

The Water-Energy Nexus in the Middle East and North Africa under Climate Change

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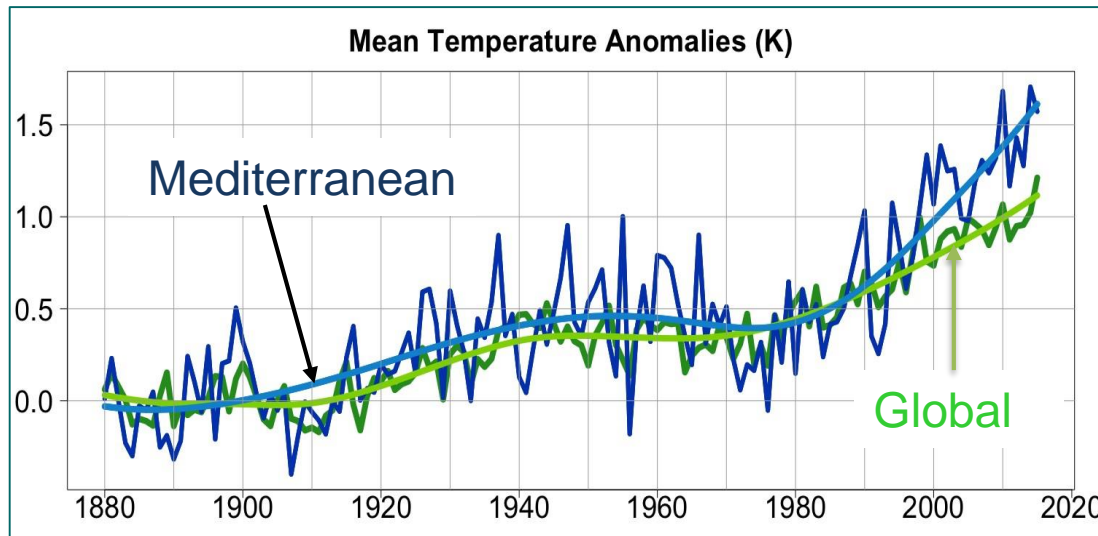
The Cyprus Institute, Nicosia, Cyprus

MENA Region: Major Characteristics

- Middle East North African Region (MENA): home to some 500 million people – and growing
- Increasing urbanization: climate warming and worsening air quality pose enhanced risks to human health
- Widely varied political and economic settings and a rich cultural heritage
- Multiple pressures on water availability, energy supply, food security and environmental integrity ⇒ exceedance of the region's bearing capacity
- Political and societal transformations and crises ⇒ challenges to human well-being and sustainable future
- This needs a well-conceived, integral strategy for mitigation/adaptation to enable a sustainable future

