WISER MENA Scoping Report

Opportunities for improved weather and climate information in the Middle East and North Africa region

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Glossary

AA	Anticipatory Action
ARPEGE	Action de Recherche Petite Echelle Grande Echelle
ARRCC	Asia Regional Resilience to a Changing Climate
CMIP6	Coupled Model Intercomparison Project Phase 6
COF	Climate Outlook Forum
CORDEX	Coordinated Regional Downscaling Experiment
DMA	Disaster Management Agencies (government)
ECMWF	European Center for Medium-Range Weather Forecasts
EM-DAT	Emergency Events Database
ENSO	El Niño–Southern Oscillation
EWS	Early Warning Service
FAO	Food and Agriculture Organisation
FBA	Forecast Based Action
FBF	Forecast Based Financing
FCDO	Foreign, Commonwealth and Development Office (UK)
GCA	Global Center on Adaptation
GFS	Global Forecasting System
GPC	Global Producing Center
ICPAC	IGAD Climate and Prediction Center
ICRC	International Committee of the Red Cross
IDP	Internally Displaced Person
IFRC	International Federation of the Red Cross
IOD	Indian Ocean Dipole
IPCC	Inter-Governmental Panel on Climate Change
MENA	Middle East North Africa
NCEP	National Centre for Environmental Prediction
NGO	Non Governmental Organisation
NMHS	National Meteorology and Hydrology Service

NMS	National Meteorological Service
NWP	Numerical Weather Prediction
ODA	Overseas Development Assistance
OECD	Organisation for Economic Cooperation
PHENOMENAL	Pioneering a Holistic approach to Energy and Nature-based Options in MENA for Long-term stability
RCC	Regional Climate Centre
RCCC	Red Cross Climate Centre
RCP8.5	Representative Concentration Pathway 8.5
REAP	Risk Informed Early Action Partnership
SSP5	Shared Socioeconomic Pathway 5
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNICEF	United Nations International Children’s Emergency Fund
WCIS	Weather and Climate Information Services
WFP	World Food Programme
WISER	Weather and Climate Information Services
WRF	Weather Research and Forecasting Model

Executive summary

The Middle East and North Africa (MENA) region already experiences a range of weather and climate hazards in the form of extreme heat, floods, droughts and dust storms. The frequency and intensity of these hazards will increase as the climate changes. Whilst some wealthier nations in the region are more resilient to hazards, other countries are afflicted by poverty, state fragility and conflict. High levels of displacement and migration linked to this make huge numbers of people vulnerable and exposed to the impacts of weather, climate change and variability.

Weather and Climate Information Services (WISER) MENA sits under the Foreign, Commonwealth & Development Office's (FCDO) Pioneering a Holistic approach to Energy and Nature-based Options in MENA for Long-term stability (PHENOMENAL) programme. It will invest £5 million to enable greater use of weather and climate information to support policy, planning and decision making at regional, national, sub-national and community levels, in order to build resilience and support adaptation.

This scoping report summarises evidence gathered on the impacts of weather and climate in the MENA region, who is affected and what action is taken to mitigate and avoid these. It also examines the provision of short-range weather forecasts, seasonal outlooks and climate projections in the region and explores how forecasting skill and scientific capability may be relevant to supporting decisions and actions that can protect lives and livelihoods.

Based on the insights presented, four potential thematic areas of opportunity for improving weather and climate information services in the MENA region are suggested. These are:

1. The need to build understanding *of,* and demand *for* weather and climate information in MENA;
2. Building resilience to extremes by supporting vulnerable communities;
3. Enhancing seasonal forecasting in the region; and
4. Supporting and strengthening other weather and climate service improvement initiatives in the region, to maximise their impact.

These potential areas of opportunity present a starting point to help steer discussions on the Theory of Change with potential users and producers of weather and climate information in the region. The development of the Theory of Change will be a participatory process and the design of the Logframe and programme plan for WISER MENA will follow this.

Building on the success and learning of WISER to date, coproduction will be a central component of WISER MENA, with the needs of users leading the design and delivery of the programme. This will ensure that services developed through PHENOMENAL's investment can be useful, usable, used and sustained and thereby fulfil the huge potential improved weather and climate information has, to build resilience and support adaptation in the region.

1. Context for WISER MENA

The Middle East and North Africa (MENA) region is typically considered to include around 19 countries and approximately 6% of the world's population. The region accounts for 60% of the world's oil reserves and 45% of natural gas reserves, making these a backbone of the region's economy.

Whilst high standards of living are enjoyed by a significant share of residents in Gulf nations and other major economies in the region, poverty and conflict prevail in states like Syria, Iraq, Libya and Yemen. These countries experience high levels of vulnerability and have led over 15 million people to have become internally displaced. This has given rise to what the World Bank describes as one of "the worst refugee crises since the second world war".

The region's climate is characterised by mainly hot and dry conditions, with heat stress limiting daily life for much of the population for most of the year. The current climate is around 1–1.5˚C warmer than pre-industrial times, and there is high confidence of further warming in the future. Water stress is already being experienced in the region and there is high confidence that regional water resource quantity and quality will reduce as temperatures rise. Food insecurity, coastal inundation, increasing urbanisation and poor health are impacts that are anticipated to become increasingly prevalent.

Extreme weather and inter-annual climate variability, exacerbated by the effects of longer-term climate change, present significant and growing threats to sustainable development globally, and particularly in MENA. This is especially true given the existing vulnerabilities in the region. The provision of relevant, timely and accurate weather and climate information services can help the public, governments and the humanitarian community to act ahead. They thereby represent important tools for building resilience and supporting adaptation efforts in the region.

However, understanding and uptake of weather and climate information among potential users who could benefit from it is low. Through the FCDO PHENOMENAL programme, an investment of £5 million is being made to transform the generation and use of weather and climate information in the MENA region through WISER MENA. This investment will build on the Met Office's WISER programme in East Africa which commenced in 2016 and is now in its third phase of implementation until 2026. With coproduction (an equitable dialogue between those who produce and use forecasts) as a central tenet, WISER has so far enabled over 3.3 million households to access enhanced information and delivered in excess of £200 million of socio-economic benefit.

2. About this report

This report presents the scoping phase of the WISER MENA programme which identifies how and where improved weather and climate information has the most potential to protect lives and livelihoods, build resilience and support adaptation. The insight gathered will be used to help inform dialogue with stakeholders in the region (users and producers of weather and climate information) on the Theory of Change, Logframe and detailed programme plan.

The scoping was conducted by the Met Office and Red Cross Climate Centre (RCCC) and builds on the Climate Risk Report for the Middle East and North Africa which was produced by the Met Office and ODI for FCDO in 2021. Using a mixture of literature reviews (academic and grey), stakeholder mapping and key informant interviews, this report explores:

- The current climate in MENA and projected changes to this;
- Weather and climate impacts in MENA;
- Vulnerability to these impacts;
- Responses taken to the impacts (among the most vulnerable);
- Analysis of weather and climate information provision in the region, and;
- Weather and climate science that could be relevant to MENA.

The analysis for this report was undertaken by the Met Office's International Development and Climate Security Teams and the Red Cross Climate Centre.

Where possible, WISER seeks to adopt a regional approach to improving the uptake of weather and climate services so that investment can benefit numerous countries or users (for example, training which can be provided by a regional centre and attended by all countries in the region, or regional platforms and tools). However, due to the diversity of the MENA region in terms of climatological, economic and political contexts, this may not always be feasible. Focus countries to include in the scoping were therefore identified as Yemen, Iraq, Palestine, Syria, Egypt and Morocco, though this list is not exclusive (Figure 1). The selection of these countries has been determined by FCDO's guidance on focus countries for the programme, exposure to hazards, the vulnerability of resident and IDP populations and the various levels of institutional preparedness to address hazards. In addition, all the countries chosen are at different states of fragility or conflict. Economically, the countries of focus are classified as least developed to developing except for Egypt which is considered as an emerging economy and one that will host COP 27 in November.

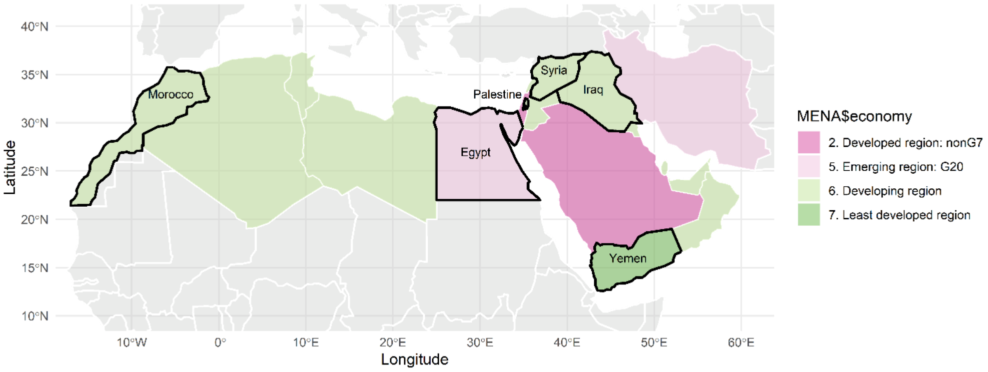

Figure 1: The MENA region and its economy; countries bordered by the black line are the special focus for this report (Data source: https://www.naturalearthdata.com/).

3. The current and changing climate in MENA

Much of the MENA region is characterised by high temperature and low water availability, a combination of variables that have the potential to lead towards the environmental limits/threshold for safe human habitation (Xu et al., 2020). This makes the region particularly vulnerable to climate change and climate variability, as small variations in climate can easily produce high temperatures or extensive droughts that are harmful to human lives and livelihoods.

Changes in temperature and rainfall patterns have already been observed in the region and are expected to change further in the near future, especially if global warming exceeds 1.5 to 2 °C above the pre-industrial level. Annual mean temperatures across the MENA region have increased between 0.3–0.5°C per decade[1] over the period 1980–2015 (Gutiérrez et al., 2021). Since the 1950s, hot and cold extremes have become warmer, the number of cold days has decreased, and the number of warm days has increased (Dunn et al., 2020). There has been an increase in heat waves intensity, frequency and duration (Perkins-Kirkpatrick and Lewis, 2020). Annual mean precipitation shows a high level of spatial variability over the MENA region. During the period 1980–2015 there have been downward trends in mean annual precipitation (Gutiérrez et al., 2021). Dry conditions, drought intensity and frequency has increased in the past over the region (Seneviratne et al., 2021).

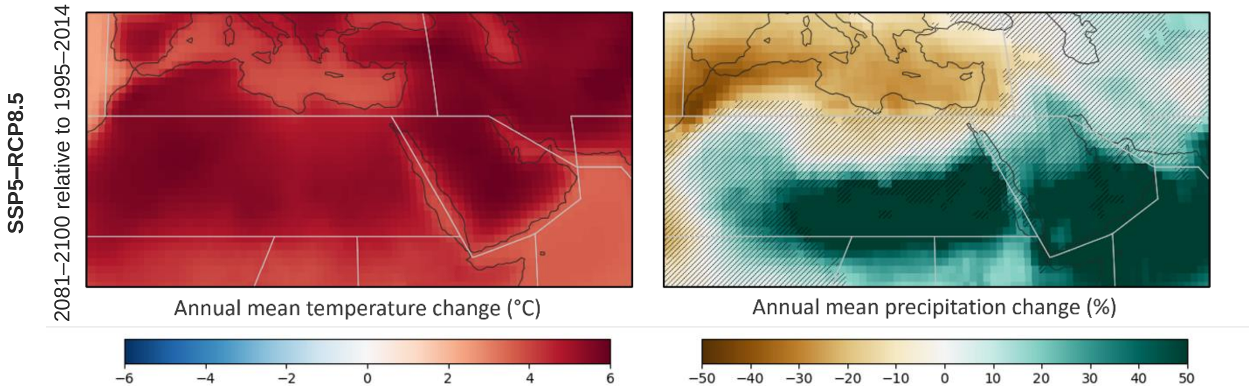

Figure 2: Projected change in annual mean temperature (left) and annual mean precipitation (right) between 1995–2014 and 2081–2100 under the SSP5–RCP8.5 scenario based on CMIP6 models (Gutiérrez et al., 2021). Note that precipitation change is given as a percentage: the large increases projected over Sahara and Arabian deserts equate to only a few millimetres of additional rainfall.

[1] This statistic equates to approximately 1–1.75 °C temperature rise between 1980 and 2015, indicating that warming across the MENA region appears to be outpacing global temperature change. This is because global temperature change is an average of all temperature change occurring around the world, including the oceans, which are warming at a slower rate than over land. Regional temperature change can therefore easily exceed global temperature change, which highlights the need for regional projections to be disentangled from often quoted global values, as heat-related impacts may be more severe than otherwise anticipated.

Future temperatures over the MENA region are projected to rise by 2–2.5°C by 2050 relative to a recent 1995–2014 baseline under a high greenhouse gas concentration scenario (SSP5–RCP8.5; Gutiérrez et al., 2021), and by approximately 1.5°C for low greenhouse gas concentration scenario (SSP2–RCP4.5; ibid). There is high certainty that maximum and minimum temperature will also rise, as will the number of extremely hot days (>35 °C) that occur each year (Ranasinghe et al., 2021); this is notable, because 35 °C is an important threshold above which heat stress tends to occur in humans (Sherwood & Huber, 2010), crops and livestock (Asseng et al., 2021; IPCC, 2021).

Climate models project a decrease in total annual precipitation over Morocco, Syria, Iraq, Palestine and North Egypt, and increases over Yemen. However, projections in precipitation are less certain than temperature projections due to lower model agreement on the direction of change; this is because precipitation projections are highly dependent on model and scenario. There is, however, agreement among at least 80% of the most recent set of internationally recognised climate models (CMIP6[2]) for decreases in precipitation along the densely populated Mediterranean coastline and increases in southern parts of the Arabian Peninsula under the SSP5-RCP8.5 scenario (Gutiérrez et al., 2021; Figure 2).

In general, decreases in precipitation and increases in temperature and evaporation are expected to intensify drought severity and duration over the region. Wet season rain storms are also projected to become more intense, as a warmer atmosphere can hold more water (Ranasinghe et al., 2021; Richardson et al., 2021; Seneviratne et al., 2021). This means that while rains will be less frequent, they will be more intense, which can have implications for flash flooding when heavy rains occur over ground hardened by drought (Belachsen et al., 2017; WFP, 2021). Sea levels are also projected to rise, which will increase the frequency and intensity of coastal flooding events in the MENA region, with impacts extending to the erosion of important coastal infrastructure and the salination of agricultural land and aquifers (MedECC, 2020; Ranasinghe et al., 2021; Richardson et al., 2021).

Key climate-related hazards which affect the region include heat waves, cold waves, droughts, floods and dust storms. Annex Table 1.1 details the present day and projected occurrence of these hazards in the focus countries, while Annex Figures 1.4–4 show their geographical distribution.

[2] The Coupled Model Intercomparison Project Phase 6 (CMIP6; Eyring et al., 2016) is a collection of global climate models (GCMs) developed by different institutions around the world. These models were used to inform the most recent IPCC Assessment Report, AR6 (IPCC, 2021).

4. Weather and climate impacts in MENA

In general terms, weather is only of note when it affects people, infrastructure and ecosystems and is therefore described as being ‘impactful weather’. The development and communication of weather forecasts is increasingly moving towards being impact-based as these tend to be more meaningful and relevant to those who use them and are therefore more likely to lead to action to avoid or mitigate the forecasted impacts. The discussion of current and predicted climate in the MENA region is therefore described in terms of the impacts it will have on water, food, energy, health, urban areas, coastal regions and conflict and security.

In the last two decades the MENA region has seen substantial escalation in the number of meteorological, climatological and hydrological disasters that have impacted economies and livelihoods across various sectors. In particular, disaster risk in the Arab region is increasingly contributed to by meteorological and climatological hazards (Figure 3) combined with growing exposure and vulnerability of communities. According to the international disasters database EM-DAT (based on the 1970–2022 data, Figure 4), floods have been by far the most frequently occurring disaster for Yemen, Morocco and Iraq.

The impacts of disasters on specific sectors and how the impacts in those sectors affect focus countries is discussed below.

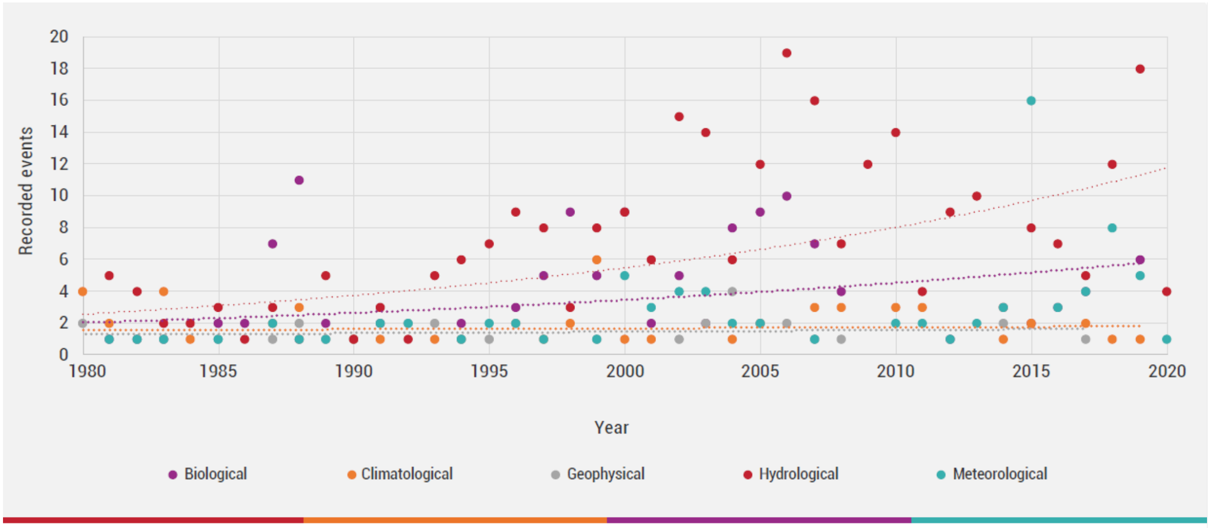

Figure 3: Disasters by type and year in the Arab region, 1980–2019 (Data: Centre for Research on the Epidemiology of Disasters (CRED), 2020; Adapted from UNDRR, 2021a).

