UNITED ARAB EMIRATES
MINISTRY OF CLIMATE CHANGE
& ENVIRONMENT

National Climate Change Adaptation Program

Adaptation of the UAE's Environment to Climate Change

Risk Assessment & Options for Action

2019

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Executive Summary

As part of the National Climate Change Adaptation Program, this report presents the findings of the climate change risk assessment of the UAE's natural environment. The assessment was conducted by the Ministry of Climate Change and Environment (MOCCAE) according to a framework developed from global best practices. The UAE Sectoral Climate Risk Assessment Framework consists of five steps: 1) take stock of climate trends and relevant sectoral issues; 2) identify potential impacts of climate change on the sector; 3) evaluate the magnitude and likelihood of impacts to understand the risks; 4) assess and prioritize the risks; and 5) identify potential adaptation actions.

Climate change and the environment

Climate change will result in higher temperatures across the UAE. Climate projections show a 2–3°C increase in average temperatures in the summer months of 2060–2079, although the changes may vary across the emirates. Humidity is expected to increase along the coast, while rainfall patterns are projected to change, with the Northern Emirates expected to have more intense rainfall episodes. Sea level rise is expected to increase the threats of inundation along the coastline. Furthermore, the probability of extreme weather events is projected to increase in both frequency and magnitude.

The UAE has been adapting to hyperarid climate conditions since long before climate change has become a global concern. In the future, climatic change is expected to cause a greater impact on the environment. Human-induced pressures, such as land use changes and pollution, will further exacerbate the impacts of climate change on the natural environment.

Assessing climate risks to the environment

Based on an extensive review of scientific literature on the impacts of climate change on the environment, this report identifies the most relevant impacts, which are further assessed upon consideration of the local evidence to fit the UAE context. The impacts are translated into risks through the interaction of impacts and likelihood. In this context, risk is defined as the likelihood of impact occurrence. The shortlisted risks shown in the table below encompass the different components of the UAE's natural environment, namely coastal, freshwater, ocean, and terrestrial ecosystems, and associated services.

MOCCAE conducted an initial assessment of the shortlisted risks through a five-point scale ("very low," "low," "medium," "high," and "very high"). The preliminary results were then shared with stakeholders through interactive workshops, which involved representatives from the public, private, and civil society sectors, and were facilitated by subject matter experts. MOCCAE consolidated the stakeholder inputs and reflected their comments in the final assessment while further verifying the available evidence.

As a result, the following two risks ("very high" and "high") were identified as priority risks:

- Increased frequency of coral bleaching; and
- Loss of wetlands and associated ecosystem services.

For the "medium" risks, although they are not as critical as the "very high" and "high" risks, a thorough investigation would be necessary to implement control measures to minimize the risks and prevent them from escalating into "high" risks. The "low" risks also require sporadic monitoring to determine changes in the situation that may affect the risk level.

Risk level	Impact
Very High	Increased frequency of coral bleaching
High	Loss of wetlands and associated ecosystem services
Medium	Loss of marine life
	Reduced groundwater levels and recharge capacity
	Loss of inland habitats and resources due to high salinity induced by sea level rise
	Increased soil erosion and land degradation during extreme weather events
	Reduced local food production
	Increased cases of harmful algal blooms
	Habitat destruction and fragmentation due to increased flash flood events
Low	Change in spatial distribution and temporal appearance of disease-causing species
	Increased landward migration of sandy shoreline

Options for action

Considering the UAE's current climate adaptation efforts, the below list of potential measures is proposed to address the two priority risks to the environment. To prioritize actions, current efforts may continue or expand, and new initiatives may be introduced. Some measures may require collaboration across authorities due to their inter-sectoral nature.

Type of measures	Coral bleaching	Loss of wetlands
	Examples of potential adaptation measures	
Physical safeguards	• Expand artificial reefs to compensate areas with high coral mortality. • Expand coral seeding initiatives.	• Continue mangrove restorations and periodic water quality monitoring to maintain tidal flow and nutrient levels.
Risk management	• Increase marine protected areas and reinforce policies to help build ecosystem resilience.	• Increase marine and coastal protected areas with mangrove ecosystems to help build resilience.
Knowledge	• Conduct comprehensive mapping and monitoring of coral reefs using advanced technologies.	• Establish communities of practice to widen engagement on mangrove conservation.
Enablers	• Develop an integrated marine conservation and management framework. • Incorporate climate resilience in marine and coastal development planning.	• Reinforce environmental impact assessments. • Develop a long-term strategy for wetland conservation, restoration, and management, as well as sustainable tourism.

The risk assessment shows the vulnerability of the UAE's ecosystems and associated services to the changing climate variables, which interact with a range of human-induced pressures, thereby further exacerbating the risks. The potential adaptation measures proposed in this assessment will be further analyzed and detailed to prioritize the most valuable actions and lay a roadmap for their implementation, including the nomination of lead and coordinating entities.

Introduction

As part of fulfilling its commitments under the Paris Agreement and in line with the UAE Vision 2021 and the UAE Green Agenda 2030, the UAE Government adopted the National Climate Change Plan 2050 (Climate Plan) in June 2017. The Plan aims to consolidate the country's climate action under a single framework that specifies strategic priorities, covering both mitigation and adaptation.

The Climate Plan structures action areas in three pillars: 1) greenhouse gas (GHG) emissions management; 2) climate change adaptation; and 3) private sector-driven innovative economic diversification. Under the adaptation pillar, the following outcomes are proposed:

- **By 2020:** Climate change risk assessments are performed, and immediate measures are put in place.
- **By 2025:** Adaptation planning is mainstreamed in development policy.
- **By 2030–2050:** Continuous monitoring and evaluation is conducted to ensure evidence-based adaptation measures.

As part of the implementation of the Climate Plan, the Ministry of Climate Change and Environment (MOCCAE) launched the National Climate Change Adaptation Program. The Program aims to carry out a systematic and participatory risk assessment as a basis for planning adaptation measures in four priority sectors: public health, energy, infrastructure, and the environment.

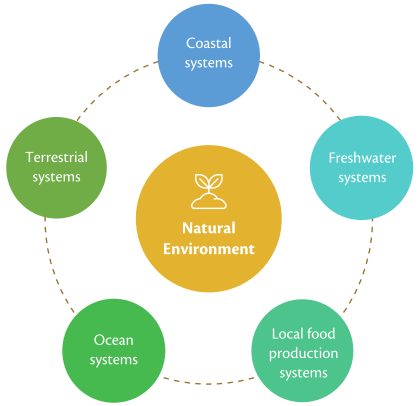
This report focuses on climate risk assessment of the UAE's natural environment. The scope of the risk assessment follows the subcategories used in the chapter "Natural and Managed Resources and Systems, and their Uses" of the Fifth Assessment Report (Working Group II) of the Intergovernmental Panel on Climate Change (IPCC): freshwater systems; terrestrial systems; coastal systems; ocean systems; and food production systems (Box 1).

The report is divided into three chapters:

- **Chapter 1 sets the scene for understanding how climate change affects the environment.** It also describes the observed and projected climate change in the UAE, as well as the global practices on climate resilience for the environment.
- **Chapter 2 focuses on the results of the risk assessment,** which was conducted based on available evidence, stakeholder consultation, and expert inputs, using a framework developed from global practices.
- **Chapter 3 presents adaptation measures** to help address the priority risks identified by the risk assessment. The measures include an extension of existing initiatives as well as new actions.

Box 1. Scope of risk assessment for the environment

- **Coastal systems:** Coastal areas, islands (natural), coral reefs, sea grasses, intertidal areas, salt marshes, sabkhas (salt flats) streams, tidal inlets, mangrove forests, beaches.
- **Freshwater systems:** Water from natural sources, such as wadis (dry riverbeds), ponds, spring water, groundwater (shallow and deep aquifers).
- **Local food production systems:** Local crop and livestock farming and fisheries.
- **Ocean systems:** Ocean waters in the UAE territories that host aquatic habitats, bottom topography, and biodiversity.
- **Terrestrial systems:** Land-based ecosystems and biodiversity, such as deserts, grasslands, inland wetlands, mountains, and terrestrial flora and fauna.



