UNITED NATIONS UNIVERSITY

UNU-FLORES

Institute for Integrated Management of Material Fluxes and of Resources

TECHNISCHE UNIVERSITÄT DRESDEN

ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

INTERNATIONAL KICK-OFF WORKSHOP

11-12 NOVEMBER 2013

DRESDEN, GERMANY

ADVANCING A **NEXUS APPROACH**
TO THE SUSTAINABLE MANAGEMENT
OF **WATER, SOIL** AND **WASTE**

Novel Approaches to Address the Energy-Water Nexus in Water-Scarce Regions

Manfred A. Lange

Director, Energy, Environment and Water Research Center

Act. Vice President of Research, The Cyprus Institute

P.O. Box 27456; CY-1645 Nicosia, Cyprus; m.a.lange@cyi.ac.cy

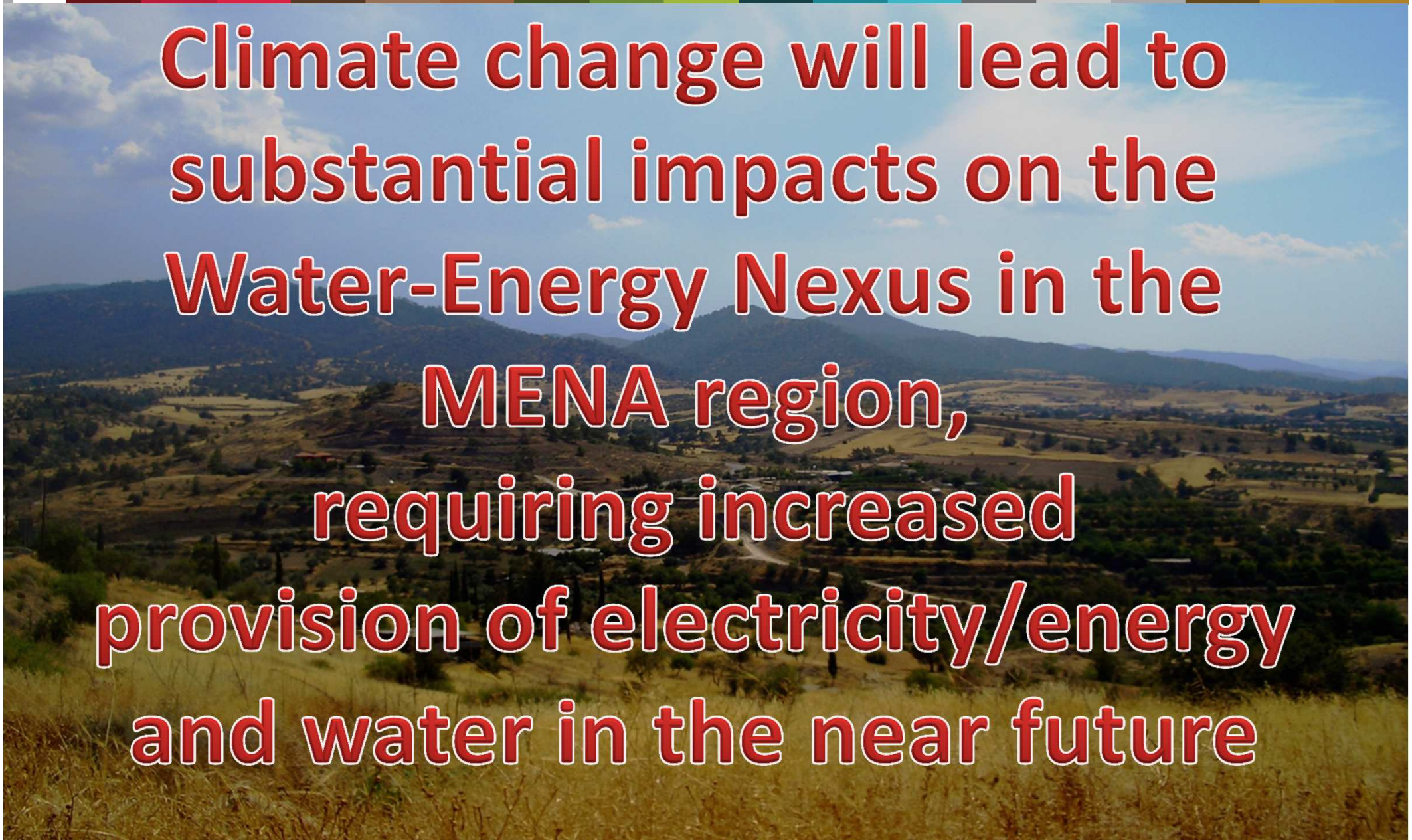
ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Background and Introduction

- **Eastern Mediterranean Region**
  - combined population of approximately 500 million people
  - strong environmental gradients
  - climate extremes, pollution and dust storms
  - diverse economic, social and cultural identities
  - recent challenging political developments
- **Climate Change**
  - region is a climate change “hot spot”
  - adverse impacts of climate change on water availability and energy consumption ⇨ **security concerns**
  - major challenges on energy and food security
  - threats to environmental integrity and biodiversity