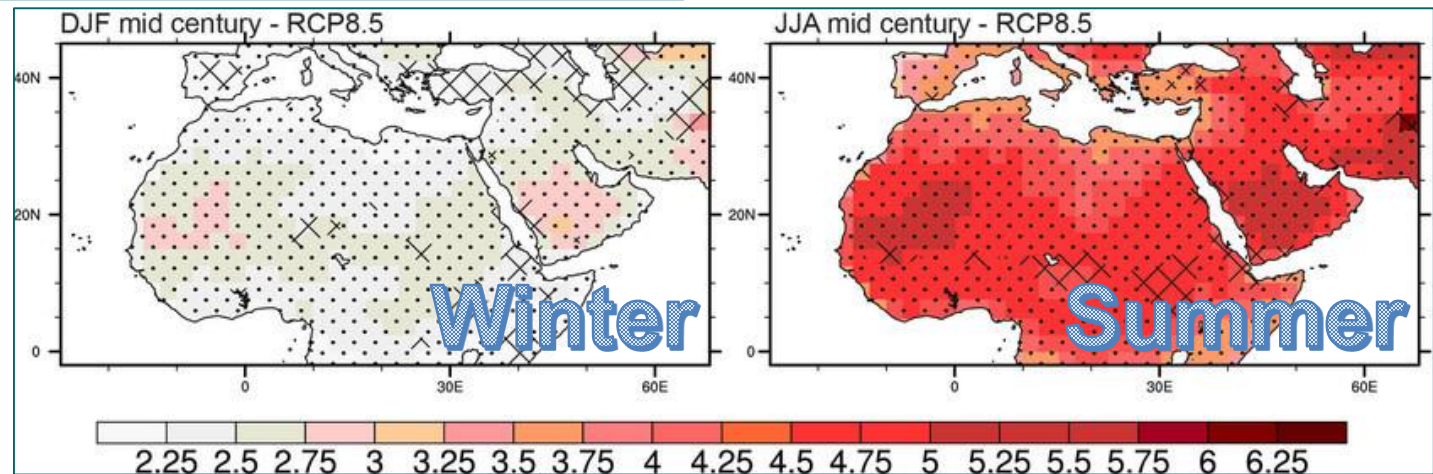
Climate Change in the MENA Region

- Temperature changes in the region exceed global means



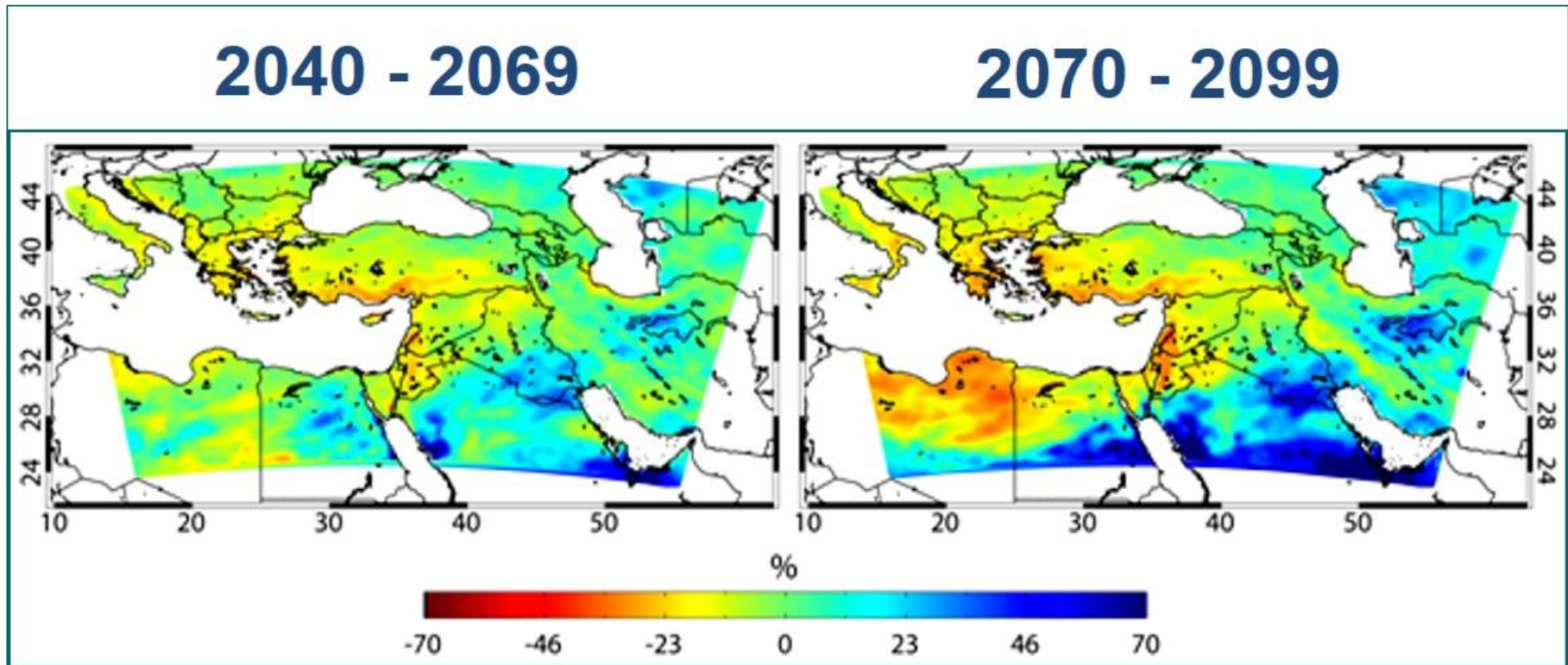
Historic warming of the atmosphere globally and in the Mediterranean Basin. Annual mean air temperature anomalies are shown with respect to the period 1880–1899, with the Mediterranean Basin (blue) and the globe (green) presented with (light curves) and without (dark curves) smoothing. Source: Cramer et al. (2018); Data from <http://berkeleyearth.org/>

