initiatives designed to generate co-benefits in reducing GHG emissions, including a federal freight rail network crossing the country and the Emirate of Dubai's investment in a multi-billion dollar light-rail / metro system.[180] These key performance indicators and investments are a fundamental part of the UAE economy and are at risk from a changing climate if potential impacts are left unmanaged.

Current climate extremes and hazards of particular relevance to the transport sector are heavy precipitation leading to flash flooding, and climate change is expected to increase these risks.[181] Observed weather-related impacts serve to provide a measure of how weather and climate-related risks manifest themselves in the transport sector in the UAE. Box 4 provides some

INCREASED PRECIPITATION WILL LIKELY

INCREASE DAMAGE AND DISRUPTION

TO TRANSPORT INFRASTRUCTURE

examples of reported flash flooding events involving overwhelming of drainage systems, damage to infrastructure, loss of life and economic activity. Climate change is expected to lead to increased rainfall intensity in the UAE (as elsewhere in the world) –by as much as 200% by mid-century (see Figure 12) and to increased variability. Unless action is taken to assess and address drainage requirements to cope with potential changes in rainfall intensity and frequency, this will likely increase damage and disruption for transport infrastructure. Furthermore, the UAE's environment is vulnerable to secondary impacts from surface runoff. Surface pollutants which have accumulated on road surfaces during periods of dry weather become mobilised due to heavy precipitation, entering water courses at concentrations that may be environmentally unacceptable.

Box 4 Extreme rainfall disruptions to transport infrastructure[182,183,184,185]

Thundershowers in Dubai in January 2015 resulted in flash flooding of streets and flooding of underpasses. The National Center for Meteorology and Seismology (NCMS) recorded over 38.2mm of rainfall at Jabal Jais, with wind speeds across the country of up to 65km per hour and wave heights in the Arabian Gulf peaking at 3.5 meters. Amongst the impacts reported were one death, 3 injuries, 7 flights diverted by Dubai Airports, highways waterlogged, traffic jams, uprooting of trees and damage to traffic control.

In 2010, heavy rain in the mountainous parts of the Northern Emirates brought flooding to the lowlands, and prompted warnings for Eid al Adha holidaymakers to take extra care on the country's roads. Some 17mm of rain fell over parts of Umm al Qaiwain, while Fujairah experienced 13mm of rain, as well as some hail, thick cloud and low temperatures.

In January 2009, schools along the mountainous stretches of the Sharjah-to-Kalba motorway were closed due to rock slides and rivers of mud which blocked roads after several days of reportedly "unusually intense" rainfall. In December of the same year, at least six people were killed and many more injured on the country's roads when the UAE was hit by near-record rainfall. The worst-hit area was a suburb of Al Ain with 146.6mm of rain falling over three days; over the same period, Abu Dhabi saw 104.2mm. Over the three days, Dubai was reported to have had more than twice the December average rainfall.

December 2008 saw heavy rains and flooding of roads in Dubai with forecasters repeatedly warning people to stay away from wadis because of the danger of flash floods. Some 20.4mm of rain fell at Dubai International Airport, above the average total for December. A duty forecaster at Dubai International Airport commented that 10mm of rain was usually enough to cause localised flooding in the city.

Picture: Emirates Road / Pablo Stuart[186]

SUSTAINED EXTREME TEMPERATURE CAN

MELT ASPHALT AND TARMAC ON ROADS AND RUNWAYS

Extreme temperatures could also have consequences for the use of public transport systems and result in secondary congestion impacts on road networks. Unless thermal comfort is adequately managed within passenger compartments and interchange nodes such as stations / bus stations, this could result in a shift to door-to-door modes such as private vehicles and taxis. Sustained extreme temperatures can also result in melting of asphalt / tarmac on roads and runways.[187,188] Hotter air with reduced density can also affect aircraft lift due to a reduction in mass of airflow over the wing. If runways are not sufficiently long to generate sufficient speed and therefore lift, the aircraft weight has to be reduced or flights cancelled.[189]

The potential for damage and disruption to the UAE's transport infrastructure due to sea level rise, increased storms and storm surge heights and changes in sandstorms and fog are highly uncertain but could be significant. Some evidence suggests that that the Arabian Gulf coast of the UAE could be exposed to tropical cyclones in the future (see Section 2.4.4). Cyclone Gonu in 2007 passed near to the UAE, and was the strongest ever recorded in the Arabian Sea. Considered extremely rare, the cyclone caused major damages estimated at US$4.2 billion in Oman[190] and US$216 million in Iran[191], with severe consequences in Pakistan and the UAE too. Impacts of storms at ports can include damage to buildings and cargo handling equipment (such as cranes) and disruption to trade and passenger movements. Reduction in visibility from fog or sand and dust storms at ports can impact on safe vessel movements with consequential disruption to business continuity (see Box 5). For coastal ports, rising sea levels combined with storms may result in increased flood risk for cargo storage areas, disruption to vehicle movements within ports and to transport off-site. For shipping vessels, sea level rise could impact on navigation and berthing at docks and operability of quays. For example, Fujairah port is more exposed to cyclones and storm surges than infrastructure on the west coast. Each of these factors should be evaluated for the UAE's ports in the light of climate change, so that the risks can be better understood and managed.

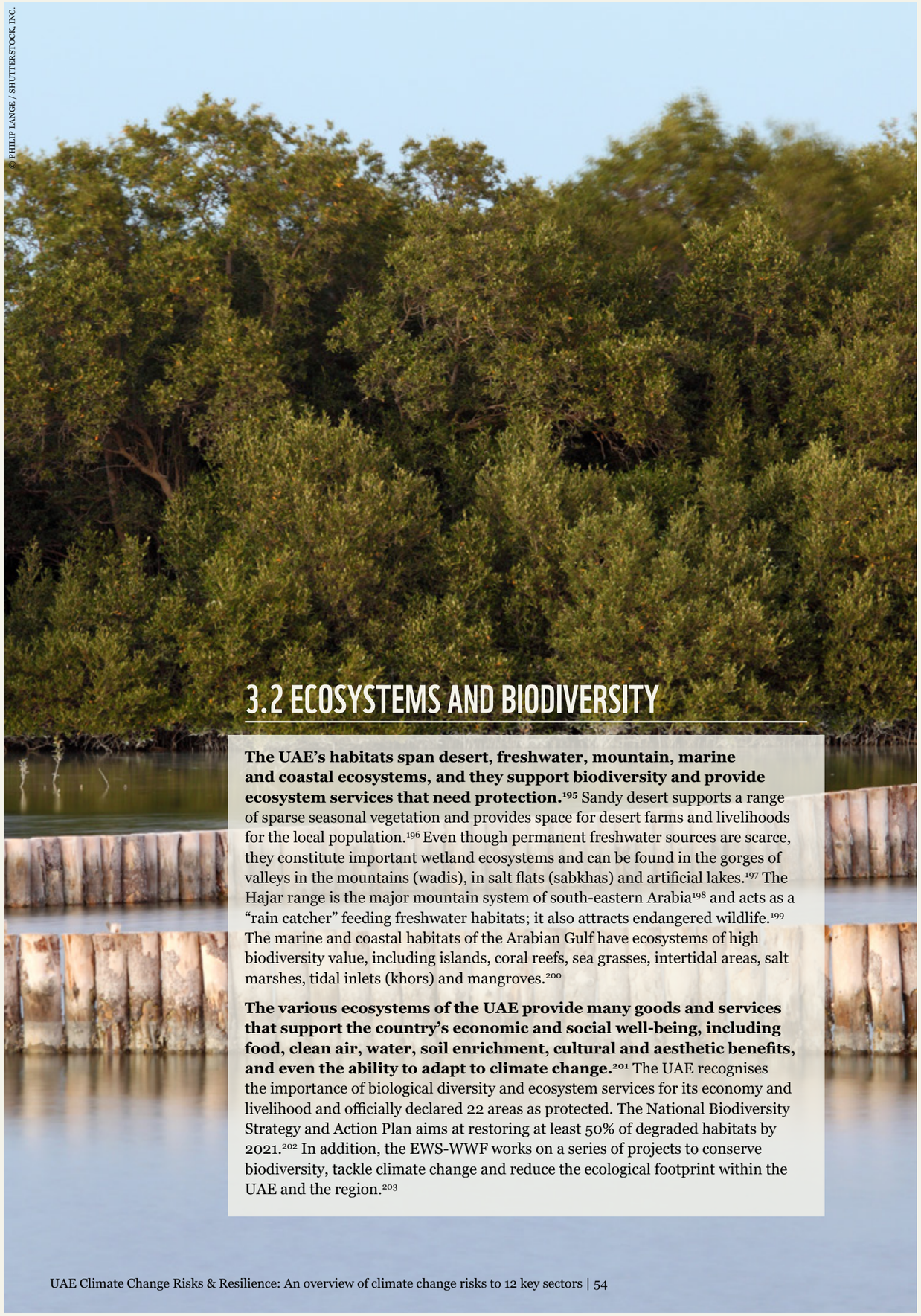
Box 5 Reduced visibility at airports[192,193]

In January 2015, Etihad Airways apologised to passengers for disruption by fog-related delays. The airline described it as a "major disruption" and an "extremely challenging few days". The company had to accommodate stranded passengers when Abu Dhabi International Airport was forced to close. Over a 24 hour period, the airline booked passengers into more than 2,000 hotel rooms in the city.

In some cases, passengers had waited for over 12 hours in planes stranded on the ground as the airport struggled to find space for planes. Etihad Airways diverted several other inbound flights to three airports in the UAE and delayed the arrival and departure of other services.

In October 2015, a thick blanket of fog resulted in delays to incoming flights in UAE's three major international airports. It also resulted in traffic congestion as visibility went down to just a few meters. More than 60 incoming flights at Dubai International were delayed while 30 incoming flights were delayed at Abu Dhabi International Airport. Another 17 flights were delayed in landing at Sharjah International Airport.

Picture: Dubai skyline / Gulf News[194].



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3.2 ECOSYSTEMS AND BIODIVERSITY

The UAE's habitats span desert, freshwater, mountain, marine and coastal ecosystems, and they support biodiversity and provide ecosystem services that need protection.[195] Sandy desert supports a range of sparse seasonal vegetation and provides space for desert farms and livelihoods for the local population.[196] Even though permanent freshwater sources are scarce, they constitute important wetland ecosystems and can be found in the gorges of valleys in the mountains (wadis), in salt flats (sabkhas) and artificial lakes.[197] The Hajar range is the major mountain system of south-eastern Arabia[198] and acts as a "rain catcher" feeding freshwater habitats; it also attracts endangered wildlife.[199] The marine and coastal habitats of the Arabian Gulf have ecosystems of high biodiversity value, including islands, coral reefs, sea grasses, intertidal areas, salt marshes, tidal inlets (khors) and mangroves.[200]

The various ecosystems of the UAE provide many goods and services that support the country's economic and social well-being, including food, clean air, water, soil enrichment, cultural and aesthetic benefits, and even the ability to adapt to climate change.[201] The UAE recognises the importance of biological diversity and ecosystem services for its economy and livelihood and officially declared 22 areas as protected. The National Biodiversity Strategy and Action Plan aims at restoring at least 50% of degraded habitats by 2021.[202] In addition, the EWS-WWF works on a series of projects to conserve biodiversity, tackle climate change and reduce the ecological footprint within the UAE and the region.[203]

THE MARINE AND COASTAL HABITATS OF THE ARABIAN GULF HAVE ECOSYSTEMS OF HIGH **BIODIVERSITY VALUE**

The UAE's natural habitats are facing several threats including, urbanisation, unsustainable use of natural resources, introduction of alien species, lack of awareness on the values of biological diversity and pollution from land- and sea-based sources.[204] The UAE's ecosystems are particularly impacted by vast increases in population and economic growth, exhaustion of limited natural resources and by an increased energy demand for cooling and water desalination plants.[205] Climate change is expected to put additional pressures on species impacting their ability to cope with additional threats, thus affecting their capacity of resilience.

The following sub-sections highlight the latest research into the risks facing marine, coastal and terrestrial ecosystems from climate change. Ongoing research efforts are currently being undertaken by AGEDI through the "quantitative assessment of the vulnerability of marine and terrestrial ecosystems and species to long-term physical, chemical and biological changes".[206,207]

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FURTHER CHANGES IN CLIMATE CONDITIONS **WILL SEVERELY AFFECT MARINE ECOSYSTEMS AND SPECIES** AS THEY ALREADY FUNCTION ON THE MAXIMUM LIMITS OF ENVIRONMENTAL TOLERANCE

3.2.1 Marine & Coastal

The Arabian Gulf is already one of the most heat-stressed bodies of water on the planet due to its prevailing climate and a high density of large-scale desalination plants discharging heated and highly saline effluent.[208] Open waters, estuary, coral reefs, seagrass beds, islands, mangrove forests, extensive intertidal flats, saltmarshes and salt flats (sabkhas) along the coast[209] are habitats for many unique and already endangered marine species, including the green turtle, the hawksbill turtle, the loggerhead turtle, the Indo-Pacific humpback dolphin, as well as the world's second-largest population of dugongs.[210] Marine ecosystems and species of the Arabian Gulf already often function at the maximum limits of their environmental tolerance and further changes in climatic conditions are likely to affect them severely.[211]

WARMER SEA SURFACE TEMPERATURES WILL
ALTER GROWTH RATES
OF SEA GRASS BEDS

Any changes in the UAE's unique ecosystems can lead to negative impacts on valued species, improved conditions for diseases of flora and fauna, as well as opening areas up to invasive species.[212] For example, an increase in sand temperature will influence the nesting of turtle species along sandy beaches and coastal sand dunes with an effect on the ratio of male and female hatchlings and thus have irreversible implications for the genetic diversity and survival of turtle species in the region.[213,214]

Warmer sea surface temperatures and changing water depths will alter growth rates of sea grass beds[215] found in shallow waters, on which a range of species feed.[216,217] Seagrass systems provide a coastal habitat and direct food value to wildlife such as dugong herds and turtles, improve water quality, and support fisheries production of both commercial and non-commercial fish.[218] Besides sea temperature, seagrass ecosystems are also be influenced by salinity, pH and changing water depths – all of which will be affected by climate change.[219] For example, a projected increase in water depth due to sea level rise will reduce available light, which then may cause a significant reduction in seagrass growth and productivity.[220]

The ability for marine species to respond to changes in sea temperature will become more relevant in the face of rising global temperatures.[221] The EWS-WWF Marine Turtle Conservation Project in the Arabian Gulf discovered a trend where marine turtles migrate to cooler waters during the summer, and return back to their original grounds in autumn.[222] This could be an example of the impacts of warmer sea temperatures caused by climate change.[223] Marine turtles regulate their internal body temperatures through behavioural responses to temperature shifts.[224] Negative influences of changes in climate regimes can have an impact on the habitat availability, nesting success, timing and periodicity, incubation success, gender ratios and hatchling fitness.[225]

Shifts in sea water temperature and ocean acidification[226] **are an additional stressor for coral reefs, and coral bleaching is already becoming more common.**[227] Coral reefs are species-rich and economically valuable ecosystems[228], globally estimated to provide about US$ 30 billion in goods and services on an annual basis, including income from, and resources for tourism, fishing and coastal protection.[229] Sea warming will lead to extensive additional coral bleaching and mass mortalities.[230] Estimates indicate that with a continuation of current trends in GHG emissions, a significant proportion of the planet's remaining coral reefs may be lost to bleaching over the next century.[231] See Box 6 for an example of how coral breaching has affected the UAE in recent years.