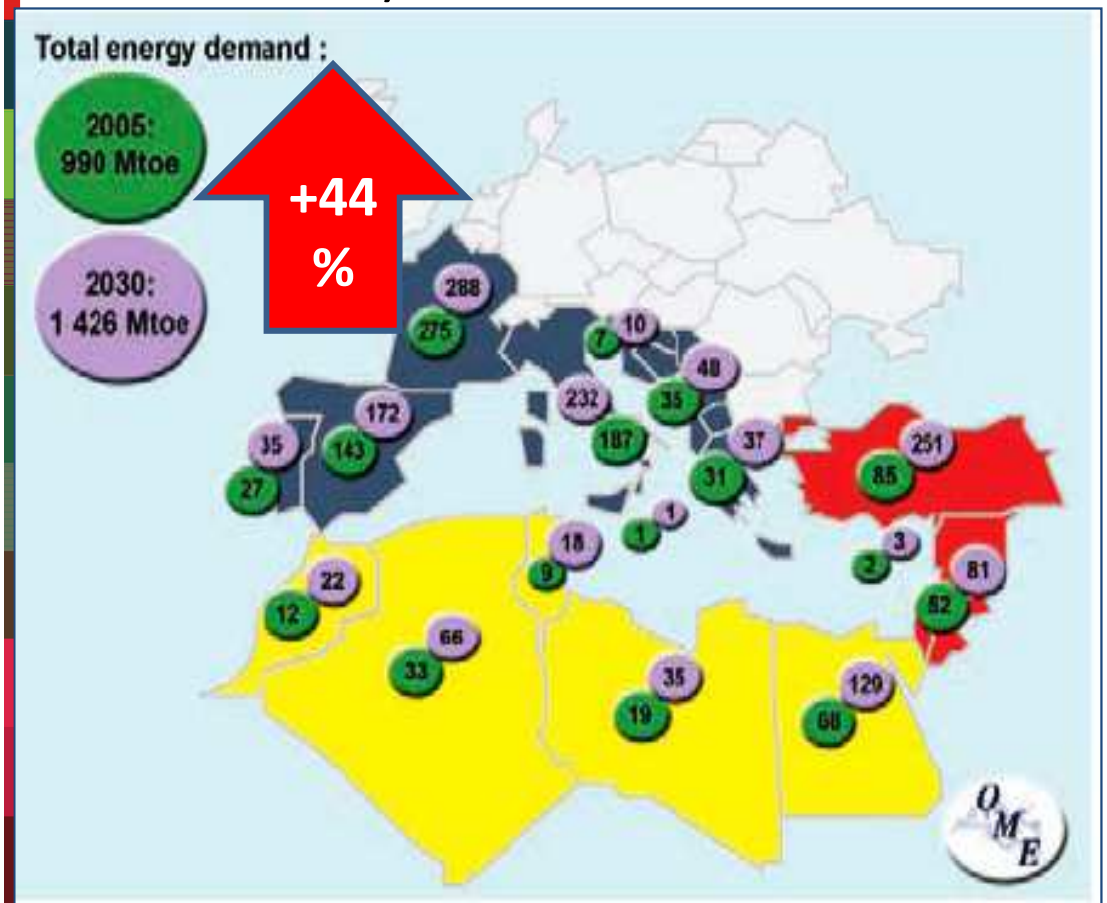
ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