Changes in end-century near-surface temperature in degrees K during Dec, Jan, Feb (DJF) and Jun, Jul, Aug (JJA) according to the RCP8.5 emission scenario; source: Lelieveld et al., 2016



Climate Change in the MENA Region

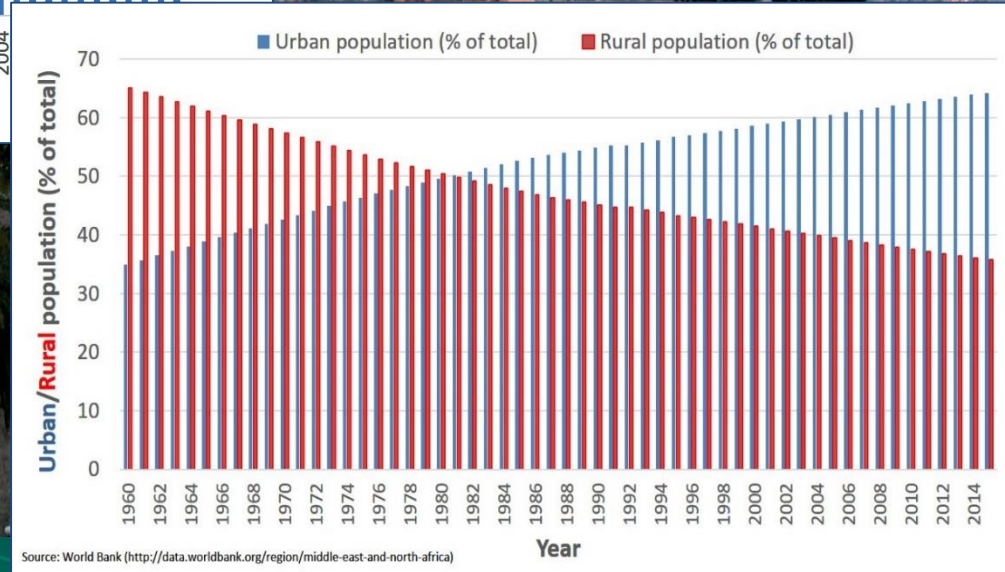
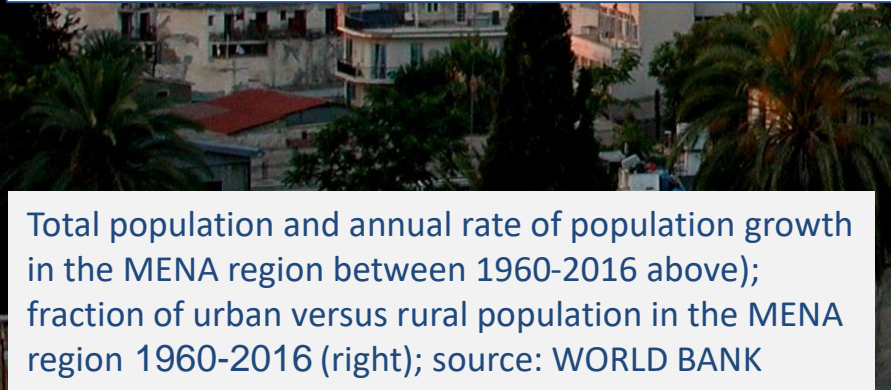
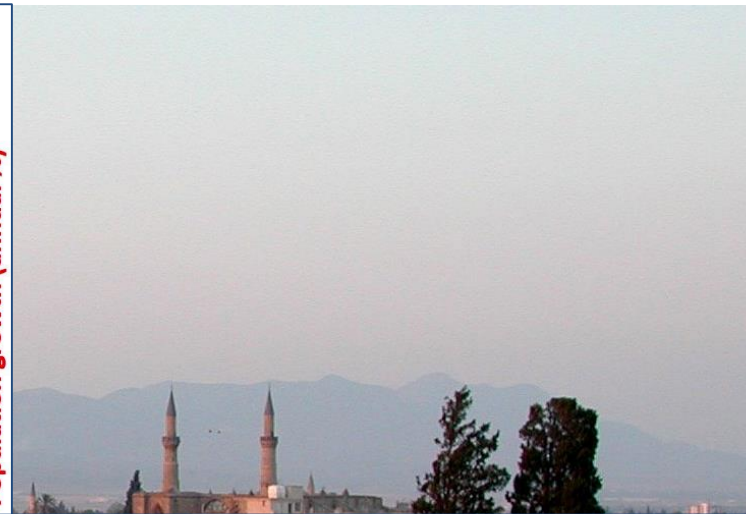
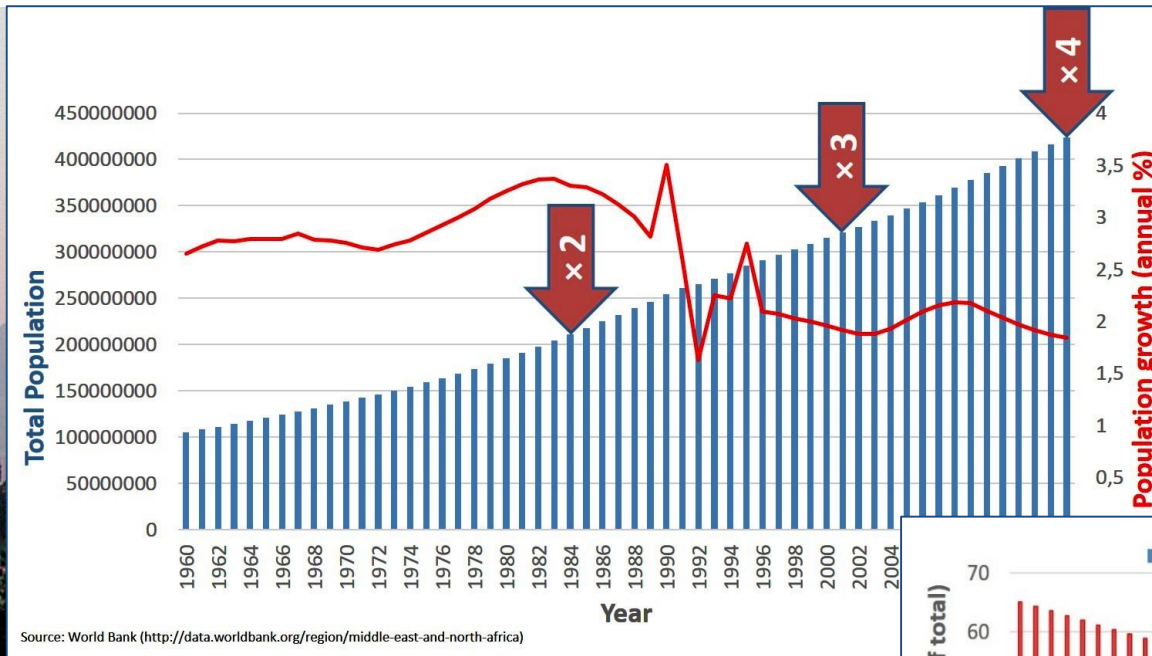
- Projected precipitation changes in the region