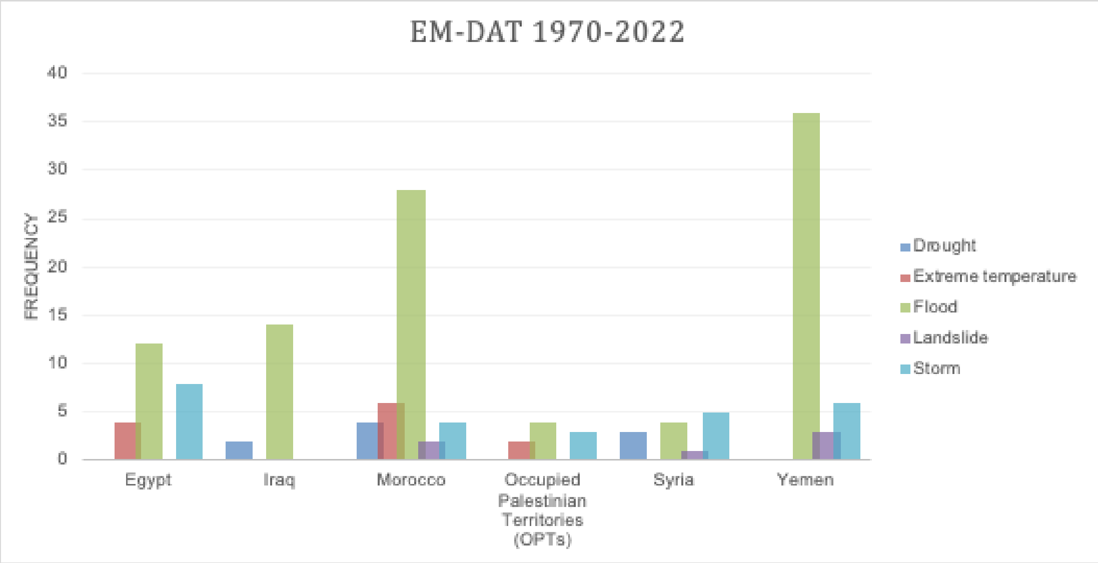

Figure 4: Types of hydrometeorological hazards Palestine, Yemen, Iraq, Syria, Egypt and Morocco (1970–2022; Data: EM-DAT, 2022).

4.1 Water

Much of the MENA region is already water stressed — it does not have enough water supplies to sustainably meet current demands. At present, 61% of the population experience 'high' or 'very high' water stress[3] (World Bank, 2018), with nine of the world's ten most water-stressed countries located within the region (WRI, 2019). Policy makers have historically focused on securing additional water supplies through groundwater extraction and desalination rather than improving existing water management practices (Richardson et al., 2021; FAO and World Bank, 2017). Another issue is that water resources tend to be distributed inequitably across the region.

There is agreement among at least 80% of the most recent set of internationally recognised climate models (CMIP6) for decreases in precipitation in regions neighbouring the Mediterranean Sea—which are densely populated relative to much of the MENA region—and increases in precipitation in more southerly parts of the MENA region (unhatched green areas in Figure 2) under the SSP5–RCP8.5 scenario (Gutiérrez et al., 2021). However, projections of precipitation across parts of MENA (hatched areas in Figure 2) are uncertain due to lack of model agreement in the direction of change. There is also high confidence that further temperature increases will occur across the entirety of the MENA region; this will act to increase evapotranspiration rates, further stressing the region's water resources.

Competition between water users—including agricultural irrigation, hydropower, potable supply, industry and tourism—is growing (Richardson et al., 2021). Agriculture is the primary

[3] 'High' water stress relates to 40% or more of the national water supply being abstracted, while 'very high' relates to 60%. Source: World Bank (2018).

user of freshwater in Syria, Yemen, Iraq, and Egypt (World Bank, 2018). The projected reductions in water availability are therefore also likely to impact regional food security (IPCC, 2022). Greater demand for water and irrigation is driving unsustainable water exploitation and depletion of groundwater reserves. In Yemen, for example, unmanaged groundwater extraction for agricultural purposes has caused water tables to drop by 2–7 metres annually (Red Cross Red Crescent Climate Centre, 2021a). Similar over-withdrawal of groundwater has occurred in Northeast Syria (Red Cross Red Crescent Climate Centre, 2021b). The rising demand for water in combination with its widely diminishing availability implies that water scarcity in the MENA region will almost certainly increase over the coming decades.

Water is a transboundary resource, with countries in the MENA region relying on rivers that cross national borders for freshwater, including the Nile, Tigris and Euphrates. For example, Egypt is highly dependent on the Nile and its tributaries, which it shares with Rwanda, Tanzania, Uganda, Ethiopia, South Sudan and Sudan. Similarly, the Tigris and Euphrates flow through Turkey, Syria, Iran and Iraq. Focus countries that are reliant on transboundary rivers for freshwater supply such as Egypt, Iraq and Syria will therefore be affected by upstream factors, both human and physical. For example, abstraction and damming of the Euphrates River in Turkey has contributed to water shortages in Syria (Chatham House, 2015), while in Egypt changing rainfall patterns over the Ethiopian Highlands in combination with greater evaporation rates may reduce the discharge of the Nile (Richardson et al., 2021). There is a risk that climate change could cause upstream countries to become increasingly protective of their hydrological assets, which has the potential to cause unpredictable impacts downstream.

Poor water quality, sometimes resulting from droughts or floods (Stringer et al., 2021), can increase the prevalence of water-borne diseases, for example the outbreaks seen in Yemen since 2016 and northeast Syria in 2021 (Relief Web, 2017; Médecins Sans Frontières, 2021). An example of inadequate water supply occurred in Syria in 2021, when record low rainfall combined with historically low water levels in the Euphrates River. This not only reduced access to water for drinking and domestic use for over five million people, but also triggered substantial harvest and income losses, decreased hydroelectricity generation, and increased water-borne diseases (El Hajj et al., 2022).

4.2 Food

MENA is one of the few regions in the world with decreasing food security (OECD, 2018). In Syria, 60% of the population is considered food insecure (CIA, 2022). Agriculture plays a large role in people's livelihoods, as well as food security in general. Agriculture comprises up to 50% of employment in MENA’s poorest regions, 75% of household livelihoods in Yemen (Nin-Pratt et al., 2018), and 40% of Morocco's workforce (CIA, 2022).

The MENA region is the highest food-importing region in the world (GCA, 2020), with

approximately 50% of its cereals imported (Jobbins and Henley, 2015). Local food production has limited scope for expansion, so dependency on food imports is high (El Hajj et al., 2022) and leaves MENA countries highly exposed to price shocks and volatility in global markets. The region may become even more reliant on food imports by the 2050s as a result of temperature and rainfall projections combining to reduce overall domestic crop yields by up to 30% under 1.5–2 °C warming, and up to 60% under 3–4 °C warming (Al-Bakri et al., 2011; Schilling et al., 2012; Waha et al., 2017). Lower domestic production will likely raise food prices and lead to more dependence on global breadbaskets such as Russia and Europe, exposing the region to fluctuations in supply such as that resulting from the 2022 Russia–Ukraine conflict (Schiavi & Serra, 2022; Turak, 2022). Food prices are highly political and have previously contributed to social and political unrest such as that seen in Egypt in 2007–2008 (Richardson et al., 2021; Korotayev and Zinkina, 2011; Al-Shammari and Willoughby, 2019). Poor populations living in conflict-affected countries with stagnant economies and increasing poverty are likely to be particularly affected (Richardson et al., 2021).

Agriculture is the region's largest user of water — agriculture accounts for at least 80% of freshwater demand in Egypt, Yemen, Iraq and Syria (Red Cross Red Crescent Climate Centre, 2021a, b, c, d; World Bank, 2018). The projected temperature increases are associated with higher evapotranspiration rates and greater risk of drought. Increased drought severity may lead to greater irrigation demand as farmland will become increasingly unsustainable under water scarcity. Some agricultural areas in MENA are rainfed such as northern Iraq (Red Cross Red Crescent Climate Centre, 2021d), while others such as the Nile basin are already heavily irrigated (Nile Basin Initiative, 2022).

Heat stress for crops and livestock, as well as humans involved in manual labour associated with farming, is projected to worsen. There is high confidence for a substantial increase in the number of days that the region is expected to experience temperatures exceeding 35 °C by mid-century (Raymond et al., 2020; Richardson et al., 2021). This is an important threshold for crop productivity, as heat stress in many crops tends to occur above 35 °C (Asseng et al., 2021).

Agriculture in the MENA region can also be impacted by dust storms and sandstorms. Projected increases in the frequency and intensity of droughts are likely to increase the available dust sources, which suggests that dust storms could become more frequent and cause more damage to crops (Richardson et al., 2021).

Fishing contributes relatively little to the economy of the MENA region. However, it is an important source of livelihood and food security in coastal communities (Richardson et al., 2021; FAO, 2019).

4.3 Energy

Temperature increases are likely to inflate the burden on energy infrastructure (Disher et al.,

2021), which may cause national grids to become less reliable. This could exacerbate issues of already poor infrastructure (IPCC, 2022), such as that in Syria.

Water scarcity and higher temperatures are expected to limit energy generation. This is because higher temperatures increase the cooling requirements of power plants, which often require water to do so. Water scarcity could also affect the ability to generate hydroelectricity, which could be important to the region as hydroelectric power currently provides 16% of energy in Morocco (CIA, 2022), and almost 10% in Iraq (Red Cross Red Crescent Climate Centre, 2021d). Finally, water scarcity will make desalination an increasingly relied upon technology for maintaining freshwater water supplies in the absence of other adaptation measures, but desalination is a highly energy intensive process that will likely further stress energy infrastructure (Richardson et al., 2021).

Higher temperatures are also likely to increase energy demands by increasing the need for air conditioning and other cooling technologies to comfortably adapt to a warming environment, at least by those who can afford to do so. The population of the MENA region is projected to increase from 526 million people to 754 million by 2050 (United Nations, 2019) which, in combination with any increases in affluence, will further increase the energy demands of the region.

Global trends towards decarbonisation could negatively impact important regional economies due to many countries in MENA currently having a high dependency on fossil fuels. Along with the regional economic impact associated with reduced investment from foreign oil and gas corporations (Tagliapietra, 2017), shifts from fossil fuels could also affect the economies of focus countries: oil and gas make up ~70% of Yemen's exports (Red Cross Red Crescent Climate Centre, 2021a), and 99% of Iraq’s export revenue (World Bank, 2022a). This could reduce the capacity of these countries to adapt to the impacts of climate change in the future.

4.4 Urban and human health

The MENA region is highly urbanised, with 65% of Morocco’s population and 71% of Iraq’s population living in cities (CIA, 2022). This is expected to increase, with 70% of the region’s population projected to live in urban settlements by 2050 (UN Habitat. 2020). This compares to 66% of the MENA region’s population being urban in 2020 (World Bank, 2022c). As urban areas grow, often in an informal way, demand for freshwater will increase while also putting more pressure on sanitation services.

Heat stress is already experienced in many parts of the MENA region (e.g., in Egypt, Yemen and Iraq; Red Cross Red Crescent Climate Centre, 2021a, c, d), and is exacerbated in cities due to the urban heat island effect (e.g., Cairo, Sanaa and Baghdad). Rising temperatures and growing urban populations suggest that heat stress will be an increasingly prominent climatic hazard that the region will be required to adapt to. Given the physiological limits of humans to withstand extreme heat in the absence of sufficient adaptation measures such as

air conditioning, parts of MENA will become increasingly uninhabitable towards the mid-century, especially along the highest emissions pathways (Pal and Eltahir, 2016).

Heat stress conditions limit productivity and economic activity (Dunne et al., 2013). For example, rising temperatures will likely reduce outdoor labour productivity in summer, particularly where access to artificial cooling is limited.

Many major settlements in MENA are coastal; the higher humidity experienced at the coast further exacerbates heat stress (Lutsko, 2021). The coastal location of many major cities (e.g., Alexandria, Egypt) in the MENA region means that they are also exposed to the threats associated with sea level rise (IPCC, 2022; see Section 4.5 for further detail).

Human health may also be impacted by reduced urban water quality, which can result from droughts (Stringer et al., 2021), sometimes through increased salinity due to lower dilution and enhanced algal production, or floods, e.g., through contamination of water supply. Heat-related and water-borne diseases are already stressing Yemen’s fragile healthcare system.

The occurrence of dust storms and sandstorms in the MENA region impact air quality, with implications for human health. “In Iraq, there have been observed increases in the frequency and intensity of dust storms due to low soil moisture. Dust storms reduce visibility significantly in several parts of Iraq, disrupting air and road transportation, and can cause loss of human productivity and (El Hajj et al., 2022) and serious health consequences such as respiratory issues and meningitis (El Hajj et al., 2022; GCRF African SWIFT, 2022).

Migrant workers and urban poor often live in vulnerable, informal settlements, making these groups highly exposed to the effects of heat stress, pollution and flooding.

4.5 Coastal regions

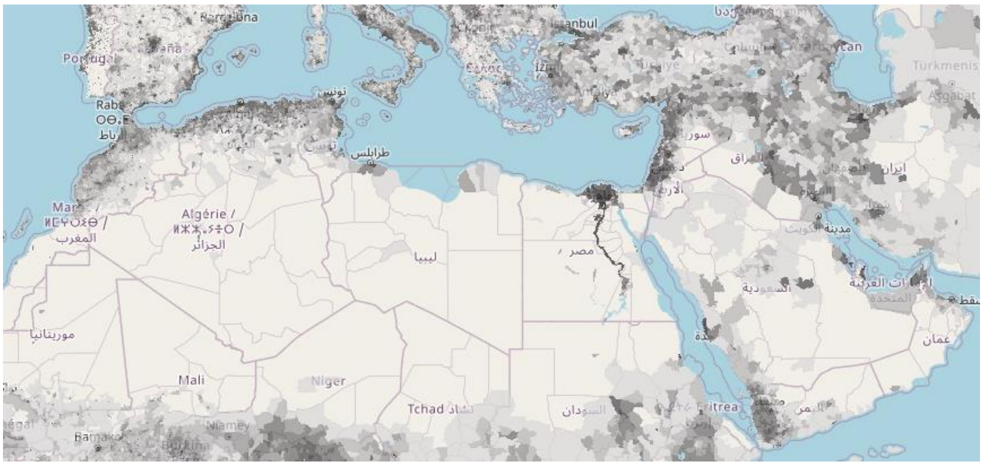

Figure 5: Population density (Met Office Global Hazard Map, 2022).

The population of the MENA region is highly concentrated at its coastal regions (Waha et al., 2017); the high population densities near the coast are particularly notable in Egypt,

Morocco and Syria (Figure 5). Coastal areas contain important assets to the region, including major ports (e.g., Tangier-Med in Morocco), tourism (e.g., Egypt; OECD, 2022) and the fishing industry.

Projected sea level rise is expected to increase coastal flooding, with Egypt and Morocco being two of the countries with the largest populations exposed to sea level rise globally (IPCC, 2022). Several coastal cities (e.g., Alexandria, Egypt) and much coastal infrastructure will be exposed to the combined impacts of sea level rise and storm surges, with potential to disrupt port operations in the Mediterranean (IPCC, 2022). Yemen is projected to experience greater frequency and severity of extra-tropical cyclones (Bloemendaal et al., 2022), likely increasing the risk of coastal flooding. Enhanced rates of coastal erosion may exacerbate this further.

Sea level rise is also associated with saltwater intrusion, which is highly damaging to agricultural productivity in coastal areas due to the salination of agricultural land, degradation of groundwater resources, and other associated damages to agriculturally important assets.

Sea level rise is expected to degrade coastal ecosystems such as wetlands, mangroves and coral reefs (Lincoln et al., 2021), in turn reducing the resilience of coastal regions to extra-tropical storms. Fisheries and aquaculture in the MENA region are not resilient to natural hazards (Tull, 2020); overexploitation, pollution, and coastal development already threaten existing fish stocks.

The shallow seas of the MENA region have been observed to experience sea surface temperature (SST) increases that exceed the global average rate, with these trends likely persisting into the future (Shaltout, 2019; Volosciuk et al., 2016). This will increase the occurrence of marine heatwaves (Mohamed, 2021) that can be especially detrimental to marine ecosystems and fisheries.

4.6 Conflict and security

Figure 6 shows the conflict incidents per focus country in 2021–2022. Political instability and fragility are already associated with high numbers of internally displaced people. In the absence of appropriate adaptation measures, the MENA region is expected to become increasingly uninhabitable under a warming climate (Pal and Eltahir, 2016). It is widely agreed that climate change is a threat multiplier (Huntjens and Nachbar, 2015), amplifying the issues associated with migration, displacement, conflict and other forms of humanitarian disaster.

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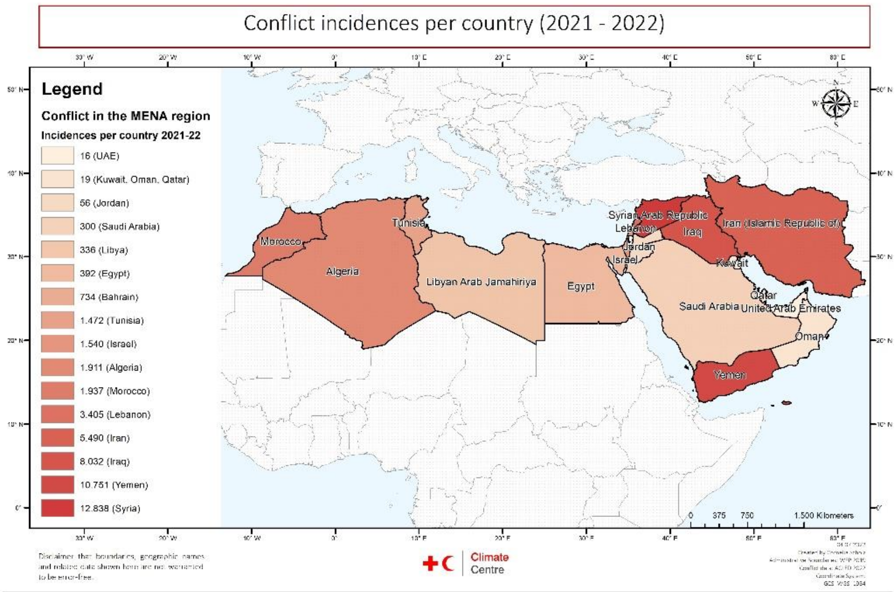

Figure 6: Conflict incidents per country (2021–2022). Source: Map: Scholz (2022); Data: Armed Conflict Location & Event Data Project ACLED (2022).