SEA WARMING WILL LEAD TO EXTENSIVE
ADDITIONAL CORAL BLEACHING AND MASS MORTALITIES

THREATS ON CORAL REEFS
MAY HAVE NEGATIVE IMPLICATIONS FOR TOURISM
BASED ON THE NATURAL ENVIRONMENT

Box 6 Climate change risks to coral reefs

Healthy coral reefs are not only important and diverse coastal ecosystems, they can also play a role in preventing coastal erosion and inundation.[232]

However, they are endangered due to coral bleaching, mass mortality, and damaging algal blooms, which have all been linked to climate change.[233,234,235] This may have serious negative implications for tourism based on the natural environment of these popular attractions (see Section 3.4.5)

A bleaching event in 2010 lead to the loss of 60% of Acropora corals in Ras Ghanada, Abu Dhabi, which is famous for its coral reefs.[236] Acropora corals are very important as their massive colonies excrete a calcium carbonate skeleton,[237] which is the basic building block of a coral reef.[238] The Environment Agency of Abu Dhabi plans to increase the percentage of protected marine areas in the capital to 14% by 2019,[239] which will not only benefit biodiversity in coral reefs but might also be beneficial for the tourism sector and its efforts to make the UAE a popular diving destination.[240,241] Research has indicated that coral culture and translocation is a feasible option in the Gulf to help conservation efforts for coral populations that might be endangered due to thermal stress events.[242]

Picture: A scientist collects samples from a coral reef in Abu Dhabi, which scientists say need more protection. / John Burt[243]

MANGROVES
REQUIRE STABLE SEA LEVELS
FOR LONG-TERM EXISTENCE

Sea-level rise caused by climate change is a threat to mangrove areas[244] **along the UAE's coastlines.**[245] Mangroves cover thousands of hectares of land along the UAE shoreline.[246] They provide habitat for dozens of fish species and a safe nesting, feeding and roosting site for many seabirds.[247] They also provide vital ecosystem services, including the protection of shorelines from coastal hazards such as erosion and storm waves[248] and sequestering carbon from the atmosphere.[249] Mangroves require stable sea levels for long-term existence.[250] Mangrove trees thrive above sea level as the mud where they take root needs to be free from inundation for some time each day.[251] Under constant inundation the trees' root system cannot take in oxygen and new trees will not be able to take root as seeds float in higher water.[252] Section 2.4.3 demonstrates that the UAE's coastline could be vulnerable to changes in sea level, as well as an increased risk of extreme storms which may also cause erosion of the mudflats where mangroves grow.[253]

CHANGES IN PRECIPITATION AND SEAL LEVEL CAN HAVE

NEGATIVE AFFECTS ON COASTAL SABKHAS

The UAE's sabkhas, low-lying, sand and salt flats, are an endangered habitat. [254] They are also recognised as one of the largest carbon storage habitats of coastal systems. [255] The UAE sabkhas are internationally recognised as the largest and most geomorphologically interesting examples in the world.[256] Coastal sabkhas can stand only a few centimeters above high-tide mark and changes in precipitation and sea level could have negative consequences on their halophytic flora and fauna.[257]

Desalination is the major source of freshwater in the UAE (See Section 3.1.2) and poses a growing threat to marine ecosystems. This can be when marine organisms get caught up in the intake screens or get drawn into the plant with the source water[258]; and by the effect that plant effluent has on the thermal and chemical properties (e.g. level of salinity) on the waters surrounding the discharge area into the ocean.[259]

Releasing hot brine and treatment chemicals into the Arabian Gulf can be damaging for marine ecosystems, particularly for corals and seagrass (see Section 3.1.2.).[260,261] As the effluent is heavier than seawater, it sinks to the bottom and slowly circulates causing harm to sea grasses and other ecosystems on which a large range of aquatic life (e.g. dugongs) depend.[262] The shallowness of the Arabian Gulf water and strong evaporation due to continuous sunlight and wind leads to very high saline and dense water.[263] Salinity levels are higher close to desalination discharge points.[264] AGEDI's report on desalination impacts shows that the intensification of desalination will be further exacerbated by climate change.[265] It was also found that water residence time along the Arabian coast of the Gulf was over three years.[266] This suggests that any type of pollution would remain in the Gulf over long periods of time.

DESALINATION EFFLUENT SINKS TO THE BOTTOM OF THE GULF AND

CAUSES HARM TO SEA GRASSES

AND OTHER ECOSYSTEMS

3.2.2 Terrestrial

INCREASED RISK OF EXTREME TEMPERATURES WILL

PUT FLORA AND FAUNA UNDER STRESS

Drylands, particularly the desert, are vulnerable to climate change because of their inherent fragility that makes slight changes in rainfall patterns and temperature a risk to their biodiversity.[267] This, combined with the threats of both anthropogenic activities as well as living in an extreme environment, limits their ability to cope, impacting the overall resilience of wildlife populations. The desert and xeric shrublands constitute a major habitat type in the UAE[268]; four-fifths of the country's land area is by definition desert.[269] Many wild and endangered animals are dependent on healthy desert and shrubland ecosystems, including the Arabian oryx, Egyptian spiny-tailed lizard, sand gazelle, sand cat, Rüppell's fox, honey badger, and the golden eagle.[270] Besides their intrinsic value, deserts and rangelands are of particular value for nature-based tourism (see Section 3.4.5).[271]

An increase in the risk of very extreme temperatures will put the flora and fauna of the wadi and mountainous region under stress.[272] In addition, without adequate planning, more severe precipitation events will run off and remain unavailable to vegetation.[273] The scarcity of plant species will affect the lifespan of animals that feed on them and thus the whole food chain.[274] The Hajar Mountains in the east of the UAE are dissected by numerous wadis and contain a high diversity of plant life,[275] most of which are therophytes, which appear after rains and disappear in dry periods.[276] Wadis, with permanent or seasonal freshwater provide critical breeding and stopover habitats for numerous birds and are home for rare amphibians and insects (e.g. dragonfly species).[277] The Arabian tahr, Egyptian vulture, mountain gazelle, Blanford's fox, and the caracal have all made their home here.[278]

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3.3 HEALTH & WELLBEING

Climate change will have significant impacts on public health, as it affects key social and environmental determinants such as clean air, safe drinking water, sufficient food and secure shelter.[279] The World Health Organisation (WHO) considers a changing climate as the greatest threat to global health in the 21st century, noting it already claims tens of thousands of lives a year due to heat-waves and other extreme weather events, outbreaks of infectious diseases; the effects of malnutrition, and environmental pollution.[280] A population's capacity to adapt to new climatic conditions depends on various factors such as level of economic development, population density, food availability, income level and distribution, local environmental conditions, pre-existing health status and the availability and quality of public health care (see Figure 18).[281]

The major climate change impacts on the UAE's public health are expected to be increased heat stress, possibly increased water-and vector-borne diseases, reduced water availability and impacts on food security.[282] The total burden of disease from climate change is difficult to conclude as there are many mechanisms through which climate change can affect public health.[283] The UAE recognises climate-related health impacts. The country's draft *National Strategy and Action Plan for Environmental Health*, for instance, states a potential increase in mortality and morbidity, and recommends actions to improve the understanding of how climate change will affect human health and wellbeing, including the monitoring of conditions likely caused by climate change; informing healthcare specialists on climate-related health issues; and identifying priority actions for health protection and disease prevention.[284]

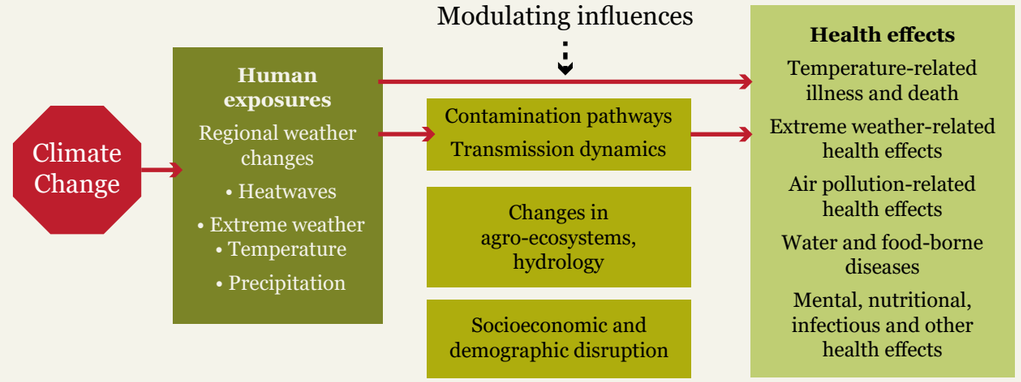

Figure 18 Main pathways and categories by which climate change affects human health (WHO, 2016).[285]

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3.3.1 Heat-related illness

SWEAT EVAPORATION IS HINDERED BY RISING TEMPERATURES AND HUMIDITY

In addition to rising temperatures, the UAE is also facing an increase in humidity levels, which intensifies heat stress[286] **by hindering the evaporation of sweat (see Box 7).**[287] The health outcomes of prolonged high temperature exposure can include heat stroke, heat exhaustion, heat cramps and death.[288] The elderly, very young[289], the socially isolated, the poor, those suffering from pre-existing chronic conditions such as respiratory, cerebral, and cardiovascular diseases[290], and those taking drug treatment for mental disorders[291], are at higher risk. Arab countries experienced seven extreme heat events from 1990-2011 with more than 100 deaths.[292] However, such published figures for heat-

related illnesses and deaths may be underestimated as differences in health care systems make morbidity measurements difficult and heat is rarely identified as an official cause of death.[293] Furthermore, air conditioning is highly prevalent in the UAE, and is a protective factor against thermal stress.[294] However, it is unknown what proportion of the population in the UAE does not have access to air conditioning.

The UAE recognises the importance of heat-related health impacts. The *Draft National Strategy and Action Plan for Environmental Health* states that public health in the UAE will be affected by climate change in relation to rising temperatures, with a possible increase in mortality and morbidity in particular among elderly people and outdoor workers, e.g. in construction and oil and gas industries.[295] It recommends evaluating and enhancing the health system's ability to deal with extreme heat, raise awareness and train health care personnel and health and safety professionals about how to protect against extreme heat, and to develop and implement an early warning system for extreme heat.[296] In addition, The Health Authority-Abu Dhabi in association with the Abu Dhabi Environment, Health and Safety Management System and the Abu Dhabi EHS Centre and sector regulatory authorities has undertaken to reduce and prevent cases of heat related illness in the workplace[297]. Several countries that have experienced heatwave epidemics, including the USA, Portugal and France (where a heatwave in 2003 caused over 14,800 deaths in a 20-day period), have developed such proactive heatwave response plans. They include a range of public health interventions such as education campaigns to prevent and identify first signs of heat stress, opening of cooling centres, as well as an increase in air conditioning use.[298] However, increased use of air conditioning as an adaptive response could be perceived as mal-adaptation[299] as the expansion of air conditioning may result in higher GHG emissions[300], additional heat would be released by air-conditioning units[301], and power grids may fail because of sudden increases in electricity demand[302].

INCREASED USE OF AIR-CONDITIONING IS MAL-ADAPTATION AS IT RESULTS IN HIGHER EMISSIONS

Box 7 Heat-Related Discomfort in the UAE, 2008-2015

News reports of hot spells in the UAE are common in the media and help to raise awareness of the dangers of becoming dehydrated and having respiratory problems due to low air quality.

The UAE comfort index has a scale from 1 to 10, with conditions being at 'danger level' above a score of 5.[303] In recent years (for instance in 2011[304], 2012[305], 2013[306], and 2014[307]), the comfort level has risen to 6 more than once during hot spells, which causes even more discomfort in areas of high humidity, e.g. coastal regions.[308,309] This is especially dangerous for those who work outside such as heat-exposed workers on construction sites.[310]

Picture: Image Credit: Asghar Khan / Gulf News[311]

GLOBAL PRODUCTIVITY LOSSES COULD RISE TO US$2TN BY 2030 DUE TO HEAT-RELATED IMPACTS

Socioeconomic factors such as housing type[312] are likely to be important when estimating possible heat-related health effects within the UAE's most populated cities. Previous studies demonstrate that mortality is more sensitive to heat in urban areas than in suburban or rural areas as the urban built environment magnifies night time temperatures (known as the 'urban heat island').[313]

A United Nations Development Program (UNDP) report on the global impacts of heat in the workplace suggests that globally, productivity losses could rise above US$2tn by 2030. This is due to outdoor employees in many regions slowing their pace, taking longer breaks and shifting their work to cooler dusk and dawn hours[314].

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3.3.2 Air pollution-related illnesses

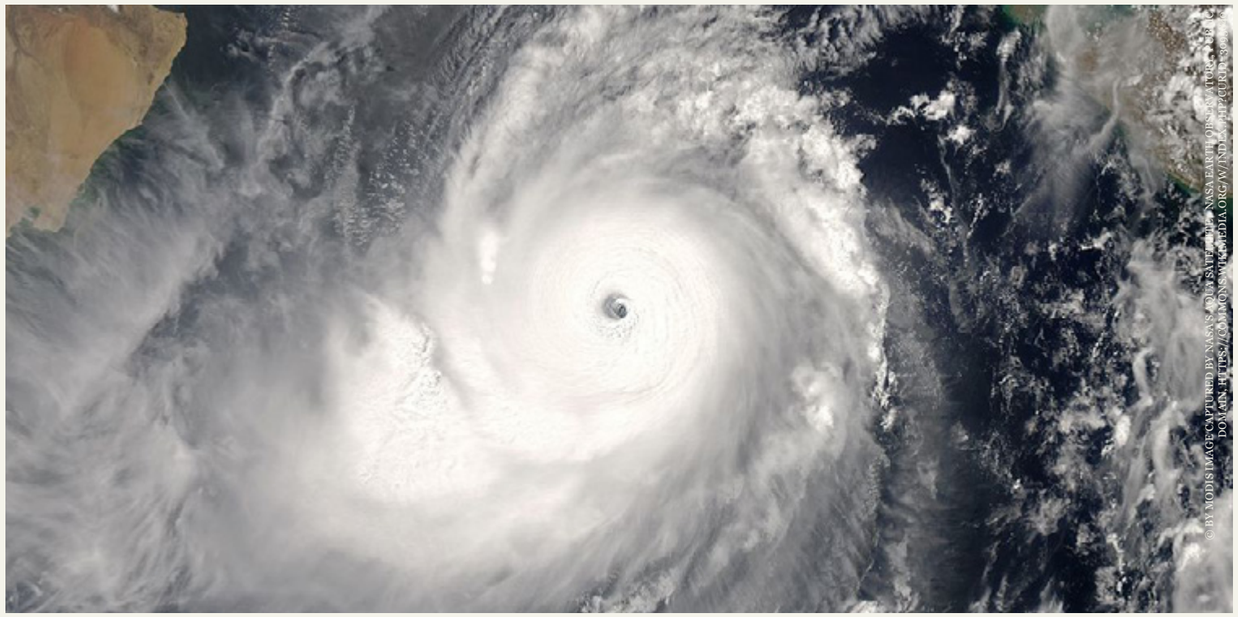
Extreme heat events exacerbate the impact of poor air pollution[315], so increasingly extreme heat in the UAE will also lead to worsening health risks from air pollution. Climate-related conditions, including solar radiation, changing wind patterns,[316] dust storms, rainfall and increases in temperature, influence the concentrations of air pollutants.[317] Higher temperatures, for instance, favour the production of low-level ozone[318]. Air pollutants such as aeroallergens (including pollen and dust),[319] particulate matter, volatile organic compounds, nitrogen oxides, ground-level ozone, carbon monoxide and sulphur dioxide, can irritate the respiratory system, decrease lung function[320], aggravate asthma, cause chronic bronchitis, irregular heartbeat and non-fatal heart attacks.[321] Increased human exposure to air pollutants may also be linked to cancer in humans.[322]
In urban areas in particular, air quality is mostly determined by the contributions of various mobile (transportation) and fixed (generators, industry) pollutant sources.[323]