Patterns of changing annual mean precipitation, from PRECIS output for 2040–2069 (left panel) and for 2070–2099 (right relative to the control period 1961–1990; source: Lelieveld, pers. comm.

Additional Challenges in MENA Region

- Demography and Urbanization



Additional Challenges in MENA Region

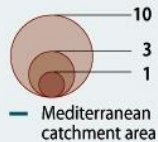
- High population densities and large urban centers already prominent in Eastern Mediterranean
- Given current demographic trends \Rightarrow continuous growth of urban centers expected

Population density and urban centres in the Mediterranean basin

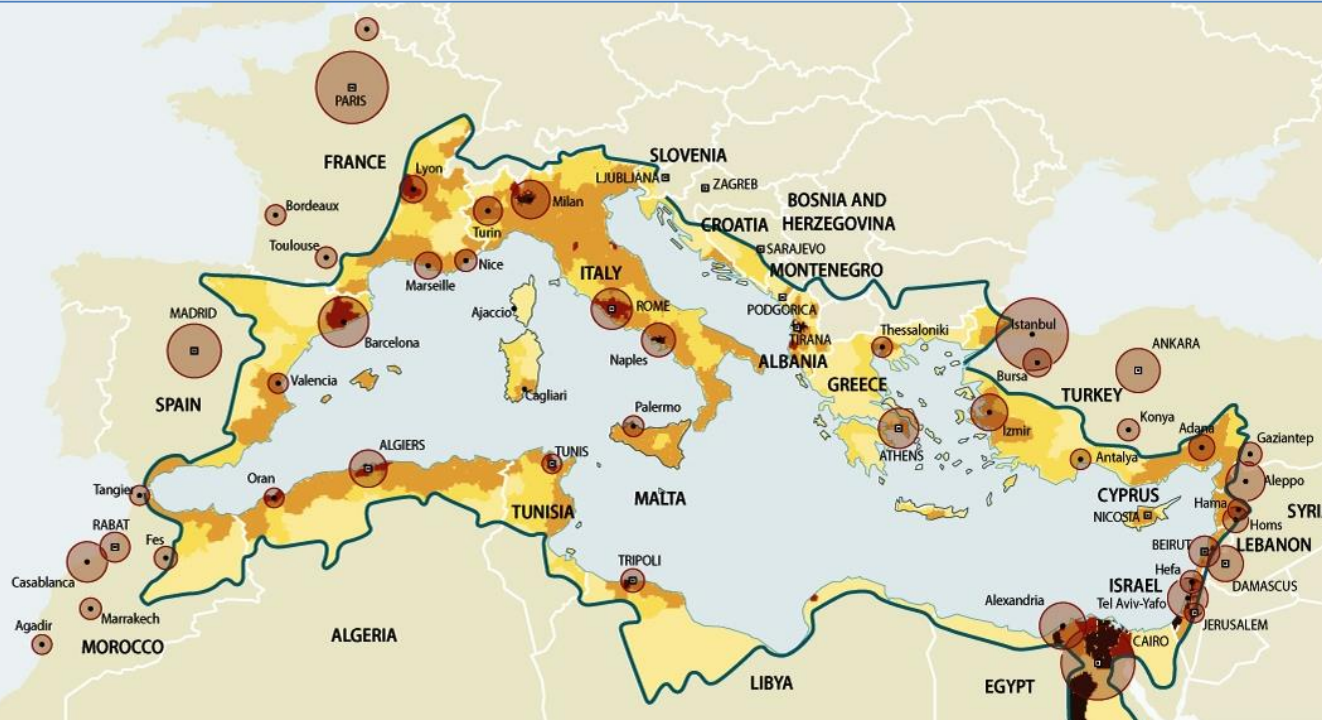
Population density, 2008
Inhabitants per square kilometre