1. Climate Change and the Environment

1.1. Climate change in the UAE

The Intergovernmental Panel on Climate Change (IPCC) has reported that the observed changes in the climate system are clear and have been unprecedented since the 1950s: increasing concentrations of carbon dioxide (CO_2), warming atmosphere and ocean, melting ice, and rising sea levels.[1] These global trends are projected to continue through this century and beyond, leading to a range of adverse local impacts.

Current trends and future projections of the UAE's climate are presented in Table 1. More information on past climate trends and future projections from various sources is compiled in the Annex. The Abu Dhabi Global Environmental Data Initiative (AGEDI) study projects that the UAE could be warmer in the future, with an expected temperature increase of 2–3°C, alongside increasing humidity. However, these changes will not be the same for all seven emirates as terrain, elevation, and weather patterns vary across the country. It should also be noted that there remain varying levels of uncertainty behind climate projections due to the complex interaction of climate, economic, social, and environmental factors, as well as the relative scarcity of climate modeling research for the region.

Table 1. Current trends and future projections of the UAE climate[2]

	TEMPERATURE	HUMIDITY	SEA LEVEL RISE	RAINFALL	EXTREME EVENTS
What has been happening?	Temperature in summer months rises to about **48˚C** in coastal cities – even **50°C** in the desert regions.	Average humidity is **50-60%** in coastal areas; **45%** in inland areas. Extreme humidity reaches as high as **90%**.	Average sea level rise over the past decades in the Arabian Gulf is **0.18-0.23 cm** per year.	Annual rainfall is around **100 mm**.	**3 super cyclones** hit the Arabian Peninsula in a span of 40 years (1977-2018).
What could happen?	**2-3°C** average increase during the summer months by 2060-2079.	Increase in humidity by about **10%** over the Arabian Gulf.	**Increasing mean high tides** in coastal areas	More **intense rainfall**, particularly in Northern Emirates and Dubai.	More **frequent and severe** extreme events. Growing risk of **high-impact storms**.

In terms of precipitation, the AGEDI study reported that rainfall is projected to increase over much of the UAE. Increases of 50–100% from current amounts are projected for Dubai, Sharjah, and the Northern Emirates. Atmospheric modeling projects a 15–20% increase in rainfall over the Hajar Mountains by 2050. Despite the projected increases in rainfall, however, the number of wet days (with over 1 mm of rainfall) is projected to decrease. This implies that larger amounts of rainfall would occur during comparatively fewer rainfall events than currently observed. That said, while there might be some positive changes in terms of rainfall in some parts of the UAE, higher rates of evaporation may cancel out the increase in volume.

Sea level is also expected to rise in the UAE, increasing the threats of inundation along the coastline. Conducting climate modeling for sea level rise remains complex due to its broad suite of characteristics. Regarding extreme events, although current models cannot accurately predict their occurrence, current projections imply that they will become more frequent, their intensity more severe, and their trajectories or pathways less predictable.

1.2. Linkages between climate and the environment

The natural environment is the life support system for all organisms on the planet, being the source of food, water, air, and other essential services that sustain life, provide livelihood, and improve overall well-being. Climate is a major factor influencing environmental processes, specifically the interaction of water, air, and soil with humans and ecosystems.

Understanding climate change risks to the environment requires an understanding of the significant roles of associated ecosystem services (Figure 1) for supporting both climate change mitigation and adaptation actions. For mitigation, for example, carbon sequestration and storage are some of the regulating services offered by wetland ecosystems. Specifically, blue carbon ecosystems, such as mangroves, tidal marshes, and seagrasses, are considered carbon sinks due to their ability to take CO_2 out of the atmosphere and store it in their biomasses.

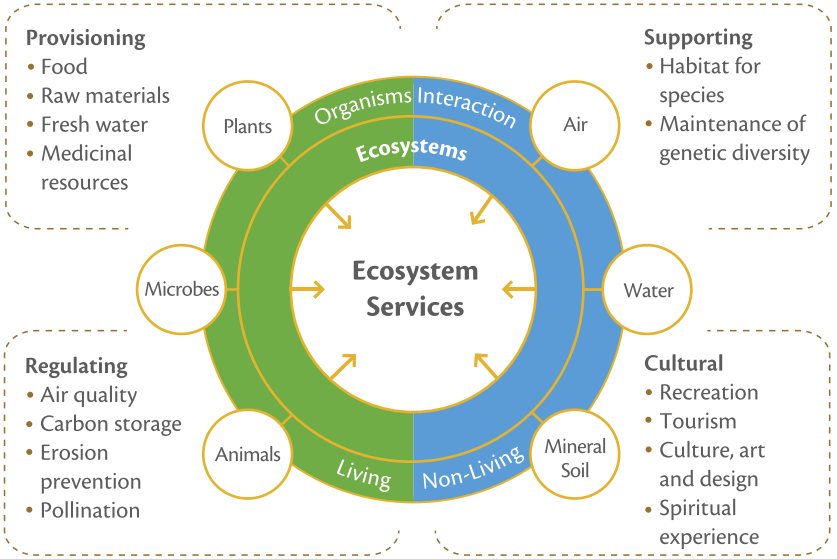


Figure 1. Ecosystem services and their roles[3]

Ecosystems also contribute to improving resilience by providing services that help their inhabitants adapt to climate change. For example, mangroves help protect coastal communities from the impacts of coastal erosion, sea level rise, and strong surge during high-impact storms. Green spaces do not only enhance air quality and recreational experiences but also help mitigate the impacts of flooding.

While ecosystems can serve as effective means of combating climate change, ecosystems themselves are being affected by climate impacts, which are further aggravated by other human-induced pressures. Figure 2 illustrates the wide range of climate impacts, either direct or indirect, on the marine ecosystem as an example. Direct impacts manifest when climate change triggers changes in sea temperature, while indirect impacts occur when climate stressors affect the seasonality, distribution, and abundance of marine species. While there are many natural factors affecting marine life, climate change brings multiple stressors and triggers disruptions in natural habitats through ocean acidification, stratification, eutrophication, and thermal expansion, among others. Combined with biological and socioeconomic pressures, climate change can push the tolerance levels of some organisms to the extent of causing shifts in species composition, migration, or even extinction.

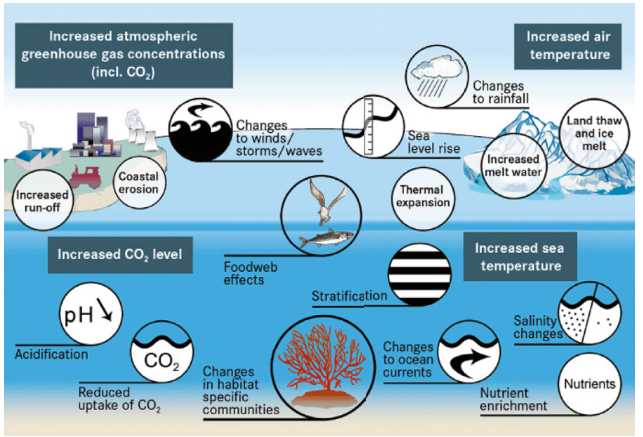


Figure 2. Examples of climate change impacts on the marine environment[4]

1.3. Global practices on climate adaptation in the environment sector

The U.N. Environment's Global Environment Outlook report series has acknowledged the scale, depth, and rate of unprecedented global drivers that are pushing the limits of ecosystems.[5] The IPCC has noted, with high confidence, that coral bleaching and loss will increase in frequency and magnitude over the next few decades.[6] Furthermore, sea level rise will lead to direct losses of coastal wetlands with associated impacts on water birds and other species.[7]

Figure 3 shows some of the projected regional impacts of climate change on the environment. Those impacts are already evident globally and projected to occur in greater magnitude and frequency in the future. The level of exposure and sensitivity varies in different regions and countries. While the focus tends to be on the negative impacts, there can also be positive ones, for example, when arid areas start to develop vegetation due to changing rainfall patterns.