Addressing air pollution is one of the key policy priorities in Abu Dhabi and climate change provides an additional driver for these efforts.[324] The Abu Dhabi Global Environment Data Initiative completed a project *Public Health Co-benefits of Greenhouse Mitigation Activities in Abu Dhabi* to carry out research on air pollution and public health within the Abu Dhabi metropolitan area.[325] On the basis of climatic and air quality modelling, estimates of the avoided mortality (premature deaths avoided) and morbidity (health care facility visits avoided) risks from the implementation of GHG mitigation policies were generated.[326] Despite this initiative, research focusing on the effects of ozone, particulate matter, and other temperature-enhanced air pollutants on human health is still scarce in the Arab region.[327] This is also due to the fact that analysis of how heatwaves alter air pollution and the resulting impacts on human illness and death requires integrating knowledge of atmospheric chemistry, climate patterns, environmental health, epidemiology, medicine, and other science fields.[328]

POPULATIONS MAY FACE
INCREASED RISK OF DISEASE
AS RISING TEMPERATURES CREATE NEW TRANSMISSION ZONES

3.3.3. Infectious diseases

The incidence of vector-borne diseases such as malaria is closely linked to temperature and humidity conditions.[329] Vector-borne illnesses are infections where transmission is via the bite of infected arthropod species, such as mosquitoes, ticks, triatomine bugs, sand flies and blackflies.[330] Vector reproduction, parasite development cycle, and bite frequency generally rise with temperature.[331] Therefore, populations with little or no immunity to new infections might face an increased risk as new transmission zones are created in line with rising temperatures.[332] There is limited research on how climate change could affect vector-borne disease in the UAE specifically. However, the UAE is situated in an endemic malarious region.[333] After a campaign against malaria, the UAE was declared as malaria-free in 2007 by the World Health Organization.[334] The ability of UAE's public health system to meet any possible increased risk will determine future malarial burden due to climate change.[335]

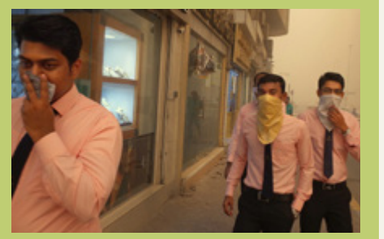


3.3.4 Extreme weather events

As climate change is likely to make extreme weather events more common, they can be expected to have an increasing effect on morbidity and mortality in Arab countries[336] **burdening healthcare systems, increasing healthcare costs and decreasing economic productivity.**[337] During the last 30 years, the Arab region was affected by more than 270 natural disasters, causing more than 150,000 deaths and affecting approximately 10 million people.[338] The Arab region often experiences natural disasters such as flash floods, droughts, storms and sandstorms[339] (see Box 8); and these events are expected to become more common.[340] Information on the effects of extreme weather events on public health and safety in the Gulf Region and UAE in particular is limited and further research is needed in this area.

CLIMATE CHANGE IS LIKELY TO MAKE
EXTREME WEATHER EVENTS MORE COMMON

Box 8 Extreme events and peoples' health



Although intense cyclones are rare in the Arabian Sea, Cyclone Phet in 2010 was the second-strongest recorded (behind Gonu in 2007) and brought wave heights of 10 meters to the east coast of the UAE, causing severe damage to the port area and the loss of a boat with 10 passengers.[341] More recently, in 2015, two cyclones hit nearby Yemen and caused several deaths.[342,343]

In recent years the UAE and its neighbouring countries have been repeatedly affected by serious flooding after heavy rainfall,[344,345,346] often leading to deaths,[347,348,349,350,351,352] traffic accidents,[353,354] and mass evacuations.[355,356] Extreme rainfall in 2013 caused over 20 deaths in Saudi Arabia and Oman, over 4,200 road accidents within 36 hours, the rescue of over 900 civilians and the need for emergency shelter for 700 people.[357]

In 2015, the media reported a sandstorm in the UAE that blanketed the country and caused a rise in the number of patients admitted to hospital.[358] Extra staff had to be put on duty to cope with the influx of patients.[359] Exposure to a sandstorm can trigger acute attacks among sufferers of asthma.[360,361] During these events, the number of patients suffering from asthma-related problems can increase by 25%.[362] The dust storms also bring a rise in the number of car crash victims due to poor visibility (see Box 5).[363,364] A cross-sectional study of 850 schoolchildren in the UAE associated dust storms and humidity with the prevalence of asthma.[365]

Picture (top): Rain and Floods Cause Chaos in Gulf Region / Floodlist[366]

Picture (bottom): Sandstorm causes spike in patient numbers at UAE hospitals / The National[367]

3.4 ECONOMY & BUSINESS

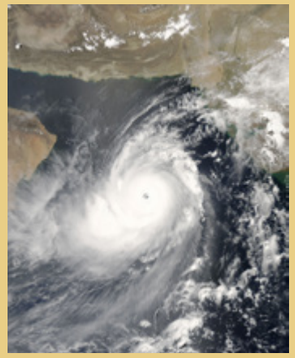
3.4.1 Oil and gas

The potential for damage and disruption to oil and gas assets and activities due to sea level rise, increased storms, increased storm surge heights and changes in sandstorms and fog are significant areas of uncertainty. Oil and gas assets and operations which can be affected include shipping, tug operations, berthing, loading / unloading at ports, jetties, pipelines, power production and helicopter operations.[368,369] In turn, damage to offshore oil and gas assets and disruptions in operations due to extreme weather events can pose significant pollution risks for marine and coastal ecosystems. The oil industry in Fujairah, on the Gulf of Oman, has a higher vulnerability to extreme climate events than other parts of the UAE, owing to its high concentration of oil terminals and its greater exposure to cyclones.

New high temperature extremes due to climate change can be estimated with greater confidence, and will lead to efficiency losses for processes which are sensitive to ambient temperatures. They could also lead to equipment failures if design thresholds are exceeded. These areas require targeted research and analysis to evaluate the level of risk (see Box 9).

Box 9 Climate Risks to the Oil and Gas sector in the region

In 2007, Cyclone Gonu hit Oman, bringing torrential rains, strong winds and high waves. Mina al-Fahal, Oman's only outlet for crude oil exports, had to be shut down for several days, as did the Oman LNG terminal at Sur, where 10 million tonnes of LNG are handled each year.[370]



Three years later, Cyclone Phet led to a halt in Omani oil and gas production; no ships could be loaded due to the rough seas.[371] The same cyclone made the port of Fujairah, one of the biggest bunkering operations in the world, harder to access and only a few ships came into port.[372] Oman LNG and Qalhat LNG had to be shut down temporarily.

As mentioned in Section 2.4.4, the Arabian Gulf coast of the UAE could be exposed to tropical cyclones in the future, which might also put the country's petrochemicals industry at risk.

Picture: Cyclone Gonu at the northeastern shore of Oman / NASA image by Jeff Schmaltz, MODIS Rapid Response Team, Goddard Space Flight Center)[373]

SENSITIVITY OF LNG PRODUCTION TO CHANGES IN AMBIENT AIR TEMPERATURE VARIES CONSIDERABLY

Rising temperatures will have a negative effect on Liquefied Natural Gas (LNG) production facilities, with potential impacts on the amount of LNG available for import to the UAE. LNG is an important element of the fuel supply mix in the UAE, where gas fired thermal power plants make up more than 90% of generation. The UAE has been a net gas importer since 2007. Dubai currently purchases approximately 3 million metric tonnes of LNG per year, with Abu Dhabi also seeing increased requirements.[374] The joint venture company, Emirates LNG, is looking to build an import and regasification facility at Fujairah with a capacity of 9 million metric tonnes per year, expected in 2018.[375] Liquefaction of methane, the main constituent of natural gas, involves decreasing its temperature to approximately -162˚C at atmospheric pressure. The efficiency of LNG production is affected by several parameters including the ambient air temperature, feed gas composition and equipment design and performance.[376] Refrigeration compressor performance affects the rates at which LNG can be produced[377], and as ambient air temperature increases, production decreases. The sensitivity of LNG production to changes in ambient air temperature varies considerably, depending on the technologies used.[378] It would be useful to evaluate the impacts on LNG production facilities in other countries which provide LNG to the UAE.

Increased rainfall intensity could overwhelm the capacity of drainage systems at oil and gas facilities (see Section 2.4.2). If drainage systems are unable to cope with increased rainfall intensity, this could lead to flooding, pollution incidents, damage to ecosystems, and reputational impacts for oil and gas companies. Abu Dhabi National Oil Company (ADNOC) operates its facilities with the goal of preventing environmental incidents, and applies the principle of Pollution Prevention and Control (PPC). Efforts are focused on taking a proactive approach to environmental protection rather than on remedial actions alone.[379] Dedicated analysis is required to understand the capacity of drainage systems in the oil and gas sector to withstand higher rainfall intensities due to climate change, and the potential need for system upgrades. Some international oil companies are already adjusting their design standards for new projects and, for existing assets,

HIGHER TEMPERATURES INCREASES THE RISK TO WORKERS AND WILL REQUIRE DIFFERENT PRACTICES

they are identifying those that are most vulnerable to climate change and taking appropriately timed action, for example, by upgrading refinery drainage systems.[380]

Worker health and safety practices, for example, in the oil and gas industry will need review in light of higher temperature extremes. The UAE's oil and gas industry is a major employer and ADNOC and its Group Companies alone have a workforce of more than 60,000.[381] Construction of new facilities also brings large numbers of construction workers. The Shah Gas Development Project, operated by Al Hosn Gas, for example, employed over 43,000 contractors at its peak in 2014.[382] ADNOC places a strong emphasis on safe and responsible operations for its own workforce, and its suppliers, contractors and partners. ADNOC sets operational standards through legally binding agreements and has established a centralised framework of operational standards against which compliance is mandatory. These standards provide comprehensive coverage of oil and gas industry activities posing Health Safety and Environmental (HSE) risks.[383] With higher temperature extremes expected due to climate change, risks to workers may increase, and this may require changes to working practices.[384]

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3.4.2 Industry

The UAE economic growth and diversification strategy is driven significantly by the development of its industrial sector, including manufacturing, utilities, construction and mining, amounting to 16% of GDP in 2013.[385] Besides petrochemicals, the metal industry (aluminium, iron and steel) see the world's largest companies based in the UAE; also, mineral (cement), chemicals (ammonia), automotive, and electrical machinery productions are in expansion, thus making the industrial sector the second major energy-consuming sector in the UAE.[386,387] The GHG emissions from industrial processes went from 9

million tonnes CO_2-equivalent in 2005[388] to 28.8 million tonnes CO_2-equivalent in 2014[389], representing about 13% of the total emissions of the UAE.

At the government level, there is a growing concern about impacts of industrial processes on already scarce resources, as well as growing demand for water and energy to fulfill production needs. Following the government initiative, the number of industrial establishments that have obtained the Environmental Performance Card, ensuring compliance with environmental standards and reducing negative impacts on the environment, including on water resources, has raised from 25 in 2010 to 71 in 2013.[390] The government is dealing with extremely high electricity and water demand with significant investments in assets and R&D to augment the capacity of power and desalination plants, and improve efficiency through breakthrough technological response (e.g. combustion efficiency; district cooling).[391]

Climate change is likely to aggravate the existing situation and cause losses and damages to the industrial production and manufacturing through different channels[392,393]. In general, changing climate will affect industry through changes in prices/availability and quality of inputs and raw materials, as well as changes in supply chains, logistics and the production processes, including energy demand, mainly in relation to increasing temperatures and extreme events. Also, assets, site conditions and workforce may be subject to augmented risk of sea level rise (SLR), flooding and extreme temperatures. Ultimately, changes in the market for certain products, especially for primary products and construction material are likely to occur in response to changing prices and new requirements to adapt to climate change.

Climate change will significantly impact the UAE industry through increased power demand for cooling purposes potentially resulting in higher costs for companies. Assuming that industrial cooling demand will rise to maintain output in the face of increased temperatures in the medium-term, many common industrial processes that generate heat (e.g. cooling systems, compression systems, pumps and motors) will need more power for cooling or cleaning, thus becoming less efficient in absence of adequate energy saving measures. In particular, industrial processes that require cooling water may experience a loss of operating efficiency as sea water temperatures rise. Likewise, air temperature warming will increase costs for ambient cooling. Given that the non-oil & gas industry uses about 45% of the UAE's total electricity output (2011 data)[394,395], the sensitivity of this sector to increases in ambient air temperature has the potential to influence the overall national energy demand. This is particularly relevant in a context of phasing-out of electricity subsidies.[396]

AIR TEMPERATURE WARMING WILL INCREASE COSTS FOR AMBIENT COOLING

Industrial segments in the northern Emirates based on critical logistics and operations may incur losses or lower revenues if summer power disruptions[397] become more frequent. Power outages already affect the northern Emirates on occasion, where industries including small scale quarrying, cement, ceramics and other metals are based. As a result, to cover the increased production costs and possible losses, end products might be pricier, and companies could eventually become less competitive.

Climate change is likely to lead to increased competition for water use led by the industry sector causing additional stress on scarce freshwater resources. Current water stress in the UAE may be worsened due to climate change combined with possible increase of water demand due to industrial use, although the industrial component is minor compared to domestic use, amenity sectors and agricultural use.[398] To manage increased water demand, investments to boost desalination output will imply additional financial and environmental costs. This is in line with the preliminary findings from the AGEDI Energy & Water Nexus and Climate Change report which frames the water issue "not only by quantity limitations, but by examining the energy implications and the costs of that energy to treat the water to suitable quality for consumption, which varies by usage."[399]

"JUST-IN-TIME" DISTRIBUTION SERVICES MAY EXPERIENCE MORE FREQUENT DISRUPTIONS

Climate change is likely to trigger direct losses and damages to production, logistics and assets in relation to rising sea levels, flooding and heatwaves. Industrial plants, manufacturing sites and specialised data centers, that are typically located on the coast, may be subject to more frequent flooding or high-water events in the medium-term and from sea level rise in the longer-term, causing direct damages to physical assets, inability to operate, system failures and longer downtime for clearing up activities, with consequent competitiveness losses.[400] Furthermore, supply chains and transports are vulnerable to extreme weather events, and "just-in-time" distribution services may experience more frequent disruptions where the infrastructure is not climate-resilient.[401]

Coastal erosion is affecting industry located on the coast. Coastal erosion is already being observed in the UAE and will be exacerbated by higher sea levels and storm surges. An industrial production facility on the UAE's East coast reported having experienced significant coastal erosion in the last ten years or so. The company was forced to build a concrete barrier and a 1.5 metre high levy to address the issue.[402]

COASTAL EROSION IS ALREADY OBSERVED AND WILL BE EXACERBATED BY SEA LEVEL RISE AND STORM SURGES

Climate change will have negative impacts on the health, safety and productivity of the UAE workers in relation to heatwaves and new diseases. Hotter ambient mean temperatures and more frequent or longer heat-waves are likely to cause discomfort and possible serious health and safety issues for outdoor workers. On the other hand, unexpected precipitation can lead to health and safety issues as well. For example, transportation of liquid aluminium without proper protection against rain or usage of wet aluminium scrap in the smelter without prior treatment in the preheat facility can cause serious accidents. Emerging health risks under changing climate in relation to air pollution and water- and vector-borne diseases may affect workers. Without appropriate technological innovations, manual labor productivity may decrease.[403] Employees working indoor may require more cooling of the working spaces, with consequent higher operating and capital costs to create adequate working conditions.