Population in urban centres, 2010
Millions

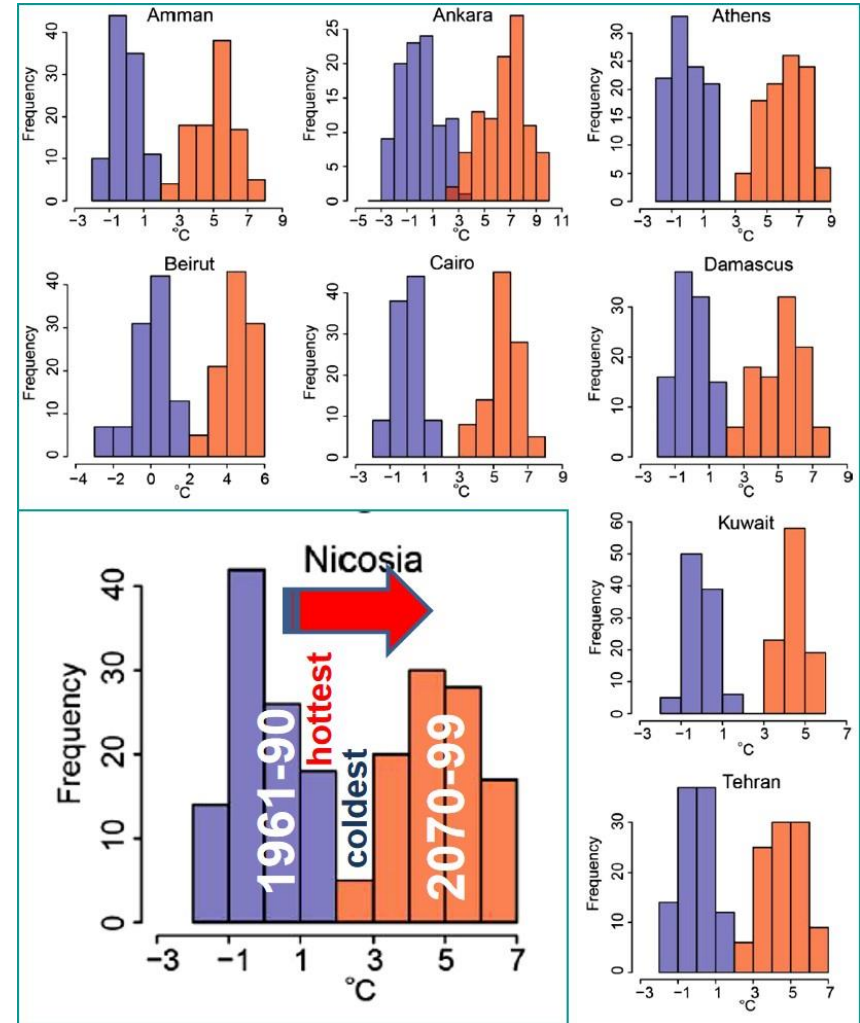


Sources: personal communication with Blue Plan, data collected from national sources, 2011; UNDESA, Population Division, online database, accessed in August 2011.



Additional Challenges in MENA Region

- Cities will see an **enhanced heat accumulation** compared to the surrounding rural land due to
 - heat-build-up in buildings,
 - transportation sector and infrastructure,
 - enhanced human life styles
 - reduced ventilation within cities