Climate change is expected to increase competition for resources, particularly water (Huntjens and Nachbar, 2015).

Tensions over water can be at a local level, as well as larger scales, for example between nations. The Nile, Tigris-Euphrates and Jordan are river basins that are associated with transboundary resource-related tensions within the MENA region (Swain, 2001, Richardson et al., 2021).

Although transboundary water resources are often contested, there is little evidence of this directly leading to inter-nation armed conflicts (Katz, 2011, Richardson et al., 2021). Instead, disagreement over water resources can antagonise already hostile relationships, potentially causing them to become violent, especially at the subnational level, though this effect should not be exaggerated (Richardson et al., 2021). Nevertheless, conflicts can perpetuate water insecurity. For example, water infrastructure has been physically damaged during conflict in Iraq and Syria (FAO and World Bank, 2017; Richardson et al., 2021). Water resources have been targeted specifically in MENA conflicts, with opposing groups attacking and taking control of critical water infrastructure, negatively impacting on the lives of local populations (Schillinger et al., 2020; Richardson et al., 2021).

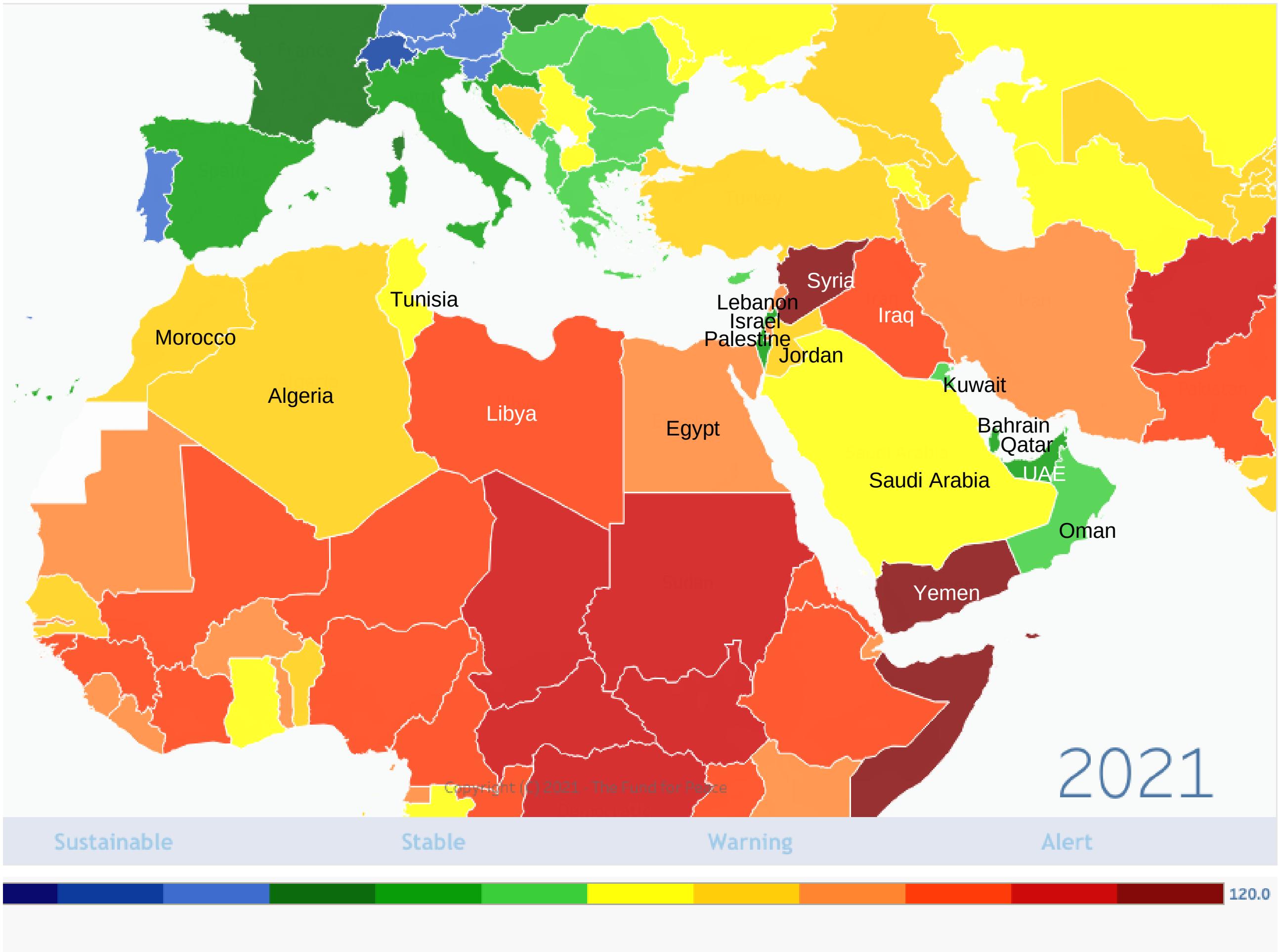

Figure 7: Fragile States Index (https://fragilestatesindex.org/)

The MENA region contains many fragile states (Fragile States Index, 2021; Figure 7), meaning that the capacity of many countries in the region to adapt to the impacts of climate change is limited. For example, people living in Internally Displaced Person (IDP) camps are less resilient to impacts of flash flooding than those living in more formal or permanent settlements. (Relief Web, 2021a).

4.7 Sectoral impacts in focus countries

The following section describes the specific sectoral impacts of climate risks for the six MENA countries explored in more detail in this report.

Palestine

Climate change poses a severe threat for Palestine's economy and the livelihood of its people. Decreasing precipitation, significant warming, increasing frequency and intensity of extreme weather, and sea level rise have the potential to lead to increased water scarcity, decreased agricultural productivity, and saline water intrusion into the extremely important Gaza coastal aquifer. The agriculture sector is especially important to Palestine's small economy, yet it remains highly exposed to extreme weather events such as drought; this can have catastrophic impact on food security in a country that is heavily constrained in its ability to mitigate due to its limiting borders.

Yemen

Yemen is among the least prepared countries for climate shocks and among the most vulnerable to climate change due to its damaged infrastructure and governmental apparatus (OCHA, 2022c). Yemen is highly vulnerable to the impacts of hydrometeorological disaster, with agricultural sectors, water resources and coastal regions being particularly at risk. Yemen will likely face increasingly intense water scarcity which, in combination with reductions in water quality, could lead to decreased agricultural productivity as well as livestock productivity. In addition to food and water insecurity, the health sector will also be impacted as heat-related and water-borne diseases put further pressure on an already fragile health system that is compromised by ongoing civil war (RCCC, 2021a).

Iraq

Iraq is the fifth most vulnerable country in the world to changes in the climate (OCHA, 2022b). Extreme weather and climate events have direct social, economic and environmental consequences that impact the country's water resources, agriculture, biodiversity, and health sectors. Drought and water scarcity are pressing concerns, and the marshlands of southern Iraq are among the most affected areas. Water supplies are under pressure from upstream water management practices, droughts and infrastructural decline, with flooding arguably posing the greatest risk to the country. Annual flooding in the Tigris (February–June) and Euphrates (March–July) rivers cause substantial infrastructural damage, especially in southern parts of Iraq. In recent years, the frequency and intensity of dust storms have also increased due to low soil moisture. Dust storms reduce visibility significantly in several parts of Iraq, disrupting air and road transportation, cause serious health consequences and limit economic productivity.

Syria

Syria is anticipated to experience considerable socio-economic impacts as a result of climate change. Drought is one of the more serious climate hazards affecting the country, which has

major impacts on agricultural sectors and national food security. In early 2021, record low rainfall combined with historically low water levels in the Euphrates River not only reduced access to water for drinking and domestic use for over 5 million people, but also triggered substantial harvest and income losses, decreased hydroelectricity generation, and increased the prevalence of water-borne disease. Flooding is another climate risk that poses significant socio-economic threat for Syria, with the country having suffered several flood events in the past decade that have resulted in death and destruction of property, affecting both livestock and vital infrastructure. These flood events are usually the result of heavy winter rains, or rapid snowmelt in the spring. In the mid- to long-term, flooding and drought are expected to have serious and cumulative impacts on health, food insecurity, malnutrition rates, and potentially irreversible environmental degradation in parts of the country (OCHA, 2022a).

Egypt

Egypt is considered highly vulnerable to climate change due to its primary dependence on the Nile River. The Nile River serves the country's needs for potable water, agriculture, industry, fish farming, power generation, inland river navigation, mining, oil and gas exploitation, cooling of industrial machinery, and power generation. The dependence on the Nile River's water makes the country vulnerable to rising temperatures and reduced rainfall. Egypt experiences heavy rains, which often result in flash floods that wash away property, claim lives and displace people from their homes and livelihoods. Extreme spikes in temperature can cause deep depressions in the Egyptian desert, which in turn cause dust storms that are known locally as the Khamsin winds. With the number of extremely hot days projected to increase across Egypt and a general drying trend over the region, dust storms could become increasingly prevalent with impacts extending to topsoil losses, crop damages, and respiratory health complications. Moreover, tourism is important to the Egyptian economy, but climate change could reduce the desirability of Egypt as a holiday destination, potentially reducing the economic capacity of the country to adapt to further climate change (RCCC, 2021b). Finally, Egypt receives over 80% of its wheat from Russia and Ukraine (Turak, 2022). Food security could be turbulent in the short-to-medium term due to the ongoing Russia–Ukraine conflict, as any climate-related shocks to domestic crop yields would be especially impactful without stable supply lines.

Morocco

Morocco is vulnerable to multiple climate-related hazards, including annual floods, droughts, extreme temperature variations, major forest fires, and has a coastline that is exposed to Atlantic storms, with their probability of occurrence increasing. Floods threaten many regions in Morocco, and they rank first in terms of frequency of occurrence and represent the priority risk from the perspective of local stakeholders. These events have significant economic consequences, because the country is highly dependent on sectors such as agriculture, fisheries, and tourism. Extreme temperatures pose a particularly high risk to animal and human health, as well as to crops and wider ecosystems.

5. Vulnerability to weather and climate impacts

A recent study by Namdar et al. (2021) investigating vulnerability to climate change in the MENA region on the basis of water, food, health, ecosystem services, human habitat and infrastructure sectors, showed the country with the highest vulnerability to be Yemen (‘very high’), followed by Iraq, Syria, Libya and Oman (‘high’), and Egypt and Morocco (‘medium’) (Figure 8).

Figure 8: Climate vulnerability in the MENA region (Namdar et al., 2021).

In the MENA region, vulnerability is often determined by exposure to conflict and poverty. Vulnerable populations can be made up of migrants, refugees, IDPs, rural (isolated) communities, and communities in areas with ongoing conflict. These groups of people are often most impacted by the impacts of climate change. In addition, vulnerable communities in the MENA countries often include rural households and communities dependent upon rainfed agriculture, fishermen, and urban populations living in precarious conditions and a lack of services. The populations living in the vicinity of rivers and coasts often have higher vulnerability due to flood exposure.

The MENA region consists of many groups of IDPs (Figure 9) and refugee populations, many of which live in or have migrated from Iraq, Syria, Palestine, and Yemen. Syria has the highest number of IDPs, followed by Yemen and Iraq with 6.6 million, 3.6 million and 1.2 million IDPs, respectively, according to IDMC (2020).

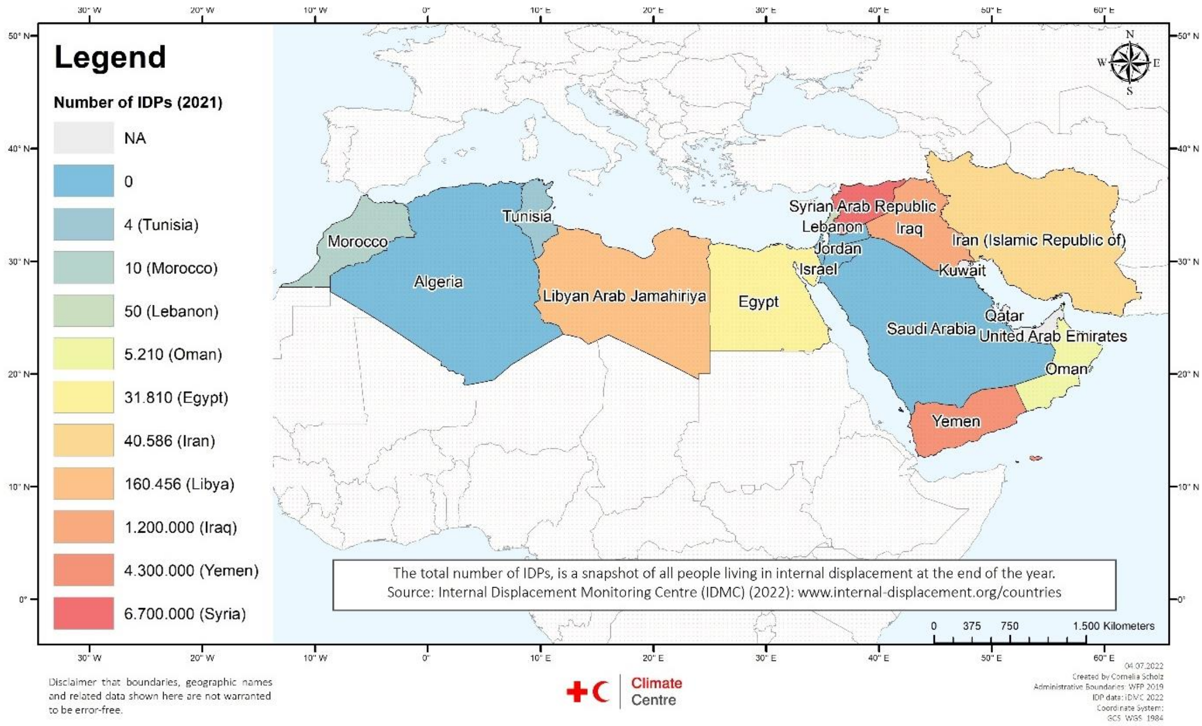

Figure 9: The national distribution of internally displaced persons (IDPs) in MENA. Source: Map: Scholz (2022); Data: Internal Displacement Monitoring Centre IDMC (2020).

In **Syria,** there are roughly 6.7 million IDPs and 6.6 million refugees, and overall 13.6 million people in need of humanitarian assistance (UNHCR 2022). Families from north-eastern and eastern Syria were displaced into informal settlements in Deraa and Damascus following the severe drought of 2006–2010. In 2021, torrential rain and strong winds in Aleppo Governorate damaged or destroyed at least 25,000 tents in 407 IDP sites, leaving 142,000 people living in increasingly unsanitary and unsafe conditions (OCHA, 2022a).

In **Iraq**, drought conditions and reduced availability of water cause serious economic and health consequences to IDPs and refugees. In summer 2021, several hundred returnee families were re-displaced due to water scarcity in the northwest of the country (Ninewa Governorate), mainly due to the severe conditions for their livestock (OCHA, 2022b). Climate change, and specifically extreme weather events in the southern governorates of Iraq such as recent high temperatures and flash floods, have further impacted the livelihoods of vulnerable households and are forcing rural-to-urban migration. Farmers and women in rural areas are particularly vulnerable to climate change impacts such as drought, heat and sandstorms, which will act to decrease food security and negatively impact livelihoods (OCHA, 2022b).

In **Palestine**, people residing in low-lying areas are exposed to the risk of flooding during the rainy season, as well as the overflow of stormwater facilities and sewage pumping stations, due to the poor status of sanitation infrastructure (OCHA, 2020). The Palestinian Adaptation Programme of Action (PAPA)—and its companion document, the Climate Change

Adaptation Strategy for the Occupied Palestinian Territory — had identified three regions as having particularly high levels of climate vulnerability: Massafer Yatta (in West Bank), the easternmost Palestinian-occupied areas of the Jordan River Valley (in West Bank), and the Gaza Strip (UNDP, 2010).

In **Yemen**, the ongoing civil war since 2014 has resulted in over four million IDPs (equivalent to around 13% of the total population) and 66% of the population (around 20.7 million people) requiring some form of humanitarian assistance (OCHA, 2021; OCHA, 2022c). In 2020, more than 300,000 people, most of them IDPs who fled conflict areas, lost their shelters, incomes and potential livelihoods due to devastating flooding in southern Yemen which was followed by several years of abnormally intense cyclonic activity (OCHA, 2022c). Yemen is also particularly vulnerable to agricultural drought. Households during times of drought are left to cope with subsequent food and water insecurity. Negative coping mechanisms (e.g., selling assets) often include loss of livelihood and a high reliance on assistance or credit.

Yemen: Compounding impacts of conflict and flooding (RCCC, 2022a)
IDPs are more likely to be living in conditions or areas more exposed to flood risk. For example, in Sana'a (Yemen's capital city), IDPs mostly rent accommodation in flood-prone neighbourhoods rather than safer neighbourhoods, which can be up to four times more expensive. The vast majority of IDPs live in auto-constructed settlements making their property and shelter vulnerable to flood damage. From a UN OCHA update on the 30th of April 2020, an estimated 4,764 households have been affected by flood related impacts in IDP sites in southern governorates, including 1,812 families in Aden, 1,037 in Abyan, 917 in Taizz and 770 in Lahj governorates. Further UN OCHA updates have found that approximately 32% of identified IDP sites are at risk of flooding. This was calculated by the inter-cluster coordination mechanism using data from Camp Coordination and Camp Management (CCCM) site reporting. CCCM coordinates the temporary assistance and protection activities of people living in camps or camp-like settlements. **In 2020 sudden onset disasters displaced more people than violence and conflict.**

6. Responses taken to the impacts of weather and climate

6.1 How coproduction enables weather and climate services which support decision making

In-region responses to the impacts of weather and climate change can include: humanitarian activity and disaster relief to protect people from hazards and support recovery; resilience building initiatives to improve people's ability to proactively anticipate and respond to hazards and climate change; and adaptation measures which aim to enable communities, livelihoods and economies to thrive in a changed climate.

Weather and climate information on a range of timescales can play a fundamental role in underpinning these responses when it is used to inform policies, decisions and actions.

For weather and climate information to be used effectively, it usually needs to be developed into a service which meets the specific needs of users and is communicated in a way that is relevant to them. This process of developing user focused weather and climate services is referred to as coproduction, which was pioneered by and has underpinned the approach to weather and climate information services in WISER to date.