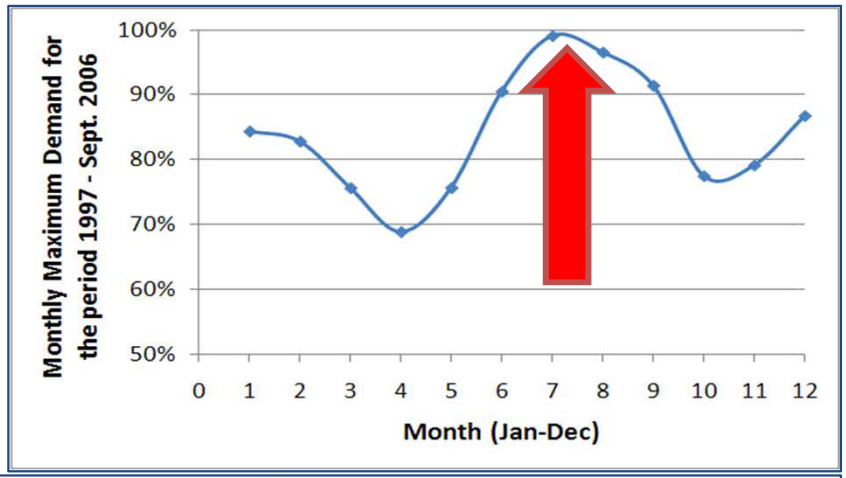
Thesis

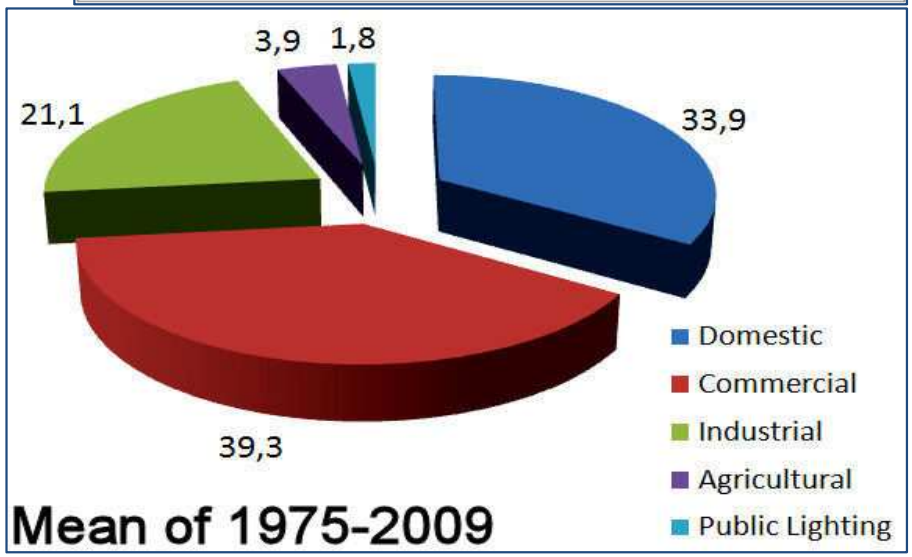


Energy Demand

- Electricity demand (Cyprus): summer maximum (space cooling) and domestic consumption
- Energy demands (Mediterranean Basin): bound to increase





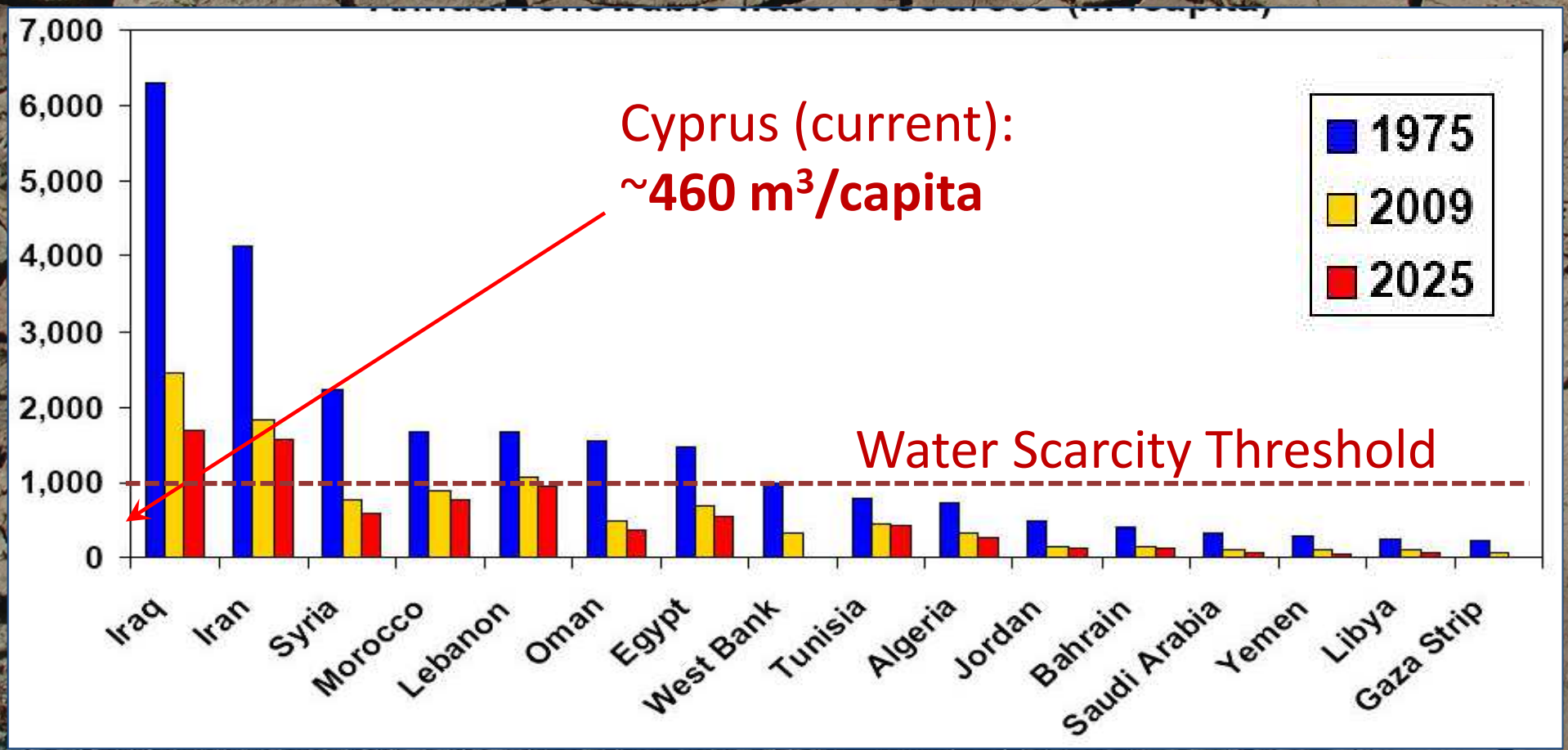


Monthly maximum electricity demand (1997 to 2006; top) and increase in mean monthly electricity consumption in Cyprus (1966-2009; bottom); source: TSO (2010)

ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Water in the MENA Region

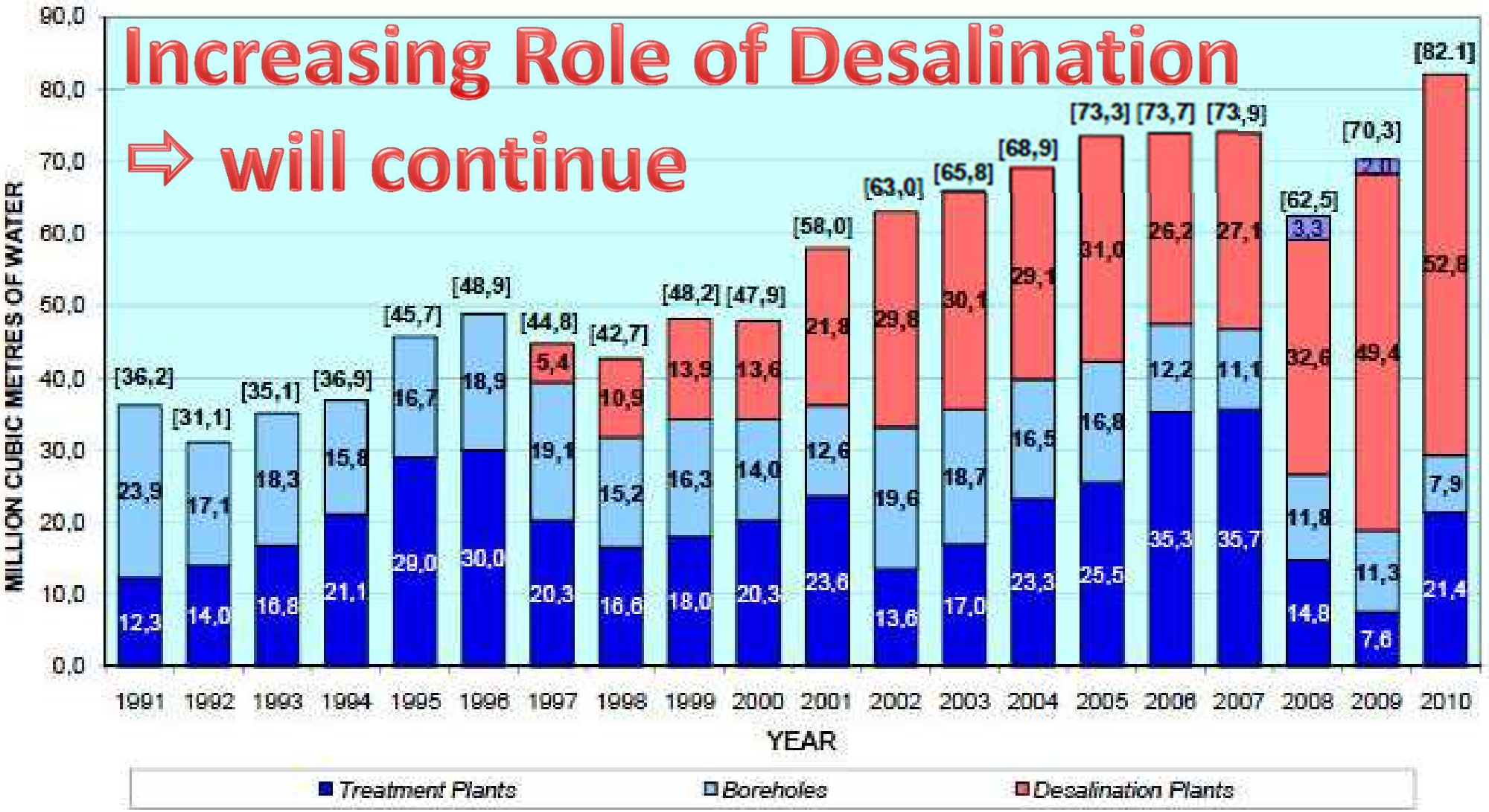
- Annual renewable water recourses (m^3/capita): already low
- Most countries expected to fall below water scarcity threshold in the foreseeable future



ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Water on Cyprus

- Domestic water demand



Government Water Works – Domestic Supply Sources 1991-2010; source: Water Development Department, 2010