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3.4.3 Buildings, construction and real estate

THE UAE'S COASTAL INFRASTRUCTURE IS **EXPOSED TO INUNDATION**

As in other Arab countries, coastal urbanisation is a fast-growing phenomenon in the UAE, with the highest number of real estate developments located in low-lying zones.[404] Coastal areas host approximately 85% of the population of the UAE as well as many prestigious properties including hotels and resorts.[405] For example, in Dubai, the urban area has almost tripled in less than two decades (1984-2003), with an artificial expansion of the city surface thanks to the Palm Islands and the World archipelago projects, thus making the share of built environment potentially exposed to inundation significant.[406] Likewise, Abu Dhabi is considered vulnerable to SLR as the city's major developments and industrial infrastructure are built along the Emirate's islands[407,408]. There is also a risk that further urban development could occur close to natural flood plains and wadis, which are areas of natural water collection, as it is happening in many countries in the region.[409]

The designs of modern urban centers, such as Abu Dhabi, Dubai and Al Ain, are generally inefficient in terms of energy and water consumption.[410] To accommodate the needs of the growing population, most of the new buildings developed in the last years in many Arab countries were not built according to the traditional techniques - well suited to the arid climate - but were instead inspired by designs popular in less extreme climates, with a selection of materials based more on aesthetics and cost rather than environmental performance.[411,412] In the UAE's major cities, tall buildings with enormous glass façades generate huge water and electricity bills to cope with overheating under the current weather conditions, becoming significant sources of GHG emissions.[413] For example, it is estimated that operating buildings accounted for 28% of the total energy consumption and 59% of total water consumption in Dubai in 2014.[414]

Under the current scenario, urban water demand for household and public facilities is expected to grow in the UAE, in contrast with other sectors' projections.[415]

Building and construction is already a sector of concern in relation to the national energy and water budget. The UAE federal government and the emirates recognise the urgency of the issue and have launched green initiatives for energy and water efficiency, such as district cooling projects and efficiency standards for buildings and interior systems, as well as retrofit programmes.[416] While the Emirates Green Building Council contributes to promote best practices,[417,418] Abu Dhabi's Estidama initiative[419,420] and Dubai's Green Building Codes are gradually implementing appropriate building codes and regulations for energy and water efficiency. However, there are no professional bodies providing coherent design codes/standards for the UAE. Climate change will further impact on the thermal performance of buildings and affect how well building design standards and materials perform (as well as energy demand - see Section 3.1.1). Although such programmes represent a concrete opportunity to consider projected climate impacts in future investments, barriers to innovation may still be perceived in this sector. For example, retrofitting of low-quality existing buildings may not be always economically viable[421].

SEA LEVEL RISE OF 1M+ BY 2100 IS POSSIBLE ACCORDING TO GLOBAL AND REGIONAL PROJECTIONS

Climate change is likely to affect the growth of the housing and real estate market by making the coast a less safe and more expensive place. Coastal cities are likely to be at increasing risk from sea level rise, storm surges and associated flooding. Although the implications for the UAE (and elsewhere) are still very uncertain[422] (see Section 2.4.3), SLR of 1m or more by the end of the century is possible according to global and regional climate projections, which would inundate about 8.1% of the Emirate of Ajman, 1.2% of the Emirate of Sharjah and 5.9% of the Emirate of Umm Al-Quwain.[423] Fujairah and the East coast generally are regarded as being more vulnerable to cyclones, storm surge than West coast (where most industrial facilities are) and locations inside the Gulf.

Conscious of the threats of fast, unregulated urbanisation and in line with the Union's diversification agenda, long-term investments in sustainable cities are booming across the emirates, led by pioneering examples of planned urban development.[424] However, in contrast with Abu Dhabi's Masdar City - designed to be carbon-neutral and climate change resilient, raised above the surrounding land[425], some water canal projects[426] may be a less sustainable investment in the longer term due to possible risk of coastal flooding.

THE URBAN HEAT ISLAND EFFECT MAY BECOME MOVE SEVERE AS AVERAGE CLIMATE CONDITIONS CHANGE

Climate change will worsen local environmental stresses caused by urbanisation. The "urban heat island effect" (where urban areas see higher night temperatures compared to more rural areas) may become more severe as average climate conditions change.[427] Also, more frequent and/or intense precipitation events are likely to encounter a reduced ability of the soil to absorb water, compounded by insufficient building drainage, causing local flash flooding.[428]

Increasing physical risks induced by climate change can directly impact upon real estate investments in the UAE. The real estate a market is valued US$ 39 billion with a projected growth rate in excess of 9% until 2016[429] and some of this is in areas that may become at high risk of flood or extreme weather events (see Section 2.4). There have been cases in the world's most attractive holiday locations (e.g. the Bahamas) where property insurers decided to withdraw from

the market due to weather-related risks, although in a relatively small and specific geographic area, causing a decline of real estate values.[430]

Climate change is likely to impact construction causing longer building time and potentially higher costs. While hotter, more humid weather can reduce the productivity of outdoor workers, heavy precipitation events may slow down the completion of building projects in case flood protection structures, slope stabilisation, and dewatering of foundations become necessary, also involving additional costs for staff and technical equipment.[431]

3.4.4 Financial services

The financial sector in the UAE is generally considered to be "resilient to shocks". The UAE Central Bank sees "*no imminent threat or a significant build-up of vulnerabilities that could impact financial stability*", as banks' foreign exposures are well diversified and the whole system is relatively solid due to its conservative, traditional banking model.[432,433] Economic drivers include export-oriented services in Dubai (targeting the private sector), infrastructural and real estate developments in Abu Dhabi (targeting the public sector), as well as demand from consumer finance.[434,435] In particular, Dubai has gained the status of an international financial center and banking hub.[436] The insurance market of the UAE is also the largest in the Arab region, with huge potential for further developments especially for health-related insurance policies[437,438], but is limited compared to other countries.

Nevertheless, climate change represents a systemic risk to the real economy which could affect equity and debt investments,[439] and global business leaders have recently identified climate change-related risks among the top reasons of concern for the global economy in the next 10 years (see Box 10).[440] First of all, climate change will impact a number of economic factors internationally, causing uneven and unpredictable changes in global markets, especially for food and energy commodities. Secondly, at the national scale, there will be adjustments in markets of certain goods and services, changes in costs/revenues and capital expenditure of businesses and infrastructure, increasing need for compensation of losses and damages, rising insurance costs, possible higher depreciation rates of assets at risk or difficult to insure against climate change (e.g. real estate on coastal areas).[441] Assets held abroad, such as croplands for agricultural production, may be subject to physical damage and financial devaluation, whose indirect consequences may resonate with the UAE's food supply and trade flows (see Section 3.5). These impacts could in turn weaken the financial performance of debtors in the medium term, and thus potentially increase the number of non-performing loans, an issue which has represented the biggest challenge for the UAE in recent years.[442]

GLOBAL BUSINESS LEADERS IDENTIFIED THAT **CLIMATE RISKS ARE A TOP CONCERN** OVER NEXT 10 YEARS

a) Distribution of UAE/GCC land acquisitions

b) Details of UAE land acquisitions

Country	Size (hectares)	Production	Total
Algeria	31,000	Milk, olive oil, potatoes	31,000
Egypt	48,500 20,000	Fodder, dill, maize, potatoes, wheat	48,500 20,000
Ghana	10,000	Maize	10,000
Indonesia	100,000	Fruit, palm oil, rice, sugar cane	100,000
Morocco	700,000	Citrus and olives	700,000
Namibia	200	Date Palm	200
Pakistan	369,100	Rice, crops, dairy, alfalfa, livestock	395,100
Romania	50,000	Cereals	50,000
Spain	5,050	Alfalfa	5,050
Sudan	1,799,100	Cereals, fodder, cotton, sugar cane, peanuts	1,799,000
Total			3,132,950

Figure 19 Distribution of land acquisitions by UAE and GCC; details of UAE land acquisitions (source: GRAIN, 2012[443] cited in AGEDI, 2015[444])

COUNTRY CREDIT RISK MAY BE RATED HIGHER, WITH CLIMATE STRESS

Climate change trends can also affect the attractiveness of private equity investments in the UAE. Due to their longer-term nature, such investments could be more exposed to climate change-induced business risks, making projections of returns and exit strategies more uncertain if climate change consideration are not properly taken into account from the outset.[445] In general, country credit risk may be rated higher[446], with climate stress (e.g. water and food crises) becoming a component of economic stability in the Arab region (see Box 10).[447]

FINANCIAL INSTITUTIONS WITH LIMITED REACH MAY STRUGGLE TO DIVERSIFY RISK UNDER CLIMATE CHANGE SCENARIOS

Furthermore, climate change, adding to pre-existing financial stressors, may involve higher corporate financial risks for investment institutions operating in the UAE.[448] Financial institutions may face a variety of challenges, such as higher client payment default probability because of less profitable business investments; increased capital reserves requirements to cover exposures; lower returns on equity investments; and unfavorable investment portfolio performances[449,450]. While in the short to medium term, high capital mobility can offer protection against climate-induced financial risks; in the longer term, financial institutions may struggle to diversify risk; this is especially true for those institutions with local or limited reach.[451] Besides indirect consequences on the economy, the conditions that make Dubai one of the largest financial centres may be undermined as a result of direct physical impacts of climate change on the UAE in the future. For instance, Dubai's large re-exports facility and its complex infrastructure may be subject to more frequent disruption associated with power outages, thermal stress, flooding, etc, and become less efficient.

Climate change may also generate new opportunities for banking and investment, supporting the development of innovative markets for climate change mitigation and adaptation-related products and services. Financing clean energy technology R&D and implementation, energy efficiency projects as well as climate-resilient infrastructural developments, such as the Masdar initiative and Sustainable City, are among the prospects for economic expansion in the UAE taking into account future climate change. In the context of the UAE Green Agenda 2015-2030, developed to implement the Green Growth Strategy with a concerted effort of federal and local authorities, the Green Diversification Programme offers a Finance and Investment Support Scheme aimed to stimulate the country's financial sector towards investment in green projects and innovating green finance products and services[452]. Based on a recent survey on readiness among national financial institutions, a roadmap is envisaged to mainstream green finance in the UAE[453].

Financial institutions are integrating social and environmental factors, including climate risk, into their lending globally, and in the UAE. Disclosure requirements for climate exposure in investment portfolios are becoming more and more important: investment managers are increasingly required to signal to their asset owners and shareholders that they are 'climate aware', by accounting for, and assessing climate risk and resilience[454]. Several financial institutions have adopted the Equator Principles (see Box 10), and some have also established further and more stringent policies for lending to sectors perceived at higher risk (e.g. water infrastructure etc.).

Box 10 Equator Principles and ClimateWise principles for climate resilience in the financial sector

The Equator Principles (EP) are a risk management framework for determining, assessing and managing environmental and social risk in projects and is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making.[455] Currently 83 Equator Principles Financial Institutions (EPFIs) in 36 countries have officially adopted the EP, covering over 70 percent of international Project Finance debt in emerging markets.

ClimateWise is a global network of over 30 leading insurers, reinsurers, brokers and industry service providers who share a commitment to reduce the impact of climate change on society and the insurance industry. The ClimateWise Principles are an international standard tailored specifically to the insurance sector – aiming to ensure that all aspects of the industry's core business activities are aligned with climate change risk. [456]

Principle 1
Lead in risk analysis

Principle 2
Inform public policy making

Principle 3
Support climate awareness amongst our customers

Principle 4
Incorporate climate change into our investment strategies

Principle 5
Reduce the environmental impact of our business

Principle 6
Report and be accountable

Infographics: ClimateWise.

THE INSURANCE INDUSTRY IS EXPOSED TO CLIMATE RISKS THROUGH ITS INVESTMENTS

The insurance sector is exposed to future liabilities from climate impacts[457]**.** Climate change events and insured global losses are on the rise (see Figure 20). Climate change affects risk profiles for many types of insurance: property, commercial, health, liability risk etc. Furthermore, the industry is exposed to climate risk through its investments. Globally, the insurance industry had assets under management of US$ 24.1 trillion (as of 2012). These assets are critical for covering underwriting obligations and generating additional income, and can be impacted by climate change. Industry-wide collaboration and public-private partnerships are emerging, such as the ClimateWise initiative (see Box 11). In addition, the sector is being increasingly scrutinised by regulators in relation to insurers' short and long term capital management strategies around climate risk.

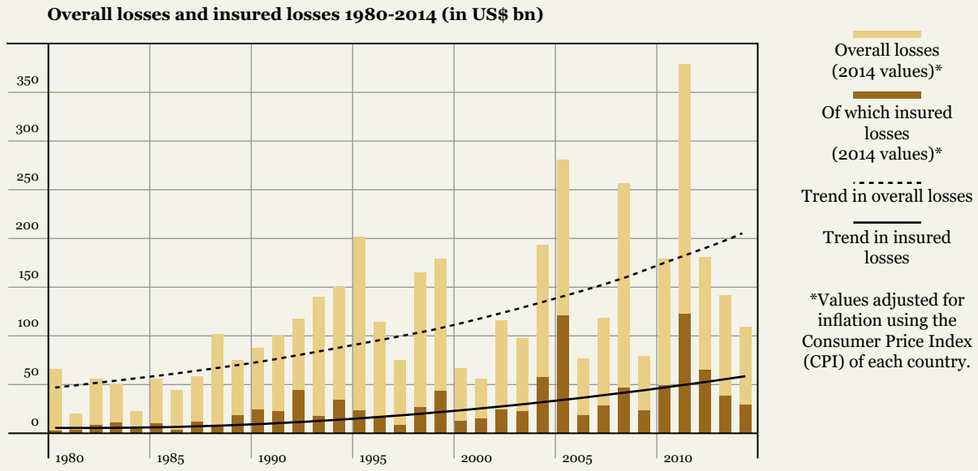


Figure 20 Overall losses (which include insured and economics losses) and insured losses alone worldwide due to major natural catastrophes from 1980-2014 (Munich RE, 2015).[458]

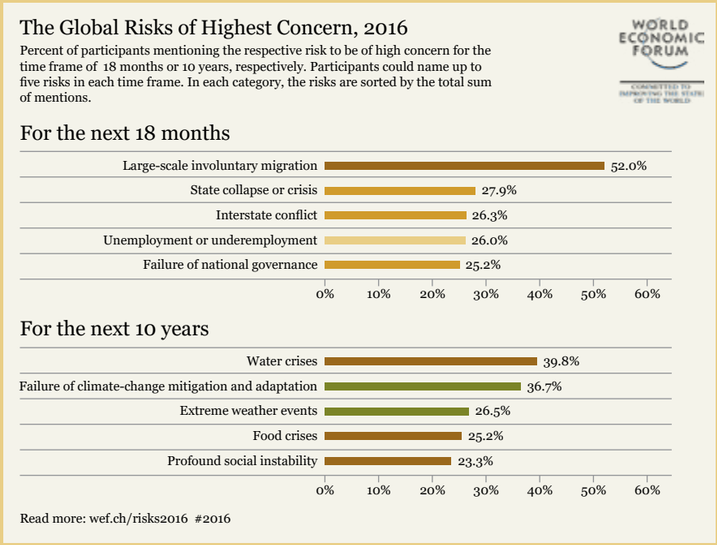
CLIMATE CHANGE BRINGS OPPORTUNITIES FOR THE MARKET TO DEVELOP INNOVATIVE INSURANCE SCHEMES AND PRODUCTS

Consideration of climate change impacts could lead to adjustments in the insurance sector of the UAE towards innovative schemes and products. Due to the additional risks induced by climate change, more risk capital may be needed for businesses, which will in turn raise insurance premiums, for example, to cover asset damages by extreme weather events.[459] While insurance companies may gain from increased premiums in the short term, they may decide to abandon certain markets or locations if assets become uninsurable in the future, as has been observed in the U.S.A. for properties located on the Gulf coast region and areas prone to wildfire.[460] Further, insurers based in the UAE may be exposed to climate-related losses in other countries: a local insurance company based in the UAE reported significant technical losses from its core re-insurance subsidiary associated with the Thailand floods in 2012, which were considered among the top five costliest natural disasters in modern history.[461] However, in the context of the still-evolving UAE insurance industry, in the short to medium term climate change brings opportunities for the market to develop innovative insurance schemes and products that meet the need of corporations, households and investors as well as financial institutions. In particular, operations related to major energy efficiency and clean energy projects require specific instruments to cover business risks (e.g. underproduction) and new services to assess and mitigate climate risks[462].