Coproduction between those who produce weather and climate information and those who use it (such as the public, governments, NGOS and businesses) relies upon (amongst other elements) an appetite for services, a willingness to cooperate and adequate time and resources to support the coproduction process, as coproduction can be time intensive. Learning from WISER and Future for Climate Africa (FCFA) shows there are a number of building blocks that inform coproduction, which best support the development of useful and used forecast services. The building blocks are shown in Figure 10 and explained in WISER's Coproduction Guide.

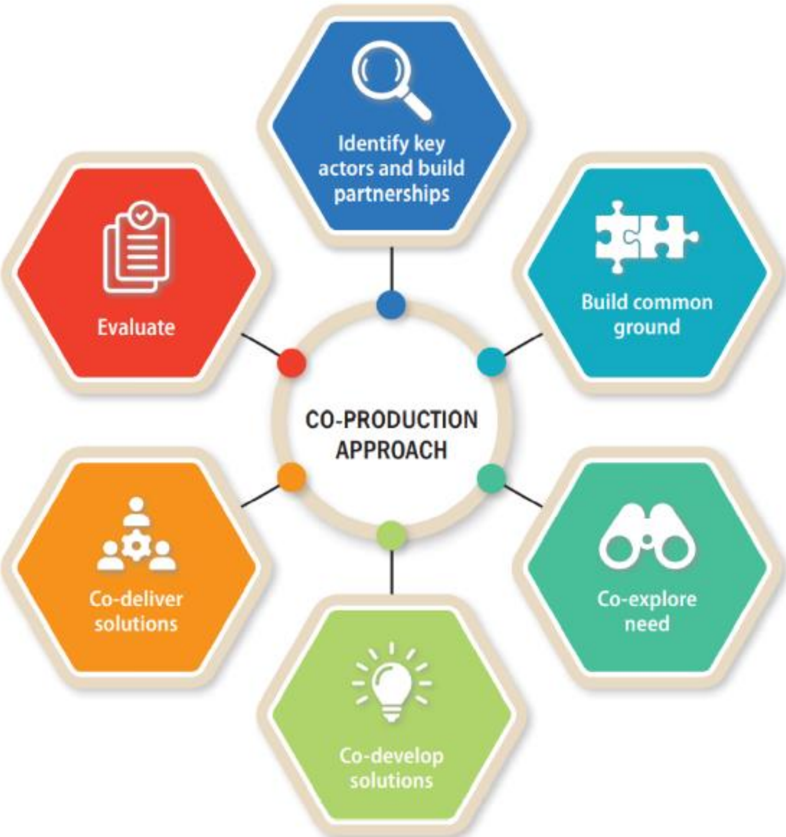

Figure 10: The building blocks of co-production (Source: Building on models developed by AMMA-2050, Visman et al., 2017b and KCL engagement in two BRACED consortia projects in Visman et al., 2018 and WISER, 2017

6.2 Users of weather and climate information in MENA

The users of WCS in countries of the MENA region are governmental (e.g., national disaster risk management agencies and Ministries such as on water and agriculture), non-governmental (e.g., United Nations agencies, NGOs, Civil Society Organisations, research centres or institutions, and Red Cross Red Crescent (RC/RC) Movement partners, such as National Societies, the International Federation of Red Cross and Red Crescent Societies (IFRC) and the International Committee of the Red Cross (ICRC) as well as first mile users (e.g. represented by community groups).

Engagement with stakeholders in these sectors in the MENA region was carried out by the scoping team to explore

- the extent to which the potential weather and climate information has, to inform resilience building and adaptation in MENA is understood, and
- specific examples of where improved weather information could strengthen and support decision making.

A stakeholder map and engagement approach was developed based on key contacts in the region. Signposting and introductions enabled this to develop holistically to capture a wide

range of producers and users of information in the region, including: UNHCR, World Food Programme, World Bank, UN OCHA, Red Cross Climate Centre, FAO, KS Relief, Community Jameel, the Arab Network for Environment and Development (RAED). A full list of stakeholders is shown in Annex table 2.1.

Key informant interviews were conducted to explore the organisations' activities in the region and their current or potential use of weather and climate information.

The findings from these interviews indicate that:

- Overall, demand for weather and climate services is low within governments and there is limited dialogue and evidence of coproduction between government agencies and NHMS. This could indicate a lack of understanding of their potential to build resilience and support adaptation.

- In cases where weather information or services already exist, users with high interest and potential to effect change may not be aware of the existence of such information, or providers do not have the capacity to analyse the data or information effectively for their needs to address pertinent climate risks.

- Absent or weak systematic approach to dissemination of weather and climate information (e.g., early warnings) also contribute to the issue. Information often reaches stakeholders that either do not have the means or the capacity to act on the information, or to understand it in the first place. This means forecasting information is not a critical tool supporting response planning and preparation, and the forecasting organisation does not become a trusted government partner. Without this trust from users, it is hard to make people pay attention to warnings being issued.

- The humanitarian and disaster risk management sectors have a need for weather and climate information. Whilst the concept of Anticipatory Action/Forecast Based Action is nascent in the region, feasibility studies are underway by the World Food Programme and the Red Cross Climate Centre. These indicate that short to medium range forecasts will be required in coming years. Furthermore, organisations like UNHCR who operate in fragile contexts such as Yemen and Syria have clearly expressed the need for forecasts to help protect vulnerable communities from weather extremes, including those living in IDP camps. Difficulties obtaining this from national meteorological services in these countries means humanitarian organisations cannot obtain forecasts from local sources.

- Weather and climate information is also being used in water, food security and agriculture, and in health and energy sectors to a lesser degree, but uptake is generally low (which is also found in other regions).

- In wealthier MENA nations, whilst climate change is being experienced, many residents (excluding remittance workers) are insulated from the impacts, with governments therefore not viewing climate change as a pressing concern. The use of climate change projections to inform infrastructure planning (e.g., for water resources) could however be an opportunity to ensure climate information supports climate-smart development.

- There is interest from funders in the MENA region (such as Community Jameel, KS Relief and Saudi Arabia's ODA) to support vulnerable populations and adaptation measures and there could be opportunities through WISER MENA engagement to encourage greater proportion of Gulf State ODA flows to support these aims.

- There is limited use of seasonal and subseasonal information in the region, but this type of information could be useful to inform planning across a range of sectors.

- Users of weather and climate information in focus countries are shown in Annex Table 2.2-2.7 These are users who are documented as working with NMHS in online documentation. It is not clear whether these are organisations who are in receipt of forecasts only, or if they have been actively engaged in coproduction to design the forecast in line with the decisions they need to make using it so this would need further exploration (where relevant in the inception stage).

7. Providers of weather and climate information in MENA

7.1 Introduction

The World Meteorological Organization (WMO) is the United Nation’s specialised agency for Weather, Climate and Water resources and which governs and mandates providers of weather and climate information. Within each country in the MENA region, there is either a National Meteorological Service (NMS) or a National Meteorological and Hydrological Service (NHMS). NMS or NMHSs are responsible for observing the weather and keeping climate records, forecasting the weather at various timescales and for developing and delivering forecast services and warnings suitable for their stakeholders.

Global Producing Centres (GPCs), such as the Met Office, are centres which have supercomputing capacity and run weather and climate models which are made available freely to other member states in the WMO. There are no GPCs within the MENA region, but seasonal and climate information (months to years ahead) is often handled by the NMHS or Regional Climate Centre (RCC) but can also be the mandate of other government organisations in a country, or universities.

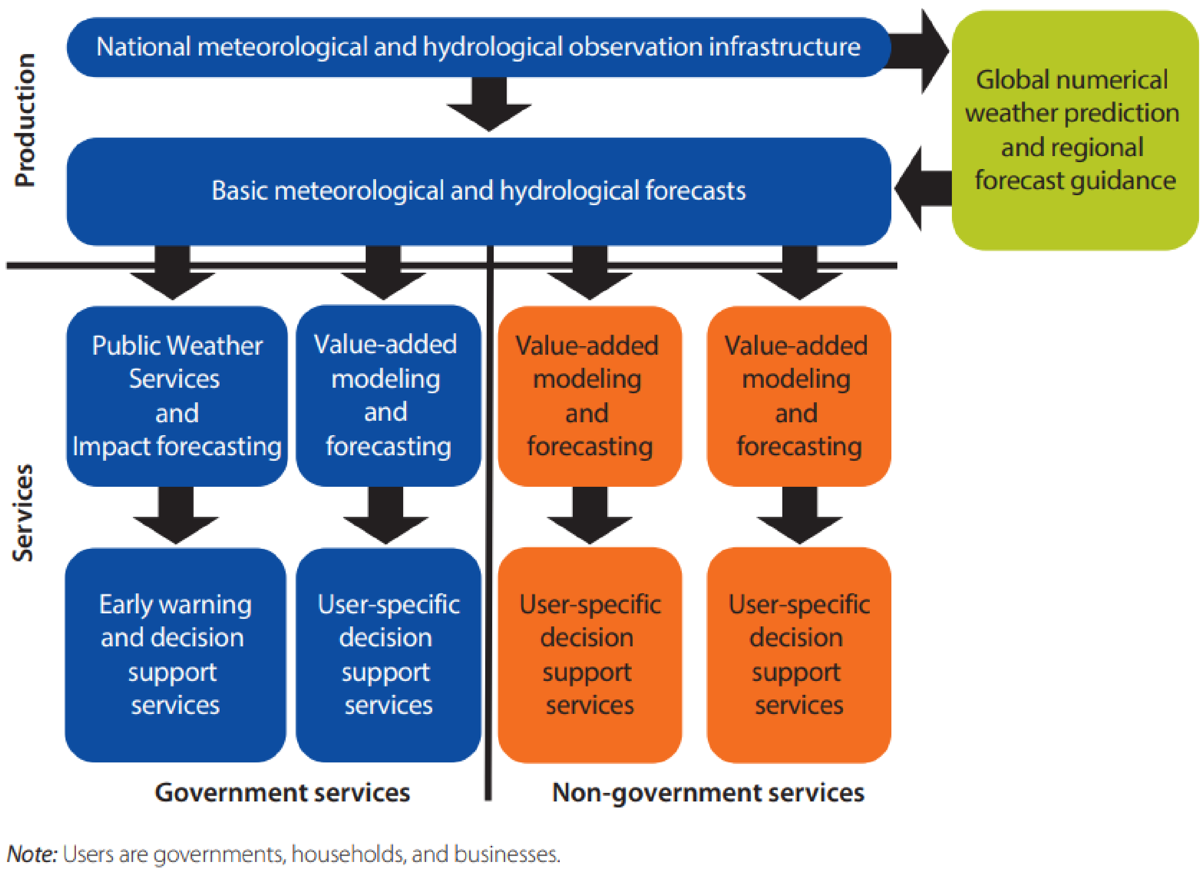

Figure 11 - Weather and Climate Services Value Chain (World Bank, 2022d)

Figure 11 illustrates the value chain of information provision directed from NMHS's and GPC's down to the users. Given the wide range of socioeconomic status of countries within the MENA region, there is an equally diverse range of capacities between providers of weather and climate information at the national level. Applying the value chain to the MENA region, aside from a few select countries (as detailed in section 7.2), NMHS's are providing basic meteorological and hydrological forecasts to their users, and some are delivering both early warning and user specific decision support services.

A summary of the NMHS's in the focus countries and the RCC and RCOF processes is shown below.

7.2 Focus countries within MENA

Palestine

The Palestinian Meteorological Department (PMD) is the national weather and climate service provider, has observer status within the WMO and it sits within the Ministry of Transport.

PMD is headquartered in Ramallah, employing 70 personnel (although it is understood that a number located in Gaza are not able to work due to the ongoing political situation) and operates on a 24/7 basis, providing forecasts out to 5 days for a range of weather and climate service users. These are split across government, DRR, national and international NGOs as well as academic or research institutes. PMD issue forecasts out to 5 days for various sector users and also issue severe weather warnings.

The agricultural sector is an important part of the economy and is also particularly vulnerable to expected climate change and increasing water scarcity in the region. Agromet services are likely to play a key role in the future output of PMD. It is not known yet what capacity PMD may have to scale this up and this should be the focus of further research in this project.

Yemen

According to OCHA (2022), Yemen is among the least prepared countries for climate shocks and is consequently also highly vulnerable to hydrological and meteorological disasters. It is unfortunate then that (due to the context in the country) capacity is low in the Meteorological Authority, which sits alongside the Civil Aviation Authority, the service is known as both CAMA and YMS.

Due to this situation, Yemen is likely to be most effectively supported via a regional body, reaching directly to those who most need weather and climate information.

A number of avenues may be open to this intervention mechanism, firstly support may be provided via the proposed RCC in Saudi Arabia (see section 7.2 of this report for further

details). Secondly, forums such as the Panel on Tropical Cyclones (these are WMO established inter-governmental bodies promoting measures to improve tropical cyclone warning systems, developing activities under five components: Meteorology, Hydrology, DRR, Training and Research) may be leveraged. Yemen is one of the few countries in the MENA region to experience tropical cyclones and preparedness and end to end warning systems are likely to be a crucial part of the country's future meteorological needs. National and International NGOs are one of the primary weather and climate users within the country but given the lack of capacity from the national meteorological provider, their sources of information are from outside of Yemen.

Iraq

The Iraqi Meteorological Organisation (IMO) sits within the Department of Transport and incorporates seismology with offices split between Kurdistan and Baghdad. The organisation produces a suite of daily weather forecasts as well as limited monthly and annual climate bulletins. It is believed that severe weather warnings are issued but with limited or no coordination with DRR sectors or other stakeholders. Weather forecasts are produced for decision makers and the public, as well as aviation, agriculture, and other sectors. As of 2015, IMO had 484 personnel. IMO have an agricultural and hydrological department whose remit is to collect and report on rainfall statistics, these used by irrigation and agricultural sectors. River flooding is a notable hazard across parts of Iraq even since the USGS assisted the Iraqi Ministry of Water Resources to install over 100 remote gauging stations.

The Black Sea and Middle East Flash Flood Guidance System covers Iraq; however the operational status of this initiative is unknown. The main objectives of this system are to:

- enhance NMHSs capacity to issue flash flood warnings and alerts,
- enhance collaboration between NMHSs and DRR agencies,
- generate flash flood early warning products and
- provide training to hydrometeorological forecasters.

Syria

The Syrian Meteorological Department (SMD) is the national provider of weather and climate services and sits within the Ministry of Defence who, it is understood, is their main client. Daily 24-hour weather bulletins are provided to the Syrian Arab News Agency, but otherwise no other forecasts could be found online. Drought and fluvial flooding are the main meteorological and hydrological hazards, however due to the large number of IDPs there is significantly increased vulnerability to cold waves (heavy snow and low temperatures). There is no known severe weather warning service and like Yemen, the primary users of weather and climate information are those involved in humanitarian sectors and DRR and they predominantly get this information from outside the country. The Black Sea and Middle East

Flash Flood Guidance System may be relevant but, as for Iraq, the status of this is unknown. SMD is very likely to be severely lacking in capacity, although further research is required to establish the extent of this. As such, the most effective methods of intervention are expected to be through a regional body.

Egypt

The Egyptian Meteorological Authority (EMA) is the mandated national weather and climate service provider and is a node within the RCC network of North Africa (see section 7.2 of this report for further details), holding joint responsibility for training alongside the National Meteorological Centre in Libya. Egypt regularly hosts or engages with the Regional Climate Outlook Forums of ArabCOF and MedCOF so is seen as an active member of the meteorological community in the region. The services which EMA provides extend out to 6 days and cover Egypt, the south-eastern Mediterranean and the Red Sea EMA host a data repository for downloading weather and climate data. EMA run their own WRF model and supplement its use with GPC data such as ECMWF and GFS. The World Bank identified that coordination with stakeholders was limited however, their status within the RCC network and their engagement with RCOFs could be utilised to empower them to take on more of an operational remit within the region.

Morocco

The General Directorate of Meteorology produces a wide range of products and services including a sophisticated early warning service. Their stakeholders are diverse, spanning from water and energy, industry, agriculture, aviation and marine. They hold significant regional status and expertise, being part of the North Africa RCC and functioning as the node on Long-Range Forecasting, using this expertise at both ArabCOF and MedCOF.

7.3 Regional Climate Centres in MENA

Regional Climate Centres (RCCs) are designed to be centres of excellence that strengthen the capacity of WMO Members in each region to deliver the best climate services to national users. RCC regional products include climate data sets, monitoring products and longer-range forecasts such as seasonal forecasts. Where the capacity does not exist for a single member to perform all the required duties, a network of nodes is adopted, effectively sharing the responsibilities across a number of members. Nodes generally fall into the categories of *Long-Range Forecasting*, *Climate Monitoring*, *Data Services* and *Training*.

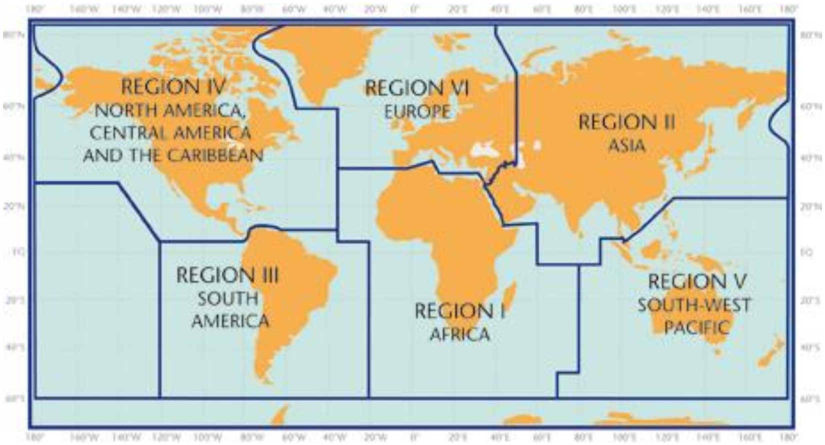

Figure 12 – Map of WMO regional division. Note that three WMO regions span MENA.

As shown in Figure 12, the MENA region falls under the designation of three different WMO regions and as such, three RCC's hold responsibility for different areas. North Africa falls under Region I, the Levant in Region VI and the Middle East and Gulf States in Region II. Figure 13 illustrates that for North Africa the RCC responsibility is spread across a Network of members which was established in 2017. For the purposes of this project, it may be important to be able to leverage or capacitate RCCs, and it is therefore proposed to explore their roles and capabilities further within the MENA region.