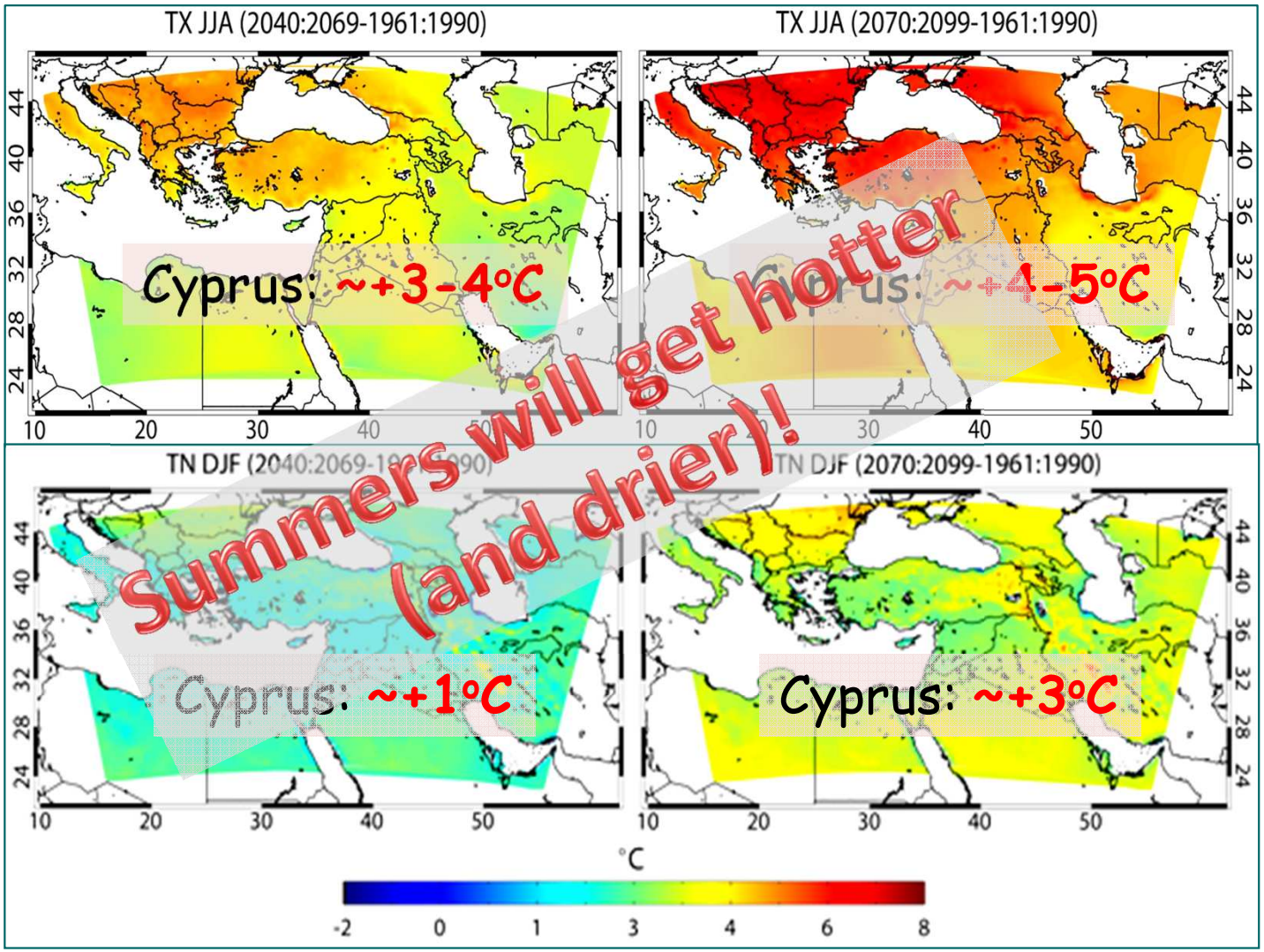
ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Climate Projections: Temperature