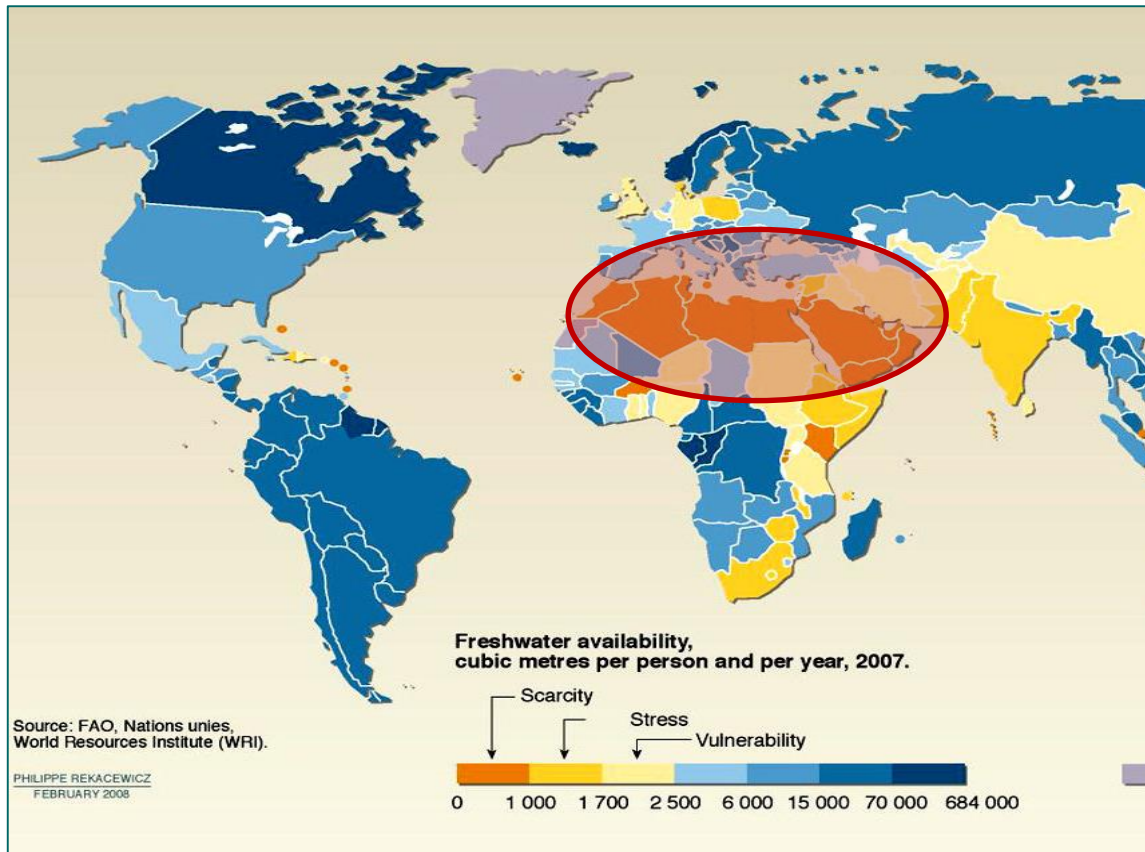


Recent and end-of-century temperature anomalies for a number of MENA and eastern Mediterranean country capitals.

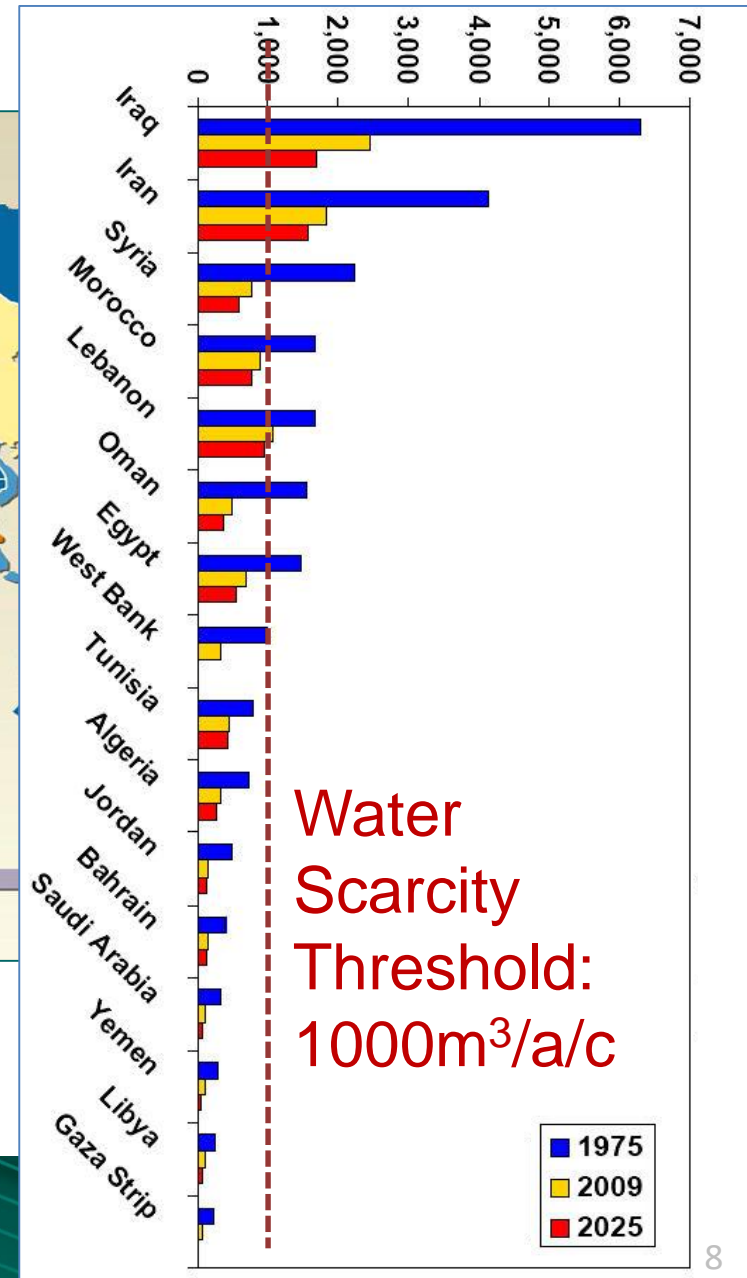
Model calculated frequency histograms (%) of daytime maximum summer (JJA = June, July, August) temperature deviations from the three-months-mean, relative to the period 1961–1990, based on the A1B scenario. Blue is for the period 1961–1990 (hence centered around 0 °C) and red for the period 2070–2099; the large insert illustrates the major characteristics of the observed warming trend for Nicosia; adapted and modified from Lelieveld et al. (2014)