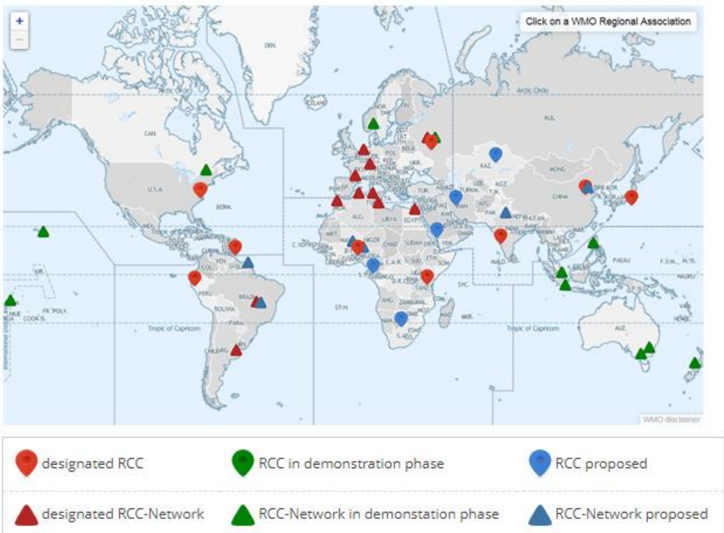

Figure 13 - Map of global WMO RCC designation.

7.4 Future changes to RCC provision in MENA

The National Centre for Meteorology (NCM) in the Kingdom of Saudi Arabia, having support from WMO, is working on its ambition to become an RCC for the MENA region. As part of this, two centres of excellence are under development:

- National Centre for Climate Change
- Regional Sand and Dust Storms Early Warning and Advisory Centre

Whilst the timeframe of these endeavours is unknown, this is likely to produce a step-change in research and development in both science and technical capability. Further information is required around the details and timeframe of these new capabilities, but they are likely to play a key role in the MENA region. NCM have approached the Met Office for support with the development of these centres and an MoU is currently in progress.

7.5 Regional Climate Outlook Forums in MENA

Regional Climate Outlook Forums (RCOFs) carry out WMO mandated roles bringing the RCC and NMHSs in a designated climatological region together to develop a consensus forecast for the upcoming season. This is sometimes tailored at a national level into a National Climate Outlook Forum or into a Monsoon Climate Outlook Forum.

RCOFs focus on assessing the current state and expected trends of large-scale climate drivers, whose links are known to provide sources of seasonal predictability. The primary aim of a RCOF is to establish the preferred seasonal forecast for the given region to be used by governments and user sectors, enabling more effective national and cross-border resource planning.

All COFs around the world are embarking on a shift from what has historically been a subjective forecasting process, towards an objective process (Kumar *et al*, 2020). This transition is being led by the WMO and aims to ensure that the forecasting process incorporates all the available model output, is repeatable and verifiable. RCOFs also serve as a training forum for both the providers and users of seasonal climate information.

The Met Office has been involved in a number of RCOF interventions, including the Greater Horn of Africa Climate Outlook Forum (GHACOF) and South Asia Seasonal Climate Outlook Forum (SASCOF) and has demonstrated that investment in this area can significantly improve the uptake of actionable seasonal information. This was, for example, a successful activity of the WISER programme in East Africa. They can also be leveraged to bridge the gap between seasonal and sub-seasonal timeframes – a key area of technical development within meteorology. From Figure 14 the RCOFs which operate within MENA are:

- Regional Climate Outlook Forum for Northern Africa (PRESANORD);
- Arab Climate Outlook Forum (ArabCOF);
- Gulf Cooperation Council Climate Outlook Forum (GCC-COF) *not pictured;*

- Mediterranean Climate Outlook Forum (MedCOF); and
- South Eastern Europe Climate Outlook Forum (SEECOF).

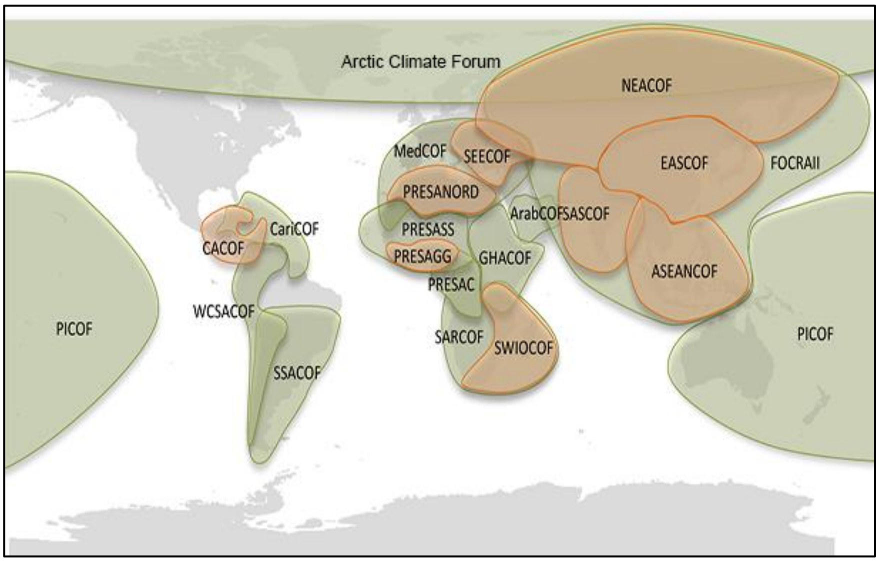

Figure 14 - Map showing areal responsibility of Regional Climate Outlook Forums (available at: https://public.wmo.int/en/our-mandate/climate/regional-climate-outlook-products).

ArabCOF, GCCCOF and PRESANORD

ArabCOF operates as an overarching entity in support of Prévisions Climatiques Saisonnières en Afrique du Nord (PRESANORD) and the Gulf Cooperation Council Climate Outlook Forum (GCCCOF). The Met Office, as guests of WMO and UN-ESCWA were invited to attend the joint session of ArabCOF-9, PRESANORD-17 and GCCCOF-6 during 30th and 31st May 2022 (held virtually). This attendance served three main functions.

1. Establish the processes used to verify the previous seasons forecasts and get to the consensus statement
2. Identify the key actors within the process
3. Identify the main issues facing the region and the forum, and the level of uptake of the forecast.

WISER MENA was introduced to the forum and participants expressed interest and willingness to engage, particularly around the prospect of training provision and capacity building. During discussions on what training was required at the COF, the need to train users in seasonal forecasts, (in terms of what they are and how to use them) was identified as well as training for members in concepts in seasonal forecasting like terciles. The potential to involve individual countries and sectors was also recognised and their

engagement would ideally be strengthened both by increased attendance and active participation in the COF events, enabling the output to be adapted to make it more relevant and useful to each individual country or sector

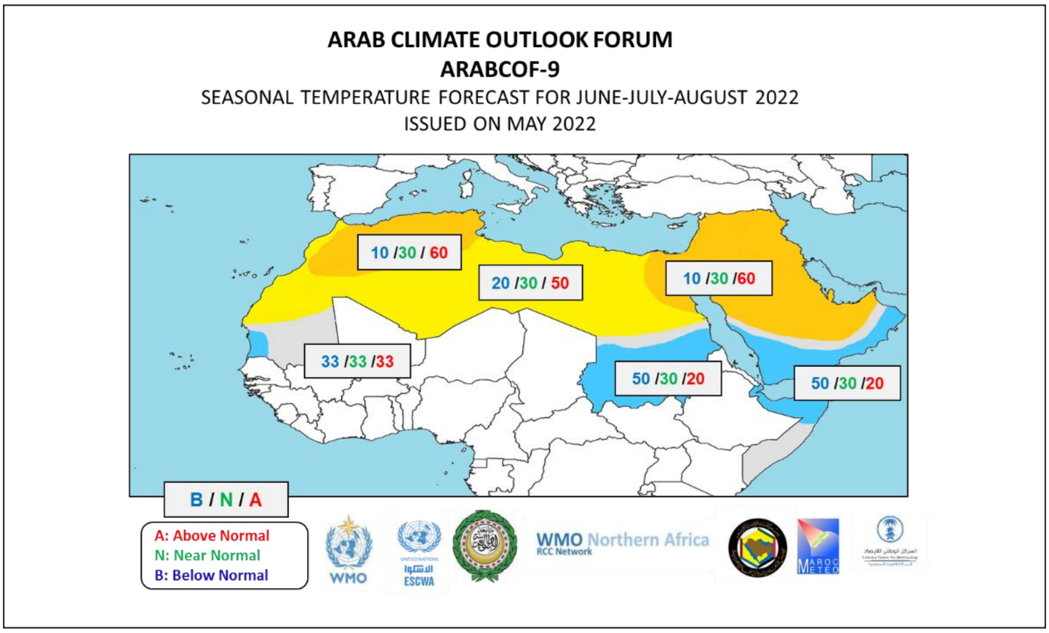

Figure 15 - Sample output from ArabCOF-9, showing the consensus forecast for June, July and August 2022.

MedCOF

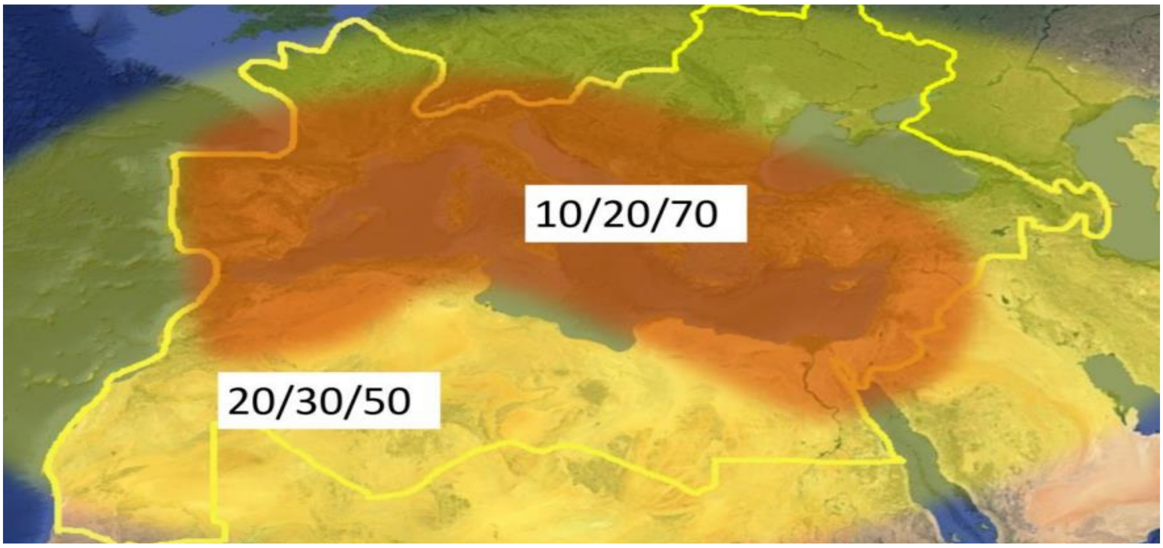

Figure 16 - Example output from MedCOF-18 of the 2022 summer temperature forecast. Numbers denote chance of each tercile category.

The Mediterranean Climate Outlook Forum (MedCOF) is coordinated by the Meteorological Service of Spain (AEMET) and brings together countries involved in PRESANORD and SEECOF, as well as the MENA countries of Jordan, Lebanon and Syria.

Of all the output produced by the COFs within the MENA region, MedCOF represents the most comprehensive offering, especially the analysis and verification of the previous seasonal forecast. Through discussion with the co-ordinator of MedCOF, it is clear that there has not been strong interaction between users and institutions due to the subjectivity of the process, as well as a lack of useability of the output. In order to address this, MedCOF has proposed two working groups, the first focussed on the development of the forecast itself, with the second focussing on applications of seasonal forecast information. MEDSCOPE is a project with close links to MedCOF and spans seasonal to climate timescales, aiming to improve the forecasting skill across the Mediterranean region, as well as developing methods and tools for forecast verification. A number of prototype products have been developed, these tailored towards sectoral application, and they are envisaged to be used as a starting point, taking onboard feedback from users and then further adapted. Clearly there is some alignment in objectives between this project and WISER MENA and there is scope for collaboration in this area.

A survey commissioned by the MedCOF into the needs of its users highlighted the desire for training on climate predictability and tools for analysis of seasonal climate information The forum acted on this, and a recent event was held online between 31st May and 1st June: "Elements for the production of Objective Seasonal Forecasts: MedCOF sub-region". This included the development of tools in three priority sectors (renewable energy, water management and agriculture/forestry).

SEECOF

The South East European Climate Outlook Forum was the first COF to be established within Europe in 2008. As shown in Figure 17,members of SEECOF extend from Azerbaijan in the east to Slovenia in the west, but also included are various Levant countries, namely; Jordan, Palestine, Israel and Lebanon. Every participating country is given the opportunity to present their national verification of the previous seasons forecast, but those countries in the Levant, barring Israel are notable by their absence through recent years.

The presentation of the seasonal forecast requires expert interpretation and no provision for user sectors is evident from the online repository (hosted at http://www.seevccc.rs/). Training is also an area which appears deficient among the SEECOF community. Further insight is required before any interventions may be considered.

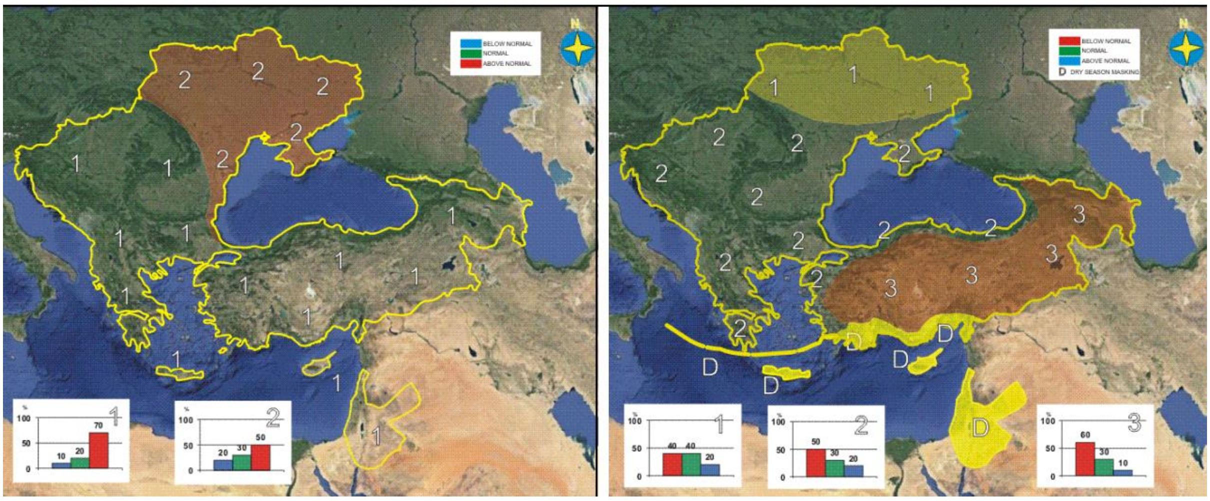

Figure 17 - Example output from SEECOF-27, temperature (left) and precipitation (right) for June, July and August 2022.

8. Advances in weather and climate science that are relevant to the MENA region

The viability of weather and climate services developed or funded by the WISER MENA programme depends heavily on the existence of weather and climate models that can:

- provide skilful[4] predictions for relevant meteorological variables;
- at useful lead times;
- over the (sub)regions of interest.

Without skilful forecasts of weather and climate, interventions such as impact-based forecasting (IBF) and forecast-based financing (FBF) will be difficult to implement. This section provides a top-level skill assessment of current modelling capability over the MENA region at climate timescales (Section 8.1), seasonal timescales (Section 8.2), and weather timescales (Section 8.3). 8.1 Climate timescales

Despite much of the MENA region having an arid or semi-arid climate characterised by high annual mean temperatures and scarce precipitation, its highly varied terrain means that modelling the region's climate remains challenging. For example, there are vast deserts (e.g., the Arabian and Saharan deserts), tall mountains (e.g., the Atlas and Taurus ranges), undulating highlands (e.g., northeast Iraq and Hadhramaut in Yemen), complicated coastlines (e.g., the Persian Gulf and the Red Sea), and several ocean bodies (e.g., the Atlantic and Indian Oceans, and the Mediterranean Sea). These varied terrains all act to influence weather and climate in the MENA region, meaning that they must be adequately represented in climate models. High-resolution climate models tend to better capture differences in local topography, which mean that they also tend to simulate climate more skilfully. Moreover, modelling at high-resolution allows important atmospheric processes such as convection to be more accurately represented.

High resolution projections are typically achieved using Regional Climate Models (RCMs) that model climate over a smaller domain than in Global Climate Models (GCMs), which increases the number of grid cells that can be used to represent a given area (see Rummukainen (2010) for further detail on regional climate modelling). There are several RCM simulations currently available for the MENA region under the Coordinated Regional Downscaling Experiment (Giorgi & Gutowski, 2015).

CORDEX-MENA Regional Climate Models

The Coordinated Regional Downscaling Experiment (CORDEX) is an international programme that offers a common protocol for creating and running RCMs. The MENA domain (Figure 18) has been modelled within the CORDEX-MENA subprogramme since

[4] Forecast skill quantifies how much better a forecast is than simply issuing a forecast of climatologically average conditions, or sometimes how much better it is than simply issuing a forecast of current atmospheric conditions (persistence).

2015, for which there are 24 individual simulations run by seven contributing climate modelling centres, including: Turkey, Italy, Germany, Cyprus, Morocco, the United Arab Emirates, and Sweden.