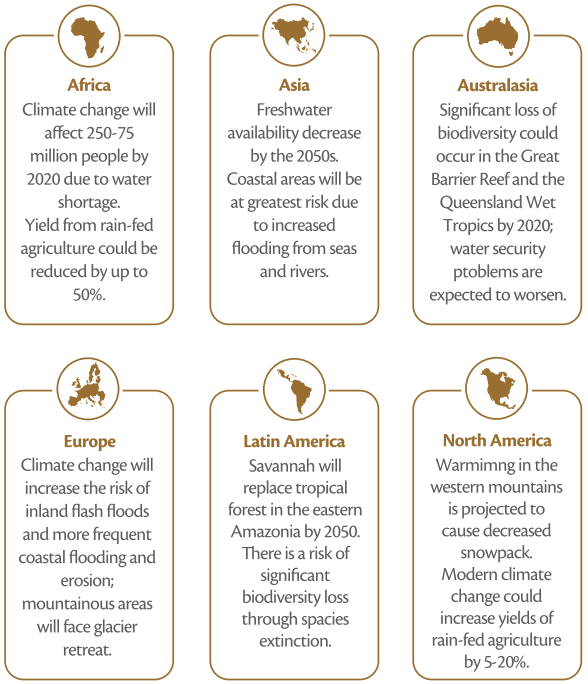
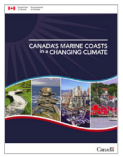


Figure 3. Examples of projected regional impacts of climate change[8]

As adaptation actions are expected to play a key role in the Paris Agreement,[9] countries are now investing more resources in adaptation planning and implementation. Several countries have started undertaking risk assessments and developing evidence-based strategies and plans to advance adaptation as part of their development policies (Table 2). Through this process, some of the commonly observed challenges include overcoming climate information and environmental data gaps; mobilizing investments for environmental initiatives; and measuring the outcomes of adaptation measures. Addressing these barriers is critical to ensuring that plans are translated into improvements in outcomes.[10]

Table 2. Examples of climate adaptation strategies in selected countries

Country	Initiative
Australia 	• The **Reef 2050 Long-Term Sustainability Plan** (2017)[11] is an overarching strategy that coordinates actions and guides management of the Great Barrier Reef. It aims to respond to the challenges confronting the reef while allowing sustainable development and use. Actions include: • Enhancing water quality: Support the delivery of the Reef Water Quality Protection Plan. • Maintaining biodiversity: Promote water quality improvements, habitat restoration, and species recovery. • Mitigating risk: Ensure port activities have minimal impact on the reef through navigation and pollution prevention controls. • Improving information and awareness: Promote water quality initiatives, improve scientific research, and help businesses have better environmental practices.
Canada 	The **Canada's Marine Coasts in a Changing Climate** (2016)[12] examines the country's marine coasts, focusing on the shoreline and the interface between land and water. Notable findings and requirements include: • Barriers to adaptation: limited resources, institutional capacity, and a lack of "usable" research. • Commercial fisheries sector: shifting the types of species being fished and relocating operations. • Information: a sea level rise primer for local governments. • Resilience measures in coastal areas: protection, revegetation, and stabilization of dunes; maintenance of sediment supply; and provision of buffer zones, rolling easements, or setbacks.
United Kingdom 	The **UK Climate Change Risk Assessment 2017: Evidence Report (Chapter 3: Natural environment and natural assets)**[13] examines the impacts of climate change on the country's landscapes and habitats. Priorities for further action and research include: • Habitat rehabilitation: End damaging management practices and deliver the restoration of degraded habitats. • Integrated natural resource management: Advance more flexible and integrated approaches to managing natural capital. • Research: Assess the nature and scale of changing land suitability, including research into more resilient crops and farming systems. • Risk assessment: Understand the magnitude and scale of risks to marine ecosystems and fisheries from climate change.

2. Assessing Climate Risks to the Environment

2.1. Sectoral risk assessment framework

The UAE Sectoral Climate Risk Assessment Framework (Assessment Framework) consists of a five-step approach as illustrated in Figure 4. The succeeding discussions in this section are based on the application of the five steps. The process of risk assessment combines a literature review, stakeholder consultation, and expert inputs (see the Assessment Framework document for more details).

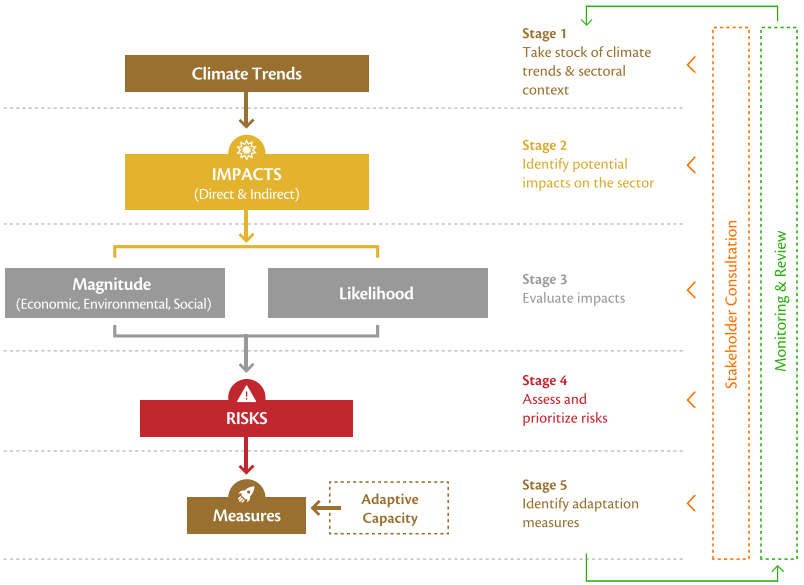


Figure 4. UAE sectoral climate risk assessment framework

2.2. UAE's natural environment

Stage 1 of the risk assessment framework aims to provide a contextualization of the UAE's natural environment and the prevailing challenges, including human-induced pressures and climate change. While the UAE has been known for its oil resources and vast desert lands, it is also blessed with diverse ecosystems and wildlife as described below.

Types of ecosystems

- **Coastal systems.** Extending for about 650 kilometers (km), the coastline of mainland UAE includes the Arabian Gulf coast in the north (flat with warm shallow water) and the Gulf of Oman coast to the east (natural deepwater harbors). The UAE has at least 200 islands, mostly small and flat. Coastal habitats include mangroves, saltmarshes, tidal flats, beaches, coastal flats, sand dunes, sabkhas, and cliffs.[14] The country also hosts marine life, such as a large population of dugongs, dolphins, turtles, and sea snakes. Mangroves are important nesting and resting areas for migratory bird species.