Additional Challenges in the MENA Region

- Water scarcity



Global compilation of water scarcity highlighting the extreme scarcity in MENA countries; source: Vital Water Graphics, UNEP/GRID Arendal;
<http://www.unep.org/dewa/vitalwater/>



Global Change Impacts in MENA Region

- Major impacts of these challenges and changes include:
 - a lengthening of the dry season for most MENA countries
 - significant reductions in surface and subsurface water availability
 - Insufficient water for irrigation ⇒ threats to food security
 - reduced availability of drinking water for city inhabitants and green spaces
 - provision of additional water through desalination ⇒ significantly enhanced energy demand
 - Increased energy required for space cooling
- Issues need to be considered **holistically** in the framework of the **Water-Energy-Nexus**

Water-Energy-Nexus in MENA Region

- Energy Sector
 - Satisfying the rising energy and electricity demand requires the construction of additional electricity generation facilities
 - Holistic assessment for decisions about electricity generation technologies is needed
 - Consumption of water in power plants varies widely among different electricity generation technologies
 - renewable technologies: clear advantage over conventional (hydrocarbon) technologies by being less water demanding
 - Replacement of conventional power generation technologies by renewable technologies appears to be a viable alternative
 - Region offers copious potential for renewables (solar)

Water-Energy-Nexus in MENA Region

- Water Sector
 - Currently increasing deficiencies in water availability in the MENA region
 - Several countries in the region face already severe water stress
 - MENA countries with high population numbers will also have the highest gaps in available water
 - This trend will likely increase with progress in climate change
 - Future total unmet water demand in the MENA region is expected to amount to $\sim 200 \text{ km}^3$
 - MENA countries with crude oil and gas production (Iraq, Iran, Egypt, and Saudi Arabia) face particularly high water demand gaps

Adaptation/Mitigation Options/Strategies

- Maintaining energy and water security as well as adequate indoor living conditions in the MENA region requires well-conceived measures
- Measures should aim at minimizing the adverse effects of these changes (adaptation) and should address the reduction of forcings behind their origin (mitigation)
 - need to find ways to enhance the adaptive capacity on the local, national, and regional scales ⇒ effective adaptation strategies represent an urgent priority
 - total population of the MENA region accounts for only 5.8% of the global population, but their emission of carbon dioxide stands at 8.6% of the total ⇒ effective mitigation needed

Adaptation/Mitigation Options/Strategies

- Options/Measures/Strategies in the water sector include:
 - planning for extremes (floods): modeling and mapping flood extends and hazards;
 - artificial recharge of groundwater resources by reservoirs and check dams;
 - shifts from water intensive to draught tolerant crops;
 - analysis of environmental flow requirements and options;
 - improving rainfall-runoff management and stormwater use in urban areas, such as rain water harvesting;
 - improved leakage detection in urban water distribution systems;
 - offering incentives for reduced water consumption in private households through tailored tariff systems

Adaptation/Mitigation Options/Strategies

- Options/Measures/Strategies in the energy sector include:
 - deployment of renewable energy technologies in combination with enhanced energy efficiency provides significant opportunities to satisfy enhanced energy demand and to reduce greenhouse gas emissions in MENA countries;
 - shifting to renewables increases energy security in the MENA region by reducing dependencies on oil/gas producing countries
 - Employing renewables reduces water demand in energy sector
 - intermittency of solar and wind reduces energy security
 - possible remedy: employment of concentrated solar power (CSP)
 - thermal energy storage device/tank enables 24h/365d operation
 - CSP enables co-generation of electricity and potable water

Innovative Adaptation/Mitigation



Schematic representation of the co-generation of electricity and potable water through CSP (**insert**); overview of the experimental CSP installation at the southern coast of Cyprus by the Cyprus Institute

Thank you for your kind attention

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