Box 11 Illustration of climate change intertwined impacts on international trade

Climate change represents a concern to the more and more interconnected global markets. The World Economic Forum 2016 Global Risk Report highlights that executives in oil-exporting countries in the Middle East and North Africa perceive the risk of energy price shocks and water crises among the most serious threats to their investments, with low oil prices leading to a decline of exports and revenue, and water being a depleting key input in industry, energy production and agriculture.[463]

The 2017 Global Risks Report also features environmental concerns as a top area of risk with extreme weather events and natural disasters considered in the top 3 risks in terms of likelihood.



The production of food and energy commodities concentrated in a handful of countries tends to be more exposed to extreme weather events that can disrupt processes, infrastructure, transport networks and supply chains. Higher volatility of prices of internationally traded commodities resulting from shortages in supply is likely to generate financial shocks in both importing and exporting countries by the 2020s.[464] Political instability may be an undesirable consequence of such price shocks, when climate change compounds with other vulnerability factors. Some researchers assert that climate change was a "necessary component" of the complex scenario that led to the 2011 Arab Spring riots, triggered by wheat price spikes following a major drought in Russia and other key countries in 2010.[465,466]

Infographic: Global risks of highest concern for business in the next 18 months and 10 years. The percentages show the number of participants to the WEF global survey mentioning the respective risk to be of high concern for the 18-month and 10-year timeframes. Risks are ranked according to the total sum of mentions. – World Economic Forum (2016)

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3.4.5 Cultural heritage, tourism and hospitality

The UAE is one of the world fastest-growing travel destinations[467] welcoming over 10 million business and leisure travellers in 2013, with Dubai's tourists at 13.2 million in 2014.[468,469] The tourism industry contributed 14% to the UAE's GDP and attracted about a quarter of the country's total investment in 2012,[470] and provided more than 307,000 jobs in 2014, with expectations to rise to 420,000 by 2025[471]. In Dubai alone, the direct contribution of tourism to Dubai's GDP was AED 37 billion in 2012.[472] Annual international tourist arrivals to the UAE are expected to total 26 million by 2023.[473] The tourism sector in the UAE relies heavily on resources that attract travellers and thus generate income for local economies.[474]

CLIMATIC CONDITIONS ARE THE THIRD MOST COMMON ATTRIBUTE IN TOURISTS' DECISION-MAKING IN CHOOSING A DESTINATION

The continued success of the UAE's tourism industry is potentially at risk from climate change.[475] Studies suggest that the UAE ranks amongst the countries set to lose out on visitors by 2025 due to climate change[476,477] and predict a 55% decline in international tourists visiting the UAE by the end of the century.[478] However, more research is needed to project changes in tourism behaviour and responses to the impacts of climate change on the UAE.

There will be a decline in the "tourist comfort climate index" in the Arab region in the coming decades.[479] Climatic conditions are the third most common attribute in tourists' decision-making in choosing a destination[480], and determine the length and the quality of a tourism season.[481] Indicators of tourism comfort combine data on temperature, precipitation, sun and wind conditions, and humidity, to indicate the degree of climatic comfort that tourists feel at a given site.[482]

CLIMATE INCIDENTS TO TOURIST FACILITIES COULD INTERRUPT BUSINESS AND CAUSE INCOME LOSS

Tourism businesses, which are usually location-specific, have a lower adaptation potential than tourists themselves, who have a wide range of destination options.[483] Many tourism assets, including hotels, resorts, beaches, waterfront promenades, as well as heritage assets which draw tourists to the UAE are in the coastal zone, and therefore may be vulnerable to increased flood risk due to sea level rise. Tourist facilities can also be affected by other extreme climate-related events. In March 2014, for instance, many areas in Dubai were flooded due to heavy rain and caused the closure for safety purposes of the 'Global Village'[484], the region's leading outdoor theme park with a capacity of 6 million annual visitors[485]. These kinds of incidents, if they happen more frequently, can lead to business interruption, income loss, repair costs and reputational damage. The reputation of the tourism industry can also be affected by impacts on transport infrastructure, such as weather-related disruption at airports (see Section 3.4.5).

Climate change has effects on many environmental resources which constitute important assets for the UAE tourism sector such as its biodiversity and landscape.[486] The UAE offers its visitors a diverse ecological profile, including a long coastline, beaches, rich marine life, mountains, valleys, deserts and several natural reserves.[487] The Abu Dhabi Global Environmental Data Initiative estimated that the amenity which the coastal and marine resources supply in Abu Dhabi are worth some US$141 million.[488] A well-protected coastline around Abu Dhabi is therefore important to remain both the economic revenues from tourism and beach leisure activities, as well as to secure the image of Abu Dhabi.[489] The latter is especially crucial given the intention to market Abu Dhabi as a global destination of choice for international and predominantly high value visitors.[490] However, any tourism based on the natural environment in Arab countries will be affected by climate change.[491] Coastal tourist destinations in the UAE are particularly vulnerable to extreme events, floods, saline intrusion, harmful algal bloom events and loss of coastal areas, though, as noted elsewhere in this report, the impacts of climate change on the UAE's coastline are not currently well understood.[492] The high sensitivity of coral reef ecosystems to climate change may have serious negative implications for these popular tourist attractions (see Section 3.2.1).[493] These climate change impacts may also lead to the UAE being a less attractive place for expats to live and work.

TOURISM BASED ON THE NATURAL ENVIRONMENT WILL BE AFFECTED BY CLIMATE CHANGE

Tourist facilities are likely to see increased energy and food costs due to climate change. Energy consumption will be driven upwards by higher cooling demands as temperatures rise, and increase the imperative for tourist facilities to take strong action on energy efficiency. Food prices are also projected to rise due to climate change, with impacts on prices of food imported into the UAE (see Section 3.5 for further discussion).

3.5 FOOD SECURITY

3.5.1 Domestic agriculture, fishing & aquaculture

The development of the UAE agricultural sector is hampered by a lack of arable land, high temperatures, depleting freshwater resources for irrigation, soil salinity, elevated production costs, pests (locust swarms) and post-harvest losses[494,495]. In the UAE, the share of cultivated land has been decreasing sharply (-13% in crop areas in 2012 compared to 2011[496]) due to a combination of factors including salinization of soils as well as rapid population growth and related urbanization, while agricultural productivity has been increasing overall (+3.3% between 2007-2012[497]). Despite the growing number of farms operating as well as organic production areas,[498] agriculture still accounts for a minor share of the UAE's GDP (about 1% in 2007)[499] as well as of the total GHG emissions (1% in 2014).[500]

Subsidies in the agricultural sector contributed to a rapid rise in demand for groundwater resources for irrigation at rates that exceed natural aquifer recharge - with water tables dropping between 1.5 to over 5 meters per year.[501,502] Despite the small size of the sector, water demand for agriculture is large. It has been estimated that productive agriculture (excluding forestry and landscape management) currently absorbs 32% of all water resources in the whole UAE[503] and 50% in Abu Dhabi.[504] In the context of the UAE's agricultural expansion, water demand for agriculture is, however, expected to decline[505] relatively as a result of the efforts made by the government to promote water-saving irrigation systems (rather than flood irrigation methods)[506] and implement adequate policy frameworks and management measures. Climate change could weaken the progress made in water resource management in agriculture because of higher irrigation requirements, thus increasing the competition for water use among sectors.

WATER TABLES IN THE UAE ARE DROPPING BETWEEN 1.5 TO OVER 5 METERS PER YEAR

Climate change will impact domestic agriculture in the UAE due to increased mean temperatures, reduced availability of freshwater resources, increased short-term weather hazards, soil erosion and loss of arable land, and increased disturbance from fires, plant diseases, pest outbreaks, leading to an overall decline in agricultural output.[507] In the absence of adaptation, agricultural and food production of vegetables, fruit crops and field crops are threatened by climate change as it increases vulnerability to existing stresses. Impacts could be greater on the economies of Abu Dhabi and Ras Al Khaimah, as these emirates are the major contributors to this sector in terms of crop land.[508]

The UAE has been officially recognised as the world leader in date palm farming, an activity characterised by high social and cultural importance, but production has faced several challenges which will be exacerbated by climate change. Dates were the top-produced commodity in terms of quantity and value in 2012.[509] The main weaknesses currently associated with date production include low yields, spread of pests (Red Palm Weevil) as well as processing and marketing constraints, besides the unsustainable usage of water resources. Climate change will boost the distribution of the Red Palm Weevil pest, and affect the fragile oasis agro-ecosystems through direct and indirect impacts on water[510], thus further affecting the already-vulnerable date farming industry in the UAE. Recent case studies show that in Morocco a number of oases have lost 40% of their vegetation, and in Libya some palm orchards disappeared completely due to the combined effects of climate change and depletion of aquifers in the desert.[511]

HIGHER TEMPERATURES WILL AFFECT LIVESTOCK AND CONTRIBUTE TO SPREADING ANIMAL DISEASE OUTBREAKS

Thermal stress induced by climate change will negatively impact on pastures and livestock production. Livestock in the UAE include sheep, goats, camels and imported cattle for meat and dairy farming, as well as intensive poultry farming. In the absence of adaptation measures, higher temperatures will affect livestock. Temperature increases are also considered a key factor in the spreading of new or re-emerging animal disease outbreaks.

Camel breeding and camel milk production is a traditionally sustainable activity that is becoming more and more vulnerable to desertification. The UAE has the highest density of camels (more than 2 camels/km²) in the world[512], particularly significant in terms of cultural heritage. In several countries traditional camel farming has been undergoing changes (e.g. growing camel population, less productivity/adaptability of the species due to lack of selection, intensification of the management system) that undermine its low environmental pressure nature when confronted with growing desertification.[513] Challenges may arise for the UAE in this sector in relation to industrial camel farming which relies on fodder from Australia, where its production will be impacted by climate change. Also, traditional camel farming which relies on local fodder, although smaller in numbers, requires consideration.

Fish is a vital food resource in the UAE and increased fish stock vulnerability caused by overfishing is being partially balanced by aquaculture developments. The UAE waters are home to nearly 280 fish species, including important commercial ones, which represent the only major food source the UAE does not need to import. The UAE fisheries sector is experiencing a remarkable decline in output, both in terms of a reduction in the quantity of fish caught (-3.2% in 2012 compared to the previous year) and value of the country's production of fish (-11.3% in 2012).[514] Following the 1999 fisheries protection,

ACIDIFICATION AND LOSS OF MARINE HABITATS AND BREEDING GROUND WILL REDUCE FISH AVAILABILITY

exploitation and conservation regulations, sustainable aquaculture projects are developing, with a selection of marine species made to provide a partial compensation for the loss of fish stock due to overexploitation by the capture fishery sector.[515] Thanks to favourable hydrographical conditions along the east coast, commercial scale aquaculture (or mariculture) is also emerging, with various crustaceans, pearl oysters cultivations, and finfish[516] including the largest sturgeon farming in the world for caviar production[517].

Climate-induced impacts on fisheries, aquaculture and mariculture will mainly depend on changes in sea water temperature and related alterations in natural habitat conditions, affecting existing vulnerable fish stock (see Box 12). Acidification of waters and related loss of natural marine habitats and breeding grounds (mangroves, coral reefs) would impact food chains and ultimately reduce the availability of fish resources (see also Section 3.2.1). For example, changing surface water temperatures might affect the availability of commercially important fish species, such as kingfish,[518] shrimp, snapper, grunt fish and sea bream.[519] Moreover, decreasing water quality could also imply potential human health threats in relation to production of molluscs in areas affected by toxic tides, due to eutrophication and harmful algal blooms associated with higher water temperatures[520].

Box 12 Illustration of Climate Change Impacts on UAE's Fishing Industry

Climate change can have various impacts on fisheries. Capture fisheries can face challenges due to altered fish productivity and distribution, as well as a migration patterns.[521] Disruption to business for fishermen is increasingly being observed in the region, as was seen during the 2010 heatwave in Qatar[522], the 2014 strong wind event in the UAE[523], and the 2015 cyclone in Yemen.[524]

A growing aquaculture industry might be faced with changing species composition due to changing water temperatures; feed composition could be affected and the risk for disease outbreaks in the farms might increase.[525] Ambitious aquaculture initiatives such as sturgeon farming may have to bear additional costs to mitigate climate change-induced risks in relation to water and energy, and become less cost-efficient. In both cases, the rising risk of extreme weather events might make relocation of production, harvest, and landing sites necessary.[526]

Although the bulk of the fish and seafood consumed in the country is imported, the UAE's consumption is amongst the highest in the Gulf,[527] thus risks to the national and international fishing industry represent an important problem. The frequency of dangerous algal blooms can also be impacted by the changing climate;[528] they can harm or even kill fish stocks in the Arabian Gulf by depleting oxygen in water or even producing toxins.[529] So-called red tides (overgrowth of algae that makes the water appear red) killed large amounts of fish in 2008 and 2009 and could be a threat to open-water fish farms as well.[530]

Picture: Fishermen / Emirates 24/7[531]

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87% OF THE UAE'S FOOD SUPPLY IS IMPORTED AND DEPENDANT ON INTERNATIONAL TRADE FLOWS

3.5.2 International food imports

The UAE is usually classified as a 'food secure' country, at least at the macro level, based on a food security index for the MENA region (2012) and FAO data (2015)[532]. However, the UAE's food supply is highly dependent on international trade flows. According to the report on "Food security and climate change" recently released by AGEDI, given the low volumes of domestic agricultural production, the UAE relies heavily on international food imports (for 87% of food supply in 2011), with certain products (e.g. oil crops, sugar, cereals) being entirely contingent on the production of a small group of food-exporting countries that will in turn be subject to increasingly negative climate conditions for agricultural production.[533] Furthermore, the report indicates that UAE serves as a major regional hub for re-export of food commodities. Despite recent policy improvements, food insecurity may remain an issue locally.[534]

The definition of food security, however, needs to be fine-tuned in the UAE context. The UAE managed to translate its economic growth into improved quality of life for its citizens, including a broad and diversified food security. This is intended to provide high-end food availability accessible to virtually everybody, and this is expected to be maintained in the decades - and centuries - to come.