- **Freshwater systems.** Freshwater resources in the UAE are very limited. The country's renewable freshwater volume per capita is estimated at 33 cubic meters (m^3), which is below the freshwater scarcity threshold (1,000 m^3) set by the United Nations.[15] The Environment Agency — Abu Dhabi (EAD) records that only 18% of all groundwater in Abu Dhabi is directly usable, where only 3% is freshwater and 79% is saline, and can only be used after treatment through desalination.[16]

- **Food production systems.** Despite its arid climate and scarce water resources, the UAE has invested in local food production (i.e., cereals, milk, vegetables, fruits, meat, fish, seafood, eggs, etc.) as advanced farming technologies and irrigation systems have enabled the expansion of farms. Nevertheless, the country is still heavily reliant on food imports, which account for more than four-fifths of the domestic food supply.[17] [18]

- **Ocean systems.** Over the years, the UAE has relied on ocean resources for livelihood (e.g., pearl fishing), trade, leisure, and desalinated water. One-third of the 80 known species of whales and dolphins, five of the seven recognized species of marine turtles, and eight sea snake species thrive in the country.[19] Its coral reefs extend across most of the Arabian Gulf coast[20] and the Gulf of Oman.[21]

- **Terrestrial systems.** The UAE hosts more than 800 species of plants, 70 species of mammals, 440 species of birds, 75 species of reptiles, and more than 5,000 species of invertebrates.[22] The terrestrial habitat types include inland sand sheets and dunes; plains; mountains and wadis; coastal sand sheets with dwarf shrub vegetation; coastal and inland sabkhas; oases; farmland; forestry plantations; and urban areas.[23]

State of the environment

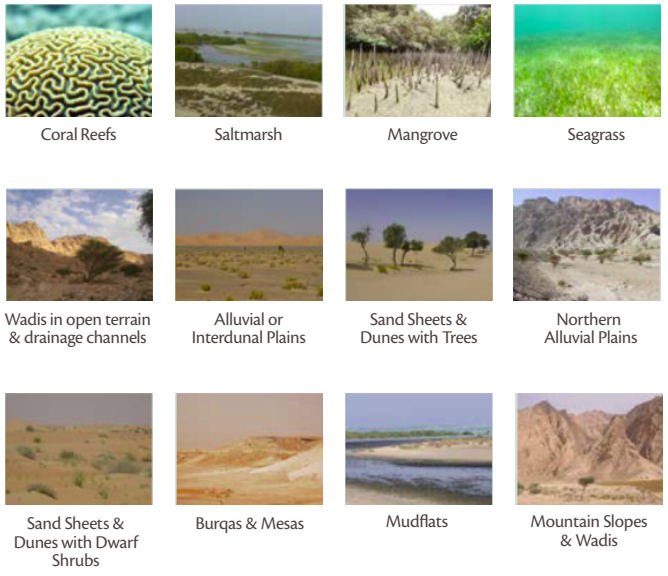
The U.N. Environment Programme introduced the Drivers-Pressures-State-Impacts-Responses (DPSIR) framework to monitor the state of the environment in different countries and their policy responses in a consistent manner. In the UAE, the main "drivers" influencing environmental changes are increasing population (mainly driven by the influx of expatriate workers) and rapid economic growth as demonstrated by rising consumption patterns and urbanization. The main "pressures" affecting environmental changes include a combination of both anthropogenic and climate-related stressors, such as water scarcity, air quality issues, land degradation, and biodiversity loss. The "impacts" of climate change on the environment are considered as an additional driver of change, although they are not independent of the other drivers. Table 3 encapsulates the different factors affecting Abu Dhabi's environment according to EAD's analysis, which can be generally applied for the UAE as a whole.

Table 3. State of Abu Dhabi's environment[24]

	Drivers	Pressure	State	Impact	Response
Air Quality	•Population growth •Resource demand •Transport emissions	•Emission from industry and transpory •Natural dust events	•Increased in concentrations of sulphur dioxide	•Health, environment, social, and economic impact	•Regulations, enforcement, planning •Research, awareness
Soil	•Wind erosion •Salinization •Vegetation loss	•Natural soil erosion •Soil salinity •Overgrazing	•85% of land in Abu Dhabi naturally degraded	•8,000 farms abandoned or nearly abandoned	•Soil salinity inventory •Monitoring programs •Soil archiving facility
Water	•Low natural recharge rate •Increasing demand for water	•Overextraction •High domestic water consumption	•Declining groundwater •Usable groundwater reserve slightly increased	•Increased reliance to desalinated water •Increased discharge of brine water	•Integrated water management •Natural water conservation
Marine water quality	•Population growth •Economic development	•Coastal development •Industrialization •Tourism	•Eutrophication from coastal industry •Treated wastewater discharges	•Incidences of harmful algal blooms •Effects on health and marine life	•Water quality monitoring •Marine water and sediment quality limits
Biodiversity	•Population growth •Economic growth •Urban and industrial development	•Habitat loss •Degradation •Climate change	•Less than 2% of species classified as "threatened"	•Habitat loss on biodiversity •Bleak outlook for some species	•Protected areas •Monitoring •Reintroduction programs
Fisheries	•Population growth •Tourism expansion	•Overfishing •Coastal development •Desalination and pollution	•Overexploitation •90% decline of demersal species	•Less employment •Less recreation •Less ecosystem function	•Sustainable fisheries program •Nationwide fisheries change management
Forestry	•Urban growth •Infrastructure development	•Groundwater depletion •Finance •Cultural heritage	•3.5% of Abu Dhabi covered by forests •79% of forests in good condition	•Groundwater depletion affecting 21% of forest in Abu Dhabi	•Classification of forests •Measurement of groundwater

EAD identified 12 critical habitats and eight environmentally sensitive habitats within the emirate.[25] "Critical habitats"[a] include corals; mangroves; seagrass; saltmarshes; sand sheets and dunes with distinct dwarf shrub cover or shrub cover; burqas and mesas; wadis and floodplains; alluvial interdunal plains (gravel plains); mountains and rocky terrains; northern alluvial or interdunal plains with tree cover; sand sheets and dunes with tree cover and mudflats; and sand exposed at low tide. "Environmentally sensitive habitats"[b] include the coastal sabkhas; intertidal flats with cyanobacterial mats; coastal sand sheets and low dunes; islands (salt dome) and coastal rocky cliffs; storm beach ridges; beach rock and gravelly beaches; sand sheets and dunes with perennial herbs and graminoids; and macroalgal communities (Figure 5).

12 Critical Marine and Terrestrial Habitats



(a) EAD defines critical habitats as "priority ecosystem types that any further loss or deterioration of condition in these habitat types could result in severe loss of endemic or threatened species and ecosystem function" and/or "ecosystem types that are already under threat, likely to have lost some of their structure and functioning in the Emirate, UAE, or region, and will be further compromised if they continue to lose natural habitat or deteriorate in condition."
(b) EAD defines environmentally sensitive habitats as ecosystem types where "any further loss of its natural habitat or deterioration of condition in these habitat types could result in it becoming critical" and/or those that are "likely to have lost some of their structure and functioning and will be further compromised if they continue to lose natural habitat or deteriorate in condition."

8 Environmentally Sensitive Marine and Terrestrial Habitats

Figure 5. Critical and sensitive habitats in Abu Dhabi[25]

Environmental policy framework

Protecting the environment is at the core of the UAE's sustainable development efforts. The UAE Vision 2021 highlights "sustainable environment and infrastructure" as one of the national development priorities, with specific targets related to air quality, waste management, energy, and water.

MOCCAE is the lead agency with the mandate to coordinate the country's efforts to address climate change and environmental protection at the national level. Emirate-level environmental agencies or municipal departments collaborate with MOCCAE in the implementation of environmental policies and initiatives. These include the EAD, Dubai Municipality, Environment and Protected Areas Authority — Sharjah, Ajman Municipality, Umm Al Quwain Municipality, Environment Protection and Development Authority — Ras Al Khaimah, and Fujairah Municipality.

The UAE has passed legislations in the form of federal laws, Cabinet decrees, and ministerial decrees at the national level. Recently approved development plans and strategies that mainstream the importance of environmental sustainability include the UAE Green Agenda 2030, the Climate Plan, and the National Biodiversity Strategy and Action Plan, while similar plans at the emirate level are also in place.

These have been translated into concrete programs and projects nationally and locally. In addition to its ratification of the Paris Agreement, the UAE is also a signatory to various multilateral environmental agreements, such as the U.N. Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Migratory Species (CMS), and the Convention on Wetlands of International Importance (Ramsar).[c]

2.3. Evaluation and prioritization of climate risks

Climate impacts on the environment

To evaluate and prioritize risks, a list of impacts has been first developed based on readily accessible international and local literature, in accordance with Stage 2 of the risk assessment framework. Table 4 identifies and characterizes climate impacts relevant to the UAE's environment.