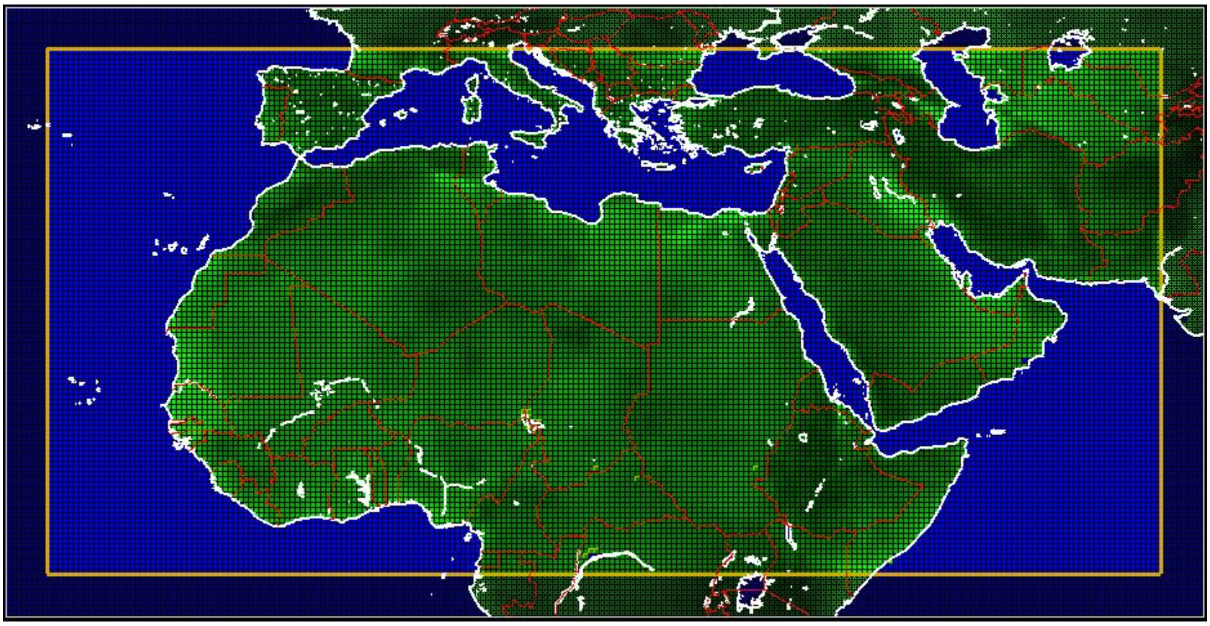

Figure 18: The CORDEX-MENA modelling domain. Source: (WCRP CORDEX, 2015)

CORDEX-MENA models are all run at a horizontal resolution of either 0.22° x 0.22° (approximately 20 x 24 km over the domain) or 0.44° x 0.44° (approximately 40 x 48 km). For comparison, the most recent CMIP6 GCMs are run at ~1° x ~1° horizontal resolution (approximately 93 km x 113 km) in their standard configurations, meaning that these RCMs offer significantly higher resolution climate projections over the MENA region than previously available. The CORDEX-MENA models are run at daily resolution over the approximate period 1950–2100, with the exact dates varying by simulation. The simulations are mostly run under either the mid-emissions (RCP4.5) or high emissions (RCP8.5) greenhouse gas scenarios; *see Annex Table 3.1 for further detail on the CORDEX-MENA RCM configurations.* The output variables comprise temperature (mean, minimum and maximum) and total precipitation.

The useability of the CORDEX-MENA models is high because they are run at daily resolution. From daily temperature and precipitation data, useful variables can be calculated such as the Standardised Precipitation Evapotranspiration Index (SPEI) which represents 'droughtiness'; the duration and frequency of occurrence of dry spells; and the intensity of extreme rainfall events (e.g., what does a 1-in-50-year rainfall event look by the end of the century?) [5]. These variables can be used to inform climate change adaptation measures, for example in agricultural planning, water management, and the development of climate resilient infrastructure.

[5] This could be calculated by applying Extreme Value Theory (EVT) methods to the daily rainfall data.

Annex Figure 3. 1, Annex Figure 3. 2, Annex Figure 3. 3 and Annex Figure 3. 4 present bias[6] assessments for the main GCM–RCM configurations taken from the available literature (Bucchignani et al., 2016; Bucchignani et al., 2018; Graham & Sjökvist, 2017; Ozturk et al., 2018). These studies indicate that the CORDEX-MENA RCMs generally well-represent climate in the MENA region. However, as with all climate models, there are model biases which we broadly summarise to be:

- The CORDEX-MENA RCMs provide a better representation of the current climate over North Africa and the Levant than they do over the rest of the Middle East.
- Although not certain, this implies that they will also provide more reliable projections of the future climate over these regions.
- Temperature biases are generally larger than precipitation biases across all of the CORDEX-MENA RCM simulations.
- Temperature biases are greatest over the Arabian Peninsula, particularly towards the south of the landmass during summer (i.e., Oman and Yemen).
- Precipitation biases are generally greatest over the Mesopotamian Valley (Iraq and northeast Syria) and the highlands of Iran.
- The representation of extreme rainfall in CORDEX-MENA RCMs is improved when the models are run in high-resolution configurations (0.22° x 0.22°).

Note that biases can be partially corrected using bias correction techniques. This brings projections 'in-line' with observations, which is common practice in climate impact studies. Temperature biases are simpler to correct than precipitation biases, which means that the large temperature biases in the CORDEX-MENA RCMs are not especially problematic. Bias-corrected projections could therefore be used to provide climate change information to stakeholders to help inform any adaptation efforts or 'build back greener' strategies occurring in the MENA region.

In addition to the RCMs described above, there are also GCM simulations that can be used to augment any climate change impact/adaptation assessments in the region. The most recent set of internationally recognised climate models (CMIP6[7]) provides a large ensemble of well-studied climate simulations, with the scientific literature already using these to analyse climate change impacts across the MENA region (e.g., Babaousmail et al., 2022; Majdi et al., 2022). See Kim et al., (2020); Papalexiou et al. (2021); Qiao et al. (2022); Song

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[6] Bias in climate models refers to the difference between the data in the climate model and data from the real-world (i.e., observations), over a shared period (e.g., 1981–2010). For example, if a model is persistently warmer in a location than its real-world counterpart, then the model is considered to have a 'warm bias' over that area. Similarly, if rainfall is persistently overestimated during the winter, then it is considered to have a wintertime 'wet bias'.

[7] The Coupled Model Intercomparison Project Phase 6 (CMIP6; Eyring et al., 2016) is a collection of global climate models (GCMs) developed by different institutions around the world. These models were used to inform the most recent IPCC Assessment Report, AR6 (IPCC, 2021).

et al. (2021); and Tselioudis et al. (2021) for assessments of CMIP6 model performance.

8.2 Subseasonal-to-decadal timescales

It is not possible to predict the weather on a particular day at long lead times, for example several weeks to several months ahead. Over the course of a whole season, year or decade, however, factors in the global weather system act to make some outcomes more likely than others. Long-range predictions generally forecast the average meteorological conditions that are expected to occur over a specified time period. However, they do not indicate that these conditions will prevail continuously, as the period is likely to contain a range of weather types. Nevertheless, long-range weather forecasts are utilised by many sectors across both the developed and developing world, including water management, energy, agriculture, public health, and in disaster preparedness.

Broadly speaking, subseasonal-to-decadal prediction encompasses three areas of model research: subseasonal timescales (approximately two-to-five weeks ahead), seasonal timescales (two-to-six months ahead), and decadal timescales (one-to-ten years ahead, the aim being to bridge the gap between seasonal forecasts and climate change projections).

Of the three, seasonal forecasting has received the most attention and research. This is because there is a surprising amount of predictability in the Earth's oceans (see Figure 19), which are important drivers of global climate at seasonal timescales. For example, sea surface temperatures in the equatorial tropical Pacific (known as the El Niño–Southern Oscillation, or ENSO[8]) are strong predictors of the prevailing global climate at certain times of the year. Moreover, relationships exist between ENSO and local climates around the world, meaning that variations in ENSO can cause wetter-than-average conditions over one region, while simultaneously causing drier-than-average conditions in another. There are many oceanic influences similar to ENSO that seasonal forecasts draw predictability from.

[8] ENSO is an oscillation in sea surface temperature anomalies in the tropical Pacific Ocean. When SSTs in the central and eastern tropical Pacific Ocean are anomalously warm ENSO is in a positive or El Niño phase and when the SSTs are anomalously cool, ENSO is in a negative of La Niña phase. ENSO typically varies on a timescale of 4–7 years. ENSO is a globally important mode of climate variability in the tropical Pacific Ocean that causes changes atmospheric variations through changes in the Hadley circulation (ascent near the equator and descent in the subtropics) and Walker circulation (ascent in the equatorial western Pacific and Atlantic Oceans and descent in the equatorial eastern Pacific), which affect temperature and precipitation patterns around the world.

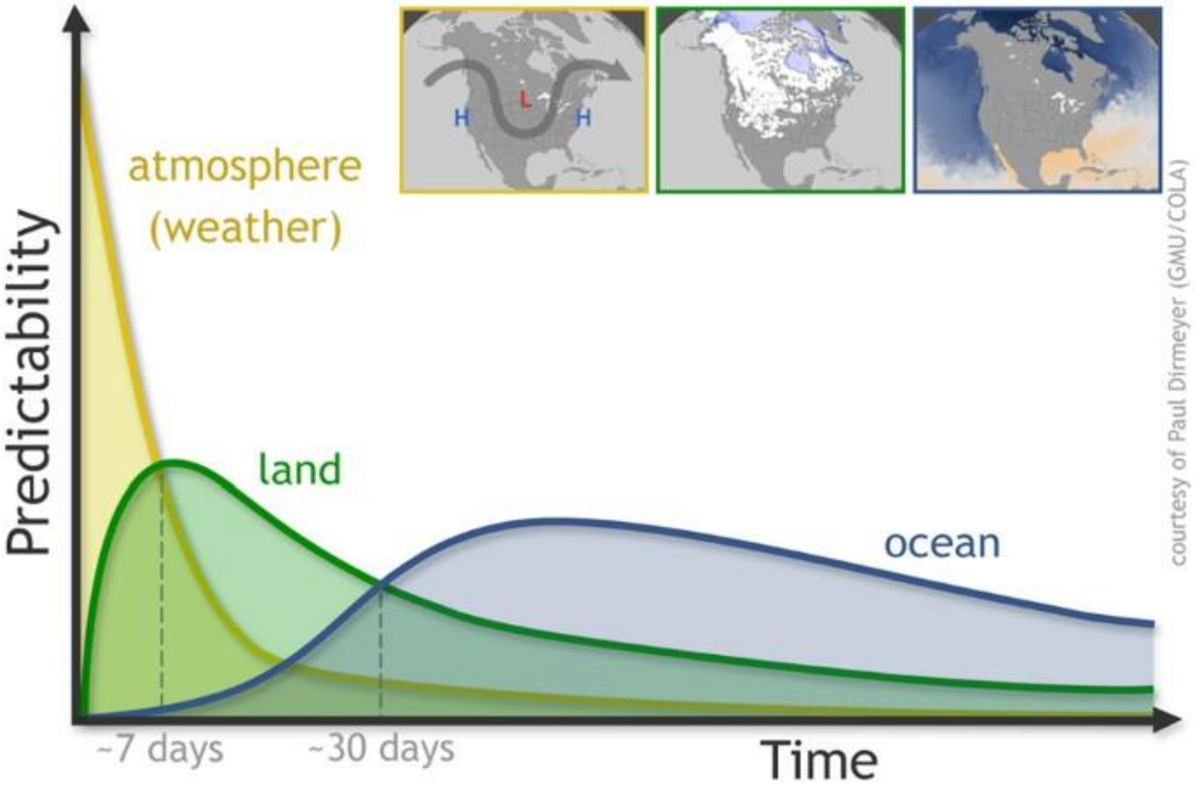

Figure 19: Sources of predictability at different timescales. For short lead times, the initial state of the atmosphere is the most important predictor. At 2-week to 4-week lead times, knowledge of the land surface is also needed, for example sea ice extent. Forecasting more than 30 days ahead typically requires knowledge of the ocean, such as the sea surface temperature variations linked to El Niño. Source: (Mariotti et al., 2018).

Subseasonal and decadal forecasting are less established, both in their methods and their dissemination (Mariotti et al., 2018; White et al., 2022). Despite this, demand for information at these timescales is high—subseasonal forecasts can provide information that is highly actionable in sectors such as agriculture, energy and humanitarian aid (e.g. Macleod et al., 2021; Soret et al., 2019; Wetterhall & Di Giuseppe, 2018), while decadal forecasts (e.g., WMO, 2022) can help guide decision-making at policy-relevant timescales across business and government. Effective forecasting at these timescales is a rapidly improving discipline, but a lack of evidence and awareness of the potential socioeconomic benefits of forecasting at these timescales is generally seen as a limit to their wider uptake (White et al., 2022). Moreover, incorporating probabilistic subseasonal and decadal forecasts into existing decision-making operations is not trivial (ibid). Successfully developing and implementing new subseasonal and decadal predictive services will require user needs to be placed at the forefront, with coproduction and open dialogues required to promote the awareness, value, and usage of subseasonal and decadal forecasts.

GloSea6

As described in the previous section, the ocean and land surface evolve much more slowly than the atmosphere and this makes them more predictable; these surfaces leave lasting imprints on the atmosphere, meaning that they can be used to forecast likely weather

conditions at long-range timescales. Global Producing Centres (GPCs) of subseasonal-to-decadal forecasts generally use large ensembles of coupled atmosphere–land–ocean–sea-ice models to generate a distribution of likely outcomes; these are then digested into probability forecasts. The Met Office Global Seasonal Forecast System (GloSea6; Davis et a., 2020) is an example of this, generating probabilistic forecasts up to six months ahead.

There is potential for Met Office GloSea6 forecasts to help inform decision-making at seasonal timescales in the MENA region. If GloSea6 demonstrates skilful prediction over the focus countries at lead times that could be potentially useful to in-country partners, then stakeholder dialogues could be opened to explore if there is appetite for either seasonal information or seasonal forecast service co-production. Moreover, GloSea6 outputs could provide helpful information to any Climate Outlook Forums operating in the region, such as ArabCOF[9].

GloSea6 model evaluation

Long-range forecasting systems are typically evaluated using hindcasts that test if the model can skilfully represent past weather conditions at a given lead time. Figure 20 presents skill assessments for GloSea6 model performance when predicting 'well-above average' and 'well-below average' temperature and precipitation over the MENA region, for the summer and autumn seasons with forecasts generated at two-to-four-month lead times.

Skill in Figure 20 is presented using Relative Operating Characteristic (ROC) scores: ROC values below 0.5 indicate that there is no skill in the model; values above 0.5 indicate that there is at least some skill present, and values of 1 indicate perfect skill. The overall value of a forecast depends on additional factors such as the forecast user's cost-loss ratios (e.g., Mylne, 2002), but generally a ROC score above 0.7 indicates that the forecast has potential useability if a suitable user can be found (Met Office, 2019).

[9] https://riccar.org/basic-page/arabcof

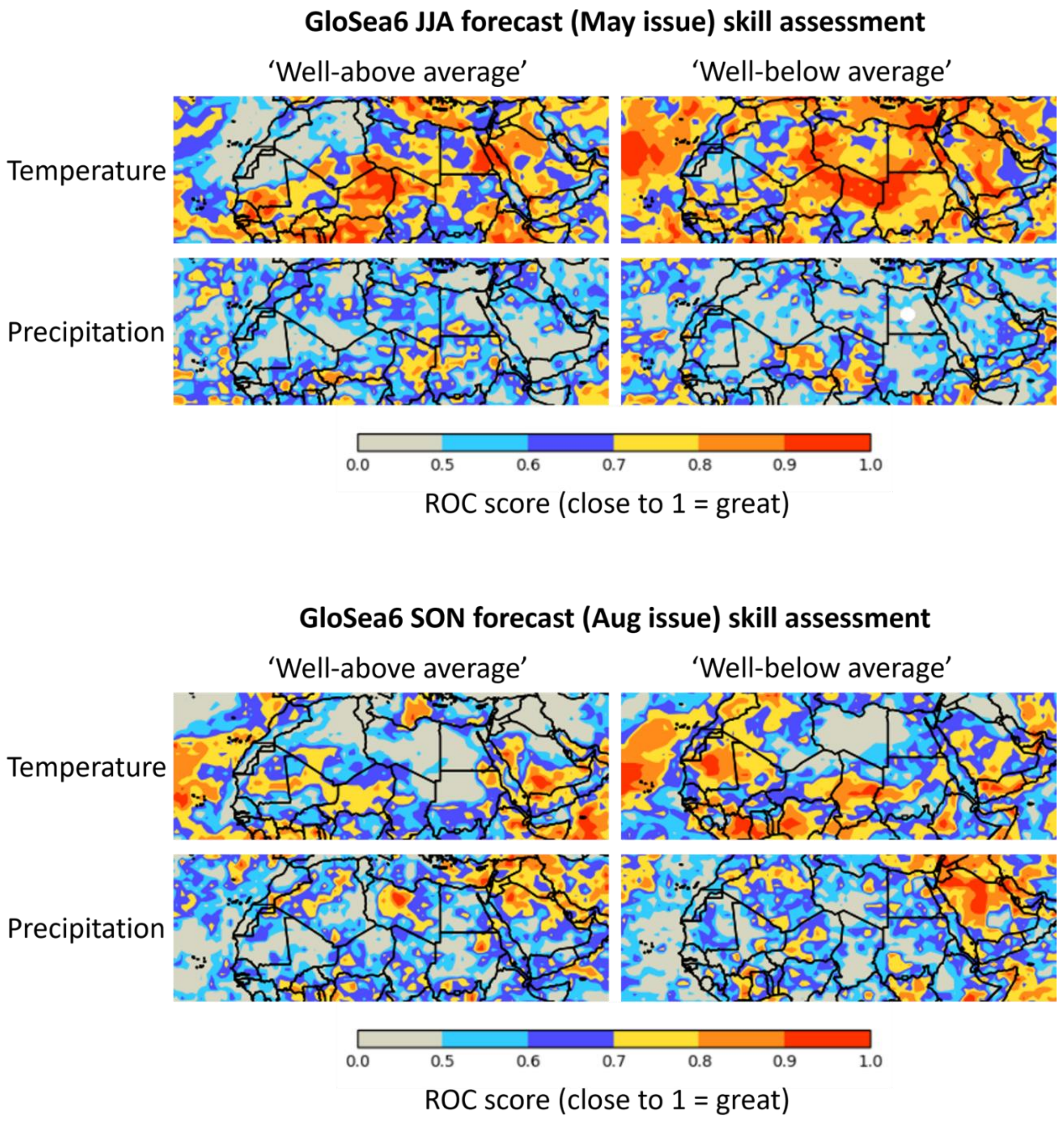

Figure 20: Maps of ROC scores over the MENA region in the Met Office GloSea6 ensemble prediction system. Yellow, orange and red colouring indicates potential forecast useability. 'Well-above average' and 'well-below average' relate to the top and bottom quintiles of climatology, respectively.