2040 - 2069 | **2070 - 2099**

Summer

Winter



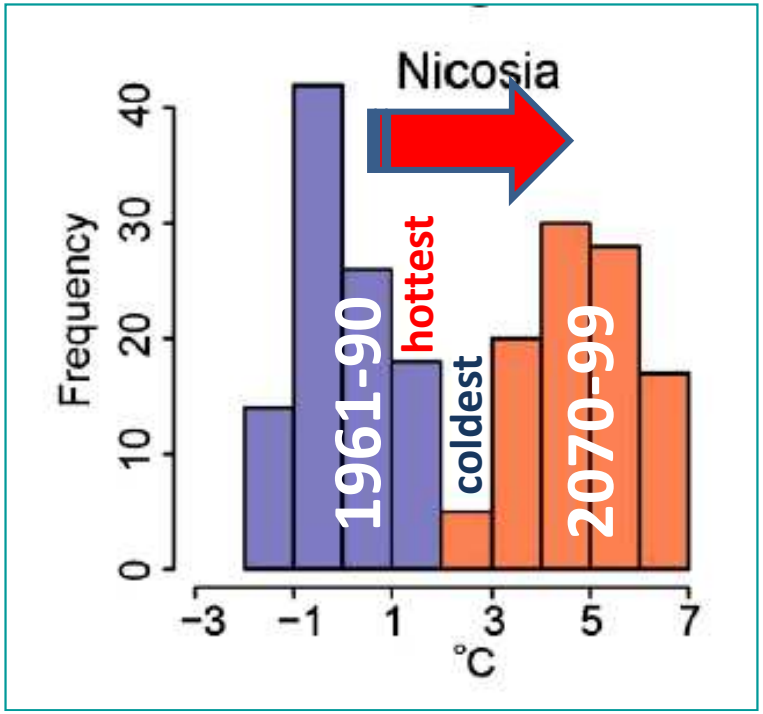
Patterns of changing mean summer maximum (JJA) and mean winter minimum (DJF) temperatures, TX (top) and TN (bottom), respectively, calculated from PRECIS output. The left panels show the mean changes for 2040-2069 and the right panels for 2070-2099 relative to the 1961-1990 control period; source: Lelieveld et al, 2012

ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Hot Weather in Cyprus

- Number of hot days/nights per year in Nicosia ⇨ significant increase expected
- Climate models project particularly severe warming in large cities in the Eastern Mediterranean

Quantity	1981-2000	2081-2100	Chan-ge
Daytime: T_{max} > 35°C	57	110	**+100%**
Nighttime: T_{min} > 25°C	15	83	**+450%**



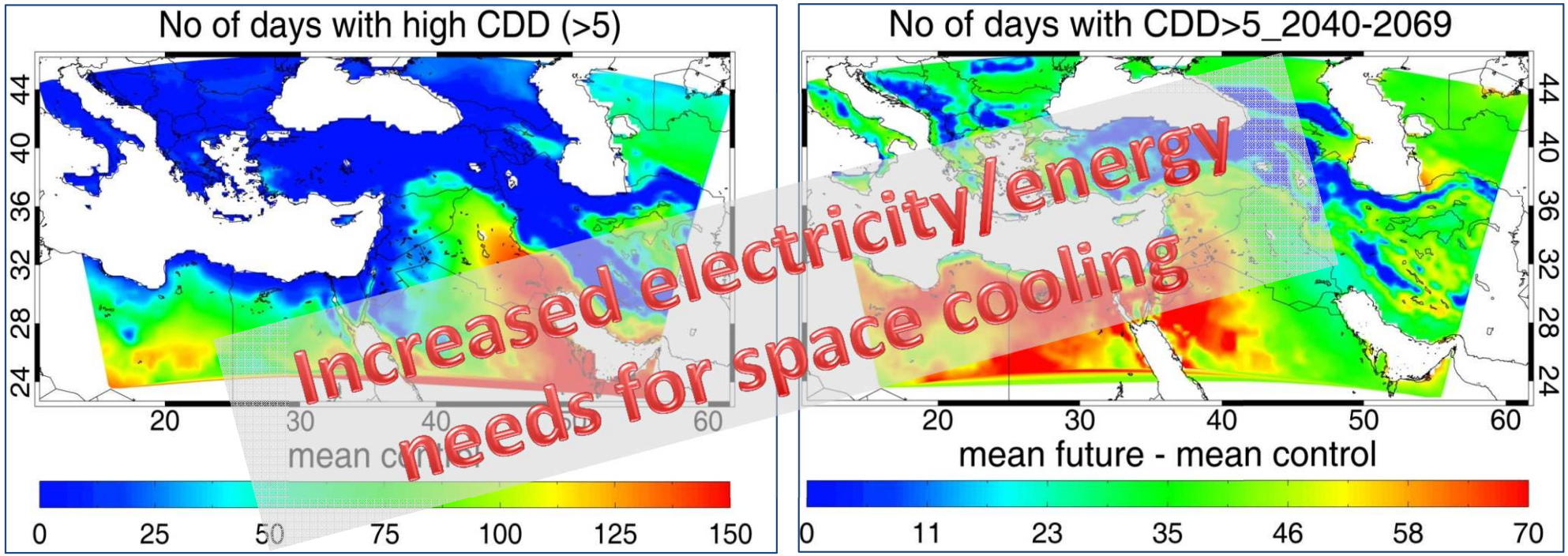
Recent and end-of-century temperature anomalies. Model calculated frequency histograms (%) of summer (JJA) daytime maximum temperature (TX) anomalies relative to the period 1961-1990, based on the A1B scenario. Blue is for the period 1961-1990 (hence cantered around 0°C) and red for the period 2070-2099 [Lelieveld et al., (2012]

ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Impacts on Required Space-Cooling

- Increased summer heat enhances need for space cooling
- This can be captured by the Cooling Degree Day index CDD_i:

  $CDD_i = \max(T_i - T^{**}, 0)$ with $T^{**}=25°C$; T_i=mean daily temperature summed over a certain time period