Table 4. Impacts of climate change on the environment[d]

Climate events/signals	Direct and indirect impacts
Rising temperature complemented by increasing humidity	• Increased frequency of coral bleaching and loss of marine life due to increased ocean temperature and acidification • Increased ecological regime shifts,[e] such as shifts in biodiversity and composition of flora and fauna and distribution of habitats and associated ecosystem services • Reduced local food production due to an increase in drought episodes, pests, and other stressors during extreme weather and climatic change • Poorer water quality due to reduced water levels and groundwater recharge because of increasing temperature • Change in spatial distribution and temporal occurrence of vector-borne diseases that may impact the health of plant and animal species • Degradation and loss of terrestrial wetlands and associated biodiversity, such as migratory bird species • Increased episodes of harmful algal blooms due to favorable conditions when seawater temperature rises, combined with increased nutrient loads • Increased desertification due to warming of air temperature and decreasing rainfall during an extended drought season
Rising sea level	• Loss of coastal wetlands as well as low-lying habitats and their associated biodiversity due to coastal inundation • Increased landward migration of sandy shoreline that may lead to the development of sabkhas and changes (+/-) in dryland flora and fauna • Loss of inland habitats and resources due to sea level rise and change in salinity
Extreme weather and climatic events (storm, flooding, sandstorm)	• Increased soil erosion, mainly in areas of higher elevation leading to increased stream sediment and nutrient loads in the downstream • Change (+/-) in freshwater, coastal (including mangroves), and terrestrial (including mountains, wetlands, wadis, and agriculture) ecosystems • Increase in virus aerosols through sand and dust during extreme events that may affect the composition of flora and fauna and associated ecosystem services • Reduced local food production due to the destruction of agricultural areas during the occurrence of intense cyclones or monsoon patterns • Increased occurrence of flash flood events, leading to habitat destruction and fragmentation in areas with hardened soil during extreme events
Extreme drought	• Increased desertification due to extreme drought seasons, leading to potential habitat, vegetation, and eventually biodiversity loss • Reduced water levels and groundwater recharge due to lack of precipitation during extreme drought events • Reduced local food production resulting from decreased soil moisture and fertility due to increased desertification • Increased occurrence of flash flood events, leading to habitat destruction and fragmentation • Increased ocean salinity due to extreme drought and lack of precipitation, leading to changes (+/-) in coastal and marine ecosystems

(c) In October 2018, the UAE became the first Arab country to host the Conference of Parties of the Ramsar Convention.
(d) The selection of preliminary risks involved a review of chapters from the most recent IPCC assessment reports. MOCCAE examined the contents and arguments related to the environment and selected the most evident impacts. It also used reports from organizations of global authority to verify the evidences and check for consistencies. The risks are then localized through a review of local evidence, such as scientific and policy studies conducted in the country. Through a consultation workshop, stakeholders provided inputs, and the risks are further revised, incorporating their feedback.
(e) The Stockholm Resilience Centre defines regime shift as "large, persistent changes in the structure and function of social-ecological systems, with substantive impacts on the suite of ecosystem services provided by these systems."

Based on the long list above, a final list of nationally relevant direct and indirect impacts is developed as shown in Table 5. These risks are exacerbated by both climate and non-climate pressures, such as land use change, excessive extraction of natural resources, and pollution. It is important to note that the severity of climate impacts on the environment may differ in the seven emirates due to their geographical, climatic, and socioeconomic conditions. Ecosystem-specific risks will also vary depending on the location, composition, and adaptive capacity of the natural asset. The list in Table 5, however, applies to most of the emirates.

Table 5. Final list of impacts for risk assessment

Direct impacts
1. Increased frequency of coral bleaching due to increased ocean temperature and ocean acidification
2. Loss of marine life due to increased ocean temperature exacerbated by increased salinity and acidification
3. Reduced groundwater levels and recharge leading to poorer freshwater quality due to increasing extreme temperature, high evaporation rate, and nonuniform rain patterns
4. Loss of terrestrial wetlands due to increasing extreme temperature and drought events; loss of coastal wetlands and low-lying habitats due to sea level rise-induced coastal inundation and extreme events
5. Loss of inland habitats and resources due to sea level rise and the associated change in salinity
6. Increased soil erosion and land degradation due to extreme weather and climatic events, including severe wind storms and cyclones
Indirect impacts
7. Reduced local food production due to climate-induced drought and pests; degradation of agricultural areas during extreme events; decreased soil moisture and fertility due to uneven rainfall patterns[f]
8. Change in spatial distribution and temporal appearance of species (i.e., mosquitos causing vector-borne diseases); increased distribution of virus aerosols through sand and dust
9. Increased episodes of harmful algal blooms due to favorable conditions when seawater temperature rises, combined with increased nutrient loads, leading to changes (+/-) in coastal and marine ecosystems
10. Increased landward migration of sandy shoreline that may lead to the development of sabkhas; changes (+/-) in dryland flora and fauna due to coastal erosion and/or submergence during sea level rise
11. Increased flash flood events, leading to habitat destruction and fragmentation due to hardened soil with reduced absorption rate during an extreme drought combined with extreme precipitation

(f) While rainfall is expected to generally increase in the UAE, it will not be uniform across the country, including agricultural areas, such as parts of Sharjah, Al Ain, and Ras Al Khaimah.

Evaluating the magnitude and likelihood of impacts

Table 6 presents the magnitude and the likelihood of the occurrence of the direct and indirect climate change impacts in the above final list. According to Stage 3 of the risk assessment framework, the magnitude of impacts was examined from three dimensions: economic, social, and environmental, whereas the likelihood was assessed based on the estimated chance that the impact may occur in the future. The combined assessment of magnitude and likelihood results in the determination of the risk level of the impacts.

Table 6. Evaluation of impacts

Impact	Magnitude			Likelihood	Risk level
	Econ	Env	Soc		
1. Increased frequency of coral bleaching	Very large	Very large	Very large	Almost certain	Very High
2. Loss of marine life	Large	Large	Large	Likely	Medium
3. Reduced groundwater levels and recharge capacity	Very large	Large	Moderate	Likely	Medium
4. Loss of coastal and terrestrial wetlands as well as associated biodiversity and ecosystem services	Very large	Very large	Very large	Very likely	High
5. Loss of inland habitats and resources due to sea level rise and the associated change in salinity	Very large	Very large	Very large	Likely	Medium
6. Increased soil erosion and land degradation during extreme weather and climatic events	Large	Large	Large	Likely	Medium
7. Reduced local food production	Large	Moderate	Large	Likely	Medium
8. Change in spatial distribution and temporal appearance of disease-causing species	Small	Moderate	Small	Likely	Low
9. Increased episodes of harmful algal blooms	Large	Large	Large	Very likely	Medium
10. Increased landward migration of sandy shoreline	Very large	Small	Small	Likely	Low
11. Habitat destruction and fragmentation due to increased flash flood events	Very large	Very large	Small	Very likely	Medium

In line with Stage 4 of the risk assessment framework, the climate impacts with "very high" and "high" risk levels have been identified as priority risks that the UAE may need to address most urgently. The risk of increased frequency of coral bleaching was identified as "very high," whereas the loss of coastal and terrestrial wetlands was judged as a "high" risk:

- **Increased frequency of coral bleaching.** Coral reefs are highly productive ecosystems, providing a wide range of valuable goods and services, such as seafood, recreation, and protection from storm surges.[27] The economic, environmental, and social impacts of "increased frequency of coral bleaching" in the UAE are considered "very large." As coral reefs are regarded as highly valuable resources globally, any form of damage or destruction to them could lead to a significant economic cost. Moreover, since the impacts of coral bleaching have already been widespread in the UAE, the probability for its recurrence is almost certain given current and projected temperature changes.

- **Loss of coastal and terrestrial wetlands as well as associated biodiversity and ecosystem services.** Mangrove swamps, coral reefs, inland swamps, and sabkhas are the common types of coastal, marine, and inland wetlands in the UAE. The economic, environmental, and social impacts of climate change on both mangroves and corals are significant considering the wide range of ecosystem services that they provide. For example, since 85% of the population live in coastal areas and many people[28] still rely on fish for their income, the social magnitude would be considered very large.