Figure 20 demonstrates that seasonal forecast skill over the MENA region in GloSea6 varies geographically, seasonally, and by meteorological variable. Notable points from this brief analysis include:

- Forecasts of 'well-above average' summer temperatures appear to be skilful over the focus countries of northern Iraq/eastern Syria, south-eastern Egypt, and southwestern Yemen (the most populated region in the country; see Figure 5).
- *This indicates that there could be potential for summer heatwave warnings to be issued in these regions at two-to-four-month lead times.*

- Although forecasts of ‘well-below average’ summer temperatures appear to be very skilful across the MENA region, the applicability of this information may be limited.
- Forecasts of ‘well-above average’ and ‘well-below average’ summer precipitation do not appear to exhibit skill at the three-month lead time shown here.
- Forecasts of ‘well-below average’ autumn temperature appear skilful over Yemen and Morocco.
- Forecasts of ‘well-above average’ and ‘well-below average’ autumn precipitation appear skilful over Iraq and Syria.
    - *This indicates that there is potential for autumn precipitation forecasts to be issued in these regions at two-to-four-month lead times. The autumn is typically when river basins recharge, meaning that advance knowledge of the likely rainfall distribution could assist water management strategies in the Tigris and Euphrates river systems.*

A comprehensive analysis of GloSea6 forecast skill is outside the scope of this report. If improving seasonal forecasting capabilities in the MENA region is to be considered under the WISER programme, then there may be benefit in undertaking a more detailed assessment of model performance over the region. This could involve examining all possible initialisation dates and seasons, and over all possible forecast categorisation schemes[10].

Other sources of useful predictive information

NMHSs without access to high performance computers or forecasts produced by GPCs may use statistical forecasts instead of dynamical forecasts (such as GloSea6). These statistical forecasts draw from the empirical relationships that exist between climate indices such as ENSO and regional temperature and precipitation fields (often at various lag times) to generate seasonal forecasts. Where relationships between regional weather and global climate indices are particularly strong, these can provide relatively skilful forecasts (e.g., Seibert et al., 2017; Wilks, 2008).

Figure 21 plots the statistically significant (p-value < 0.05) observed contemporaneous relationship between ENSO and temperature in the MENA region, showing that positive ENSO (‘El Niño’) events are associated with below-average temperatures over Syria and Iraq during the spring and summer. The corollary is that negative ENSO (La Niña) is associated with above-average temperatures over the same regions, indicating that slow-varying predictors such as ENSO could be leveraged to inform long-range summer heat warnings (including subseasonal timescales) in focus countries such as Syria and Iraq. Similar figures in Annex 4 show the relationships between the slow-varying predictors [11]

[10] For example, the tercile categorisation scheme involves ‘above average’, ‘average’ and ‘below average’, while the quintile categorisation scheme also includes ‘well-above average’ and ‘well-below average’. There is also a two category scheme comprising of ‘above median’ and ‘below median’.

[11] The Indian Ocean Dipole (IOD) is an irregular inter-annual oscillation of SSTs in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean (Saji et al, 1999). For example, a positive IOD occurs when SSTs in the western Indian Ocean are warmer than normal, while SSTs in the eastern Indian Ocean are cooler than normal; similarly a negative IOD occurs when SSTs in the western Indian Ocean are cooler than normal, while SSTs in the eastern Indian Ocean are warmer than normal.

and North Atlantic [12] with temperature and precipitation over the MENA region. These could be used as a basis for developing a climate service, for example like that developed by the Met Office (Palin et al., 2016) which used the NAO to forecast winter disruptions to the UK transport system, and Clark et al. (2017) who demonstrate the utility of skilful seasonal predictions based on the NAO to the European energy sector.

A combination of dynamical and statistical forecasts can sometimes provide the most skilful predictions at seasonal timescales (Schepen et al., 2012). Where possible, blending dynamical and statistical forecasts into a reproducible, objective procedure that is verifiable is the seasonal forecasting approach recommended by WMO (2020).

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[12]The NAO represents variability in sea-level pressure (SLP) in the North Atlantic. In the average state of the atmosphere, the North Atlantic surface pressure is relatively high in the subtropics at latitudes 20°N to 40°N ('the Azores High'), and lower further North at latitudes 50°N to 70°N (the 'Icelandic Low'). The North-South pressure difference determines the strength of the westerly winds across the Atlantic and is known as the NAO. A positive NAO is associated with Northern and Central Europe experiencing stronger westerlies leading to above-average winter temperature and rainfall, whereas Southern Europe and the Mediterranean (including North Africa and the Levant) experiences below-average winter temperature and rainfall under the same phase (Scaife et al., 2008). Conversely, the negative phase of the NAO results in strong westerly flow in Southern Europe and the Mediterranean, and weak westerly flow in Northern and Central Europe. This results in below-average temperature and rainfall in Northern and Central Europe, and above-average winter temperature and rainfall in Southern Europe and the Mediterranean (including North Africa and the Levant).

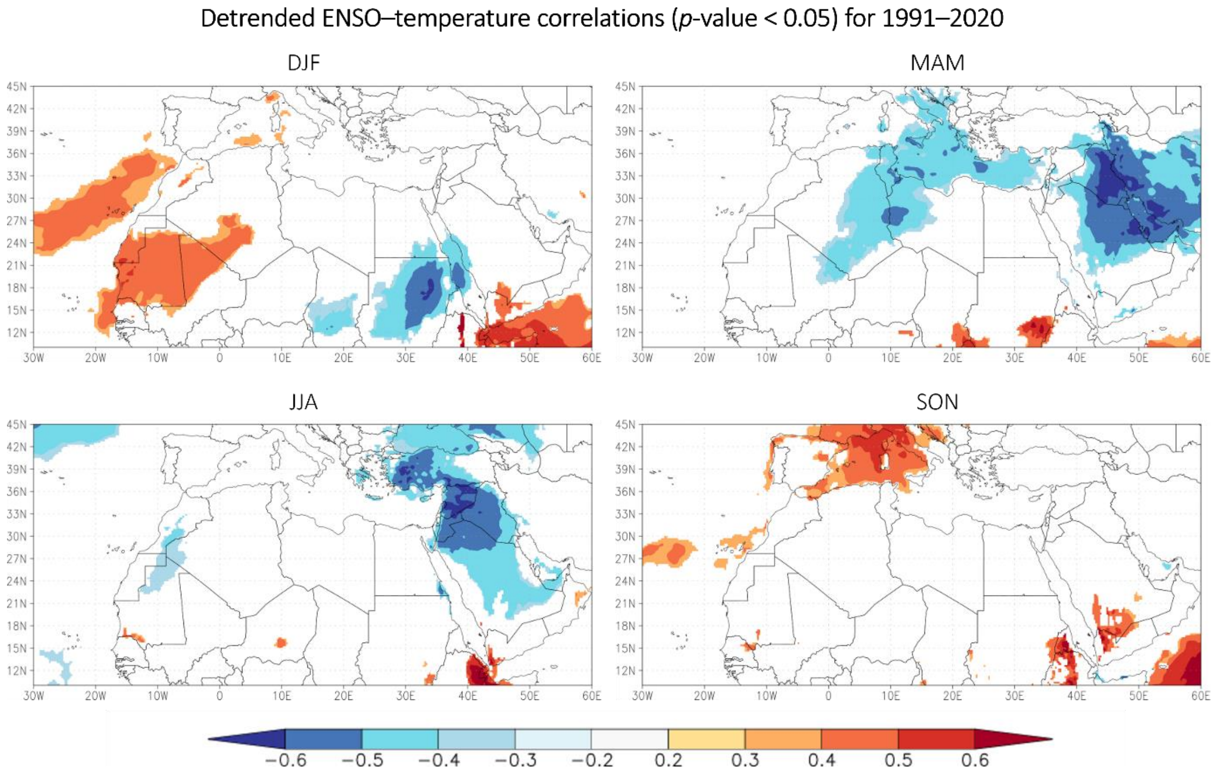

Figure 21: Statistically significant ($p < 0.05$) observed relationships between ENSO (Niño3.4 index) and temperature (ERA5) over the MENA region between 1991 and 2020, for the winter (DJF), spring (MAM), summer (JJA) and autumn (SON) seasons.

Considerations

Subseasonal-to-decadal predictions (including seasonal forecasts) are typically presented using percentages that indicate the likelihood and risk of event occurrence; they do not provide advance warning of definite events. It is possible that two locations located close to each other could experience different outcomes that are not detected at long-range, especially in regions with highly variable terrain such as the MENA region. Because subseasonal-to-decadal forecasts are based on likelihoods and probabilities, the full benefits of long-range predictions are only realised if they are used to guide decision-making over a long period of time, for example several years to a decade. All these factors should be considered should the WISER programme seek to develop long-term predictive capabilities in the MENA region.

8.3 Weather timescales

Since its inception, the skilful range for numerical weather prediction (NWP) has improved with time. Figure 22 demonstrates how NWP skill has improved over the past four decades. Generally speaking, the longest lead time at which a weather forecast contains useful skill

has increased by approximately one day per decade, meaning that a six-day forecast is now as skilful, on average, as a five-day forecast made a decade ago. Traditionally, forecasting in the northern hemisphere was more skilful than the southern hemisphere due to an absence of observational data, but improved satellite technologies, among other factors, have made up-to-date observations more readily available; this improves overall NWP model initialisation and allows better forecast verification which, in combination with higher resolution modelling and advances in computational capability, have greatly contributed to the to the improvements in forecast skill seen in Figure 22.

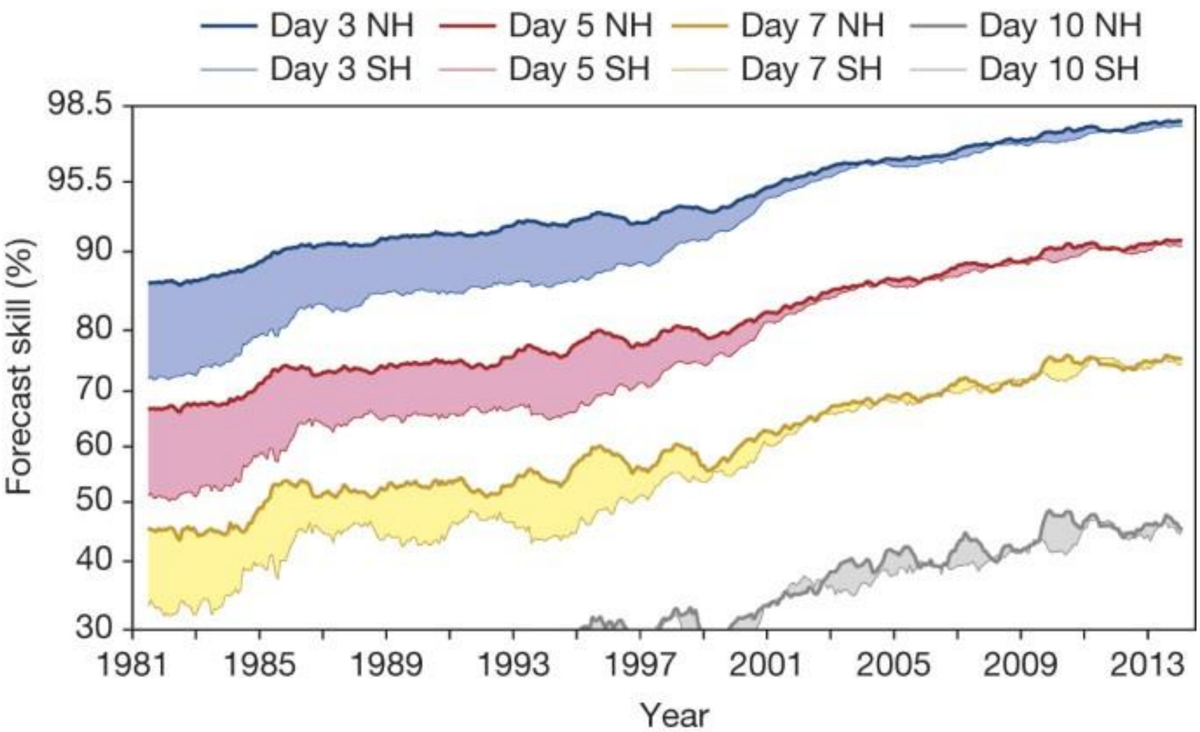

Figure 22**: A measure of forecast skill at three-, five-, seven- and ten-day ranges, computed over the extra-tropical northern and southern hemispheres. Forecast skill is the correlation between the forecasts and the verifying analysis of the height of the 500-hPa level, expressed as the anomaly with respect to the climatological height. Values greater than 60% indicate useful forecasts, while those greater than 80% represent a high degree of accuracy. The convergence of the curves for Northern Hemisphere (NH) and Southern Hemisphere (SH) after 1999 indicates the breakthrough in exploiting satellite data through the use of variational data. Source: Bauer et al. (2015).**

Given the above, forecasting in regions further removed from the dense observing grids of Europe and North America (such as the Middle East and North Africa) has greatly improved, relatively speaking. However, it is difficult to find quantitative evaluations of forecast skill in the MENA region. This is partly because there is likely an absence of forecast verification being undertaken by local NMHSs, and partly because most centres would not make this information publicly available. This is a key area that needs to be understood in order to

ensure forecast integrity and assess the viability of developing early warning services and forecast-based financing. Skill assessments could be a joint activity between the Met Office and NMHSs in the region to foster trust and in weather and climate services in the region.

The best performing forecast providers for the Middle East could be potential provisioners of NWP services in countries with weak NMHSs, e.g., Syria and Yemen. According to ForecastWatch (2020), these are The Weather Channel for temperature and wind, World Weather Online for cloud cover, and Foreca/Vaisala for precipitation.

As with climate modelling, both global and regional models are leveraged for NWP provision. Global models are used to anticipate large-scale weather patterns 3–10 days in advance, while the high-resolution regional models are used to provide weather forecasts up to 3 days in advance. The three most used global models are the Global Forecast System (GFS) developed by (National Oceanic and Atmospheric Administration), the UK Met Office (UKMO) global model, and the European Centre for Medium-Range Weather Forecasts (ECMWF) global model. Generally speaking, the ECMWF and UKMO products outperform the GFS model (e.g., Sillin et al., 2019), though usually a combination of these models with various layers of post-processing is employed by forecasting centres to capture the full range of forecast outcomes and associated uncertainty.

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9. Weather and climate related programmes/initiatives in MENA

An understanding of existing weather and climate related initiatives in the region helps to identify the current situation and potential gaps in weather and climate information services.

The following is an overview of the initiatives that exist in the MENA region at a country level. The information was gathered by the Red Cross Climate Centre in their 'Assessment of Responses to Weather and Climate Impacts in the MENA Region: A Scoping Review' (El Hajj et al., 2022). The tables of the key initiatives can be found in the Annex 5.

9.1 Initiatives at a country level

Palestine

There is evidence of weather and climate services initiatives in the Agriculture, Disaster Risk Reduction (DRR), Water and Energy sector in Palestine (El Hajj et al., 2022). As an example, the output from the National Agricultural Sector Strategy 'Resilience and Sustainable Development' (2017–2022) includes development of a monitoring report on weather information and rain as well as periodic reports on early warning in relation to weather and climate change. One of the priorities under the second strategy objective includes taking measures and arrangements to adapt with or avoid negative impact of climate change and natural hazards, particularly high temperatures and fluctuating precipitation or declining rainwater (Annex Table 5. 1).

Yemen

There is evidence of weather and climate services initiatives in Agriculture and Disaster Risk Management (DRM) sectors in Yemen. For example, the Met Office worked in partnership with UNICEF and other actors on a Cholera Anticipatory Action initiative. This involved the Met Office providing a rainfall 7-day hindcast, 7-day forecast, 4-week forward outlook and a summary of the high impact weathers to UNICEF. This information helped to inform the cholera monitoring and response activity in Yemen to provide the necessary resources and services accordingly (Annex Table 5. 2).

Iraq

There is evidence of weather and climate services initiatives in Agriculture, DRM/DRR and Water sectors in Iraq. For example, the 'Building Resilience of the Agriculture Sector to Climate Change' (BRAC) is a project led by the Adaptation Fund that aims to strengthen the agro-ecological and social resilience to climate change in four targeted regions, by enhancing water availability and use efficiency, promoting adaptive agricultural practices and technologies for improved livelihoods and food security of rural households. The project is designed to deal with the growing scarcity of irrigation water and to assist the country with strengthening its capacity at the national level for monitoring climate change patterns and

providing information to farmers to enable them to undertake adaptation and risk mitigation measures through an early warning system. (Annex Table 5. 3)

Syria

There is evidence of weather and climate services initiatives in Agriculture, DRM/DRR, Water and Health sectors in Syria. For example, a drought Early Warning System is in development. This is in response to the 2009 Syria Drought Response Plan aimed to address emergency needs and to prevent further impact on the 300,000 people most affected by prolonged drought. One of the objectives of the Plan is a national Early Warning System (EWS) for drought with emphasis on the rangelands and marginal areas. Activities included improving and implementing procedures for data collection, processing, analysis and dissemination, training at institutional and community levels, and establishing procedures, manuals and networks of dedicated government officers and community representatives. (Annex Table 5. 4)

Egypt

There is evidence of weather and climate services initiatives in Agriculture and DRR sectors in Egypt. For example, Hudhud is a mobile application launched in 2021 funded by the Egypt Ministry of Agriculture with one of the components providing climate predictions for farmers. This Arabic mobile application relies on artificial intelligence techniques to provide guidance to farmers such as the steps to take if there are infectious crops, farmers can take a photo of the infected plant using their smartphone and send it to Hudhud to identify through artificial intelligence the disease and it will provide the farmer with the necessary instructions to stop the infection. (Annex Table 5. 5)

Morocco

There is evidence of weather and climate services initiatives in Agriculture, DRR and Water sectors in Morocco. For example, 'Vigilance-Maroc-Meteo' is an early warning system that has recently developed. The system includes forecasts and alerts on a finer spatiotemporal scale which meets the needs of decision-makers at a local city level. The information is communicated through a smartphone application and web platforms and includes a weather forecast which is distributed frequently to local decision-makers via SMS. This makes it possible to closely monitor and follow extreme weather with an indication of its severity within a 48-hour period using a colour scheme (green, yellow, orange and red) to indicate the severity. (Annex Table 5. 6)

9.2 Regional weather and climate initiatives in MENA

There are also regional weather and climate initiatives and programmes in the MENA region. The most prominent being the Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR), a multi-partner initiative coordinated by the United Nations Economic and Social Commission for Western Asia (ESCWA). In 2017, RICCAR issue the Arab Climate Change Assessment Report which presents a detailed picture of climate change impacts expected

on freshwater resources in the Arab region until the end of the century and how this will affect the vulnerability of water resources, agriculture, natural ecosystems, human settlements, and people.