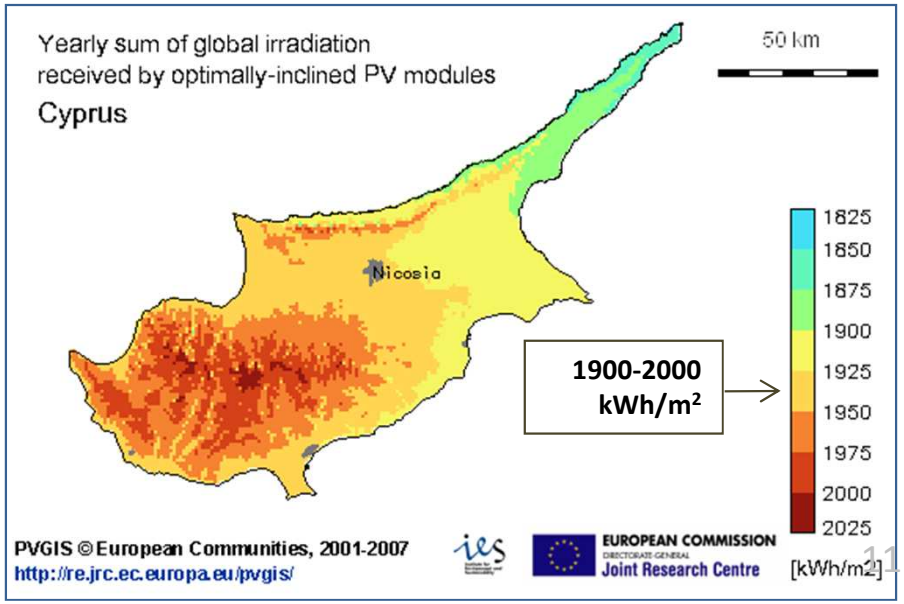


Patterns of mean number of heavy cooling degree days/year (CDD>5°C) for the control period 1961-1990 (left) and additional CDD>5°C days for the period 2040-2069 (right), calculated from PRECIS output;
source: Lelieveld et al., 2012

ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Adaptation/Mitigation Strategies/Measures

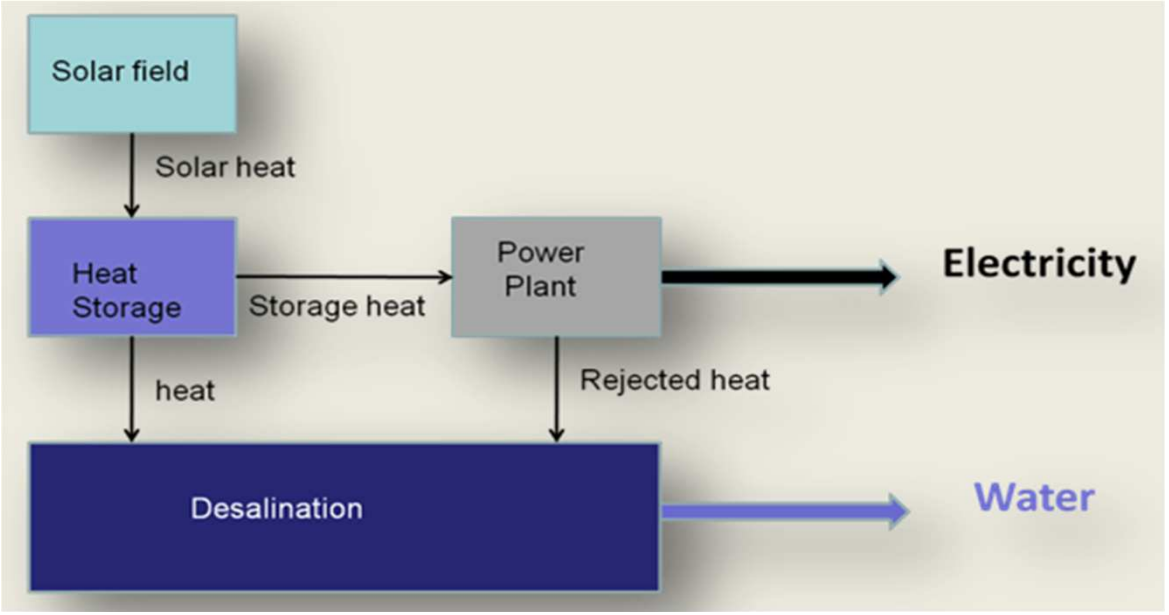
- Current Situation/Challenges
  - Current electricity need for seawater desalination: 214 GWh/year; with expansion to annually 92,3 Mm^3: 415,4 GWh/year
  - Additional electricity needs for space cooling
  - Enhanced urban heat island effects ⇨ adverse human health impacts
- Adaptation/Mitigation Options:
  - Increased seawater desalination ☹
  - Import of water by ship ☹
  - Switch from oil- to natural-gas fired power plants 😐
  - Use of renewable energy sources
    - Solar energy seems most effective ☺
    - Concentrating Solar Power (CSP) holds significant promise



ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

Adaptation/Mitigation Strategies/Measures

- **Co-generation** of **electricity** and **desalinated sea-water** from Solar Energy:
  - use of heliostats and central receiver technology
  - thermal energy storage in molten salts for 24 hour operation
  - steam turbine for electricity generation
  - thermal desalination via Multiple Effect Distillation
- Construction of a small (~50 kWth) demonstration plant in Pentakomo, Cyprus

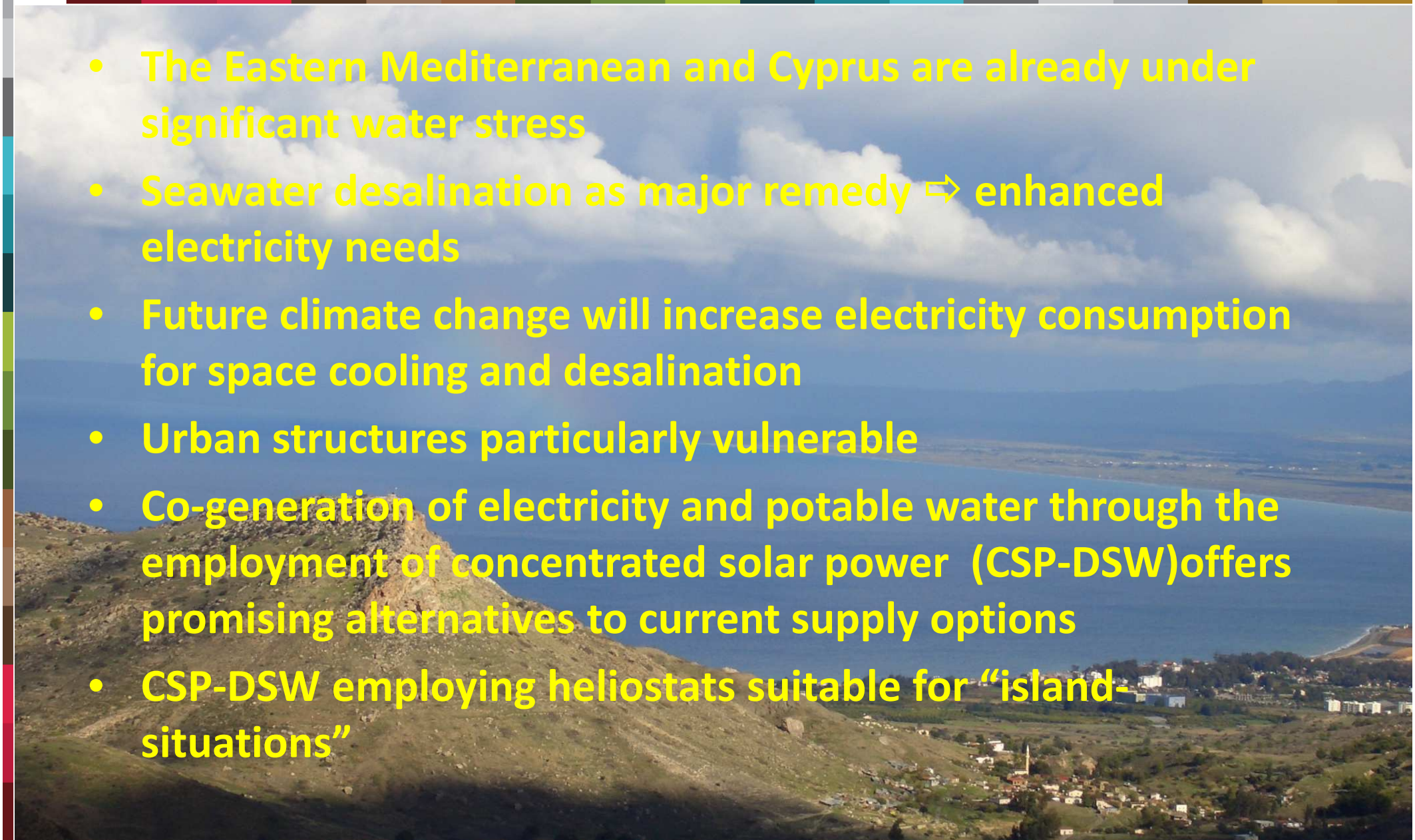


Schematic depiction of CSP-DSW plant (top) and artist's impression of experimental facility at Pentakomo (bottom

ADVANCING A **NEXUS APPROACH**
TO THE SUSTAINABLE MANAGEMENT
OF **WATER, SOIL** AND **WASTE**

Adaptation/Mitigation Strategies/Measures

Conclusions



- The Eastern Mediterranean and Cyprus are already under significant water stress
- Seawater desalination as major remedy ⇨ enhanced electricity needs
- Future climate change will increase electricity consumption for space cooling and desalination
- Urban structures particularly vulnerable
- Co-generation of electricity and potable water through the employment of concentrated solar power (CSP-DSW)offers promising alternatives to current supply options
- CSP-DSW employing heliostats suitable for "island-situations"