Other impacts fall under "medium" risks, which may be relatively acceptable in the short term, but a thorough investigation is necessary to implement control measures to minimize the risks so that the "medium" risk level will not turn into "high." The impacts with "low" risks require sporadic monitoring to determine changes in the situation which may affect the risk level. Figure 6 provides a visual way to understand and communicate the results of the assessment by plotting all 11 impacts in a 5-by-5 risk matrix.

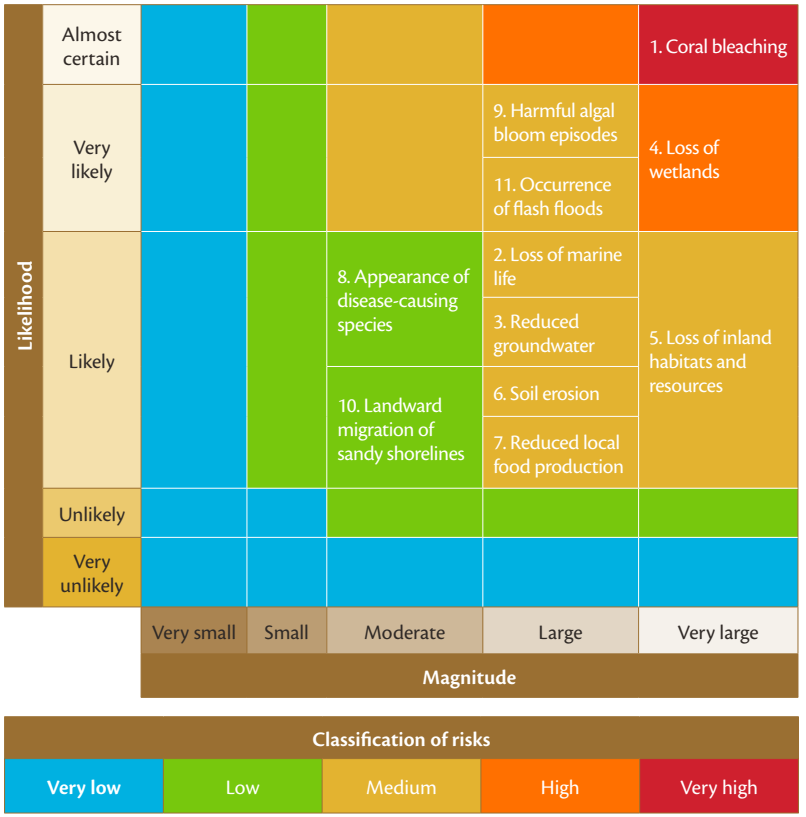


Figure 6. Risk matrix for the environment

3. Options for Actions

3.1. Initiatives on climate adaptation in the environment sector

This chapter applies Stage 5 of the risk assessment framework, elaborating potential actions to address the priority risks identified in the previous chapter. In providing recommendations, it is important to acknowledge existing initiatives relevant to climate change adaptation in the environment sector. This will help identify the gaps and explore the opportunities to address them.

Measures for climate change adaptation can be generally classified into four types[g]:

- **Physical safeguards** refer to engineered structures, technological systems, and services, as well as ecosystem-based infrastructure, that support adaptation objectives.
- **Risk management** covers the regulations, incentives, and financial mechanisms, as well as early warning systems and emergency plans, that directly address climate risks.
- **Knowledge** encompasses climate data and research, risk assessment, and awareness campaigns and communication.
- **Enablers** are foundational policies not directly targeting adaptation but providing an enabling condition for improving resilience.

Tables 7 and 8 show examples of climate actions that are relevant to addressing the priority risks identified in the previous chapter according to the four categories. The list is not exhaustive and only intends to provide illustrative examples.[h] The measures include both options directed to address the risk itself and those that could compensate or offset the risk and help build resilience. MOCCAE developed a proposal of measures based on the results of the risk assessment and existing initiatives.

(g) This typology of adaptation measures is consistent with the IPCC categories (structural/physical, social, and institutional adaptation) and the World Health Organization adaptation measure taxonomy (risk management, information, foundations).
(h) Most of the recommendations focus on either continuing current efforts or addressing the challenges through new initiatives in line with international best practices. Some measures may require collaboration across authorities due to the inter-sectoral nature of adaptation initiatives. Note that the associated costs of the proposed measures are not considered as it is beyond the scope of this report and separate analyses are required.

Table 7. Potential adaptation measures for addressing the "very high" risk of coral bleaching

Type of measures	Coral bleaching	
	Existing measures	**Additional measures**
Physical safeguards	• Coral reef monitoring and control stations. • Installation of artificial caves. • Development of coral gardens. • Cultivation and rehabilitation of coral species. • Marine habitat mapping.	• Use heat-tolerant species[i] that support the growth of coral reefs. • Expand artificial reefs to compensate areas with high coral mortality and incorporate large-scale coral seeding initiatives into the protection of coral-degraded habitats, such as breakwaters.
Risk management	• Marine protected areas. • Fishing laws (e.g., hallaq nets allowed only during certain periods). • Coastal Development Guidelines.	• Designate more marine protected areas and reinforce policies on marine protection to help build species and ecosystem resilience. • Re-examine other areas that are not designated as protected areas but also heavily impacted by natural and human stressors.[j] • Promote sustainable tourism by regulating recreational activities (e.g., introduce fees that go to coral reef conservation and a climate adaptation fund).
Knowledge	• Research projects of academic institutes (e.g., Marine Biology Lab at NYU Abu Dhabi). • UAE Smart Map of Natural Capital. • National Environmental Education & Awareness Strategy 2021. • Diving courses highlighting coral reef protection.	• Improve mapping and monitoring of coral reefs by using advanced remote sensing methods and unmanned aerial vehicle (UAV) technologies. • Highlight adaptation components in awareness campaigns on coral reef protection. • Expand volunteer programs for recreational divers to help monitor coral reef areas. • Establish a nationwide coral reef monitoring network.
Enablers	• Federal law concerning the welfare of aquatic resources (No. 23 of 1999). • Federal law on protection and development of the environment (No. 24 of 1999). • National Biodiversity Strategy & Action Plan.	• Incorporate climate resilience in marine and coastal development planning. • Develop guidelines to closely monitor coastal developments and their effects on marine life. • Develop an integrated marine conservation and management framework. • Develop local research capacity and educational programs on marine environmental management.

(i) For example, scientists from the University of Southampton and New York University Abu Dhabi (NYUAD) discovered a new species of algae in the UAE called Symbiodinium thermophilum, which can help corals survive in the warmest seawater temperatures.

Table 8. Potential adaptation measures for addressing the "high" risk of loss of wetlands

Type of measures	Loss of wetlands	
	Existing measures	**Additional measures**
Physical safeguards	• Mangrove planting, monitoring, and conservation • Satellite tagging and monitoring of important species	• Continue mangrove site restorations, alongside periodic water quality monitoring to maintain tidal flow and nutrient levels. • Use climate-resilient species and practices in support of mangrove plantation and conservation (but avoid invasive alien species). • Expand artificial reefs for improving marine ecosystems.
Risk management	• Designation of 7 Ramsar sites • Technical Guidance Document for Mangrove Planting Permitting and Management Plan	• Increase marine and coastal protected areas that include mangroves to help improve ecosystems and resilience. • Closely monitor the effects of coastal development activities (e.g., water extraction, reclamation, large-scale property projects) on wetlands.
Knowledge	• Celebration of World Wetland Day (2 February) • UAE Smart Map of Natural Capital • Capacity-building activities on coastal wetlands management	• Establish communities of practice to widen engagement on mangrove conservation activities. • Assess the economic value of wetlands and its full potential in enhancing adaptive capacity.
Enablers	• National Blue Carbon Project • Ramsar Convention membership • Federal Law No. 23 of 1999 • Federal Law No. 24 of 1999 • National Biodiversity Strategy & Action Plan	• Reinforce environmental impact assessments. • Explore the potential of payment for ecosystem services in the context of wetland management. • Develop a long-term strategy to improve wetland management and its integration in a sustainable tourism plan. • Investigate the feasibility of obtaining carbon credits or carbon offsetting from mangrove protection. • Mainstream wetland protection into infrastructure planning (e.g., transportation, sewerage). • Strengthen volunteer programs for mangrove sites restoration.