The overall dimension of food security in the UAE is affected by climate change. Access to food may be an issue for vulnerable segments of the population. At trade level, food security is an availability issue: whereas price shocks are compensated by the wealth of the nation, quantity shocks need a sound buffer provided by diversification of supply.

CLIMATE CHANGE WILL CONTRIBUTE TO

A RISE FOOD PRICES

CONSIDERABLY BY 2050

Climate change will impact the reliability of international food markets and ultimately destabilise food security in the UAE and the whole GCC region. Volatility of global food prices is associated with mainly non-climatic drivers (e.g. increasing demand, costs of fertilisers, production of biofuels from corn and sugar crops, economic speculation).[535] However, because of increased severity and occurrence of weather events negatively affecting production levels, climate change will contribute to raise food prices considerably by 2050 in several food-exporting countries.[536] According to research by AGEDI, most food imports to the UAE will be constrained under climate change, especially from Brazil, India, Iran, and South Africa (see Table 2, left panel). For the UAE wheat and rice are likely to become the most 'insecure' food items under climate change, while beef, lamb meat, and maize will remain relatively secure (see Table 2, right panel).[537]

Climate change impacts on food access will have consequences for vulnerable segments of populations and lower-income (particularly expat) households where budgets available for food will be increasingly stretched. Climate change could bring serious shifts in food spending patterns, creating more vulnerable households, especially when combined with other stressors e.g. inflation. Social protection mechanisms in the Emiratis are already in place which aim to address food access and the need for these mechanisms may increase with climate change.

Table 2 Food insecurity index per major food exporter country to UAE (left); Food Insecurity Index per food item for UAE (right). The Index ranges from 1 to 10, with 1 representing strongly secure and 10 representing strongly insecure (AGEDI, 2015).[538]

	Criterion		
Country Name	**Share of Imports**	**Climate change impact**	**Food Security index**
Argentina	4	2	3
Australia	4	2	3
Brazil	7	3	5
Canada	2	1	2
China	2	3	3
Egypt	1	3	2
Ethiopia	1	2	2
France	1	3	2
Germany	2	5	4
Gulf countries	2	2	2
India	9	3	6
Indonesia	1	4	3
Iran (Islamic Republic of)	3	8	6
Jordan	2	2	2
Lebanon	1	2	2
Malaysia	2	4	3
Netherlands	2	2	2
New Zealand	1	2	2
Pakistan	3	4	4
Paraguay	2	3	3
Philippines	2	5	4
South Africa	2	10	6
Spain	1	2	2
Thailand	2	4	3
Ukraine	2	2	2
United States of America	2	4	3
All other countries	10	3	7

Food item	**Food import status**	**Food Security index**
BEEF (i.e., Bovine Meat)	Unconstrained	1
CASS (i.e., Cassava)	Constrained	6
CHKP (i.e., Pulses)	Partially constrained	3
EGGS (i.e., Eggs)	Partially constrained	2
GRND (i.e., Groundnuts)	Constrained	6
LAMB (i.e., Mutton & Goat)	Unconstrained	1
MAIZ (i.e., Maize)	Unconstrained	1
MILK (i.e., Milk)	Partially constrained	3
MILL (i.e., Millet)	Constrained	6
ORGN (i.e., Barley)	Constrained	6
PKOL (i.e., Oil - Palm)	Partially constrained	3
PORK (i.e., Pigmeat)	Constrained	6
POTA (i.e., Potatoes)	Partially constrained	5
POUL (i.e., Poultry Meat)	Partially constrained	3
RICE (i.e., Rice Milled)	Constrained	10
RPOL (i.e., Rape)	Constrained	6
RPSD (i.e., Rape)	Constrained	6
SBOL (i.e., Soyabean Oil)	Constrained	6
SFOL (i.e., Sunflower seed oil)	Constrained	6
SNFL (i.e., Sunflower seed)	Constrained	6
SOYB (i.e., Soybeans)	Constrained	7
SUBF (i.e., Fruit)	Constrained	8
SUGC (i.e., Sugar [raw])	Partially constrained	2
SUGR (i.e., Sugar [Refined])	Constrained	7
SWPY (i.e., Sweet potatoes)	Constrained	6
TEMF (i.e.,Fruit)	Constrained	7
TOOL (i.e.,Oil - Other)	Constrained	4
VEGE (i.e., Vegetables - All)	Constrained	8
WHEA (i.e., Wheat)	Constrained	10

FOOD DEGRADATION

FROM HIGH TEMPERATURES IS LIKELY TO BECOME MORE OF AN ISSUE IN THE UAE

A decrease in food quality is considered an emerging risk in the UAE and, potentially, the wider GCC region. Food degradation due to high temperatures is likely to become more of an issue in the UAE. Furthermore, the quality of food for re-export to the wider GCC region could be affected, unless adaptation action is taken. The UAE's re-export facilities may see higher costs and efficiency losses due to physical impacts of climate change such as thermal stress and floods.

The UAE's drive to purchase agricultural land abroad may prove ineffective under changing climate - and related political - conditions. Part of the UAE government's strategy to tackle food security involves establishing physical food storage abroad and acquisition of farmland in African, European and Asian countries.[539,540] According to research by Emirates NBD, as of mid-2014, UAE investors had been involved in at least 28 agricultural deals covering approximately 1 million hectares of land for agricultural use worldwide (see Figure 21). There is significant uncertainty about the effectiveness of this long-term insurance strategy of securing land agreements with other countries in the light of climate change, as it is possible that some of them will be highly affected by climate change - both through more extreme weather events and reduced productivity over time. Political decisions driven by climate impacts could affect these agreements: for example, sudden droughts or food shortages could lead host governments to impose export bans.[541]

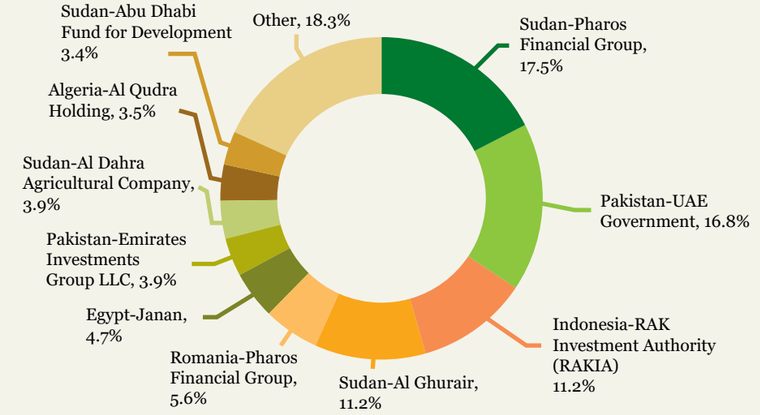

Figure 21 Top 10 UAE international agricultural projects, percentage of total 1mn hectares, as of mid-2014 (NDB, 2014)[542]

Other indirect impacts of global food price instability are a threat to financial security as well as human security. When a decreasing share of food commodities enters the global markets, these are characterised by high price volatility and high bid-ask spread. 'Agflation', or inflation driven by rising agricultural commodity prices, has been observed to contribute to broader financial crises, as occurred in the USA and European markets in 2008[543], in the context of an already volatile financial system. Emerging markets, where food goods represent larger weightings in consumer price indices, are particularly sensitive to agflation. Also, as the UAE's Dirham is pegged to the US$, the UAE may be especially subject to a concurrent fall in the value of US currency and escalation of food prices. Climate change is considered a 'threat multiplier' in the medium-term[544,545,546]; however, the extent to which climate change will induce price fluctuations and associated socio-economic impacts on the UAE will need to be assessed further.

CLIMATE CHANGE IS CONSIDERED A 'THREAT MULTIPLIER'

IN THE MEDIUM-TERM; HOWEVER, THE EXTENT TO WHICH CLIMATE CHANGE WILL INDUCE PRICE FLUCTUATIONS AND ASSOCIATED SOCIO-ECONOMIC IMPACTS ON THE UAE WILL NEED TO BE ASSESSED FURTHER.

3.6 SUMMARY OF IMPACTS ON VISIONS, STRATEGIES & POLICIES

The previous sections provided a sectoral breakdown of major impacts and risks arising from climate change in the UAE. This section aims to summarise the main consequences that such impacts and interconnected risks will have on the national agenda and existing development plans towards the achievement of economic diversification and overall social wellbeing.

The UAE's society and economy have always endured harsh environmental conditions, successfully facing water scarcity and intense heat. However, the scale of impacts that are expected from climate change may exceed the coping capacities of many sectors. Significant changes in air and sea temperature, increased variability of precipitation and unpredictable patterns of extreme events will lead to a multiplicity of secondary impacts in all sectors of the economy as shown in this report. Compounded with high demographic pressure and fast socio-economic transformation, impacts on critical assets such as water resources, coastal areas and energy will propagate rapidly to other sectors.

Interconnected risks posed by climate change are particularly evident in the water-energy-food nexus, where the increasing use of and stress on these resources has an impact on the others. These are bound to represent a challenge to the national agenda.[547] Water is at the core of most strategic sectors in the UAE. Warmer seawater used for cooling in power generation processes and other industrial functions will result in a loss of efficiency in energy production and higher costs for firms. At the same time, water desalination is an energy-intensive activity, carrying high environmental costs, and is likely to be affected by higher energy costs. Declining water quantity will have direct impacts on agricultural output and food production costs. In addition, most food supply in the UAE is reliant on agricultural production abroad, in countries prone to climate risks. Water quality in turn depends on the adequate treatment

of waste water after agricultural and industrial use, compounded by the adverse impacts on water associated with high temperatures. Reduced water quality will further affect other sectors such as public health, tourism and biodiversity. The availability of these three vital assets is likely to shrink under climate change. While changes in energy pricing have immediate effects on economic growth, water insecurity and food insecurity may have a more pervasive, longer-term impact on the socio-economic system.

THE UAE'S EFFORTS TOWARDS ECONOMIC DIVERSIFICATION **WILL BE SLOWED BY CLIMATE CHANGE** IF IMPACTS ARE UNMANAGED

The UAE's objectives of GHG emission reduction, clean energy and energy and water efficiency will be impossible to achieve without considering climate change risks. An energy demand-supply gap associated with the combination of increased energy demand for cooling for residential and industrial purposes and marginal losses in power supply may hamper energy security and GHG emissions reduction policies. Energy efficiency measures in the building and construction sector will have to deal with changing, uncertain climate conditions, requiring further adjustments in regulations, standards, designs and materials. Finally, reducing water overuse from the current 6.95 to 4.0 ratio – measuring fresh water usage (including surface water, renewable water and fossil water) as a percentage of overall renewable water in the UAE - would require the Ministry of Energy to consider future climatic pressures in the efficient management of both the demand and the supply side.

The UAE's efforts towards achieving economic diversification and overall wellbeing of the population will be slowed down by climate change impacts if left unmanaged. Direct impacts of extreme weather events as well as slow-onset phenomena such as sea level rise, will likely cause disruption in the everyday functioning of transport and infrastructure, impact the value of real estate, damage the tourism and real estate industry. Consequences will be felt in the whole national economy and the financial sector, and magnified in the context of the global interconnected markets for goods and services.

4. GUIDANCE FOR ADAPTATION POLICY PLANNING AND IMPLEMENTATION

THIS REPORT OFFERS AN **INITIAL VIEW** OF HOW CLIMATE CHANGE WILL IMPACT THE UAE BUT IS NOT A COMPREHENSIVE RISK ASSESSMENT

This report provides a comprehensive starting point for assessing risks and vulnerabilities to climate change. Building mostly on existing global and regional studies, it offers an initial view of how aspects of the UAE economy, society and ecosystems could be affected by multiple impacts associated with climate change, unless action is taken to adapt. This report, however, does not represent an in-depth climate change risk and vulnerability assessment, for which new dedicated research at the national scale is required as it will provide a deeper understanding of the sectoral risks and allow the process to build a climate-resilient, diversified economy to continue effectively.

Despite the relatively limited availability of localised information on climate-induced impacts and risks, the UAE government is beginning to take action on climate adaptation under the guidance of the new Ministry of Climate Change & Environment (MoCCAE). Climate change is already partly considered in national development policies - mostly in relation to energy efficiency - as well as in some sectoral policies. Although climate adaptation is not addressed specifically in national and local development plans, scattered initiatives bringing adaptation and mitigation co-benefits are ongoing (see Section 1.2.3).

Against this backdrop, the development and adoption of a comprehensive climate change strategy and plan containing an adaptation component, led by the MoCCAE will represent the planned continuation and enhancement of a spontaneous process underway, and allow to build a consistent framework for adaptation action in the UAE. The government would then need to ensure concrete implementation of identified strategic priorities through an action plan. The experiences in countries that have adopted a National Adaptation Strategy and are implementing a National Adaptation Plan show that these are different and complementary processes[548,549]. While a strategy is typically a vision for adaptation at the country level, a plan is the way in which it is executed (see Box 13).

Box 13 National Adaptation Strategy and National Adaptation Plan: useful definitions

In the context of climate change policies, the terms 'National Adaptation Strategy' and 'National Adaptation Plan' are commonly used and understood as follows:

A **National Adaptation Strategy** is a policy document presenting a national vision on how to deal with current and future impacts of climate change. A strategy typically identifies a set of guidelines and actions to address these impacts in key socio-economic and environmental areas or sectors, with the aim to reduce the risks posed by climate change, increase resilience of human and natural systems, and take advantage of any opportunity that may arise from the new climate conditions.

A **National Adaptation Plan** is a technical document aimed at enabling the implementation of the actions put forward in the Strategy. A plan typically covers the following elements: provisions for implementation of the Strategy (or part of it) based on priorities identified by the relevant institutions; identification of key responsibilities for implementation based on the governance structure of the country; planning and allocation of the necessary financial resources; provisions for monitoring and evaluation of the implementation process by means of indicators.

Although characterised by distinct status, scope and function, Strategy and Plan can be integrated in a single document as appropriate.

This section provides guidance on adaptation policy planning and implementation, by briefly summarising the **principles** to consider when **planning** for adaptation, as well as the processes for developing robust climate change adaptation policy frameworks and action plans.

4.1 PRINCIPLES

According to previous experiences in other countries, a simple roadmap to 'successful adaptation' can be outlined. A good climate change adaptation strategy should[550]:

- Adopt a forward-looking, long-term approach to risk management;
- Aim to reduce vulnerability and risk today and in the future, whilst avoiding foreclosing options;
- Promote flexible and iterative risk management. Risk management should be a continuous process of change management that proactively learns and responds to new information, rather than being a one-off 'optimised' decision.

Although there is no shared definition of successful adaptation, a number of commonly agreed principles to consider when planning for adaptation do exist. These are in addition to the common policy principles of effectiveness, efficiency, equity and legitimacy that are key to judge success[551]. These adaptation principles help ensure the achievement of adaptation goals without at the same time causing negative effects in other contexts, sectors or communities involved.

Guiding principles for adaptation planning and processes include the following[552,553,554,555,556]:

1

Build capacity about climate change and adaptation at all levels.