Regional weather and climate initiatives are growing within the MENA region to address the risks and a list of existing initiatives can be found in Annex 5 from the RCCC report. Examples include the 'MENA Drought Project' led by the International Water Management Institute (IWMI). This project aims to develop the necessary tools to anticipate, prepare for and mitigate the worst impacts of drought, focussing on Morocco, Lebanon and Jordan. IWMI are also delivering a project 'Al Murunah' under FCDO's PHENOMENAL programme. 'Al Murunah' aims to build Climate Resilience through Enhanced Water Security project in the MENA Region.

9.3 Opportunities to engage with other funding

There is interest from funders in the MENA region (such as Community Jameel, KS Relief and Saudi Arabia's ODA) to support vulnerable populations and adaptation measures and there could be opportunities through WISER MENA engagement to encourage greater proportion of Gulf State ODA flows to support these aims.

The National Centre for Meteorology have also approached the Met Office to request capacity development and training support in their ambition to become a regional climate centre. This would fall outside of WISER, as it would be funded by the government of Saudi Arabia, but would align well with the ambitions of WISER and FCDO in the region. An MoU is currently in development between NCM and Met Office.

As the programme progresses, opportunities to engage with organisations and funders in the region will continue.

10. Summary of key insights from scoping

- Extremely high temperatures, limited groundwater and rainfall already pervade in the MENA region. It has seen a substantial escalation in the number of meteorological, climatological and hydrological disasters in last two decades. Poverty, state fragility, internal displacement and conflict in some countries in the region have compounded climate hazards and increased vulnerability and exposure of populations to their impacts.
- MENA is already one of the most water stressed regions in the world and changes to the climate will exacerbate this further. Water availability is transboundary and interconnected with impacts on agriculture/food security, health, energy, conflict and migration.
- Heat stress represents a key hazard which is and will continue to make some areas uninhabitable and impact on health and productivity in others.
- Increasing urbanisation in coastal areas makes these areas highly vulnerable to sea level rise.
- There are estimated to be over 10 million IDP in the MENA region who are likely to be living in conditions which make them highly vulnerable to the impacts of climate change.
- Using the Notre Dame-Global Adaptation Index (ND-GAIN; Namdar et al., 2021), Yemen was identified to have the highest vulnerability to climate change (over a range of metrics, including food and water security, infrastructure, health, and ecosystem status), followed by Iraq, Syria, Libya, Oman, Egypt and Morocco.
- Understanding of how weather and climate information could be used to inform actions which address the impacts of climate change seems to be highest within the humanitarian sector, where plans for Forecast Based Action are evolving among a range of actors.
- Users in agriculture, food security, water, energy and a range of other sectors could also integrate weather and climate information into their decision making. However, understanding around how to do this seems low.
- National Meteorological Services (NMS) operate in most MENA countries with exceptions in those affected by civil war (e.g., Yemen and Syria). Enhanced dialogue between users and producers through coproduction could support more useful, usable and used services where there is appetite to do so and resources available.
- The provision of seasonal outlooks through the Climate Outlook Forum process could transform the use of weather and climate information by providing an objective platform through which longer-range information is processed and disseminated to the national and subnational levels to assist in planning and preparedness. Currently

uptake of this information is fairly low; this is because the information does not support decision making as it is not tailored to different user needs.

- On climate timescales, global and regional climate model (RCM) simulations are available. The CORDEX-MENA RCM simulations provide high-resolution projections for the region out to 2100, well-representing historical climate over most of the MENA region. Although not certain, this implies that the CORDEX-MENA RCMs can also project future change in the MENA region with some confidence, particularly over North Africa and the Levant. These high-resolution RCMs can be augmented by the CMIP6 models, which are the most recent set of internationally recognised climate models and provide a large ensemble of well-studied global climate simulations.

- On seasonal timescales, Global Producing Centres (GPCs) generally use large ensembles of coupled climate models to generate probabilistic seasonal forecasts, rather than providing advance warning of specific events. The full benefits of long-range predictions are therefore only realised if they are used to guide decision-making over a long period of time. An example seasonal forecast is the Met Office's GloSea6 (Davis et a., 2020). Skill over the MENA region in GLoSea6 varies geographically, seasonally, and by meteorological variable. There may be benefit in undertaking a more detailed assessment of model performance over the region.

- In addition to seasonal forecasts drawn from GPC model ensembles, forecasting methods exist that draw from the observed relationships between climate indices such as ENSO and regional temperature and precipitation fields (often at various lag times) to generate seasonal forecasts. These can be used alone, or, as recommended by the WMO-backed COF process, combined with GPC-issued ensemble forecasts to provide a best estimate of the upcoming season's climate.

- At subseasonal and decadal timescales, forecasts are less established than at seasonal timescales, both in their methods and dissemination; this is not exclusive to the MENA region, and is generally true worldwide. Nevertheless, subseasonal and decadal forecasting methods are rapidly advancing because they are now seen as highly relevant to disaster contingency planning and longer-term policy making, respectively.

- It is difficult to find information on Numerical Weather Prediction (NWP) forecast skill for the MENA region, e.g., in-country capabilities. This is partly because there is an absence of forecast verification being undertaken by NMHSs in the region, and partly because most centres do not make this information publicly available. This is a key area that needs to be understood to ensure integrity and assess the viability of developing early warning services and forecast-based financing in the region.

- There are numerous examples of national and regional initiatives to enhance weather and climate information already ongoing in the MENA region, and there is scope for these to be supported and/or strengthened by WISER MENA.

11. Potential areas of opportunity for WISER MENA

The evidence presented in this report on the needs and opportunities for improved weather and climate information in the MENA region shows there are opportunities for improved services to support resilience building and adaptation measures in the region.

The design of the WISER MENA programme will draw on this evidence and propose an approach which will facilitate change towards the desired outcome of the programme, which is:

WISER MENA Outcome

"To enable a greater user of weather and climate information services to inform policy, planning and decision making at regional, national, sub-national and community level"

To achieve this, four thematic areas of opportunity which could contribute towards this outcome have been identified which draw on the findings of the scoping:

1. The need to build understanding *of,* and demand *for* weather and climate information in the MENA region;
2. Building resilience to extremes by supporting vulnerable communities;
3. Enhancing seasonal forecasting in the region; and
4. Supporting and strengthening other weather and climate service initiatives in the region.

Potential activities which may be undertaken under each of these thematic areas are detailed below. Due to the high level of vulnerability among IDPs and resident populations in some MENA countries, more specific activities are described for opportunity area 2 as it is felt that if this is validated, activity could commence more quickly through awarding of a grant. For areas 1, 3 and 4 (if validated) it is proposed that a Regional Coordinator is recruited who would need to gain further insight on specific activities that can be delivered through these strands of work.

11.1 Building understanding *of* and demand *for* weather and climate information in the MENA region

NMHS should be integral to informing weather related decision making for the public, government and businesses by acting as the authority on weather and producing forecast services which people both trust and act upon.

To provide services which are trusted and acted upon, the information conveyed in them

needs to be reliable, tailored to the needs of specific users, communicated in a way which is understandable to them and delivered in a format which supports their decisions. For example, fishermen need to know when weather conditions make it safe to fish, or a farmer needs to know the onset of a rainy season so they can plant their crops at the right time.

This can be achieved when an NMHS works collaboratively with users through a process of coproduction to design and deliver forecast information services. For users to want to engage in this process however, they need to understand how the weather and climate impacts on their sector or livelihood and understand the value forecast information can have in helping them to plan ahead.

The insight gathered through the scoping phase suggested this is not well understood in parts of the MENA region and there can often be a disconnect between an NMHS and those who could benefit from its services.

Through this intervention theme, WISER MENA will seek to raise the profile of weather and climate information within the region in terms of the potential it has to improve a country's resilience and support its adaptation. Understanding will also be developed about short range, sub-seasonal and seasonal forecasts and how they can be used.

This could be achieved by appointing a dedicated WISER MENA Regional Coordinator based in region who is fluent in Arabic, French and English. The Coordinator could build on the relationships with stakeholders developed through this scoping exercise and develop new ones to support programme activity. This approach was used in the WISER 2 in East Africa and in the ASPIRE project in the Sahel region of Africa and enabled trusted relationships to be developed with producers and users of weather and climate information.

It is expected that this intervention will operate at largely regional level, but focused engagement and advocacy may be required in target countries.

Some examples of activities which could be undertaken are shown below, with green font denoting those which could be carried out between September 2022 and March 2023 (given the reduced budget for this year and subject to further planning).

- Sensitisation for potential users to the benefits of weather & climate information for decision making, resilience building and climate smart adaptation with case studies.
- Session at COP 27 in Egypt on the evidence base for weather and climate services in MENA and the importance of coproduction to develop and deliver these.
- Development of compelling communication and advocacy tools on the value of coproduced weather and climate services in helping people to stay safe and thrive.
- Engagement with the humanitarian sector in MENA around the importance and usefulness of nationally generated forecasts to underpin Anticipatory Action.
- Presence at MENA climate/environment/adaptation fora. Many events are currently focused on green growth so the Regional Coordinator would raise awareness of the benefit of weather and climate information to support adaptation.

- Raising awareness of coproduction with NMHS and regional climate centres and facilitating coproduction processes where appropriate.
- Working with WMO to build understanding of Impact Based Forecasting with NMHS and Regional Climate Centres and assessing how this could be operationalised at specific institutions.
- Focused engagement with Saudi Arabia and other Gulf states (UAE) to influence how ODA funding (and similar) is used (including KS Relief) to support and strengthen the work of WISER MENA.
- Support NCM to become a RCC for the region within WMO
- Delivering technical training where relevant e.g., in coproduction or impact-based forecasting

Further engagement with stakeholders in the region and consultation on programme design will provide an opportunity to discuss this intervention theme and its suggested associated activities.

11.2 Build resilience to extremes through supporting vulnerable communities

As presented earlier in this report, there are significant numbers of vulnerable people in the MENA region who experience high levels of poverty, and are, therefore, less able to cope with extremes in the form of heat waves, dust storms, droughts and floods (due to factors such as the type of accommodation and infrastructure around them and the need for them to adopt negative coping strategies to deal with shocks).

Government led Disaster Risk management agencies and the humanitarian community work directly with vulnerable communities and are therefore felt to be well placed to act as an intermediaries between the providers of weather and climate information in the region and the populations they serve. The humanitarian community perceive there is an opportunity for AA/FBA to be supported in the region due to the potential impact that acting before a hazard (based on a forecast) has to protect lives, livelihoods and dignity.

A grant could be provided through WISER MENA to support multi-agency cooperation around advocating for AA/FBA, supporting feasibility studies for FBF and operationalising FBF with the forecasting component coming, where possible, from the NMHS. The grant could be accompanied by Technical Assistance from the Met Office on scientific and technical aspects around forecasting and climate science.

Fora such as the Anticipation Hub and the Risk Informed Early Action Partnership (REAP) could be used to consult on the type of activities which could be supported by this grant, but the activities below are suggestions. These would combine regional level activities and targeting and specific support to the humanitarian sector in target countries:

- Undertake awareness raising and advocacy on AA/FBA in region to influence its uptake within NGOs and government run Disaster Response ministries (working with the Regional Coordinator). This could include support to relevant Communities of Practice and set of Dialogue Platforms which have been used in other regions to make the case for acting early and explain how it is done. This would also raise awareness of such initiatives with other regional funders.
- Improve coordination between humanitarian actors and organisations around AA/FBA. The lack of cooperation between actors sometimes leads to duplication of effort or lost opportunities for synergies. Agencies use different sources of weather and climate information which contributes to different interpretations and uncoordinated efforts. Improvement of the coherency and consistency within the regions amongst stakeholders as well as ongoing initiatives that use weather and climate information is important for harnessing powerful synergies that will benefit the MENA region. An example effort towards this goal can be the creation of a regional hub/platform (semi-government) for weather and climate data analysis, processing, modelling and forecasting that also provides customised regional, national and local early warning services on an ad-hoc request basis.
- Where early warnings are issued in WISER MENA's focus countries of Iraq, Syria, Yemen, Palestine, Morocco and Egypt, these are often not communicated effectively in a way that can be acted upon by the DRR/M authorities and humanitarian actors. Training on communication of short-term weather forecasts to support action could be provided which would support triggering of early action plans.
- Support the development of impact-based forecasts with focus NMHS where the need is greatest to inform humanitarian response
- Where there is a specific need from humanitarian actors for forecasts which cannot be met by the local NMHS, use the Met Office's Global Guidance Unit to provide these forecasts whilst a sustainable solution is found. For example, UNHCR need forecasts in Yemen for rainfall to inform their work to protect IDP camps from impacts associated with heavy rain and would use weekly forecasts as part of their operational planning.

11.3 Enhance seasonal forecasting

Seasonal and sub seasonal forecasts provide an indication of whether conditions over a three-month period (or longer) will deliver 'normal' (climatological) conditions or not. They often cover a large region, e.g., "the whole western part of the country may be wetter than normal" and express shifts in possibility, e.g., "there is an increased chance of an average seasonal temperature exceeding 25 degrees".

As such, seasonal forecasts can be hard to understand for users who are not familiar with the concepts of probability and uncertainty. This can prohibit their application to decision

making and prevent the uptake of a valuable tool to support preparedness in a range of sectors.

The WISER 2 programme in Africa has worked with ICPAC in East Africa to transform the way this Regional Climate Centre produces and delivers seasonal forecasts through moving from a consensus to an objective approach. Seasonal forecasts in the East Africa region are now more usable and used because they are more understandable and relevant to user's needs (see WISER CIASA refresh undertaken in WISER 2 extension).

It is proposed that a similar approach is used in the MENA region and builds on effective practice and learning from WISER and FCDO's Asia Regional Resilience to a Changing Climate Programme (ARRCC). There has been engagement with RCCs (who produce seasonal outlooks) through the scoping process, but in depth engagement with Climate Outlook Forums is required in WISER MENA's inception period to gain an understanding of specific activities that are required to enhance forecasts to aid wider use.

It is envisaged that work in this area will be largely at regional level, working with the ArabCOF and MedCOF and users of forecasts who operate at regional levels. However, where specific opportunities to mainstream seasonal and sub-seasonal information into action in target countries can also be considered.

Examples of activities under this intervention theme could include:

- Adapting seasonal forecast explainer videos so they are relevant to the MENA region. These videos were produced by the Met Office as part of the ASPIRE project to provide a basic, non-technical introduction to seasonal forecasts. These could be adapted so they are aimed at potential users of seasonal forecasts in MENA in order to stimulate demand for these services and participation in the Climate Outlook Forum process.
- Developing a relationship with Regional Climate Centres as a trusted partner and identifying how seasonal forecasts are developed and how the methods and processes around these could change to improve their accuracy.
- Looking at where seasonal forecast skill is highest (see section 8.2) to focus where enhancements to seasonal outlooks can add the most value and engaging with relevant users in those areas to explore how they could integrate seasonal information into their decision making and planning.
- Knowledge exchanges, secondments and training RCCs, between staff at Regional Climate Centres, ICPAC and the Met Office.

11.4 Support to other weather and climate service initiatives in the region

Section 9 details a variety of national and regional initiatives that have similar aims to WISER MENA. The scale of these projects and programmes is smaller than WISER MENA, but there is scope to support and strengthen these through collaboration and drawing on

learnings from WISER Africa and ARRCC. Further work to engage with existing projects and programmes in region, and to identify which WISER MENA is best placed to support (in terms of provision of technical assistance) will be assessed during inception. Selection will be led by the Theory of Change for WISER MENA, to ensure they contribute towards the change WISER MENA seeks to enable, and support will be given where possible to FCDO country office initiatives.

The scoping process also identified an opportunity to inform infrastructure projects with climate projections, so that future climate conditions can be considered during the planning phase to ensure the investment will be climate smart. Identifying examples of projects of this type and prioritising WISER MENA technical assistance to support these will also be explored further during the inception period.

In addition to supporting other weather and climate service improvement initiatives, the scoping phase also identified funders in the MENA region who are interested in supporting vulnerable populations to build resilience to extremes such as Community Jameel, KS Relief and the Saudi Arabian Government. It is therefore proposed that the programme continues to engage with these organisations.

11.5 Indicative investment per thematic area

Based on scoping insights, it is proposed that the WISER MENA budget is allocated to the four thematic areas as shown below. 'Building resilience to extremes by supporting vulnerable communities' could be allocated 40% of the budget, as insights to date show that this is where improved weather and climate service could be most transformative, based on the level of need in the region. This is subject to further development of the Theory of Change which would inform budget allocations.

Area	% of programme
Build understanding *of,* and demand *for* weather and climate information in the MENA region	20%
Build resilience to extremes by supporting vulnerable communities	40%
Enhance seasonal forecasting	20%
Support other weather and climate service initiatives in MENA	20%

11.6 Next Steps

- Market engagement exercise with potential grant holders for thematic area of opportunity 2 *September/October 2022*
- Some programme activities will commence in *September 2022* with the exception of specific emergency forecasts that are required for the humanitarian sector (where these cannot be obtained from the local NMHS), provision of which will run alongside stakeholder consultation activity.

12. Conclusions

The impacts of weather and climate in the MENA region are significant and growing in frequency and severity.

This WISER MENA scoping exercise illustrated the sensitives to these across water, food security, agriculture, energy and health sectors (amongst others) and highlighted the increased vulnerability and exposure to extremes suffered by millions of internally displaced people in the region.

Where weather and climate impacts are experienced, there can be opportunities to lessen or prevent these if forecasts and predictions are used to influence and inform actions, decisions, and policies. When used effectively, weather and climate services have the potential to save lives, support livelihoods and strengthen economies. However, understanding of their potential seems low in the region and as a result, uptake and use of weather and climate information is limited.

Thematic areas of opportunity for the WISER MENA programme have been proposed which combine regional and national activity in target countries. These will improve awareness and understanding of how weather and climate information can be used; build resilience to extremes by supporting vulnerable communities; enhance the usability of seasonal forecasting; and provide support to other regional initiatives with a weather and climate component.

Consultation on these themes will take place with stakeholders in the region and best practice, lessons, and approaches from WISER and other programmes will be built into programme design. Based on this analysis, a Theory of Change, Logframe and detailed programme plan will be developed which will articulate how PHENOMENAL's investment in the MENA region can be used to deliver weather and climate information services which can help communities stay safe and thrive.

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