3.2. Opportunities and way forward

The climate risk assessment for the UAE's environment shows how the country's ecosystems and their associated services have become sensitive to climate variables, which interact with a range of other pressures. Furthermore, climate projections indicate an increase in the frequency and magnitude of extreme events, leading to higher risks in the future. The interlinkages of risks add to the complexity of policy responses, highlighting the need for an integrated approach to climate change adaptation. But the climate risks could also be transformed into opportunities by elaborating and implementing appropriate policy actions. The following are some of the recommendations for consideration:

- **Strengthen ecosystem-based adaptation.** The Convention on Biological Diversity defines ecosystem-based adaptation (EbA) as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change."[29] A good example in the UAE is Abu Dhabi's Blue Carbon Policy, which developed a protocol for the sustainable management of mangrove forests, salt marshes, and seagrass beds within a broader framework of ecosystem-based management.[30] This policy does not only aim to restore and protect mangroves but also help deliver synergies between mitigation and adaptation, with mangroves serving as carbon storage and functioning as a natural barrier for sea level rise.[31]

- **Understand the interaction between climatic and anthropogenic factors and how it affects the environment.** While human activities are already affecting the environment in many ways, the impacts of such activities can be further aggravated by climate factors. Highlighting the interaction between climate change and socioeconomic factors, including how climate change contributes to other drivers of risks, is important to gain an understanding of climate risks to the environment. For example, a study by the Abu Dhabi Global Environmental Data Initiative (AGEDI) showed that more than 50% of the projected ocean warming in the Gulf would result from the projected growth in desalination plants across the region. Thus, understanding the interaction of population growth, demand for water, and the role of brine in influencing the overall health of the UAE's ocean resources is critical.

- **Explore the potential of payment for ecosystem services (PES) to support adaptation.** PES provides financial incentives to owners, operators, or managers of natural resources for providing ecosystem services through contributions from the beneficiaries or users of the services. Globally, PES schemes have proven effective in helping advance climate change adaptation and economic diversification. In the UAE, for example, the carbon storage services that the mangroves and other wetland provide could be considered for the expanding carbon market.

- **Assess the climate vulnerability of protected areas.** It is important to regularly assess the potential threats to highly important habitats, including impacts of climate change. For example, in response to changes in temperature, marine and avian species may migrate from one location to another to look for new sources of food. By conducting a periodic climate vulnerability assessment of sensitive habitats and ecosystems, potential threats such as invasive alien species could be mitigated.

- **Improve climate change projections.** AGEDI's work on climate change modeling is a good start, but more extensive modeling work is required to minimize uncertainty as it was based on a single climate model. Coordination of research among different universities in the country would help improve region-specific knowledge on climate change impacts in a cost-effective way.

- **Promote an integrated policy framework for resilience.** Climate change adaptation must consider alignment and synergy with other policies. The integration of disaster risk reduction, coastal management, water conservation, wetlands protection, and climate change mitigation into a single framework of strategic land use planning would deliver better climate resilience and wider benefits for the economy.

For the next steps, the list of proposed adaptation measures will be further discussed and prioritized with stakeholders using key criteria, such as effectiveness, cost, urgency, feasibility, and impact, among others. An implementation roadmap will be laid out, involving lead and coordinating entities. Furthermore, a robust monitoring and evaluation (M&E) mechanism needs to be put in place to assess the outcomes. Throughout this process, active engagement of all relevant stakeholders from different sectors and levels of government is key to the success of adaptation efforts going forward.

References:

1. Alexander, L. V., et al. 2013. "Summary for policymakers." In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). (pp. 29–3). New York: Cambridge University Press.
2. Ministry of Energy. 2010. The United Arab Emirates Second National Communications to the Conference of Parties of the United Nations Framework Convention on Climate Change.

   AGEDI (Abu Dhabi Global Environmental Data Initiative). (2016). Technical Report, Coastal Vulnerability Index. Local, National, and Regional Climate Change Program (LNRCCP). Abu Dhabi: Environment Agency — Abu Dhabi (EAD).

   AGEDI. 2015. Results of the Atmospheric Modeling Sub-Project. LNRCCP. Abu Dhabi: EAD.

   AGEDI. 2017. Sea Level Rise Primer. Abu Dhabi: EAD.
3. CGIAR Research Program on Water, L. 2014. Ecosystem Services and Resilience Framework. Sri Lanka: CGIAR Research Program on Water, Land and Ecosystems (WLE). Retrieved from: https://wle.cgiar.org/content/what-are-ecosystem-services.
4. OSPAR Commission. 2010. OSPAR Quality Status Report 2010. Retrieved from https://qsr2010.ospar.org/en/ch01_03.html.
5. UNEP (United Nations Environment Programme). 2016. Global Environment Outlook 6. Retrieved from https://www.unenvironment.org/resources/global-environment-outlook-6-regional-assessments.
6. Wong, P. P., et al. 2014. "Coastal systems and low-lying areas." In C. Field, et al., Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC (pp. 409–361). Cambridge and New York: Cambridge University Press.
7. Settele, J., et al. 2014. "Terrestrial and inland water System." In C. Field, et al., Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC (pp. 359-271). Cambridge and New York: Cambridge University Press.
8. Tamiotti, L. 2009. Trade and Climate Change: A report by the United Nations Environment Programme and the World Trade Organization. Nairobi: UNEP and Earthprint.
9. Helgeson, J., and Ellis, J. 2015. The Role of the 2015 Agreement in Enhancing Adaptation to Climate Change. Paris: OECD. Retrieved from https://www.oecd-ilibrary.org/environment/the-role-of-the-2015-agreement-in-enhancing-adaptation-to-climate-change_5jrxg3xb0h-20en.
10. Mullan, M., et al. 2013. National Adaptation Planning: Lessons from OECD countries. Paris: OECD. Retrieved from https://doi.org/5/10.1787k483jpfpsq-1en.
11. Commonwealth of Australia. 2015. Australian Government Department of the Environment. Retrieved from https://www.environment.gov.au/system/files/resources/d98b3e146-53b4-b9c-a84a-2a22454b9a83/files/reef-2050-long-term-sustainability-plan.pdf.
12. Lemmen, D.S. and Warren, F.J. 2016. "Synthesis." In D.S. Lemmen, et al. (eds). Canada's Marine Coasts in a Changing Climate, Ottawa: Government of Canada, pp. 26–17.
13. Brown, I., et al. 2016. UK Climate Change Risk Assessment Evidence Report: Chapter 3, Natural Environment and Natural Assets. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change, London. Retrieved from https://www.theccc.org.uk/wp-content/uploads/07/2016/UK-CCRA-2017-Chapter--3Natural-environment-and-natural-assets.pdf.
14. EAD. 2008. Terrestrial Environments of Abu Dhabi Emirates, United Arab Emirates. Abu Dhabi: EAD.
15. EAD. Protecting Our Shared Resource: Sustainable Water Use for Organizations. Abu Dhabi: EAD. Retrieved from https://www.ead.ae/Documents/Water_Guide_English.pdf.
16. EAD. 2015. Environment Agency — Abu Dhabi. Retrieved from https://www.ead.ae/Pages/know-your-environment/groundwater.aspx.
17. AGEDI. 2015. Food Security and Climate Change. LNRCCP. Abu Dhabi: EAD. Retrieved from https://agedi.org/item/technical-report-uae-food-security-and-climate-change.
18. Fischbach, T. 2018. Strengthening Resilience: Advancing food Security in the UAE. Dubai: Mohammed Bin Rashid School of Government. Retrieved from: http://www.mbrsg.ae/getattachment/859ddec-7f5ed-48dd99-dd4-e1b8f326112/Advancing-food-security-in-the-UAE.
19. EAD. 2014. Life in the Water. India: The Energy and Resources Institute. Retrieved from https://www.ead.ae/Publications/Biodiversity20%Series20%20%-20%Life20%in20%the20%Water/Life-in-the-Water-UAE.pdf.
20. Kassim, A. 1969. "Conflicting claims in the Persian Gulf." Journal of Law and Economic Development, 4, pp. 337–282.
21. Purser, B. H., and Evans, G. 1973. "Regional sedimentation along the Trucial Coast, SE Persian Gulf." In B. H. Purser, The Persian Gulf: Holocene carbonate sedimentation and diagenesis in a shallow epicontinental sea, pp. 231–211. New York: Heidelberg.
22. EAD. 2008. Terrestrial Environments of Abu Dhabi Emirates, United Arab Emirates. Abu Dhabi: EAD.
23. Ibid.
24. EAD. 2017. Abu Dhabi State of Environment Report 2017. Abu Dhabi: EAD.
25. Al Dhaheri, S., et al. 2017. Abu Dhabi Emirate Habitat Classification and Protection Guideline. Abu Dhabi: EAD.
26. Ibid.
27. Mamiit, R., and Francisco, H. 2001. "Diving sites, coral reefs and coral bleaching in the Philippines." Journal of Environmental Science and Management, 2–1)4), pp. 80–68.
28. El Raey, M. 2010. Impact of Sea Level Rise on the Arab Region. The Arab Climate Resilience Initiative. Amman: UNDP Regional Bureau of Arab States (UNDP-RBAS).
29. Secretariat of the Convention on Biological Diversity (CBD). 2009. Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Monteral: Secretariat of the CBD.
30. Dougherty, W., and Grimsditch, G. 2014. Abu Dhabi Blue Carbon Policy. Abu Dhabi: EAD.
31. Kovats, R., and Osborn, D. 2016. "Chapter 5: People and the built environment." In UK Climate Change Risk Assessment Evidence Report. London: The Committee on Climate Change.