Given the complex nature of climate change impacts and multiple solutions available, it is crucial to initiate or strengthen the process to build knowledge and awareness within the country in order to enable successful adaptation. A national adaptation strategy should therefore include provisions for communication, education, knowledge transfer and capacity building, targeted at the general public and different stakeholder groups, including state and non-state actors, through a variety of means (such as personal consultations, media and internet communication, targeted events, etc). The general knowledge base on potential climate change impacts and adaptation should be improved through better access to user-friendly data and information provided by the research community, especially for local levels.

2

Integrate climate change into existing processes and policies in key sectors.

Adaptation is to be intended not only as an 'environmental' policy to manage risks of current and future climate impacts on the ecosystems, but also as a process that promotes mainstreaming of climate change concerns in key public policies and private sector practices, in climate-sensitive sectors. Adapting to climate change requires modifying or supplementing the current national and sub-national legislation, as well as integrating investment plans and projects, in such a way to ensure that consideration of current and future impacts is truly apparent in a concrete decision. A common example is public infrastructure investment, where an early consideration of climate risks when developing and implementing an infrastructure strategy is understood to be important to avoid long-term 'lock-ins' of vulnerability: A new airport that is built without considering current and future climate risks may require some costly modifications or may even become unusable unless it is designed and build with climate adaptation in mind.

EFFECTIVELY INTEGRATING
ADAPTATION DEPENDS ON FACTORS SUCH AS ASSIGNMENT OF CLEAR RESPONSIBILITIES

Effectively integrating adaptation depends on factors such as assignment of clear responsibilities (e.g. for coordination, information provision, taking actions), training of staff and a sufficient dedicated financial budget[557]. However, in some cases, the modification of existing policies, structures and processes may be insufficient to address the urgency or extent of adaptation and the development of new instruments may be required[558].

So far, the government of UAE has primarily conveyed climate change adaptation through environmental policies aimed at natural resource management, including:

- *National Biodiversity Strategy Action Plan*
- *National Strategy for Combating Desertification*
- *National Strategy for the Sustainability of Marine and Coastal Environment*
- *Water Resources Conservation Strategy in UAE (2010)*
- *Water Resources Management Strategy in Abu Dhabi (2014 – 2018)*
- *Abu Dhabi Plan Maritime 2030.*

Also, mainstreaming of climate change has been initiated in other key sectoral policies, such as:

- *Draft National Strategy and Action Plan for Environmental Health.*

Considerations of climate change impacts and risks should be further stressed and integrated into public policies driving economic growth and energy, both at the federal and Emirate level, including for example:

- *UAE Vision 2021*
- *Green Growth Strategy, and related UAE Green Agenda 2015-2030*
- *National Innovation Strategy*
- *Abu Dhabi's Economic Vision 2030*
- *Dubai's Plan 2021*
- *Dubai Clean Energy Strategy 2050*

The suitability of each of these policies should be further assessed in terms of their opportunities for incorporating adaptation considerations over the short, medium or long term.

3

Ensure compatibility with existing levels of governance and how they work together.

Adaptation action spans many different levels of government, and needs coordination across departments and sectors in order to exploit inter-linkages and avoid possible conflicts (horizontal coordination). The government of the UAE could consider establishing appropriate institutional arrangements that would improve dialogue and harmonization among relevant authorities under the guidance of the MoCCAE (e.g. an inter-ministerial committee on climate change / inter-ministerial working group on adaptation). Assigning responsibility and ownership are important elements for this. Departmental 'adaptation champions' could support this cross-governmental work.

ADAPTATION REQUIRES A MULTI-LEVEL GOVERNANCE
RESPONSE SPANNING VARIOUS DECISION-MAKING SCALES

Furthermore, adaptation requires a multi-level governance response spanning various decision- making scales from international to national and sub-national administrations in order to provide adequate means to take action (vertical coordination). Continuous involvement and consultation are key to ensure direct engagement of Emirate-level authorities to adaptation decision-making, especially of smaller entities whose voice may be less often heard. For the national government it would be important to consider the level of existing capacity for adaptation across those different governance layers.

4

Work in partnership with other stakeholders to develop and implement adaptation measures through bottom-up engagement and transparent decision making.

Adaptation to the impacts of climate change is a challenge that involves - besides the federal government and local administrations - a large number of stakeholders from both public and private sectors. As seen in other countries, most adaptation is undertaken by private actors – households, firms and civil society. National government has a role to play in enabling those adaptation actors as they often face barriers as well as a lack of capacity and skills[559]. The active involvement of citizens and their associations can bring significant added value to the process of adaptation planning and implementation. Forms of involvement of the private sectors could be envisaged aimed at creating partnership in the implementation and management of priority adaptation actions. Since adaptation is expected to take place at the local scale mostly, it is key to ensure the buy-in of actual implementers.

TRANSPARENCY AND OPENNESS
ARE ESSENTIAL TO BROAD PARTICIPATION ON ADAPTATION PLANNING

Transparency and openness are essential premises to broad participation and ultimately to the sustainability of adaptation actions. Adaptation decisions are value-laden in relation to the level of risk to be accepted by a society as a whole. Therefore, such decisions need to be made transparent to be able to agree on solutions that are fair and balanced. The government of the UAE could consider establishing an open and continued communication channel, aimed at informing the stakeholders about the effects of various adaptation options, both in the near and long term, in order to improve public awareness and acceptance of the actions being taken.

Box 14 Engaging the right stakeholders

Stakeholders to be involved in the adaptation processes include:

- National, regional and local government and their departments, across sectors;
- Emirate-level regulatory bodies (such as Environment Agencies and utilities, and utility regulators);
- Representatives of Non Governmental and non-for-profit Organisations and civil society;
- Executives and managers of national and international corporations, small and medium-sized enterprises;
- Representatives of the national scientific and research community and academia;
- Individual citizens.

A variety of approaches to engaging society has been realised in support of the different phases of adaptation planning (and implementation) across European countries.

5 Implement systematic monitoring and evaluation of progress towards effective adaptation

Monitoring and evaluation (M&E) of the overall progress towards climate change adaptation is key to ensure implementation of actions and integration of climate change considerations in sectoral policies. The effectiveness of the decisions and the progress in adaptation should be the subject of a monitoring and continuous evaluation through, for example, a centralised M&E scheme with appropriately validated indicators, which are based on processes (to measure progress in implementing the measures) and results (to measure the effectiveness of the intervention).

European countries have established a different set of methodologies for tracking progress in implementing adaptation. For example, while Germany and UK have developed a quantitative method (including the use of indicators), Finland and Spain have chosen a more qualitative approach for monitoring and evaluating their strategy (periodic reports, self- assessment like).

6 Adopt an evidence-based approach to inform decision-making.

Adaptation must be based on scientific evidence, and make full use of the latest research, data and practical experience so that decision-making is well-supported and informed. In the UAE, a growing wealth of national research is becoming available, including relevant studies by AGEDI, Stockholm Environment Institute/Environment Agency of Abu Dhabi, Masdar Institute, United Arab Emirates University, and the present report, which can feed into the knowledge base for adaptation. However, extensive and in-depth scientific assessment about possible impacts, country vulnerability and risks associated with climate change is still broadly needed.

AGEDI have finalised their Local, National and regional Climate Change Programme (LNR-CCP). This includes research on the potential impacts and risks of climate change on a number of key sectors in the UAE, including desalinated water supply, terrestrial and marine ecosystems, coastal vulnerability, and the energy and water nexus, and varying levels of water resources including transboundary groundwater resources as well as Al Ain water resources.[560]

STAKEHOLDERS SHOULD HAVE ACCESS TO **CLEAR AND RELIABLE INFORMATION** ON CLIMATE CHANGE IMPACTS

An essential precondition for proper adaptation action is to improve the knowledge base in order to increase the availability of more reliable estimates and reduce the scientific uncertainties about future climate change and its impacts. Policy-makers, stakeholders, local communities, associations and citizens should have easy access to clear and reliable information about the consequences of climate change to ensure proper awareness on this issue, and practical tools can be developed that can guide them in their choices.

Open sharing of climate change related data increases access to important data. AGEDI, for example, have developed online tools so users can easily access information and data from their research programme. Understanding climate change risks better requires an understanding of the underlying 'climate sensitivities' of infrastructure, systems and people, which can only be achieved if sector experts work together with climate scientists. There are a number of examples where further research into climate risks is required in the UAE to:

7 Emphasise measures that perform well under conditions of uncertainty including adaptive management.

Applying the principles of 'adaptive management' can facilitate decision-making when scientific uncertainty about future climate may become a reason for inaction (see Box 15). In general, adaptation policies and actions should be developed and planned case by case, in order to respond effectively to the various needs and local conditions, taking into account contextual factors (such as environmental processes, as well as socio-economic, technological, cultural, and political factors).

Therefore, it is necessary to adopt a flexible approach which enables the chosen adaptation solutions to evolve according to changing external conditions, to take into account the uncertainty of future developments, and to be updated based on the latest knowledge and information from the scientific community, and as experience and technology evolve.

Adaptive management can be realised by:

- Adopting **flexible or adaptive management options,** which imply putting in place incremental adaptation options rather than undertaking large-scale adaptation interventions in one go. A good example of such an approach is being implemented for Thames Flood barrier in London, UK. Flexibility is incorporated into the adaptation strategy (rather than the individual measures) by sequencing the implementation of different measures over time, such that the system adapts to climate over time, but options are left open to deal with a range of possible different future climates[561].
- Adopting **win-win measures** which attain benefits both in adaptation and in other contexts such as climate change mitigation or environmental pollution, such as building green roofs and greens walls which entail multiple benefits in terms of reducing building temperature and rainfall runoff, and reducing energy use for heating and cooling;

- Adopting **no or low-regret measures,** which attain benefits irrespective of climate change, such as actions or activities directed at building adaptive capacity as part of an overall adaptive strategy; reducing leakage from water utility infrastructure; establishing early warning systems and insurance against floods;
- Combining **different types of 'adaptations**': actions based on an ecosystem approach (e.g. water retention spaces in urban green spaces), infrastructural and technological actions (e.g. water saving devices; water harvesting systems), and non-structural actions involving managerial, legal and political solutions (e.g. water price). Integrated Coastal Zone Management (ICZM) efforts, for example, are intended to ensure a good mix between grey and green infrastructures as well as regulatory measures for costal protection.
- In general, adopting **robust measures** under a range of possible scenarios of changing climate, i.e. that are robust to uncertainty in future climate.

Box 15 Dealing with scientific uncertainty

Uncertainty about how the future climate will evolve globally, regionally and in the UAE is inevitable. Some aspects are more uncertain than others, for example we can be confident that average and extreme temperatures will rise because observations and a range of different climate models all agree this will happen. We have less confidence projecting other aspects of the climate, for example changes in the precipitation regime and potential exposure to tropical cyclones. Another important source of uncertainty is how these changes will impact different infrastructure, sectors and people in the country.

Figure 22 illustrates the 'cascade of uncertainty' where there are a range of possible future scenarios depending on how future societies will evolve and how much GHG they emit. In turn, various representations of global and regional climate (i.e. models) present a range of climate change 'results' based on these scenarios. Finally, the effects of these changes are interpreted through local impact studies. For example, a group (usually referred to as an 'ensemble') of climate models could project a change in annual rainfall at a specific location of between -20 and +20 %. The impact of this relatively large range of change on an individual economic system, person or asset depends on many interdependent projections of other influencing factors e.g. socio-economic development, which are likely to be even more uncertain than the original rainfall projections. We are left with an 'envelope of uncertainty' against which we need to plan. It should be emphasised however that uncertainty should not be regarded as a barrier to action. Rather, it needs to be managed through adaptive management and the adoption of low regret, win-win measures etc.

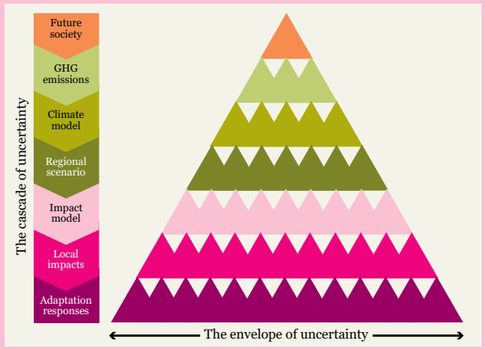

Figure 22: The cascade of uncertainty and envelope of uncertainty which confronts decision makers in the face of climate change.[562]

There are a number of ways in which the uncertainty surrounding climate change impacts can be reduced, or at least better accounted for. Firstly, through advances in climate science (e.g. observations and modelling) and secondly by a systematic assessment of climate impacts and risks. Adaptation responses can then be tested by decision makers against a wide range of plausible future conditions to find out which ones are most robust.

8 Address priority actions first.

An efficient approach to adaptation requires that the response to climate impacts should be prioritised in light of limited resources. The risks and opportunities arising from climate change must be assessed, evaluated and compared in order to formulate clear objectives and therefore identify priority responses also on the basis of specific and appropriate criteria characterizing the UAE society (e.g. urgency, effectiveness, efficiency, flexibility, reversibility, sustainability, robustness, fairness).

Early adaptation efforts should focus on action that:

- Delivers early and robust benefits (for example water efficiency),
- Avoids 'lock-in' vulnerability profiles for a long time (for example strategic decisions on infrastructure and land-use planning), and
- May have long lead times (such as research).

For example, priority for adaptation action should be assigned to sectors that are most weather- and climate-sensitive (e.g. water, agriculture and food security, tourism), those which have long lifespans or long-term implications (e.g. building and real estate, transport infrastructure and logistics, biodiversity and ecosystems), where significant investment is involved or high values are at stake (e.g. energy, oil and gas, financial services), or where support for critical national infrastructure is involved (e.g. energy, industry). Furthermore, emphasis should be given to those areas where turning risks into opportunities is achievable with relatively little investment (e.g. through improved 'harvesting' of heavy rainfall events, to collect, convey and store rain for later use from relatively clean surfaces such as a roof, land surface or rock catchment).

9 Consider adaptation and mitigation co-benefits.

Adaptation and mitigation represent two complementary aspects of a consistent climate change policy. Without substantial global mitigation actions implemented in good time under the post-2020 climate regime, the consequences will be such that adaptation will become more expensive and, after a certain threshold, ineffective. Adaptation goals at global and local scale are not, therefore, inconsistent with the collective goal of reducing GHG emissions, but will have to be articulated in conjunction, for example, by giving priority to opportunities for adaptation and mitigation co-benefits in improving energy efficiency and managing water and energy demand.

It is vital to ensure the coherence of the various sectoral policies and the necessary links with relevant national plans involving actions on GHG emission sources. So far, the government of UAE has mainly focused its actions on adaptation measures that bring mitigation co-benefits in the areas of water and energy management (such as water conservation and efficient, energy-saving desalination), coastal and marine protection (with potential for carbon sequestration known as 'blue carbon') and food security (research and technological innovation).

It is important to note that the Paris Agreement recognises mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification plans, as well as the impacts of the measures taken in response to climate change.

10 Consider synergies with sustainable development and disaster risk reduction and management.

It is important to ensure coordination and close synergies with disaster risk reduction and management when developing adaptation strategies and plans at local and national level, for an integrated approach to risk management. Building resilience to disasters and climate variability and change should be carried out in the broader context of sustainable development, integrating a comprehensive risk management framework into national development plans, strategies to fight poverty, social and sectoral policies.