Annex:
Summary of Climate Change Projections

	Global	Regional (Arabian Gulf)	National (UAE)
Temperature	**2046–2065 [A]** • RCP 2.6: 0.4–1.6°C • RCP 4.5: 0.9–2.0°C • RCP 6.0: 0.8–1.8°C • RCP 8.5: 1.4–2.6°C **2081–2100 [A]** • RCP 2.6: 0.3–1.7°C • RCP 4.5: 1.1–2.6°C • RCP 6.0: 1.4–3.1°C • RCP 8.5: 2.6–4.8°C	**By the late 21st century:** 3–4°C [B] **RCP 4.5 [C]** 2050: 1.2–1.9°C 2100: 1.5–2.3°C **RCP 8.5 [C]** 2050: 1.7–2.6 °C 2100: 3.2–4.8 °C	**2060–2079: 2–3°C [D]** **2050: 2.1–2.8°C** **2100: 4.1–5.3°C [E]**
Humidity	By 2100, the combination of high temperature and humidity is expected to compromise human activities, including growing food and working outdoors (high confidence). [F]	Heat waves due to high humidity in the Gulf could increase, leading to higher exposure to heat-related diseases. [G]	Humidity changes are greater in the summer months, about 10% greater over the Arabian Gulf, with higher humidity across most of the UAE. [D]
Sea level rise	**2046–2065 [A]** •RCP 2.6: 0.17–0.32 m •RCP 4.5: 0.19–0.33 m •RCP 6.0: 0.18–0.32 m •RCP 8.5: 0.22–0.38 m **2081–2100 [A]** •RCP 2.6: 0.26–0.55 m •RCP 4.5: 0.32–0.63 m •RCP 6.0: 0.33–0.63 m •RCP 8.5: 0.45–0.82 m	**Predicted sea level rise scenarios for the Southern Arabian Gulf by 2099:** • Low scenario: 0.21 m [H] • Medium scenario: 0.59 m [A] • High scenario: 0.81 m [I] • Extreme scenario: 2.0 m [J]	**According to different sources, all coastal cities in the UAE will experience progressively increasing inundation:** • Sea levels increasing by 20–30 cm in the coastal shallows of the UAE. [K] • Sea level rise may advance landward flooding at a rate of 23–58 m per year and result in flooding 2.26–3.81 km from the shoreline by 2100. [L] • In the worst-case sea level rise scenario, inundation may extend to 25–30 km in Abu Dhabi by 2100. [M]
Rainfall	Changes in precipitation will not be uniform. [F] It is likely that the frequency or proportion of heavy rainfalls in total precipitation will increase. [N]	By the end of the 21st century, there is a reduction of the average monthly precipitation reaching 8–10 mm in the coastal areas of the Arab Domain. Some areas, however, show increasing precipitation trends. [C]	Rainfall in the UAE will likely increase, especially in the summer (50–100% in the Northern Emirates and Dubai, and 25% in surrounding regions). [D]
Extreme events	Models project substantial warming in temperature extremes by the end of the 21st century. It is likely that the frequency or proportion of heavy rainfalls in total precipitation will increase. [K]	Being in the domain of the monsoon system, the southern part of the Arabian Peninsula is expected to receive more precipitation in the form of extreme events, such as when Cyclone Gonu hit Oman in 2007. [N]	An increasing risk for "grey swan" (high-impact) cyclones to hit the UAE is predicted. Albeit a low likelihood, this will have a high impact. [O]

[A] IPCC (Intergovernmental Panel on Climate Change). 2013. "Summary for Policymakers." In: Climate Change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the IPCC. Cambridge: Cambridge University Press.

[B] Christensen, J. H., et al. 2007. "Regional climate projections." In Climate Change, 2007: The physical science basis. Contribution of Working group I to the Fourth Assessment Report of the IPCC, pp. 847–940. Cambridge: Cambridge University Press.

[C] ESCWA (United Nations Economic and Social Commission for Western Asia), et al. 2017. Arab Climate Change Assessment Report: Main Report. Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR). Beirut: ESCWA.

[D] AGEDI (Abu Dhabi Global Environmental Initiative). 2015. Results of the Atmospheric Modeling Sub-Project. Local, National, and Regional Climate Change Program (LNRCCP). Abu Dhabi: Environment Agency — Abu Dhabi (EAD).

[E] Jack, C. and Dougherty, B. 2009. Downscaled Climate Change Projections for the United Arab Emirates. Abu Dhabi: EAD.

[F] IPCC. 2014. "Summary for policymakers." In Climate Change 2014. Synthesis report of the Fifth Assessment Report of the IPCC. Cambridge: Cambridge University Press.

[G] Elasha, B. O. 2010. Mapping of Climate Change Threats and Human Development Impacts in the Arab Region. UNDP Arab Development Report — Research Paper Series. Amman: UNDP Regional Bureau for the Arab States.

[H] Sultan, S. A. R., et al. 1995. "An analysis of Arabian Gulf monthly mean sea level."Continental Shelf Research, 15(11–12), pp. 1471–1482.

[I] Rahmstorf, S., et al. 2007. "Recent climate observations compared to projections." Science, 316(5825), p. 709.

[J] Pfeffer, et al. 2008. "Kinematic constraints on glacier contributions to 21st-century sea-level rise." Science, 321(5894), pp. 1340–1343.

[K] AGEDI. 2017. Sea Level Rise Primer. Abu Dhabi: EAD.

[L] Lokier, S., et al. 2018. "Implications of sea-level rise in a modern carbonate ramp setting." Geomorphology, 304, pp. 64–73.

[M] El Raey, M. 2010. Impact of Sea Level Rise on the Arab Region. Arab Climate Resilience Initiative. Amman: UNDP Regional Bureau of Arab States (UNDP-RBAS).

[N] IPCC. 2012. "Summary for policymakers." In Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Cambridge: Cambridge University Press.

[O] Lin, N. and Emanuel, K. 2016. "Grey swan tropical cyclones." Nature Climate Change, 6(1), pp. 106–111.

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