The benefits of such integration include a greater potential for reduction of disaster damage by means of a targeted implementation of joint measures of adaptation and disaster risk reduction; more effective use of financial, human and natural resources; strengthened effectiveness and sustainability of joint approaches. As a prerequisite to effective management of current risks, further knowledge on the effects of extreme weather events on public health and safety in the UAE is needed.

Adaptation, in this context, can address risks and opportunities associated with longer-term climate change starting with anticipatory actions that are aimed to prevent and alleviate risks associated with past and current climate variability and weather extremes. Such actions can be undertaken both by public and private actors. These include, for example, the establishment of early-warning systems against extreme weather events, the adoption of new buildings codes and design standards, the promotion of incentives for relocation, the development / purchase of insurance schemes, redesign of production processes, etc.

Box 16 Global targets for sustainable development and disaster risk reduction

The main global frameworks addressing climate change risk include the UNFCCC, the 2030 global Sustainable Development Agenda and the Sendai Framework for Disaster Risk Reduction 2015-2030, which imply national efforts to varying degrees.

Both the Sustainable Development Agenda and the Sendai Framework for Disaster Risk Reduction point at the UNFCCC as the primary international, intergovernmental forum for negotiating the global response to climate change. Addressing climate change under the UNFCCC mandate is seen as one of the most important opportunities to reduce disaster risk.

Sustainable Development Agenda post-2015. SDG #.13: Take urgent action to combat climate change and its impacts[563]

The global Sustainable Development Agenda places sustainable development at the intersection of environmental sustainability and social and economic development. It presents seventeen Sustainable Development Goals (SDGs) for 2030. Among the other priorities, the SDGs include a climate change goal and a set of targets aimed at increasing resilience and adaptive capacities to climate-related hazards and natural disasters in all countries.

Sendai Framework for Disaster Risk Reduction 2015-2030[564]

The Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted following the Sustainable Development Agenda in 2015. It aims for the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. It involves seven global targets and four priority actions. In particular, it emphasises that disaster risk drivers - like poverty, inequality, climate change, climate variability, investment incentives for the private sector, and the unsustainable use of natural resources - need to be focussed on more. The role played by national platforms in supporting the implementation, monitoring and review of the Sendai Framework through effective coordinated action at the national level and linkages with the local level as appropriate, the mobilization of key stakeholders including the private sector, communities and key technical experts in particular in the area of climate change is acknowledged to be particularly critical.

11 Avoid maladaptation.

Maladaptation results in increasing vulnerability and/or a reduction in the capacity to cope with the negative impacts of climate change. Although maladaptation actions or processes may bring short-term benefits (e.g. financial profit), they inevitably lead to medium and long-term losses.

MALADAPTATION RESULTS IN **INCREASING VULNERABILITY** AND/OR REDUCTION OF CAPACITY TO COPE WITH NEGATIVE IMPACTS

In the UAE, particular attention should be given to avoid different types of maladaptation, including:

- actions that conflict with mitigation (e.g. reliance on energy intensive desalination technology for water security; use of air conditioning against increased average temperatures);
- actions that use resources unsustainably (e.g. using ground water for irrigation in dry regions causing a decreasing groundwater level);
- actions that distribute the benefits of adaptation unequally across society (e.g. prevention from climate change induced diseases only for the most affluent groups)[565].

Careful assessment of different priority adaptation options and their long-term effects is necessary to minimise the risk of incurring in maladaptation, especially in the design phase of an intervention as indicated in the Assessment Framework by Magnan applied to coastal areas (see Box 17).

Box 17. Guidance to avoiding maladaptation in coastal areas

Various frameworks for avoiding maladaptation have been developed in specialised literature. The so-called Assessment Framework (by A. Magnan) applies to coastal areas at a local scale and to the design phase of an initiative, and consists of eleven practice-oriented guidelines spanning across environmental, sociocultural and economic maladaptation.

Useful extracts of the Assessment Framework guidelines are reported below[566]:

1. *Avoid degradation that causes negative effects in situ, i.e. in the socio-ecological system in which the initiative is implemented (direct environment).*
2. *Avoid displacing pressures onto other socio-ecological system (neighboring systems or systems that are connected ecologically and/or socio-economically).*
3. *Support the protective role of ecosystems against current and future climate-related hazards,*
4. *Integrate uncertainties concerning climate change impacts and the reaction of ecosystems,*
5. *Set the primary purpose as being to promote adaptation to climate-related changes rather than to reduce greenhouse gas emissions.*
6. *Start from local social characteristics and cultural values that could have an influence on risks and environmental dynamics.*
7. *Consider and develop local skills and knowledge related to climate-related hazards and the environment,*
8. *Call on new skills the community is capable of acquiring.*
9. *Promote the reduction of socio-economic inequalities, as they indirectly affect the exploitation of natural resources and stimulate settlements in marginalised and hazard-prone areas.*
10. *Support the relative diversification of economic and/or subsistence activities.*
11. *Integrate any potential changes in economic and subsistence activities resulting from climate change.*

12

ADAPTATION MUST TAKE INTO ACCOUNT PRINCIPLES OF SUSTAINABILITY AND INTERGENERATIONAL EQUITY

Consider ecosystem-based adaptation solutions.

Ecosystem-based approaches use biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at all scales.[567] Any form of adaptation must take into account the principles of sustainability and intergenerational equity due to finite nature of non-renewable resources. The responses to the impacts of climate change will not harm the interests of future generations, as well as the ability of other natural systems and social and economic sectors to pursue adaptation. From an environmental point of view, adaptation solutions with positive effects on the environment and on ecosystem services (such as food, regulatory services, cultural services and other supporting services) and measures that promote and use natural processes are therefore to be favoured. Most importantly, ecosystem-based adaptation can bring synergies with other goals such as mitigation and sustainable development, and in general offer improvements in other areas especially at the aggregate level (such as: increased quality of life and well-being, public health, social cohesion, land value, compliance with regulations, hazard risk mitigation, and environmental benefits)[568].

For example, according to a research by IUCN, establishing networks of marine protected areas (MPAs) is deemed a critical ecosystem-based strategy to cope with climate change and (re)building ecological and social resilience.[569] MPAs bring multiple benefits such as natural protection against storms and storm surges, natural carbon sinks that ensure new carbon sequestration and provide areas of reduced stress for fish and other marine organisms.

Besides coastal and marine areas, ecosystem-based adaptation can be applied to various sectors including urban areas, agriculture and forestry, water management and flood protection.

4.2 PROCESSES

International literature and good practice approaches from other countries and regions offer a common understanding of the elements characterising adaptation planning and implementation. In particular, the step-wise methodology for decision-making in the face of climate change risks developed by the United Kingdom Climate Impacts Programme (UKCIP), taken on by the European Commission and endorsed as a guidance for European Member States to develop and implement their national adaptation policies provides a useful approach.

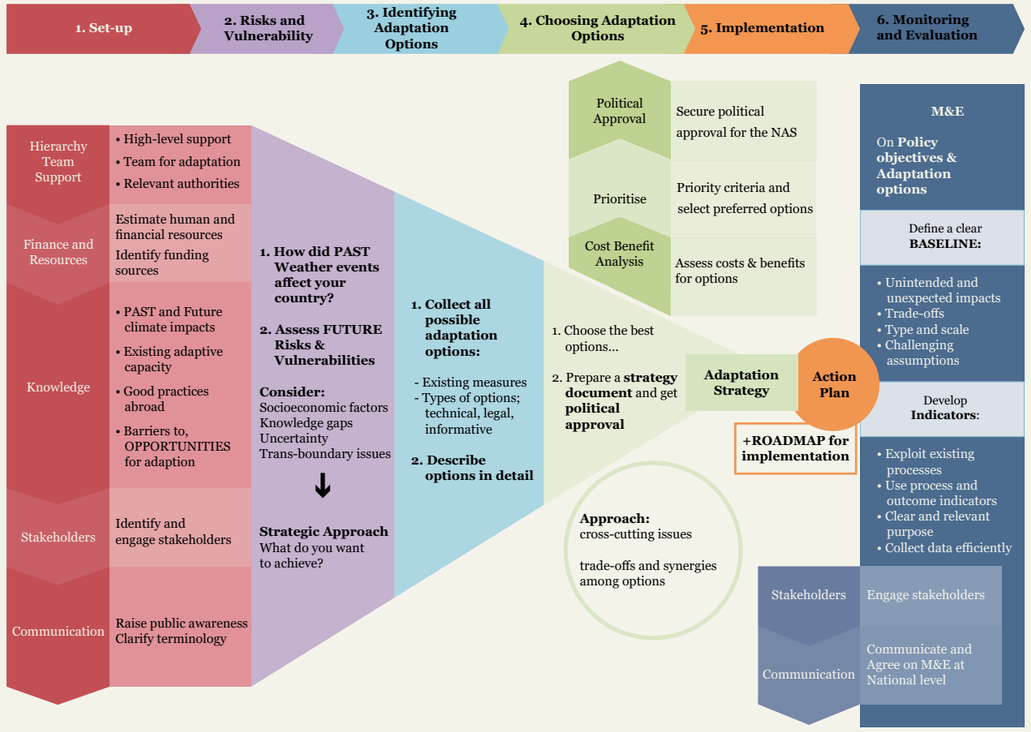

Figure 23: European Commission's step-wise model of adaptation policy planning and implementation[570].

The policy-making framework showed in Figure 23 above presents the recommended stages of the development of a national adaptation strategy followed by an action plan. These include:

1. Set-up of institutional context;
2. Evaluation of climate change vulnerabilities and risks (e.g. should it be sector based?), including definition of objectives and success criteria;
3. Identification of adaptation options to help reduce climate risks or take advantage of emerging opportunities;
4. Appraisal of adaptation options;
5. Implementation of adaptation measures;
6. Monitoring and evaluation (M&E) of policy objectives and adaptation measures.

This process should be considered an ongoing, continuous cycle where the final step serves to measure progress and improve the process itself.

1 **Stage 1: Set-up of institutional context. It is important for preparing the ground for adaptation and includes the need to obtain high political level support, establish a core team for adaptation and liaise with relevant administrative bodies.** Another key action in this stage is to estimate clearly the human and financial resources needed and identify potential sources of funding which are sustainable in the long term. Communicating clearly the impact of climate change and the need for adaptation is vital here and this EWS-WWF report contributes that endeavour.

2 **Stage 2: Evaluation of climate change vulnerabilities and risks. It involves a detailed assessment of the climate change risks and vulnerabilities a country or region.** Such assessment should be at least of qualitative nature, involving the review of existing regional and sectoral studies that are relevant to the national case. Quantitative assessments may be based on downscaled global climate scenarios, or make use of ad hoc regional / high-resolution scenarios that provide specific information for the national territory. Regional scenarios are at the basis of new- generation vulnerability studies that enable a more effective allocation of priority action on adaptation within the NAS.[571]

3 **Stage 3: Identification of adaptation options. It takes the main concerns identified and works on solutions to manage risks.** Adaptation options should be developed in sufficient detail so as to be able to assess them in terms of time, costs, benefits and effort at **stage 4**.

4 **Stage 4: Appraisal of adaptation options. Here, the 'long-list' of possible adaptation actions are whittled down based on a set of criteria.** These criteria may include:

- urgency with respect to already existing threats,
- range of effect (options covering multiple risks might be favoured),
- cost-benefit ratio,
- time-effectiveness,
- robustness under a broad range of likely future impacts (e.g. win-win, low regret measures),
- flexibility for adjustments or reversibility in case of diverging developments,
- political and cultural acceptability.

The idea is that **stage 4** concludes with the preparation of a strategy document for which political approval is sought, i.e. in the case of the UAE, this would entail approval by the cabinet. The NAS can have varying degrees of authority, ranging from a mandatory act (see Box 19) to soft-policy.

Box 19. The UK adaptation policy framework

The 2008 Climate Change Act represents the UK's overall framework for climate change policy. It has mandatory nature and encompasses both mitigation and adaptation strategies. Among other obligations, it requires the Government to put in place, and update every five years, a National Adaptation Programme (NAP), which addresses climate change risks.

The UK Climate Change Act sets a requirement for monitoring and evaluation of the adaptation policy process to be undertaken by the Adaptation Sub-Committee, aimed at evaluating progress on the implementation of the NAP and reporting to the Parliament.

For England and UK reserved matters, a NAP was adopted in 2013. The governments of Scotland, Wales and Northern Ireland, enjoying different levels of legislative, administrative and budgetary autonomy, have developed their own national adaptation programmes or plans.

The UK NAP is considered an initial milestone in an ongoing, iterative process, rather than a self-contained strategy. Its main purpose is to: (i) highlight areas of likely risk, and resolve analytical difficulties in assessing risks so that they do not prevent action; (ii) establish the principles for good adaptation over the long term, including a sensible approach to uncertainty; and (iii) define an initial set of specific, time-sensitive priorities for Government action. It should also identify potential gaps in those priorities and lay out an agenda to fill these gaps through further research and consultation.[572]

5 **Stage 5: Implementation of adaptation measures. It draws upon this strategic document for preparation of an action plan which sets out what needs to be done to convert adaptation options into action.** At this stage, it will be possible to design a plan of action and identify lead and supporting entities in implementing specific measures, with a clear timeline and allocated resources.

6 **Stage 6: Monitoring and Evaluation. It involves the development of appropriate M&E provisions for both adaptation policy's objectives and selected adaptation actions.** Performance indicators play a critical role here and should be based on data, which is relevant and efficient to collect. This process should recognise the fact that in some cases, adaptation outcomes cannot be determined for many years. Once the set-up stage is completed, the stages envisaged in the decision-making framework are circular - emphasising the importance of adaptive management - and iterative – emphasising the importance of continuous feedback for robust decisions.

5. CONCLUSION

The UAE's society and economy have always endured harsh environmental conditions, successfully thriving in the face of scarce water supplies and intense heat. However, the UAE's efforts towards achieving economic diversification and overall wellbeing of the population will be slowed down by climate change impacts if left unmanaged.

THE UAE'S EFFORTS TOWARDS ACHIEVING ECONOMIC DIVERSIFICATION AND OVERALL WELLBEING OF THE POPULATION WILL BE SLOWED DOWN BY CLIMATE CHANGE IMPACTS IF LEFT UNMANAGED

This report has presented the increasing wealth of scientific research carried out in the UAE and wider region to paint a compelling picture of how climate change has and will in the future impact the country across a range of sectors. Interconnected risks posed by climate change are particularly evident in the water-energy-food nexus, where the increasing use of and stress on these resources has an impact on the others. These are bound to represent a challenge to the national agenda. The UAE's objectives of GHG emission reduction, clean energy and energy and water efficiency will be impossible to achieve without considering climate change risks.

Understanding the risks and opportunities associated with future climate change will assist the UAE government, which is already beginning to take action on climate adaptation under the guidance of the MoCCAE. The final section of the report provides salient guidance on adaptation policy planning and implementation, by summarising the principles to consider when planning for adaptation, as well as the processes for developing robust climate change adaptation policy frameworks and action plans.

UNDERSTANDING THE RISKS AND OPPORTUNITIES ASSOCIATED WITH FUTURE CLIMATE CHANGE WILL ASSIST THE UAE GOVERNMENT

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Established in 2001 under the patronage of HH Sheikh Hamdan bin Zayed Al Nahyan, Ruler's Representative in the Western Region, EWS-WWF's mission is to conserve nature and reduce the most pressing threats to the environment by working with people and institutions in the UAE and region to implement conservation solutions through science, research, policy, education and awareness.

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